Aim #31: Representing Force and Mass for a fluid

Fluid: a substance that has definite _____ but _____definite shape.
Ex: gases and liquids

Density: mass/volume ρ

- Units:
- ρ_{water} = 1 g / cm^3 = _____kg/m^3 = _____Kg/ L

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

Weight of a Fluid – force gravity exerts on a fluid = mg

- Equation:

Specific Gravity - density of a fluid compared to the density of water.

1. A liquid has a specific gravity of 0.357. What is its density?

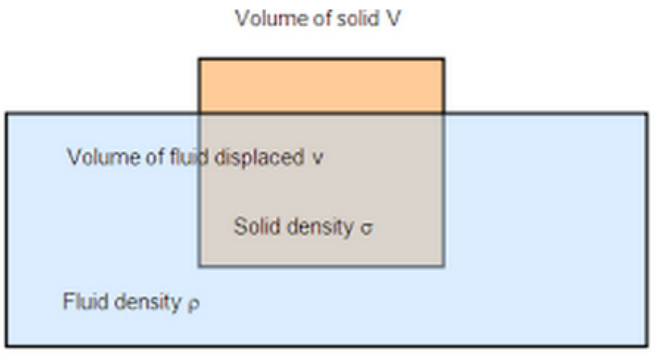
A) 357 kg/m^3 B) 643 kg/m^3 C) 1000 kg/m^3 D) 3570 kg/m^3

2. What is the weight of a liter of water?

Floatation

a. An object floats when its density is
> , =, <
_____.

Percent Submerged:



b. Ice has a density of 934 kg/m^2. What percent of the ice cube is above water level in freshwater?

c. Is it the same for saltwater? ρ = 1030 Kg/m^2

d. A ship floats in both fresh water and salt water. Compared to the freshwater, the amount of water displaced in the salt water is
A) more. B) less. C) the same. D) Cannot be determined

Pressure – _____ exerted by a fluid over an _____

$$P = \frac{F}{A}$$

- Units:

b. Concept: Suppose someone in a crowded room accidentally stomps on your foot with the heel of one shoe. Would you be better off if that person were (a) a basketball player wearing sneakers or (b) a petite woman wearing spike-heeled shoes?

c. Pressure is the same in all directions, and acts at _____ to any surface.

d. A difference in pressure will create a _____.
- The direction of the force will be from _____ pressure to _____ pressure.

e. Atmospheric Pressure:

1 atmosphere pressure, $1\ \text{atm} = 1.0 \times 10^5\ \text{N/m}^2 = 1.0 \times 10^5\ \text{Pa}$

- P_{atm} =

Net Force=

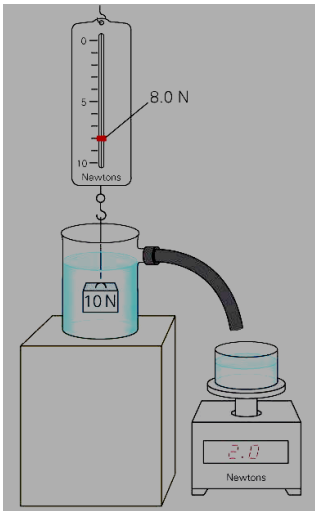
f. A sheet of paper is held horizontally in the air. Calculate the force on the top of this sheet of paper.

g. What is the net force on the paper?

Aim 32: The Buoyancy Force

Archimedes' Principle:

- A fluid exerts a net upward force on any object it surrounds.
- The Buoyancy force is always present regardless of whether it sinks or floats in the fluid.



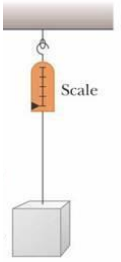
Buoyant Force, F_B

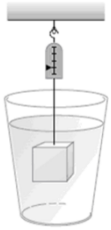
- The buoyant force is equal to the force of gravity would exert on the displaced liquid.

- Equation:

$$F_b = \rho V g$$

ex) A 280 gm cube attached to a string is submerged in water. The cube is .03 m on each side. What does the scale read?





Now what does the scale read? _____

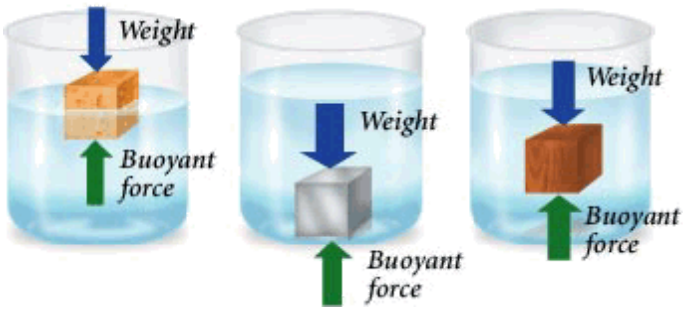
What is the volume of the mass?

