A fluid

Anything that flows, like liquid or gas

Density

ρ = m/V

ρ: density (kg/m^3)
m: mass (kg)
V: volume (m^3)

Water has density 1000 kg/ m^3

Pressure

P = F/A

P : pressure (Pa)
F: force (N)
A: area (m^2)

Pressure of earth's atmosphere "1 atm" = $1 \times 10^5\ Pa$

Problem: Pressure

A driveway is 22.0 m long and 5.0 m wide. If the atmospheric pressure is 1.0 x 10^5 Pa, How much force does the atmosphere exert on the driveway?

(A) 9.09 x 10^{-8} N
(B) 1.1 x 10^{-3} N
(C) 909 N
(D) 4545 N
(E) 1.1 x 10^7 N

Show your work:

Absolute Pressure

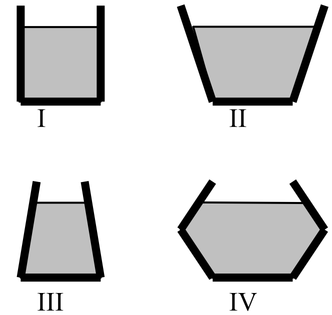
Pressure in a <u>static/</u>stationary fluid

$P = P_o + \rho g h$

P: absolute pressure (Pa)
P_o: initial pressure (usually 1 atm) (Pa)
ρ: density (kg/m3)
g: acceleration constant (9.8 m/s^2)
h: height of liquid column (m)

ρgh also called "gauge pressure"

Problem: Liquid pressure



The glasses shown are each filled to a depth *d* with water. The surface area of the bottom of each glass is the same. Rank the downward force experienced by the bottom of the glasses in order, from greatest to least.

(A) I, III, II, IV
(B) I, IV, III, II
(C) II, III, IV, I
(D) IV, III, I, II
(E) None of the above; the forces are the same.

Explain your reasoning:

Buoyant Force

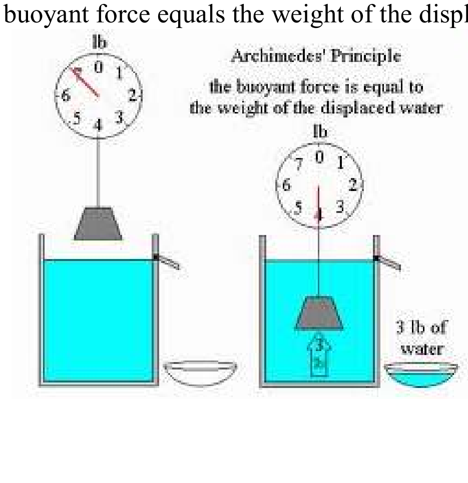
The upward force exerted on a submerged or partially submerged body.

$F_{buoy} = \rho V g$

F_{buoy}: buoyant force
ρ: the density of the displaced <u>fluid</u>.
V: the volume <u>submerged</u> (m^3)
g: acceleration constant (9.8 m/s^2)

Archimedes' principle.

- The buoyant force equals the weight of the displaced fluid

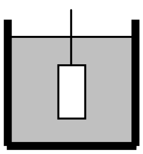


Problem: Buoyant Force

As a rock sinks deeper and deeper into water of constant density, what happens to the buoyant force on it?

A) It increases.
B) It remains constant.
C) It decreases.
D) It may increase or decrease, depending on the shape of the rock.

Problem: Buoyant Force



A 2.0 kg mass is suspended in a liquid on a string, as shown above. If the tension in the string is found to be 15 Newtons, the buoyant force the fluid is exerting on the mass is most nearly

(A) 5 Newtons
(B) 13 Newtons
(C) 15 Newtons
(D) 20 Newtons
(E) 25 Newtons

Pascal's Principal

- Pressure applied to an enclosed fluid is transmitted to every part of the fluid
- Hydraulic press
- $\frac{F_1}{A_1} = \frac{F_2}{A_2}$

F: force on piston 1 or 2 (N)
A: area of piston 1 or 2 (m^2)

Problem: Pascal's Principal

A 500 N weight sits on the small piston of a hydraulic machine. The small piston has an area of 2 cm^2 . If the large piston has an area of 40 cm^2, how much weight can the large piston support?

A) 25 N
B) 500 N
C) 10000 N
D) 40000 N

Fluid Flow Continuity

- The volume flow rate (A*v) is constant throughout the pipe.
- Garden hose principle
- Is a result of conservation of mass and an incompressible fluid

$\mathbf{A_1v_1 = A_2v_2}$

A_1, A_2: cross sectional areas at points 1 and 2
v_1, v_2: speed of fluid flow at points 1 and 2

Problem: Fluid Flow Continuity

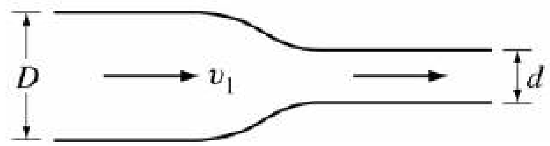
A water pipe of varying diameter is 1 cm in internal diameter at point A, where the speed of the water is observed to be 4.0 m/s. At point B, the internal diameter is 4 cm. At what speed is the water flowing at point B?

A. ¼ m/s B. ½ m/s C. 2.0 m/s
D. 4.0 m/s E. None of the above.

Show your work:

Problem: Fluid Continuity

Water flows through the pipe shown. At the larger end, the pipe has diameter *D* and the speed of the water is v_1 .



What is the speed of the water at the smaller end, where the pipe has diameter *d* ?

$(A)\ v_1 \qquad (B)\ \frac{d}{D}v_1 \qquad (C)\ \frac{D}{d}v_1$

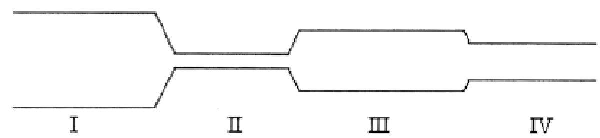
$(D)\ \frac{d^2}{D^2}v_1 \qquad (E)\ \frac{D^2}{d^2}v_1$

Bernoulli's Theorem

- The faster a fluid moves, the lower the pressure it exerts on surfaces parallel to the velocity.
- Air moves faster over the top of an airplane's wing, creating higher air pressure below and lower air pressure atop the wing, which creates the force of lift.

Problem: Fluid Continuity

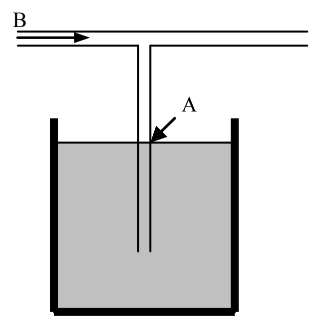
A fluid is forced through a pipe of changing cross section as shown.



a. Rank the following from <u>least</u> to <u>greatest</u> *pressure*.

b. Rank the following from <u>least</u> to <u>greatest</u> *velocity*.

Problem: Bernoulli's Theorem



The bottom of the t-tube that is open on all ends is placed in a glass of water as shown. The level of the water rises to point A inside the tube. A student blows through a t-tube in the direction indicated. What happens?

(A) The water level in the tube drops below point A.
(B) The water level in the tube rises above point A.
(C) The water level in the tube remains at point A.
(D) Air bubbles out of the bottom of the tube into the glass of water
(E) Cannot be predicted without knowing how hard the student blows.

Explain your reasoning:

Bernoulli's equation

$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$

P : pressure (Pa)
ρ : density of fluid (kg/m^3)
g: gravitational acceleration constant (9.8 m/s^2)
h: height above reference point (m)
v: speed of fluid flow at a point in the pipe (m/s)