Physics I

Pressure and Density

$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$ Definition of pressure. Measured in pascal (Pa) in SI units.

$1\text{atm} = 1.013 \times 10^5$ Pa.

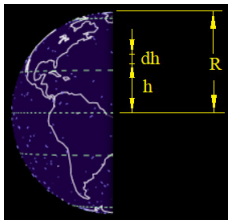
$\Delta P = \rho g h$ Hydrostatic pressure at a depth h.

Problem 1.- Estimate the pressure at the center of the Earth by integrating the hydrostatic equation ($\Delta P = \rho g h$) written in differential form:

$$dP = \rho g dh$$

So the integral will be:

$$P = \int_0^R \rho g dh$$

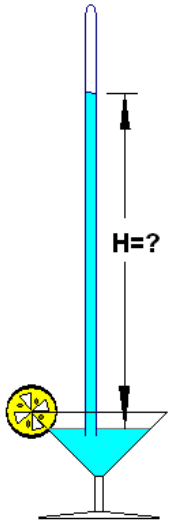


The limits of integration are from the center of the Earth ($h = 0$) to the surface ($h = R$).
Where $R = 6.37 \times 10^6$ m is the radius of the Earth.

Take the density as a constant: $\rho = 5{,}500 \frac{\text{kg}}{\text{m}^3}$.

Take g to be this function: $g = 9.8 \frac{\text{m}}{\text{s}^2} \frac{h}{R}$.

Problem 2.- How high would be the level in a barometer at normal atmospheric pressure if the fluid used were vodka martini (shaken not stirred) of density 910 kg/m^3? Would it be a practical instrument (why or why not)?



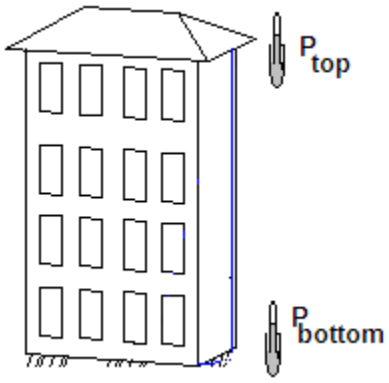
Problem 3.-

a) Which has more volume: a kilogram of aluminum or a kilogram of gold?

b) Aerogel is a new material with very special properties. The silicon variety has a density of only $\rho = 1.1 \text{mg/cm}^3$. Calculate the mass in grams of a 1.5-liter sample.

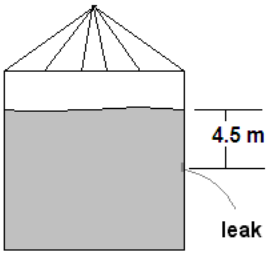
1 L=1000cm^3

Problem 4.- A precise barometer is used to measure the height of a building. It gives a change in pressure of 172 pascal between the top and the bottom of the building shown in the figure. Assume the density of air is constant and equal to 1.25kg/m^3 to find "h".

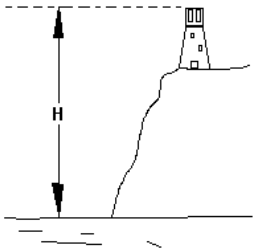


Problem 5.- If the density of air were constant 1.29kg/m^3 how high would be the atmosphere?

Problem 6.- A syrup tank springs a leak through a hole located 4.5m under the surface of the fluid. The area of the hole is 0.0035m^2. If you plug the hole with a rubber stopper, how much force must the rubber apply to stop the leak? [$\rho_{syrup} = 1{,}150 kg/m^3$]



Problem 7.- Estimate the atmospheric pressure at an altitude H=140 meters over sea level, knowing that the pressure at sea level is 1.013×10^5 pascal.
In your estimation assume the density of air to be constant $\rho_{air} = 1.29 kg/m^3$.



Problem 8.- Knowing that atmospheric pressure follows approximately the equation:

$$P = 760e^{-h/8010}$$

Where P is in torr and h is in meters. Calculate the height necessary to reach a pressure of 1 torr.

Problem 9.- Calculate the pressure at the bottom of the Dead Sea, given that its depth is 330 m, the density of its salty water is 1230 kg/m^3 and the atmospheric pressure at the surface is 1.067×10^5 Pa.

Problem 9a.- Calculate the pressure at the bottom of Lake Erie, whose depth is 64m. Assume the density of the water is 1,010 kg/m^3 and the atmospheric pressure at the surface is 1.033×10^5 Pa.

Problem 10.- Calculate the net force acting on a submarine window if the water depth is 200m and the area of the window is 0.025 m^2. Consider the pressure inside the submarine to be 1 atm. Take the density of seawater as 1,025 kg/m^3

Problem 11.- The gauge pressure in each of the four tires of an SUV is 28psi. Calculate the mass of the car if the "footprint" of each tire is 0.025m^2.

Problem 12.- To answer the two questions that follow take the density of gold and alcohol to be:

$\rho_{Au} = 19{,}300\text{kg/m}^3$ $\rho_{alcohol} = 800\text{kg/m}^3$

a) What is the volume of 1kg of alcohol?

b) What is the mass of $0.15\ \text{m}^3$ of gold?

Problem 13.- What is the difference in blood pressure between the feet and brain of a standing 1.8m-tall person? Approximate blood density to that of water.