1. Concept: Lead is denser than aluminum. **(1) Is the buoyant force on a submerged solid lead sphere**

   (a) more than, (b) less than, or (c) the same **as the buoyant force on a solid submerged aluminum sphere of the same diameter?**

2. Does your answer depend on the fluid that is causing the buoyant force? Explain.

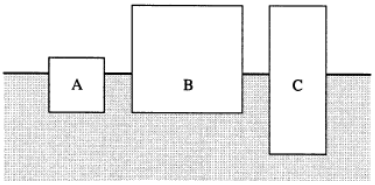
Sinking and Floating:



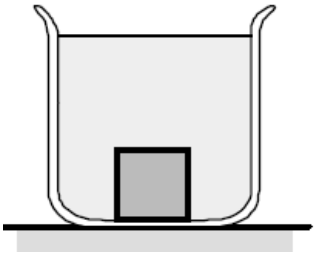
3. Concept: A wood block floats in a swimming pool. The buoyant force exerted on the block by water depends on
(a) the volume of water in the pool, **(b)** the volume of the wood block, **(c)** the volume of the wood block underwater, or **(d)** all of the above.

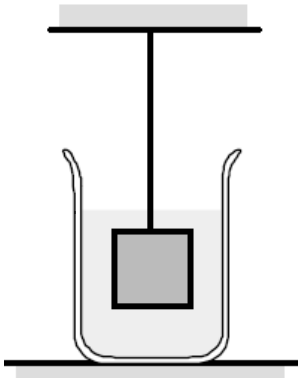
4. Concept: If the density of an object is exactly equal to the density of a fluid, the object will (1) Float (2) sink, or (3) stay at any height in the fluid, as long as it is totally immersed. Why?

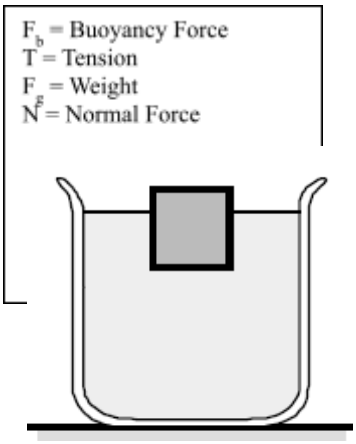
5. Rank the densities of each block from smallest to largest.



6. Each block is at equilibrium, **draw the forces**:

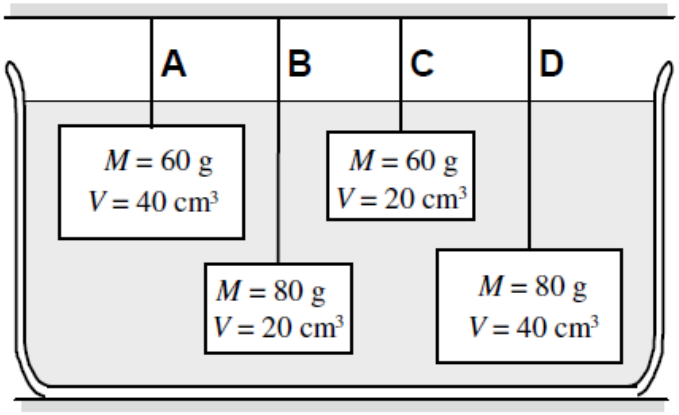






- When an object floats, the _____ acting on the object equals its weight.

Four blocks are suspended from strings in water. Cubes A and C are at the same depth, as are B and D.



Rank the tensions in the strings.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Aim 33 Solving Buoyancy Problems

i. A flask of water rests on a scale. If you dip your finger into the water, without touching the flask, does the reading on the scale
(a) increase, (b) decrease, or (c) remain the same?

In class demo: a 280 g (0.20 N) mass is placed in 100 g of water.

What does the scale read in each case:

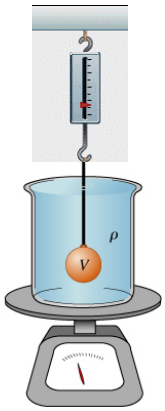
Mass of water and cup alone: _____

Mass of ball:_____

volume of the ball: _8.2_ cm^3

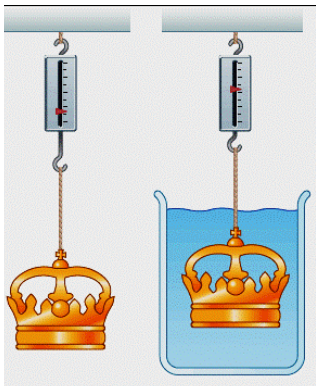
Use density 1g/cm3

F_b =



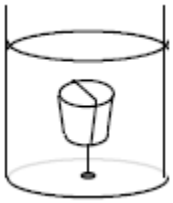
What does scale read?

1. The crown weighs 6 N in air but only 4 N in water. What is the volume of the crown?



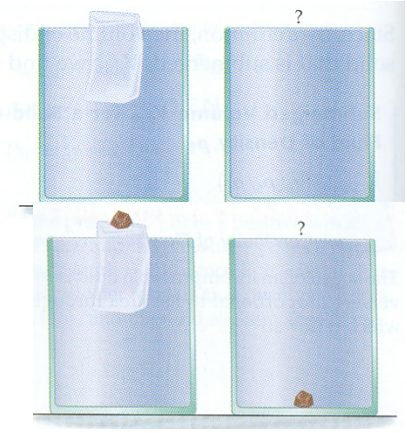
2. On a planet in a different solar system, the acceleration of gravity is greater than it is on Earth. If you float in the water on this planet, is it (a) easier to float, (b) harder, or (c) the same as on Earth?

3. A cork has a weight mg and a density 25% of water density. A string is tied around the cork and attached to the bottom of a water-filled container. The cork is totally immersed. Express in terms of the cork weight mg, the tension in the string
a)0 mg b)1mg c)2mg d)3mg E)4mg



4. When submerged under water, the apparent mass of one cubic meter of pure gold is 18300 kg. What would be its mass in air?
A) 16300 kg B) 17300 kg C) 18300 kg D) 19300 kg E) 20300 kg

5. A cup is filled to the brim with water and a floating ice cube. When the ice melts, which of the following occurs? (a) Water overflows the cup, (b) the water level decreases, or (c) the water level remains the same.



6. A cup is filled to the brim with water and a floating ice cube. Resting on top of the ice cube is a small pebble. When the ice melts, which of the following occurs? (a) Water overflows the cup, (b) the water level decreases, or (c) the water level remains the same.

7. A cube of unknown material and uniform density floats in a container of water with 60% of its volume submerged. If this same cube were placed in a container of oil with a density 800 kg/m^3, what portion of the cube's volume would be submerged while floating?
(A) 33% (B) 50% (C) 58% (D) 67% (E) 75%

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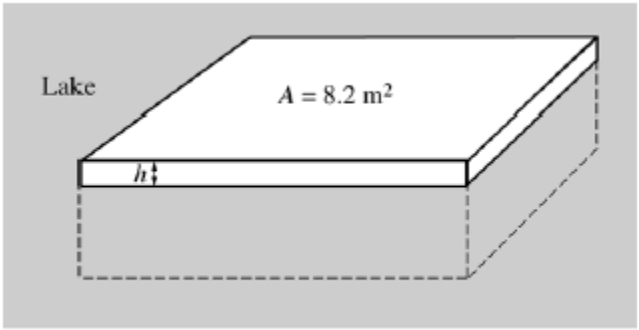
8. A large rectangular raft (density 650 kg/m^3) is floating on a lake. The surface area of the top of the raft is 8.2 m^{2,} and its volume is 1.80 m^3. The density of the lake water is 1000 kg/m^3.



Note: Figure not drawn to scale.

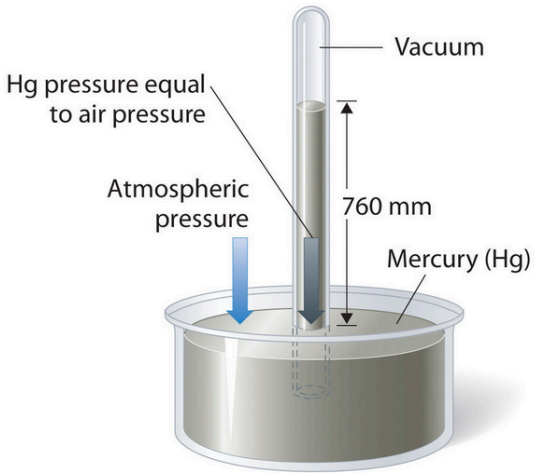
(a) Calculate the height *h* of the portion of the raft that is above the surrounding water.

(b) Calculate the magnitude of the buoyant force on the raft and state its direction.

(c) If the average mass of a person is 75 kg, calculate the maximum number of people that can be on the raft without the top of the raft sinking below the surface of the water. (Assume that the people are evenly distributed on the raft.)

Dependence of Pressure on Depth

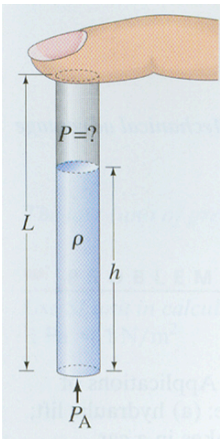
- Torricelli Barometer:
- Equation:



A $$P = P_0 + \rho g h$$

Barometer measures atmospheric pressure.

1. Concept: You insert a straw of length L into a tall glass of water. You place your finger over the top of the straw, capturing some air above the water but preventing any additional air from getting in or out, and then you lift the straw from the water. You find that the straw retains most of the water. (See Figure below) Does the air in the space between your finger and the top of the water have a pressure P that is (a) greater than, (b) equal to, or (c) less than, the atmospheric pressure P_{atm} outside the straw?

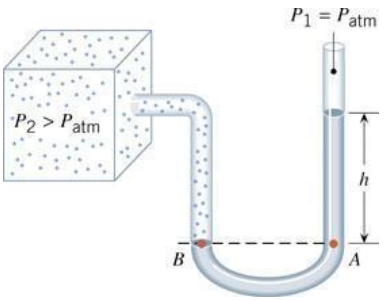


2. Concept: Two drinking glasses, A and B, are filled with water to the same depth. Glass A has twice the diameter of glass B.

(a) Compare the weight of water in the two glasses.
(b) Compare the pressure at the bottom of the two glasses.

U-shaped open tube manometer - measures pressure of the enclosed gas.

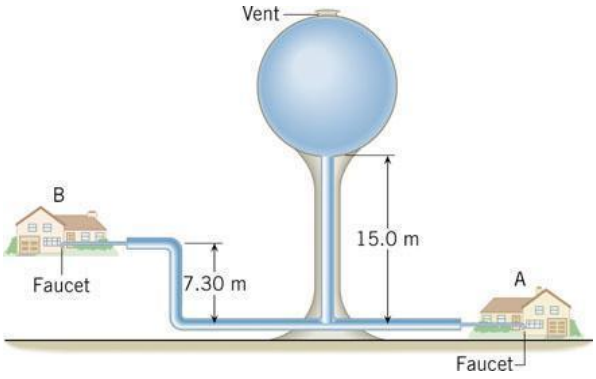
3. Calculate the pressure in the box (P_2) if the height is 12 cm. Tube is filled with Mercury (*Density = 13.6x 10^3Kg/m^2*)



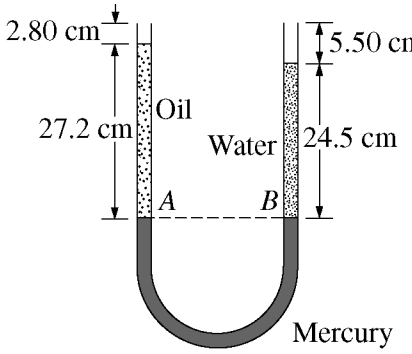
b) What would happen if atmospheric pressure drops to 9x10^4Pa?

Pressure at the same height is equal

4. If the radius of the water tower is 5m, calculate the water pressure at home a and b. Water is filled to the top of the tower.

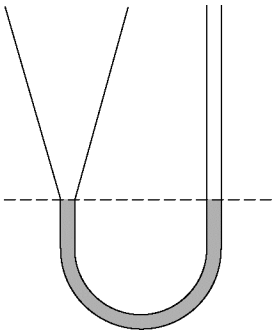


5. A glass U-tube with a uniform diameter of 0.850 cm is used to determine the density of an oil. As shown in the figure above, a 24.5 cm column of water balances a 27.2 cm column of the oil so that interfaces *A* and *B* of the mercury with the other liquids are at the same height. The density of water is 1.00×10^3 kg/m^3



(a) Calculate the density of the oil.

(b) Calculate the absolute pressure at *B,* the interface between the water and the mercury.



A new tube, identical to the U-tube except for a cone shape on the left, as shown above, is filled with the same volume of mercury that was in the U-tube. The mercury is at the same height on both sides of the new tube as it was in the U-tube, as shown by the dashed line. The same volumes of oil and water that were in the U-tube are now poured into the new tube, on the left and right, respectively.

(c) Indicate the new position of *B* relative to *A*.

_____Above *A* _____Below *A* _____At the same height as *A*

Justify your answer.

(d) A small piece of wood with density less than that of the oil is placed so that it floats in the left side of the tube. Indicate whether the pressure at the bottom of the tube increases, decreases, or remains the same.

_____Increases _____Decreases _____Remains the same

Aim 35: What is Pascal's Principal

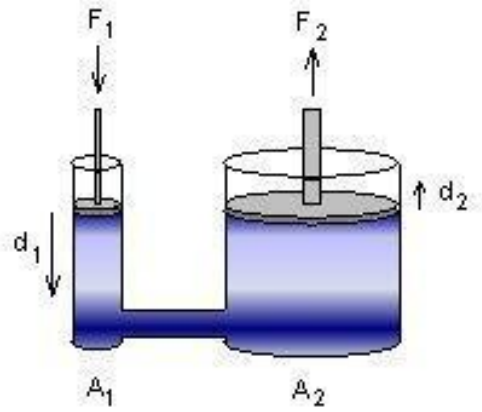
Ideal Fluids:

- will **NOT** compress.
- transmit applied pressure in all directions.
- Have no viscosity (friction) or turbulent flow

Pascal's Principal

Any change in the pressure applied to a completely closed fluid is transmitted to all parts of the fluid and its container.

$$F_2 = F_1\left(\frac{A_2}{A_1}\right)$$



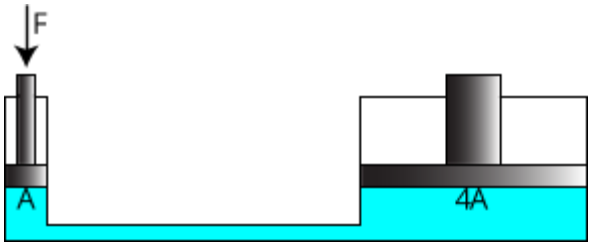
Conservation of Mass:

Mass in = Mass out

Volume in = volume out

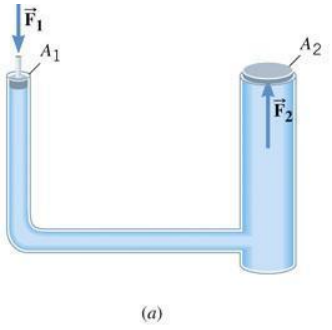
*****Conservation of Energy:** **Work in = Work out**

1. A reservoir of incompressible fluid is topped by two pistons of non-equal areas, as shown in the diagram at right (not drawn to scale). The larger piston has four times the surface area of the smaller piston. If a force *F* pushes the smaller piston down by some distance *d*, which of the following best describes the upward force and distance traveled for the larger piston



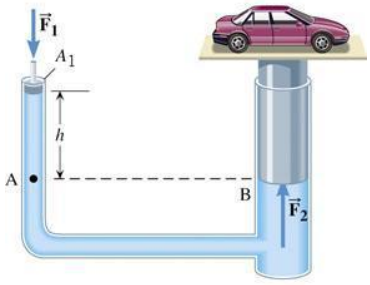
	Force	Distance Traveled
(A)	4F	d/4
(B)	F/4	4d
(C)	F	4d
(D)	4F	d

2. Calculate the force F_1 that can lift a 20,500N car. The bottom surface of the plunger and the lift are at the same level h= 0. The radius of r_1 is 0.012m and the radius of r_2 is 0.15m.



(a)

b. Now the plunger is not at the same level. Calculate F_1 if h = 1.1m (***density of hydraulic oil is 8x10^2 kg/m^3***)



(b)

3. In a hydraulic lift, the diameters of the pistons are 0.1 m and 0.5 m. A car weighing 12000N is to be lifted by the force of the large piston. a) What force is to be applied to the small piston?

4. b) When the small piston is pushed down by 0.02 m, how far is the car lifted?
5.

a. Gauge Pressure

i. A car tire is filled up to a pressure of 241 kPa (35 lbs/in2). This is called the _____.

1. However, the *pressure* inside the tire is the gauge pressure (241 kPa) plus the atmospheric pressure (Pat = 101 kPa) for a total pressure of 342 kPa.

ii. Equation: