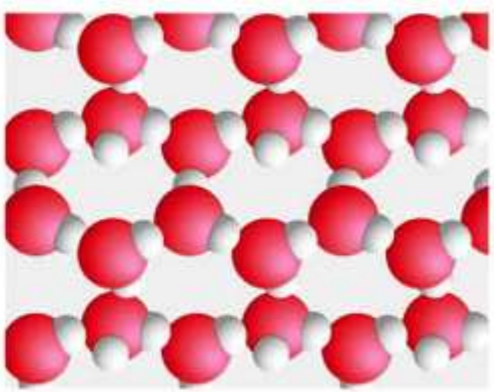
States of Matter

- Solid
- Liquid
- Gas
- Plasmas

A microscopic view

Solid

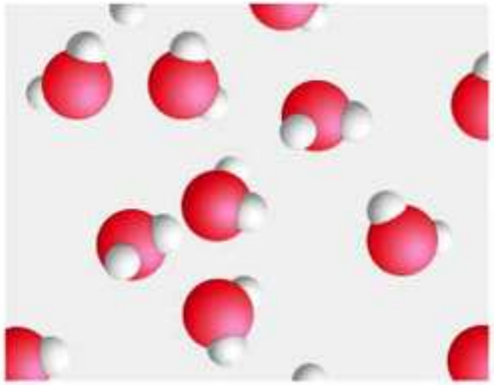
rigid body



Liquid

Fluid

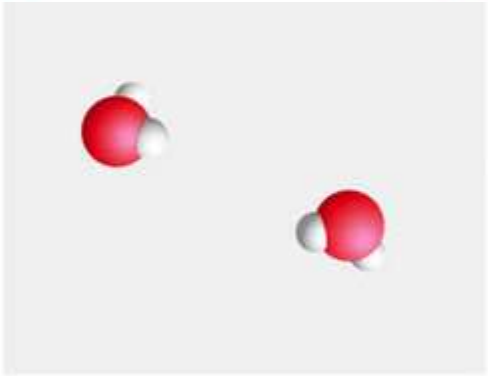
Incompressible



Gas

Fluid

compressible



Solids: Stress and Strain

Stress = Measure of force felt by material

$$Stress = \frac{Force}{Area}$$

- **SI units are Pascals, 1 Pa = 1 N/m^2**

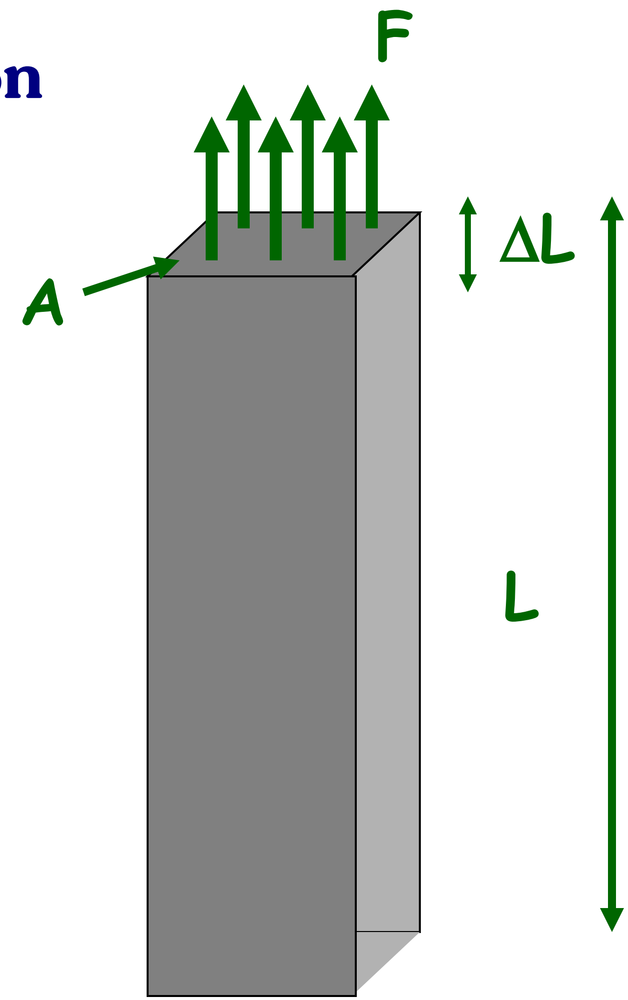
  (same as pressure)

Solids: Stress and Strain

Strain = Measure of deformation

$$Strain = \frac{\Delta L}{L}$$

- **dimensionless**

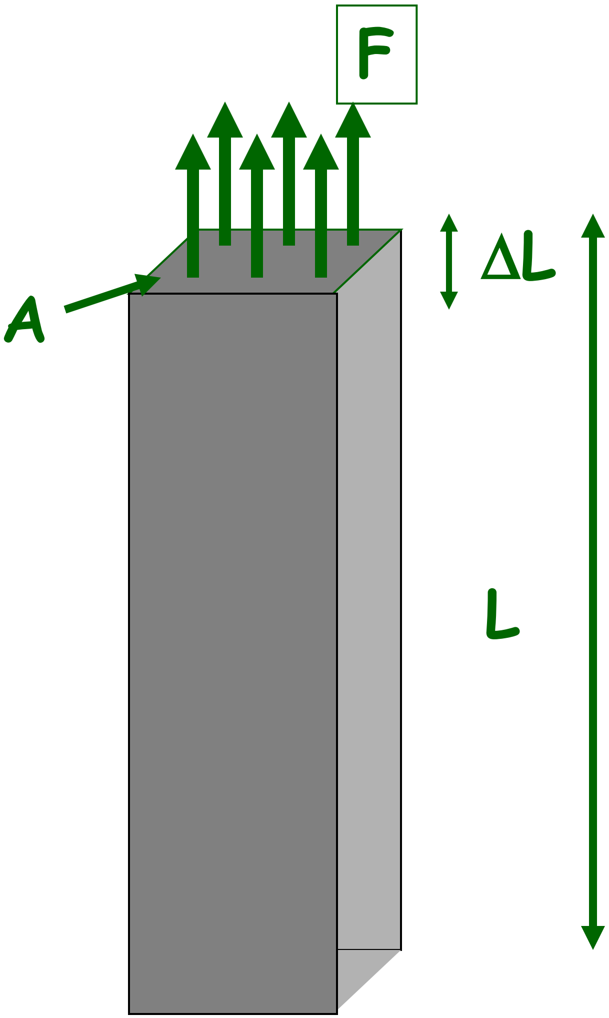


Young's Modulus (Tension)

$$Y = \frac{\left(F/A\right)}{\left(\Delta L/L\right)}$$

tensile stress

tensile strain



- **Measure of stiffness**
- ***Tensile* refers to tension**

Example 9.1

King Kong (a 8.0×10^4-kg monkey) swings from a 320-m cable from the Empire State building. If the 3.0-cm diameter cable is made of steel ($Y=1.8\times10^{11}$ Pa), by how much will the cable stretch?

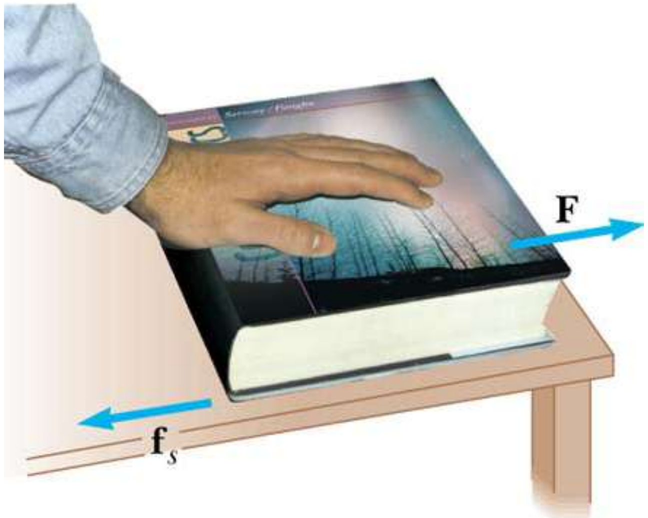
1.97 m

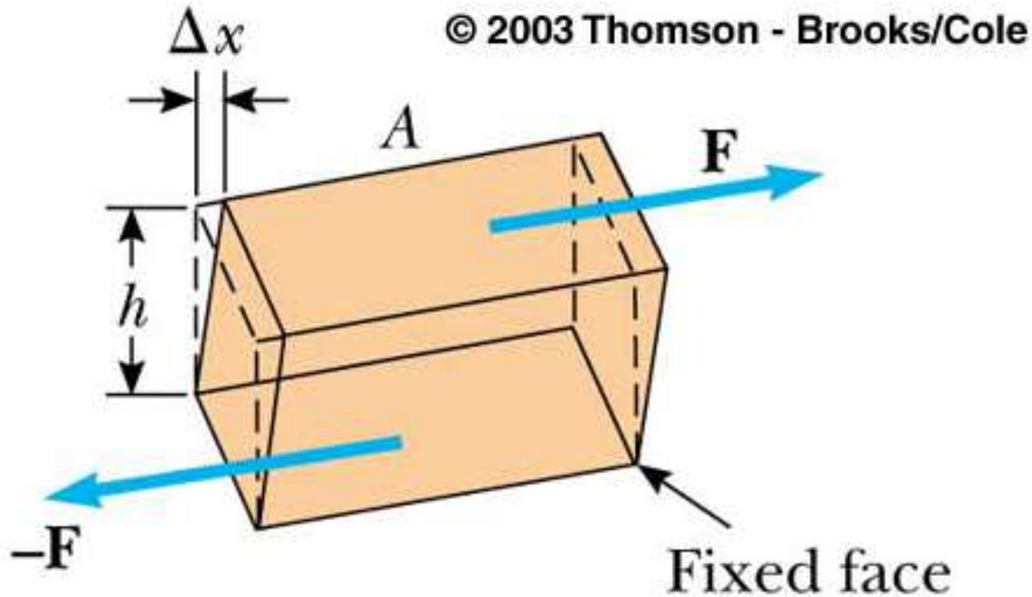
Shear Modulus

$$S = \frac{\left(F/A\right)}{\left(\Delta x/h\right)}$$

Sheer Stress

Sheer Strain





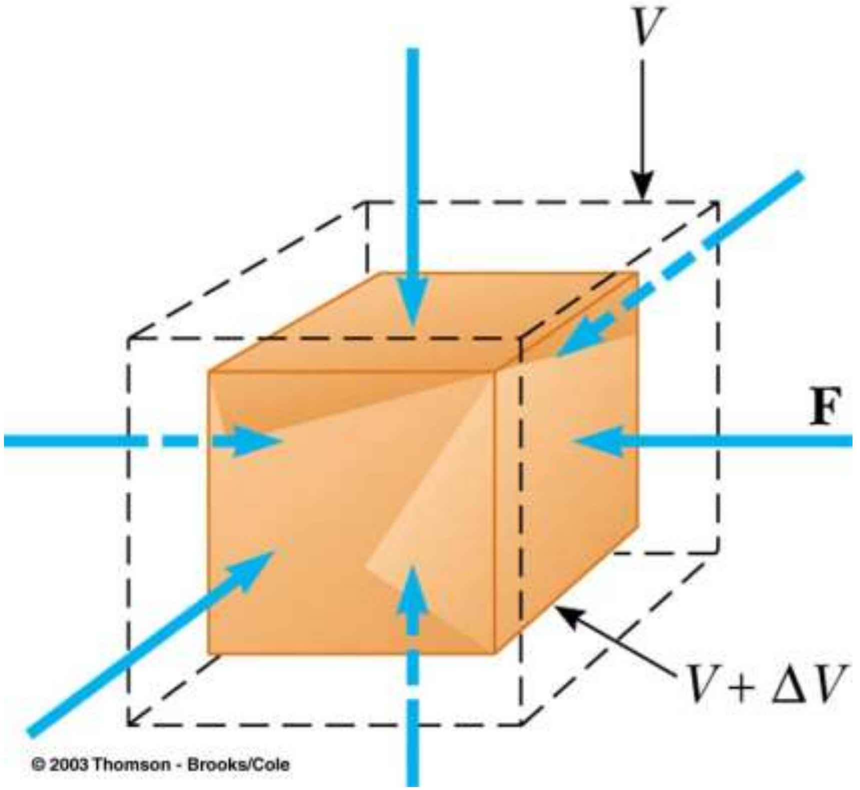
Bulk Modulus

$$B = -\frac{\Delta F / A}{\Delta V / V} = -\frac{\Delta P}{\left(\Delta V / V\right)}$$

Change in Pressure

Volume Strain

$$B = Y/3$$



What new physics is involved?

- Fluids can flow from place-to-place
- Their density can change if they are compressible (for example, gasses)
- Fluids are pushed around by pressure forces
- An object immersed in a fluid experiences buoyancy

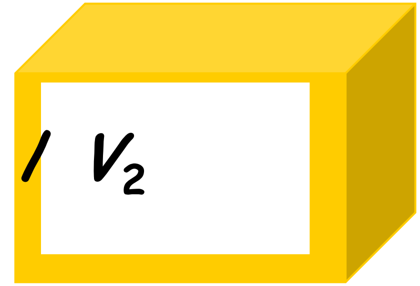
Density

- **The density of a fluid is the concentration of mass**

$$density = \frac{mass}{volume} \qquad \rho = \frac{m}{V} \qquad Units\ are\ \frac{kg}{m^3}$$

- **Mass = 100 g = 0.1 kg**
- **Volume = 100 cm^3 = 10^{-4} m^3**
- **Density = 1 g/cm^3 = 1000 kg m^3**

$$\rho_{gold} = m_1 / V_1 = m_2 / V_2$$

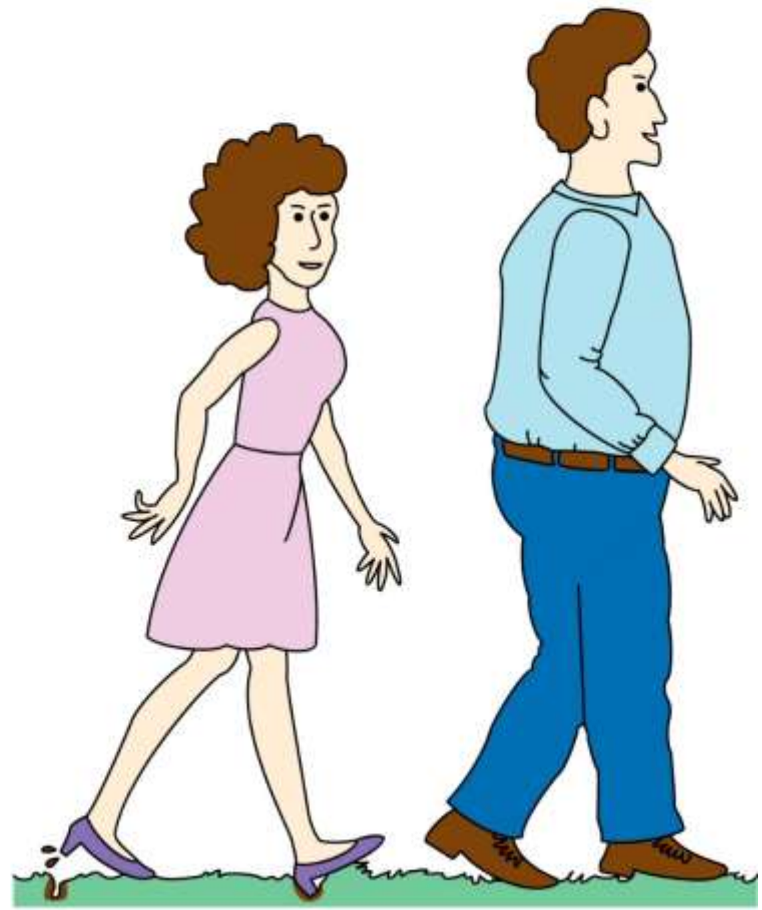


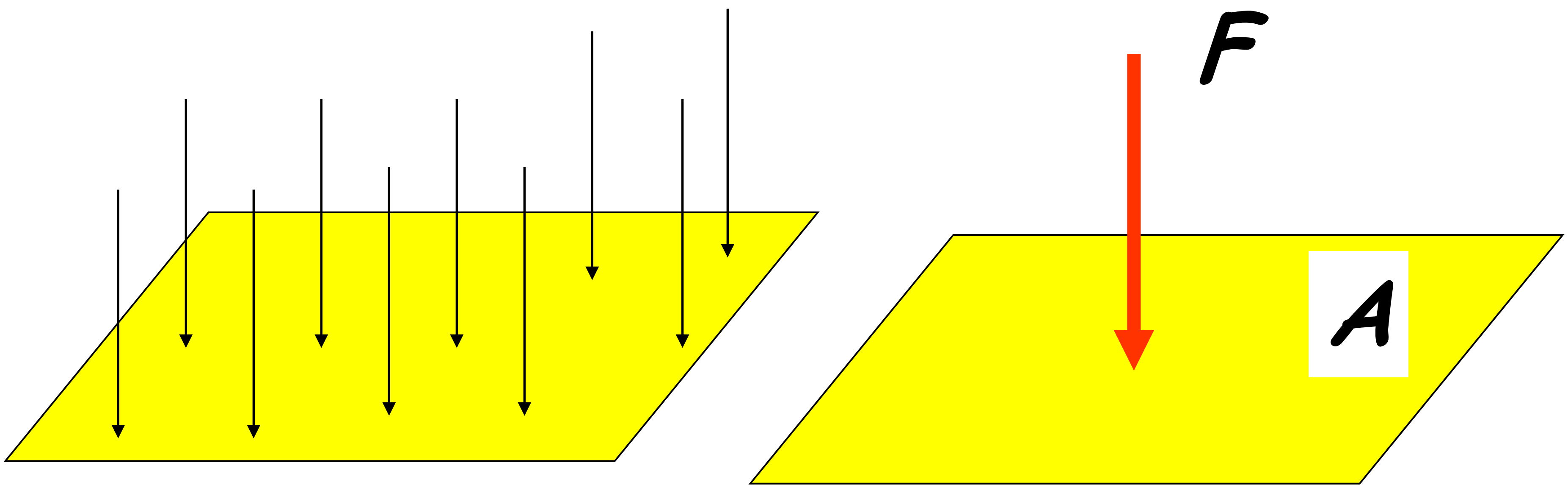
$$m = \rho V$$

$$V = m / \rho$$

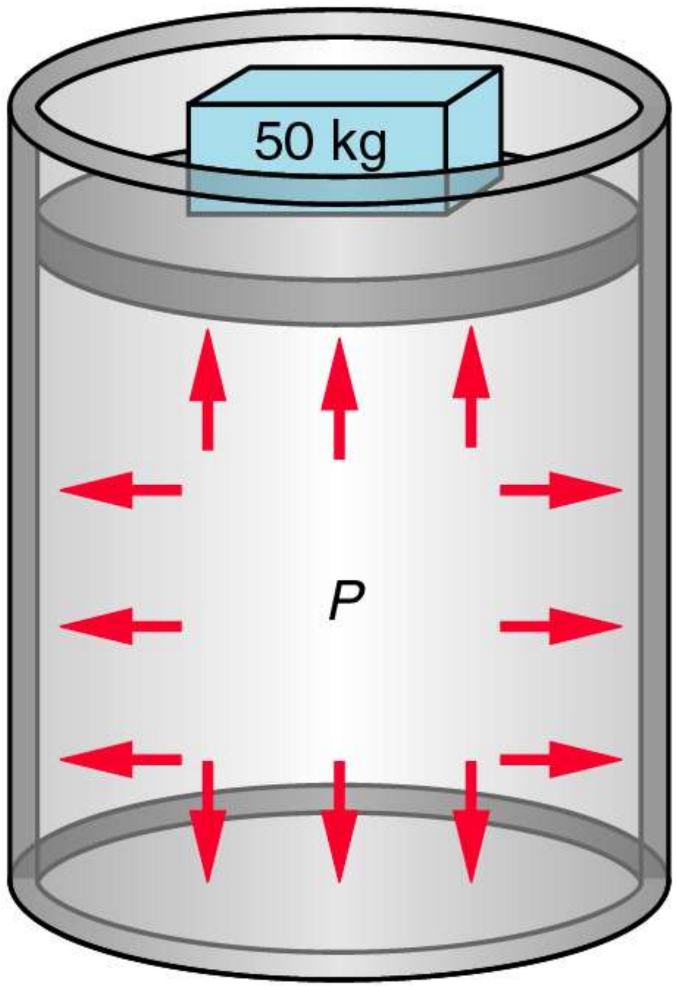
A woman's high heels sink into the soft ground, but the larger shoes of the much bigger man do not.

Pressure = force/area



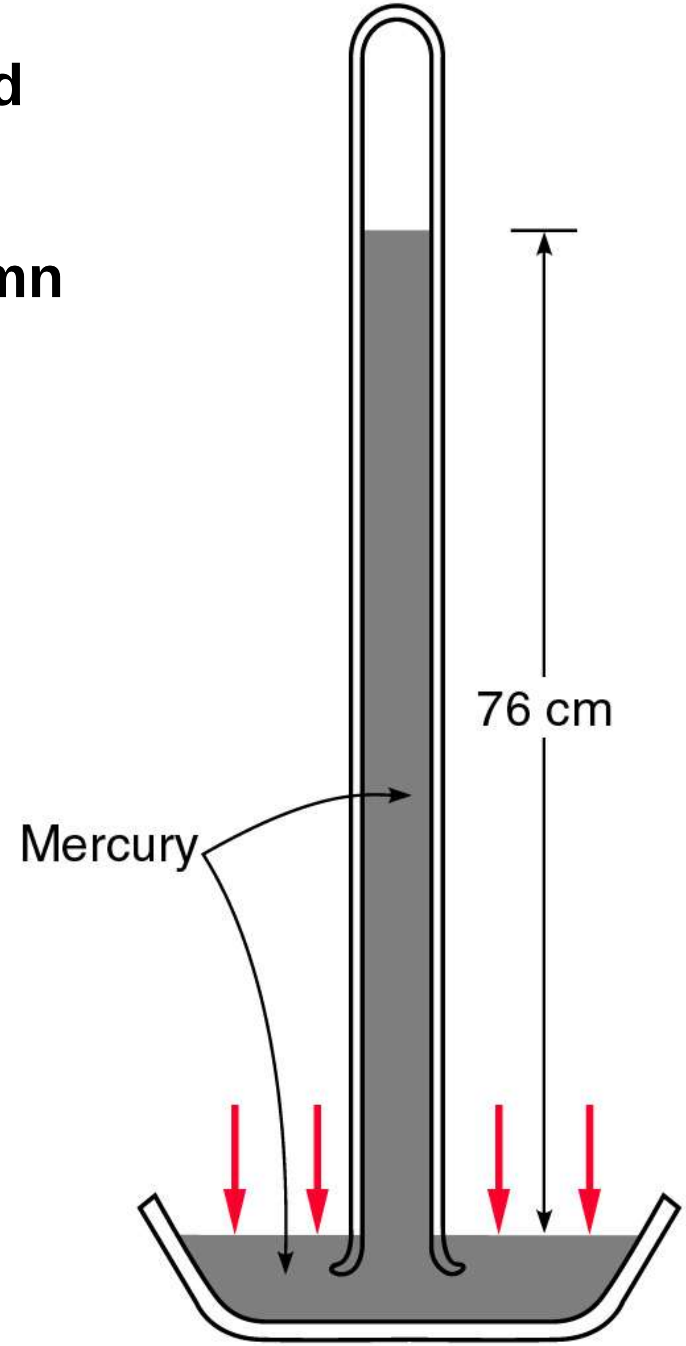

F
A

The pressure exerted on the piston extends uniformly throughout the fluid, causing it to push outward with equal force per unit area on the walls and bottom of the cylinder.



Torricelli filled a tube with mercury and inverted it into an open container of mercury. Air pressure acting on the mercury in the dish can support a column of mercury 76 cm in height.

How much does the atmosphere weigh? The same as 76 cm of mercury.



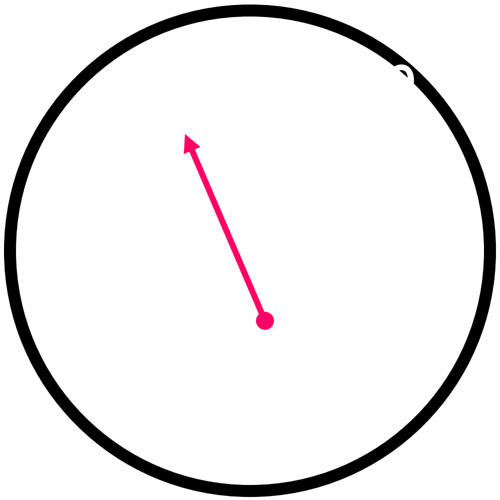
76cm mercury=1.01×10^5 pascals
Standard atmospheric pressure
32 feet of water or 14.7Lbs/in^2

Gauge and absolute pressures

Pressure gauges measure the pressure above and below atmospheric (or barometric) pressure.

P_{atm} = P_0 = 1 atm = 101.3 kPa = 1013 hPa = 1013 millibars =

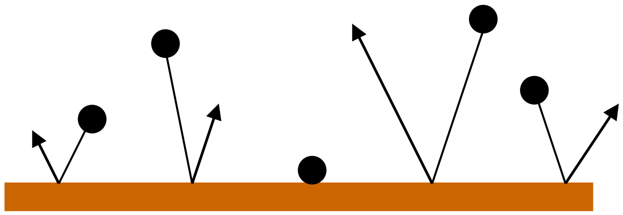
760 torr = 760 mmHg



Gauge pressure P_g
Absolute pressure P

$$P = P_g + P_{atm}$$

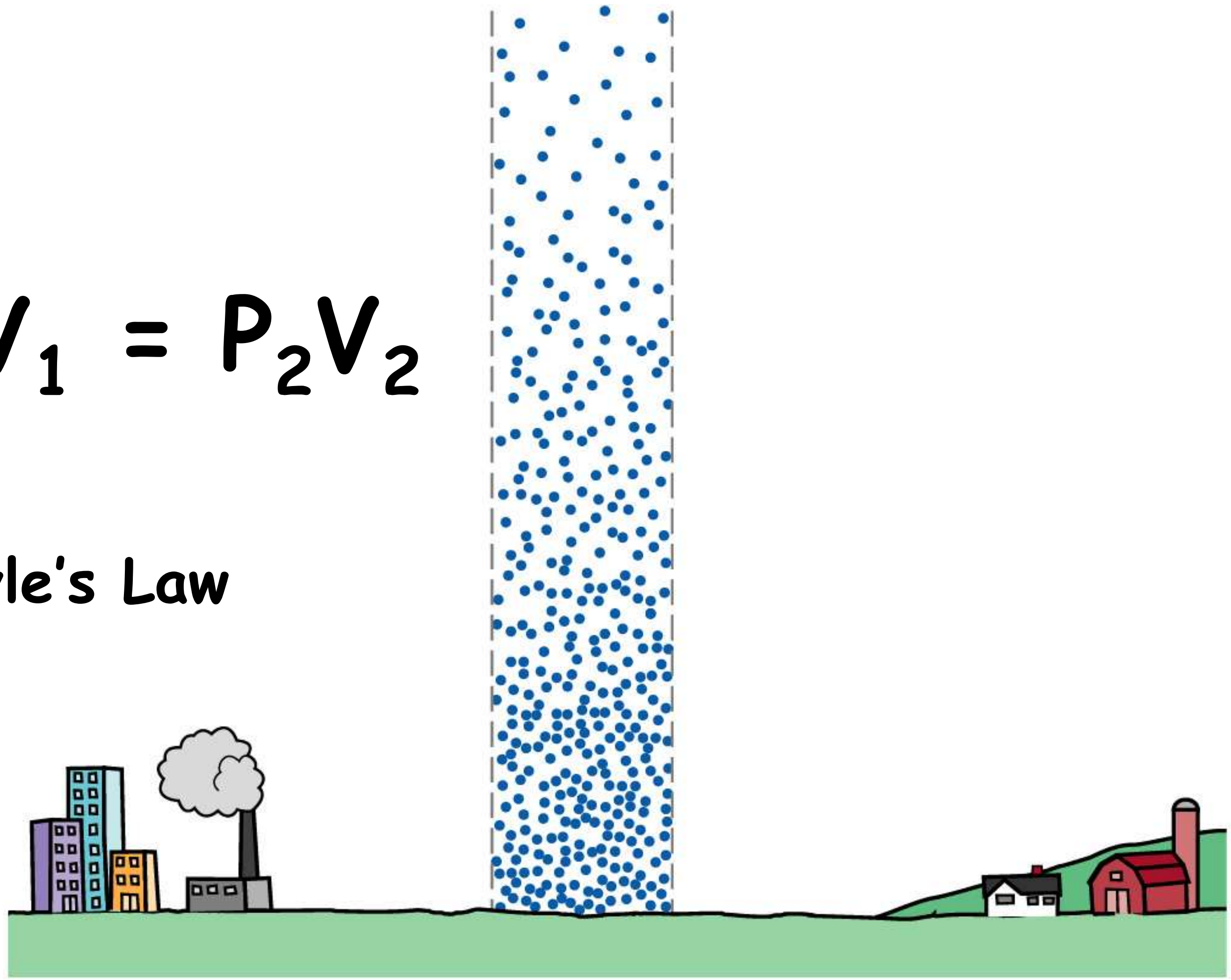
Impact of a molecule on the wall of the container exerts a force on the wall and the wall exerts a force on the molecule. Many impacts occur each second and the total average force per unit area is called the pressure.



The density of a column of air decreases as altitude increases because air expands as pressure decreases.

$$P_1V_1 = P_2V_2$$

Boyle's Law



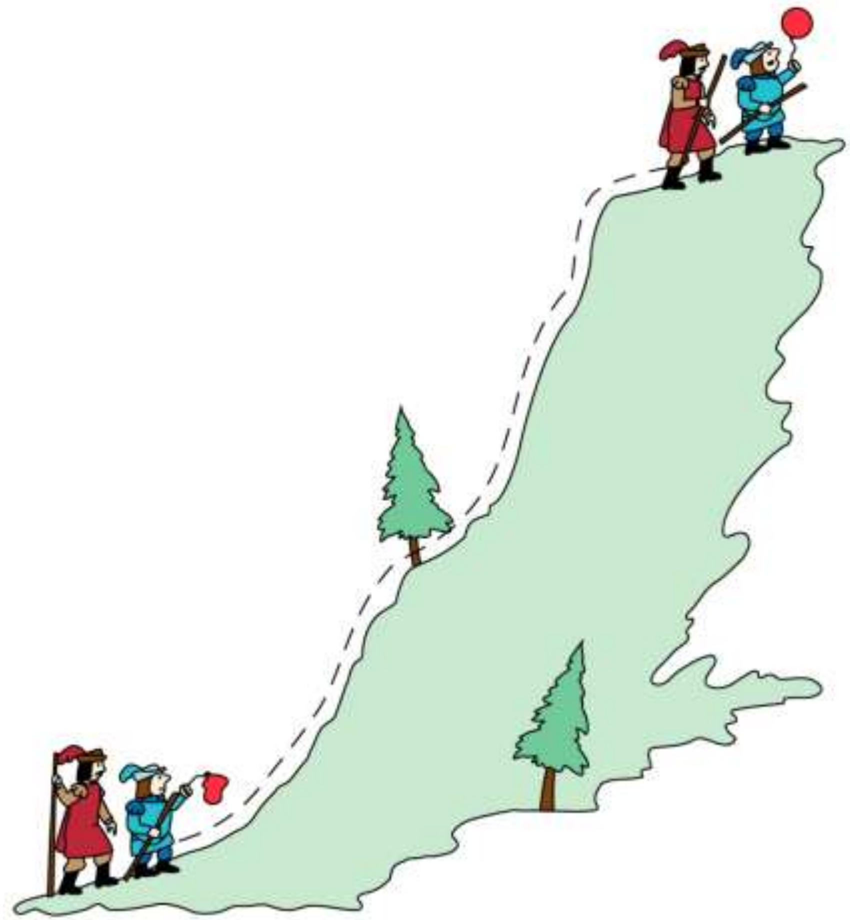
A balloon that was partially inflated near sea level expanded as the experimenters climbed the mountain.

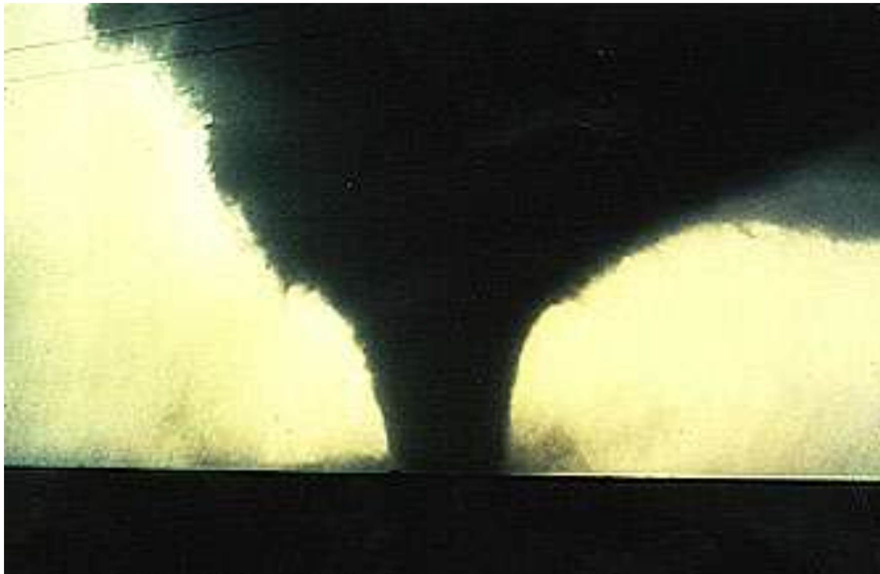
Atmospheric pressure changes with altitude.

$$P_1V_1 = P_2V_2$$

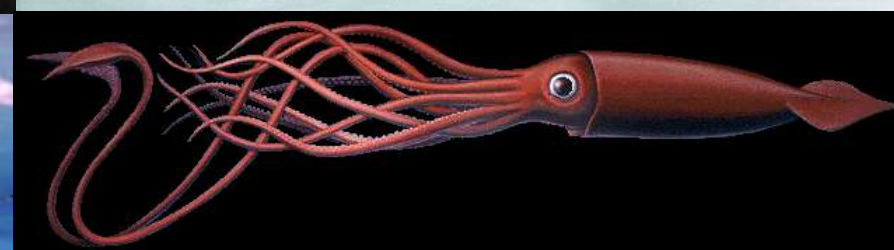
Temperature Constant

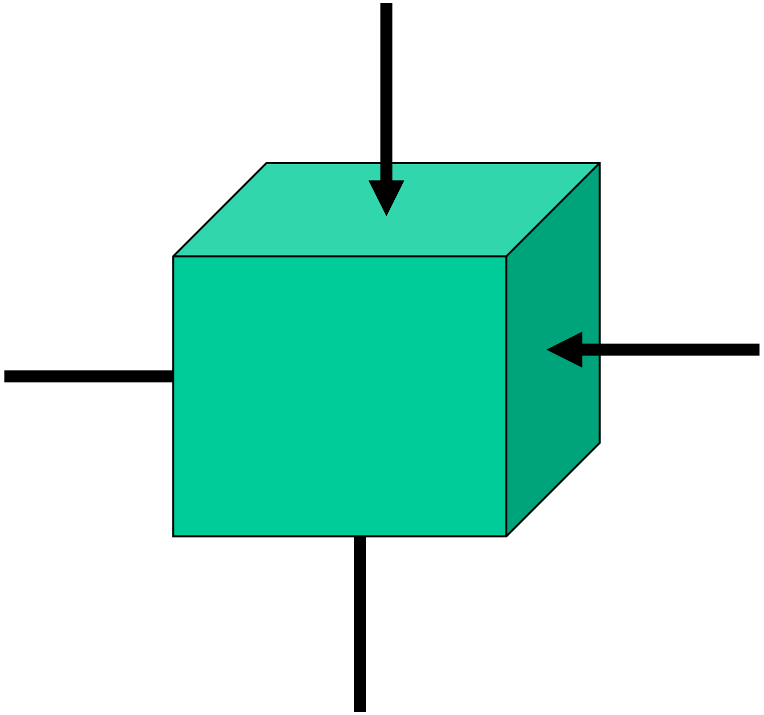
Boyle's Law



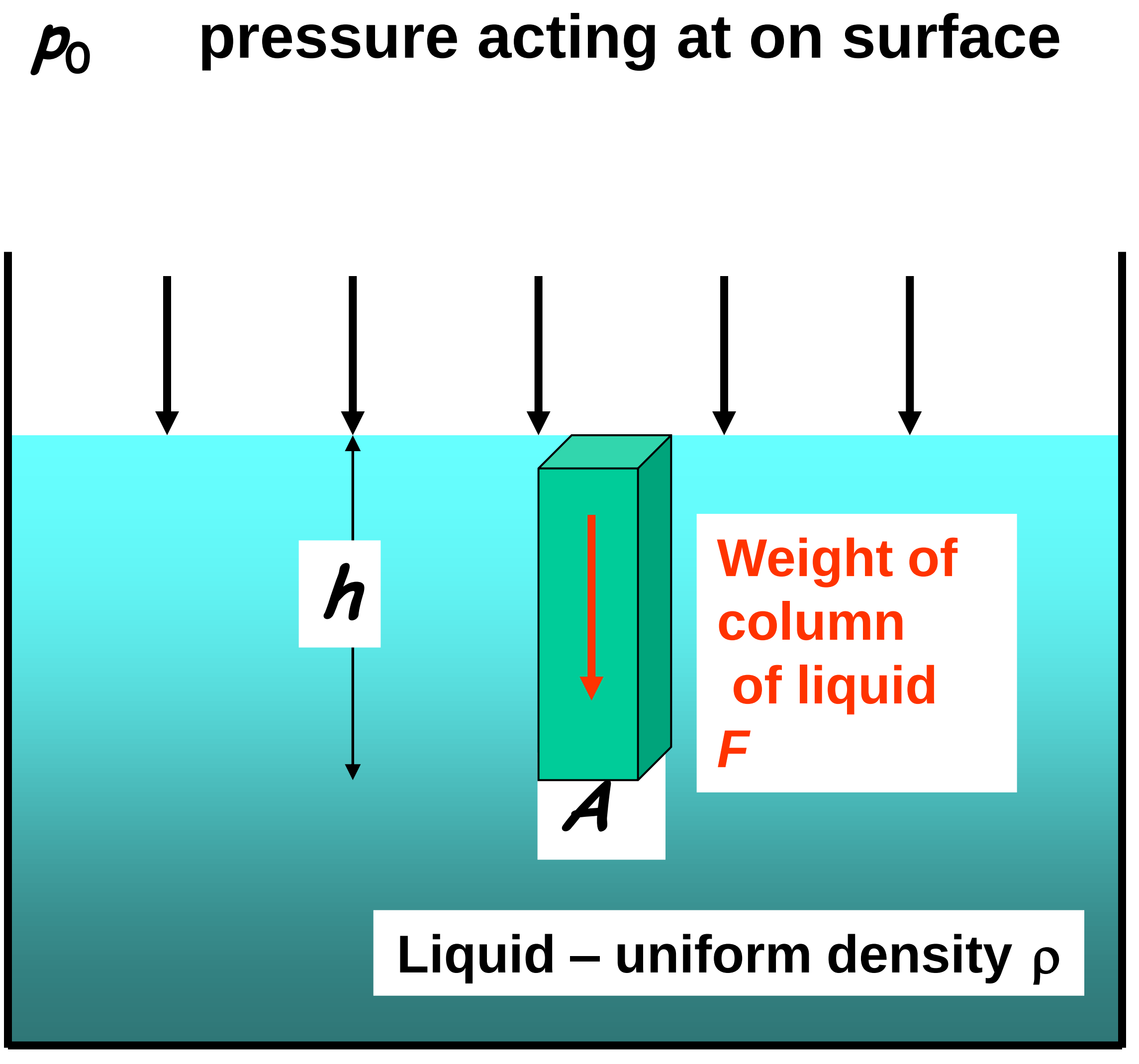



USAF

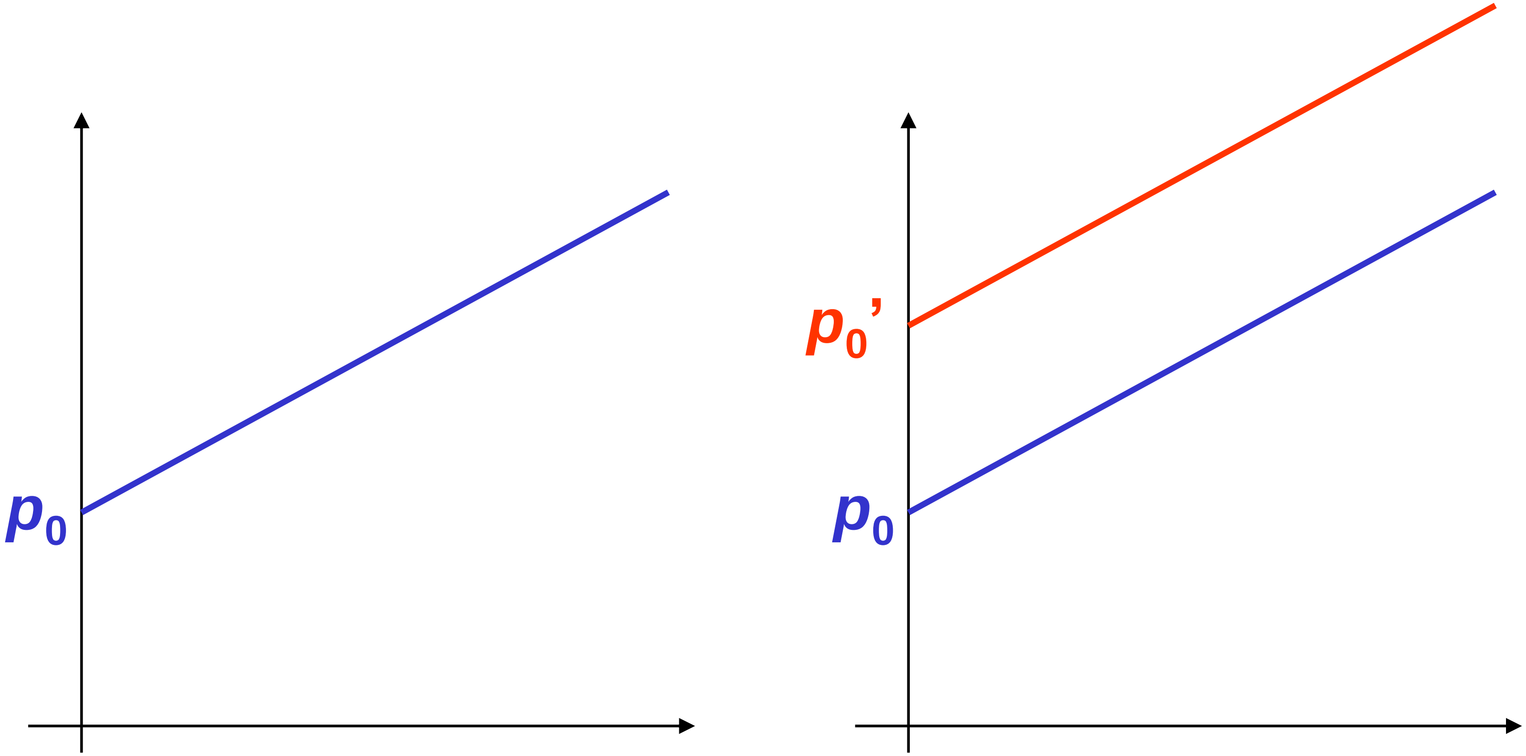




The pressure in a fluid can be defined as the ratio of the force exerted by the fluid to the area over which it is exerted. To get the pressure at a point you need to take the limit as this area approaches zero. Because of the weak cohesive forces between the molecules of the fluid, the only force that can be applied by the fluid on a submerged object is one that tends to compress it. This means the force of the fluid acts perpendicular to the surface of the object at any point.



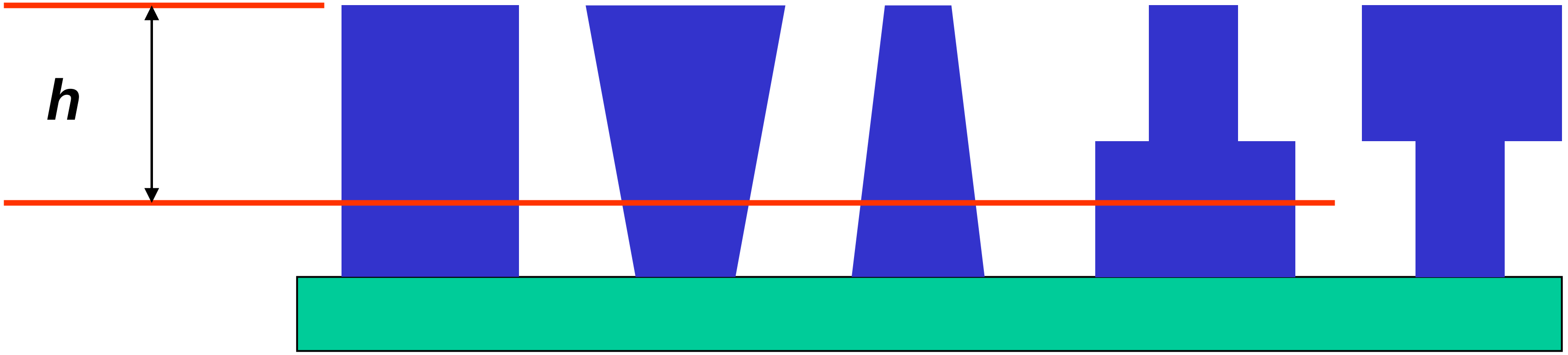
p_0 pressure acting at on surface
h
A
Weight of column of liquid F
Liquid – uniform density ρ



Linear relationship between pressure and depth.

If the pressure at the surface increases then the pressure at a depth *h* also increases by the same amount.

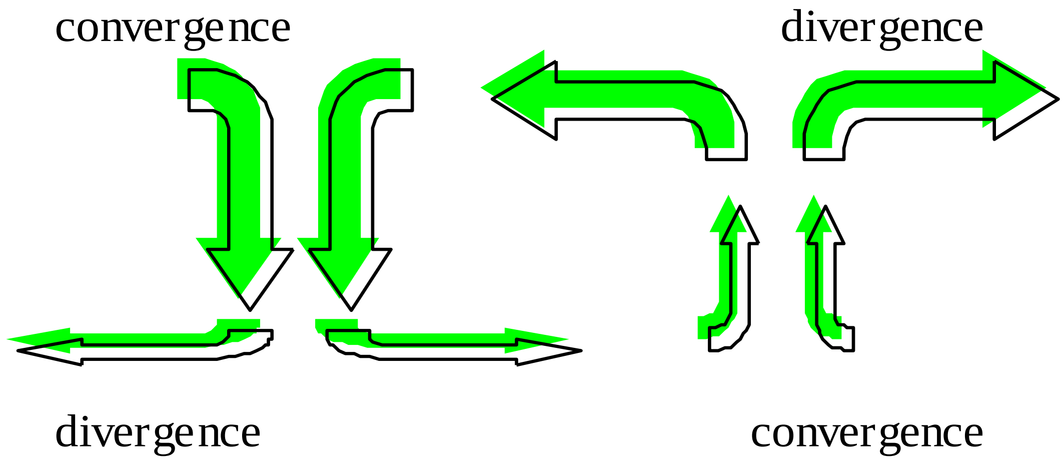
  



The pressure exerted by a static fluid depends only upon the depth of the fluid, the density of the fluid, and the acceleration of gravity

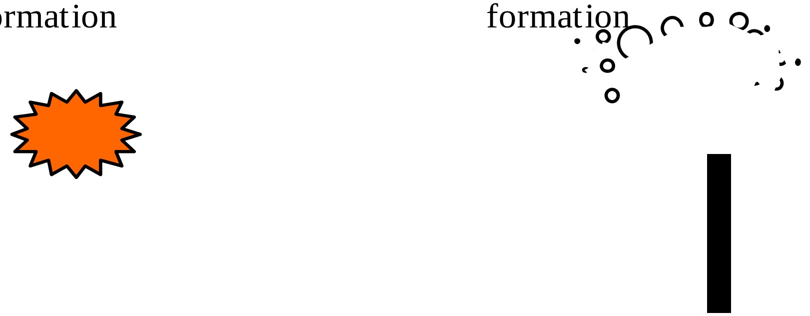
$$p_h = p_0 + \rho\, g\, h$$

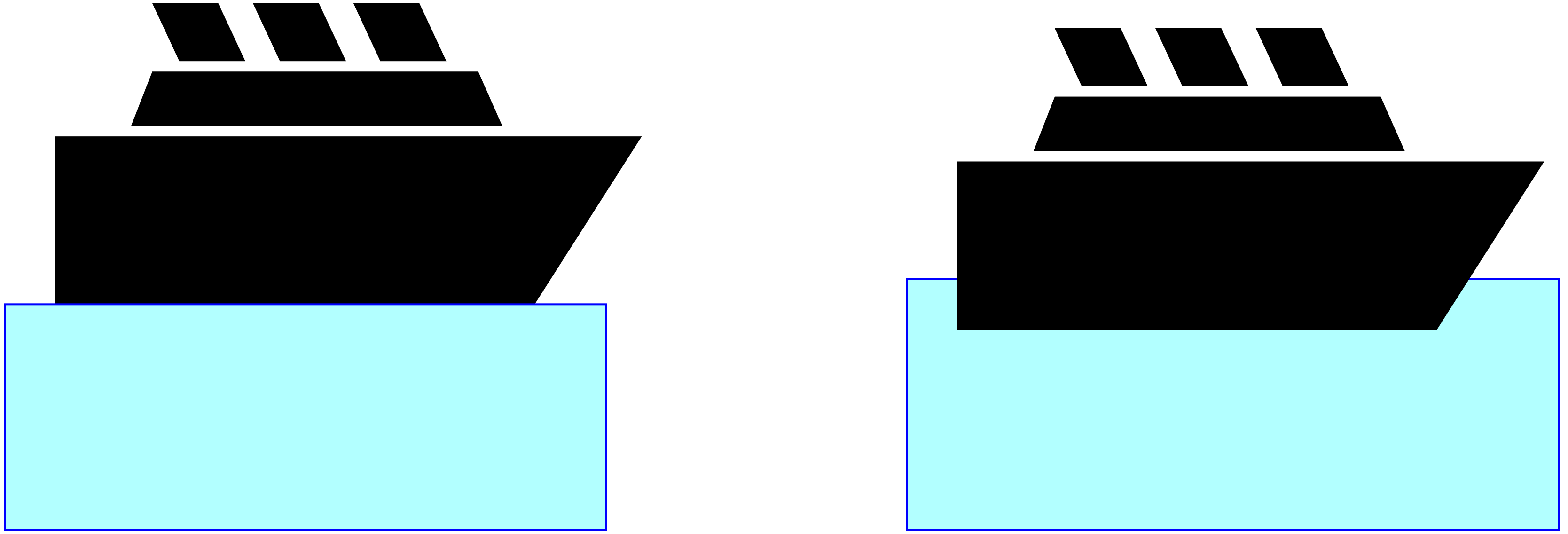
Static pressure does not depend upon mass or surface area of liquid and the shape of container due to pressure exerted by walls.



HIGH - more uniform conditions - inhibits cloud formation

LOW - less uniform conditions - encourages cloud formation

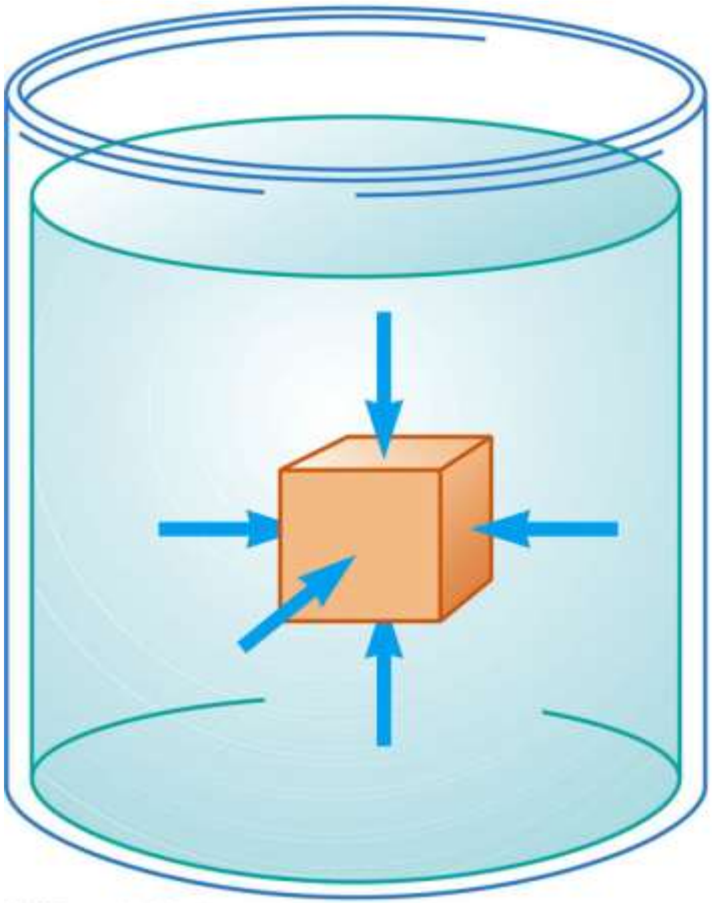




Pressure

- The pressure P of the fluid at the level to which the device has been submerged is the ratio of the force to the area

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



Pascals as units for Pressure

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

1 Pa = 1 N/m^2

Example 9.2

A large solid steel ($Y=1.8\times10^{11}$ Pa) block (L 5 m, W=4 m, H=3 m) is submerged in the Mariana Trench where the pressure is 7.5×10^{7} Pa.

a) By what percentage does the length change?

-0.041 %

b) What are the changes in the length, width and height?

-2.08 mm, -1.67 mm, -1.25 mm

c) By what percentage does the volume change?

-0.125%

Solids and Liquids

- **Solids have Young's, Bulk, and Shear moduli**
- **Liquids have only bulk moduli**

Ultimate Strength

- Maximum F/A before fracture or crumbling
- Different for compression and tension

Densities

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

TABLE 9.3 Density of Some Common Substances

Substance	$\rho(kg/m^3)^a$	Substance	$\rho(kg/m^3)^a$
Ice	0.917×10^3	Water	1.00×10^3
Aluminum	2.70×10^3	Glycerin	1.26×10^3
Iron	7.86×10^3	Ethyl alcohol	0.806×10^3
Copper	8.92×10^3	Benzene	0.879×10^3
Silver	10.5×10^3	Mercury	13.6×10^3
Lead	11.3×10^3	Air	1.29
Gold	19.3×10^3	Oxygen	1.43
Platinum	21.4×10^3	Hydrogen	8.99×10^{-2}
Uranium	18.7×10^3	Helium	1.79×10^{-1}

[a] All values are at standard atmospheric temperature and pressure (STP), defined as 0°C (273 K) and 1 atm (1.013×10^5 Pa). To convert to grams per cubic centimeter, multiply by 10^{-3}.

Density Table

TABLE 14.1

Densities of Some Common Substances at Standard Temperature (0°C) and Pressure (Atmospheric)

Substance	ρ (kg/m^3)	Substance	ρ (kg/m^3)
Air	1.29	Ice	0.917×10^3
Aluminum	2.70×10^3	Iron	7.86×10^3
Benzene	0.879×10^3	Lead	11.3×10^3
Copper	8.92×10^3	Mercury	13.6×10^3
Ethyl alcohol	0.806×10^3	Oak	0.710×10^3
Fresh water	1.00×10^3	Oxygen gas	1.43
Glycerin	1.26×10^3	Pine	0.373×10^3
Gold	19.3×10^3	Platinum	21.4×10^3
Helium gas	1.79×10^{-1}	Seawater	1.03×10^3
Hydrogen gas	8.99×10^{-2}	Silver	10.5×10^3

Density and Specific Gravity

- Densities depend on temperature, pressure…
- Specific gravity = ratio of density to density of H_2O at 4 °C.

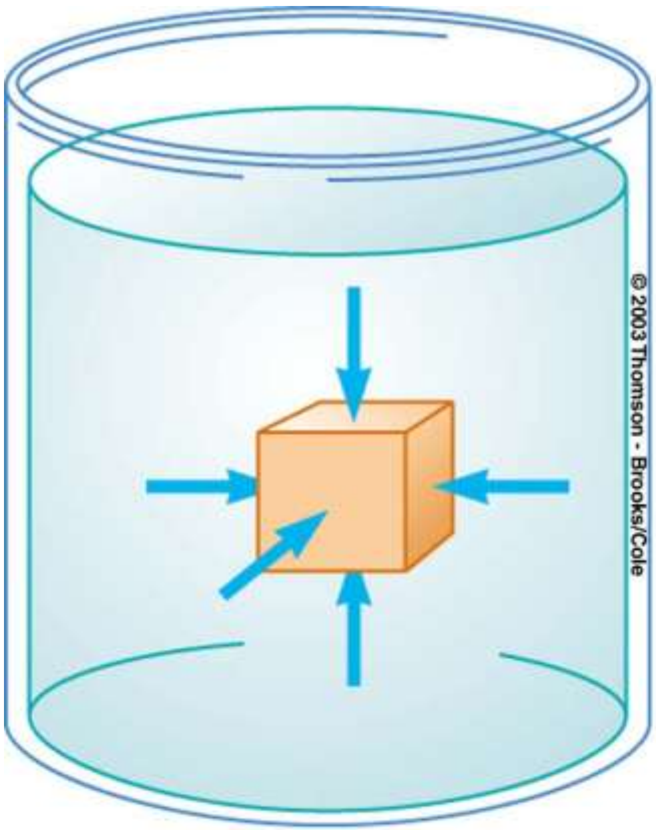
Example 9.3

The specific gravity of gold is 19.3. What is the mass (in kg) and weight (in lbs.) of 1 cubic meter of gold?

19,300 kg
42549 lbs

Pressure & Pascal's Principle

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



"Pressure applied to any part of an enclosed fluid is transmitted undimished to every point of the fluid and to the walls of the container"

Each face feels same force

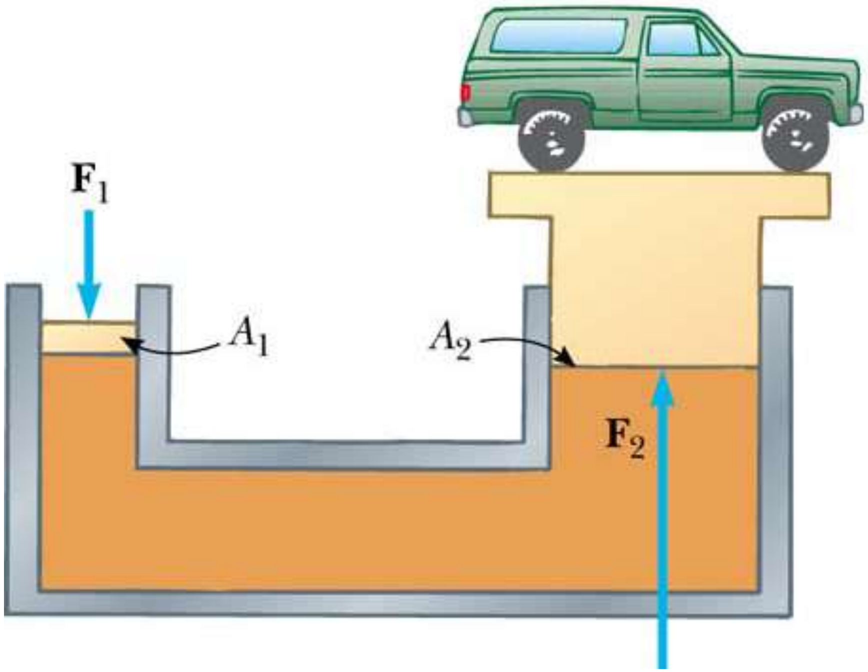
Transmitting force

Hydraulic press

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

An applied force F_1 can be "amplified":

$$F_2 = F_1 \frac{A_2}{A_1}$$



Examples: hydraulic brakes, forklifts, car lifts, etc.

Pressure and Depth

***w* is weight**

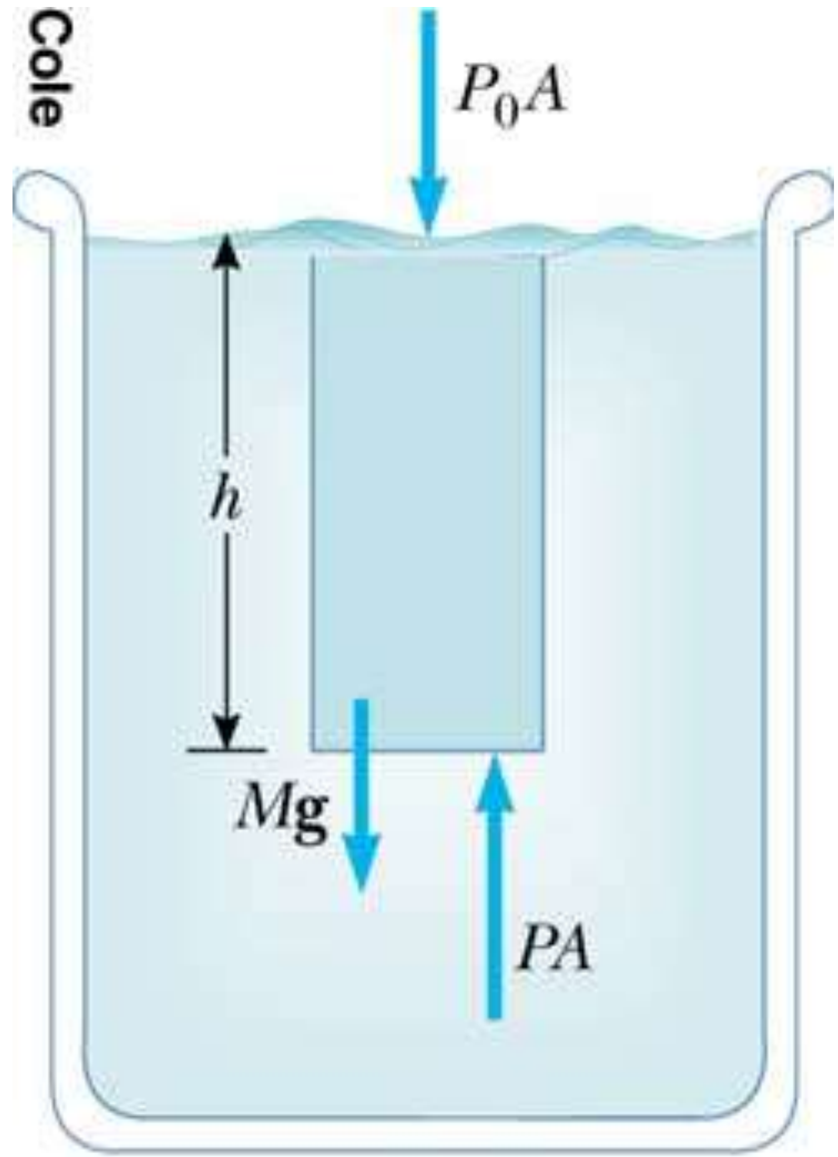
$$w = Mg = \rho Vg = \rho Ahg$$

Sum forces to zero,

$$PA - P_0 A - w = 0$$

Factor *A*

$$P = P_0 + \rho gh$$



Example 9.5 (skip)

Find the pressure at 10,000 m of water.
DATA: Atmospheric pressure = 1.015×10^5 Pa.

9.82×10^7 Pa

Example 9.6

Assume the ultimate strength of legos is 4.0×10^4 Pa. If the density of legos is 150 kg/m^3, what is the maximum possible height for a lego tower?

27.2 m

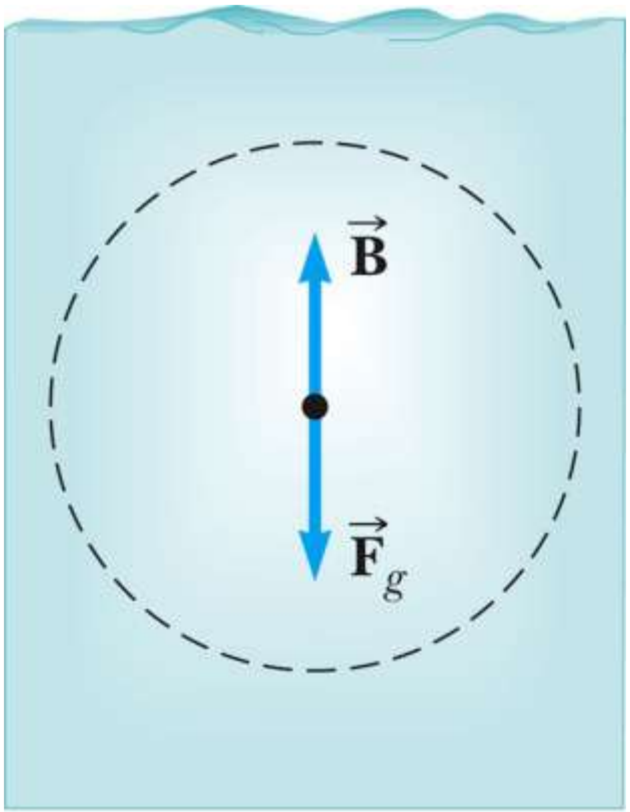
Example 9.7

Estimate the mass of the Earth's atmosphere given that atmospheric pressure is $1.015\text{x}10^5$ Pa.
Data: $R_{earth}=6.36\text{x}10^6$ m

$5.26\text{x}10^{18}$ kg

Buoyant Force

- The buoyant force is the upward force exerted by a fluid on any immersed object
- The parcel is in equilibrium
- There must be an upward force to balance the downward gravitational force



(b)

Buoyant Force, cont

- The magnitude of the upward (buoyant) force must equal (in magnitude) the downward gravitational force
- The buoyant force is the resultant force due to all forces applied by the fluid surrounding the parcel

Archimedes

- C. 287 – 212 BC
- Greek mathematician, physicist and engineer
- Computed ratio of circle's circumference to diameter
- Calculated volumes of various shapes
- Discovered nature of buoyant force
- Inventor
  - Catapults, levers, screws, etc.

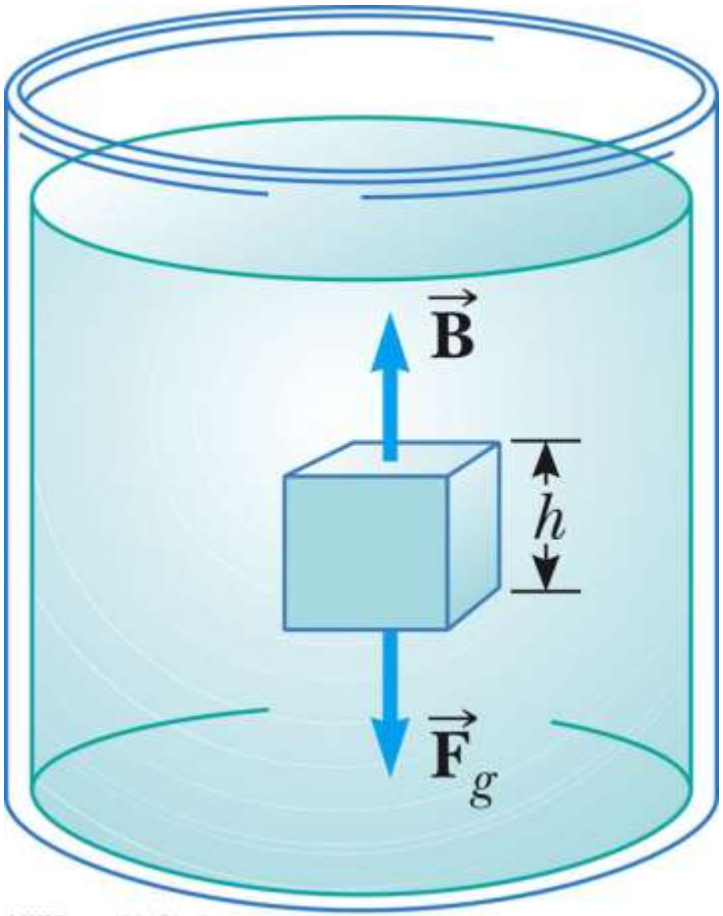
Archimedes's Principle

- The magnitude of the buoyant force always equals the weight of the fluid displaced by the object
  - This is called *Archimedes's Principle*
- Archimedes's Principle does not refer to the makeup of the object experiencing the buoyant force
  - The object's composition is not a factor since the buoyant force is exerted by the fluid

Archimedes's Principle, cont

- The pressure at the top of the cube causes a downward force of $P_{top}\,A$
- The pressure at the bottom of the cube causes an upward force of $P_{bot}\,A$
- $B = (P_{bot} - P_{top})\,A$

  $= \rho_{fluid}\, g\, V = Mg$



Archimedes's Principle: Totally Submerged Object

- An object is totally submerged in a fluid of density ρ_{fluid}
- The upward buoyant force is

$$B = \rho_{fluid}\, g\, V = \rho_{fluid}\, g\, V_{object}$$

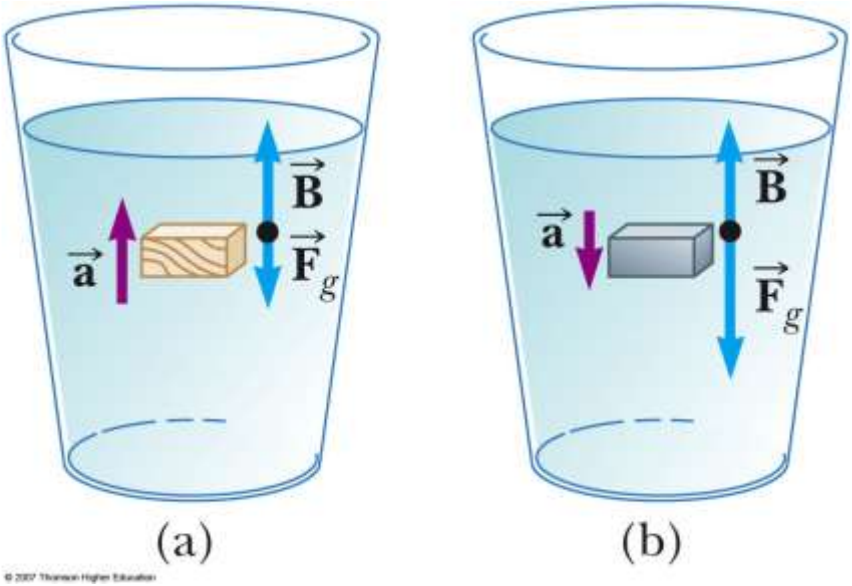
- The downward gravitational force is

$F_g = Mg = = \rho_{obj}\, g\, V_{obj}$

- The net force is $B - F_g = (\rho_{fluid} - \rho_{obj})\, g\, V_{obj}$

Archimedes's Principle: Totally Submerged Object, cont

- **If the density of the object is less than the density of the fluid, the unsupported object accelerates upward**
- **If the density of the object is more than the density of the fluid, the unsupported object sinks**
- ***The direction of the motion of an object in a fluid is determined only by the densities of the fluid and the object***



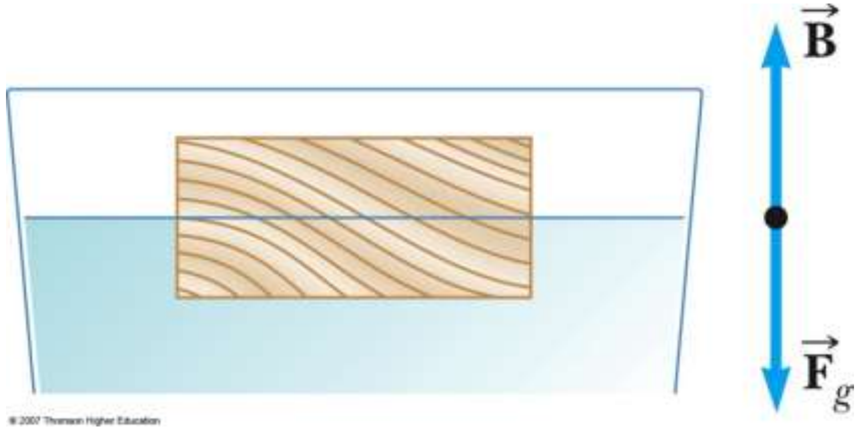
Archimedes's Principle: Floating Object

- 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

$$\frac{V_{\text{fluid}}}{V_{\text{obj}}} = \frac{\rho_{\text{obj}}}{\rho_{\text{fluid}}}$$

Archimedes's Principle: Floating Object, cont

- The fraction of the volume of a floating object that is below the fluid surface is equal to the ratio of the density of the object to that of the fluid
    - Use the active figure to vary the densities

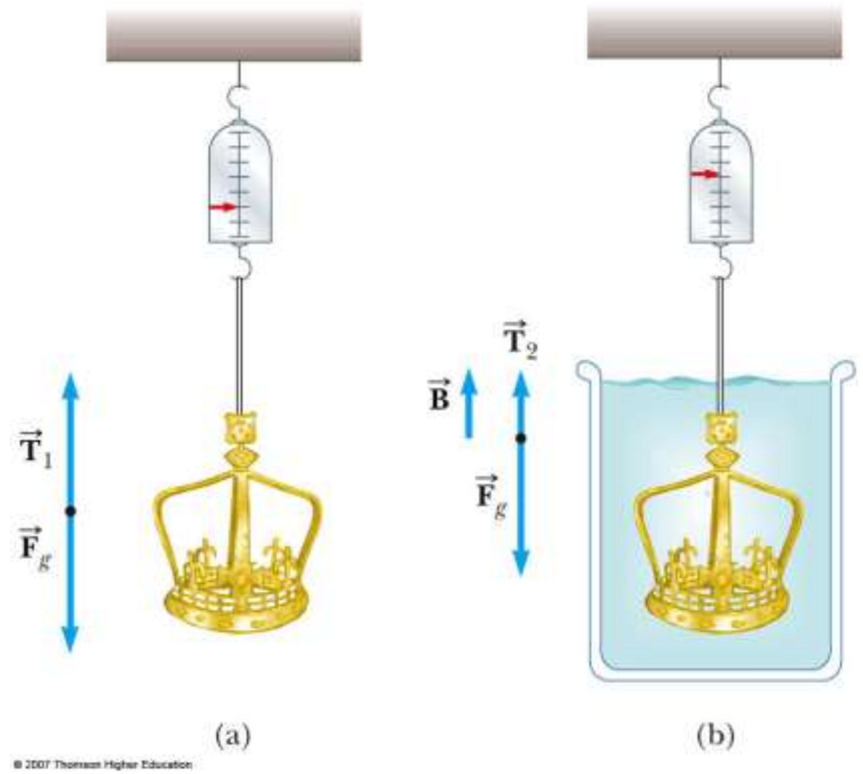


Archimedes's Principle, Crown Example

- Archimedes was (supposedly) asked, "Is the crown made of pure gold?"
- Crown's weight in air = 7.84 N
- Weight in water (submerged) = 6.84 N
- Buoyant force will equal the apparent weight loss
  - Difference in scale readings will be the buoyant force

Archimedes's Principle, Crown Example, cont.

- $\Sigma F = B + T_2 - F_g = 0$
- $B = F_g - T_2$
  (Weight in air – "weight" in water)
- Archimedes's principle says $B = \rho g V$
  - Find V
- Then to find the material of the crown, $\rho_{crown} = m_{crown\ in\ air} / V$



Archimedes's Principle, Iceberg Example

- What fraction of the iceberg is below water?
- The iceberg is only partially submerged and so $V_{seawater} / V_{ice} = \rho_{ice} / \rho_{seawater}$ applies
- The fraction below the water will be the ratio of the volumes ($V_{seawater} / V_{ice}$)

Archimedes's Principle, Iceberg Example, cont

- V_{ice} is the total volume of the iceberg
- V_{water} is the volume of the water displaced
  - This will be equal to the volume of the iceberg submerged
- About 89% of the ice is below the water's surface

(b)

Example 9.8

A helicopter lowers a probe into Lake Michigan which is suspended on a cable. The probe has a mass of 500 kg and its average density is 1400 kg/m^3. What is the tension in the cable?

1401 N

Example 9.9a

A wooden ball of mass *M* and volume *V* floats on a swimming pool. The density of the wood is $\rho_{wood} < \rho_{H20}$. The buoyant force acting on the ball is:

a) Mg upward
b) $\rho_{H20}gV$ upward
c) $(\rho_{H20}-\rho_{wood})gV$ upward

Example 9.9b

A steel ball of mass *M* and volume *V* rests on the bottom of a swimming pool. The density of the steel is $\rho_{steel} > \rho_{H2O}$. The buoyant force acting on the ball is:

a) Mg upward
b) $\rho_{H2O}gV$ upward
c) $(\rho_{steel}-\rho_{H2O})gV$ upward

Example 9.10

A small swimming pool has an area of 10 square meters. A wooden 4000-kg statue of density 500 kg/m^3 is then floated on top of the pool. How far does the water rise?

Data: Density of water = 1000 kg/m^3

40 cm

Types of Fluid Flow – Laminar

- Laminar flow
  - Steady flow
  - Each particle of the fluid follows a smooth path
  - The paths of the different particles never cross each other
  - Every given fluid particle arriving at a given point has the same velocity
  - The path taken by the particles is called a *streamline*

Types of Fluid Flow – Turbulent

- An irregular flow characterized by small whirlpool-like regions
- Turbulent flow occurs when the particles go above some critical speed

Viscosity

- Characterizes the degree of internal friction in the fluid
- This internal friction, *viscous force*, is associated with the resistance that two adjacent layers of fluid have to moving relative to each other
- It causes part of the kinetic energy of a fluid to be converted to internal energy

Ideal Fluid Flow

- There are four simplifying assumptions made to the complex flow of fluids to make the analysis easier

  (1) *The fluid is nonviscous* – internal friction is neglected

  (2) *The flow is steady* – the velocity of each point remains constant

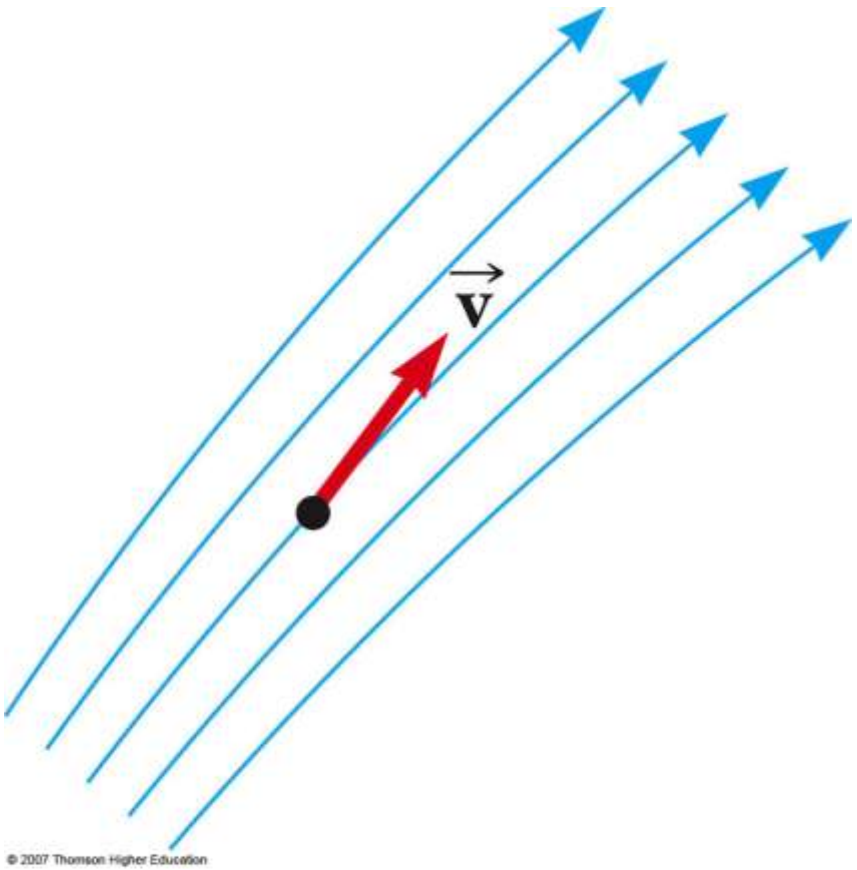
Ideal Fluid Flow, cont

(3) *The fluid is incompressible* – the density remains constant

(4) *The flow is irrotational* – the fluid has no angular momentum about any point

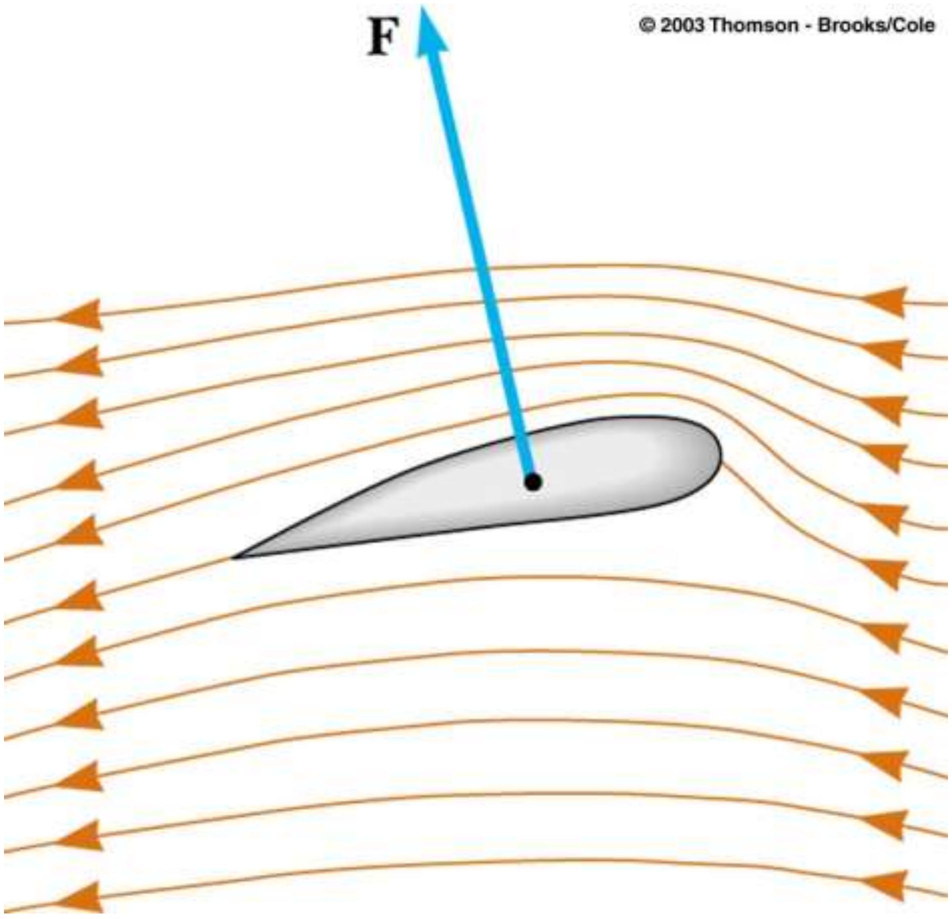
Streamlines

- The path the particle takes in steady flow is a streamline
- The velocity of the particle is tangent to the streamline
- A set of streamlines is called a *tube of flow*



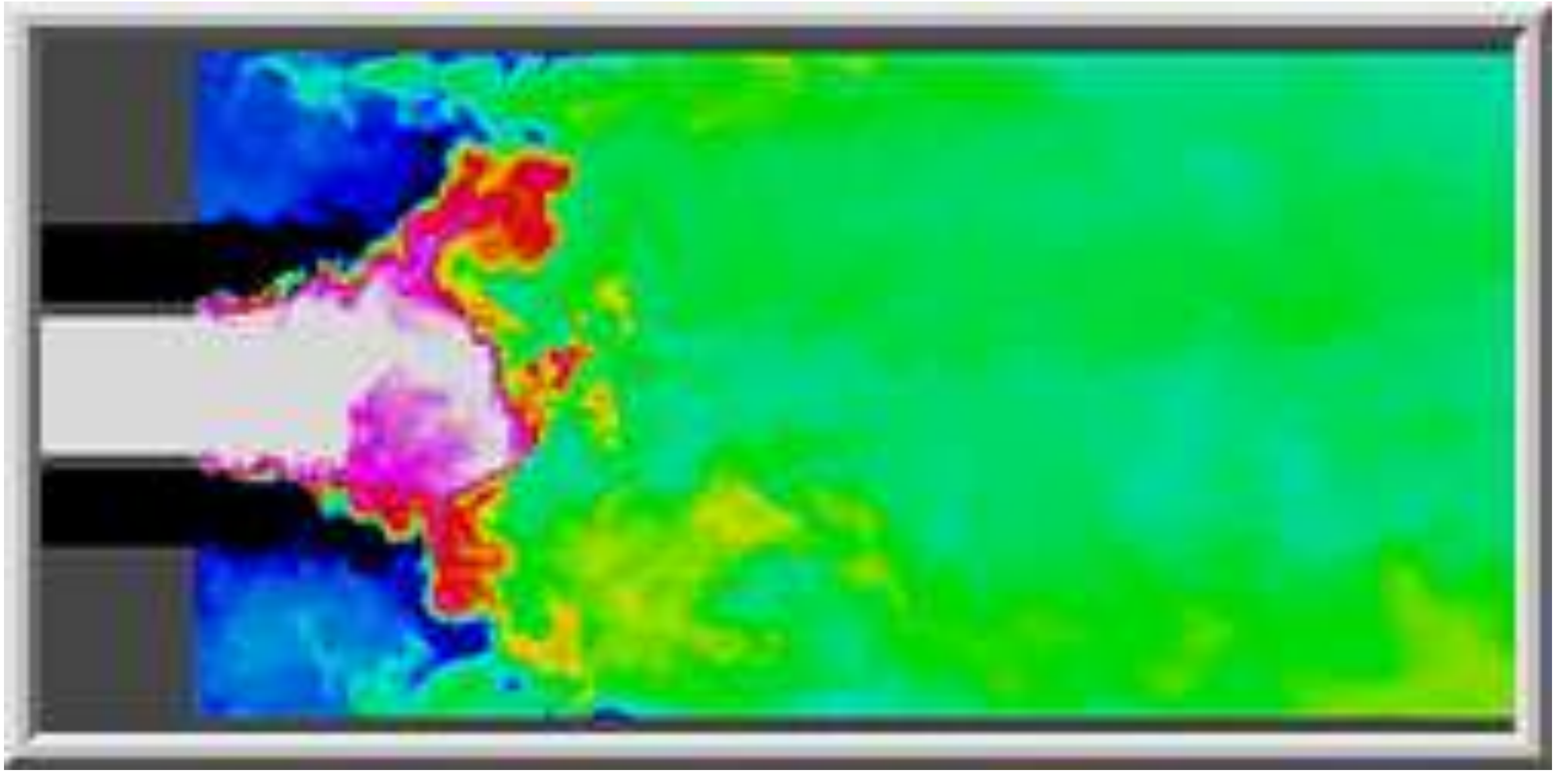
Laminar or Streamline Flow

- Fluid elements move along smooth paths
- Friction in laminar flow is called *viscosity*



Turbulence

- Fluid elements move along irregular paths
- Sets in for high velocity gradients (small pipes)



Ideal Fluids

- Laminar Flow -> No turbulence
- Non-viscous -> No friction between fluid layers
- Incompressible -> Density is same everywhere

Equation of Continuity

What goes in must come out!

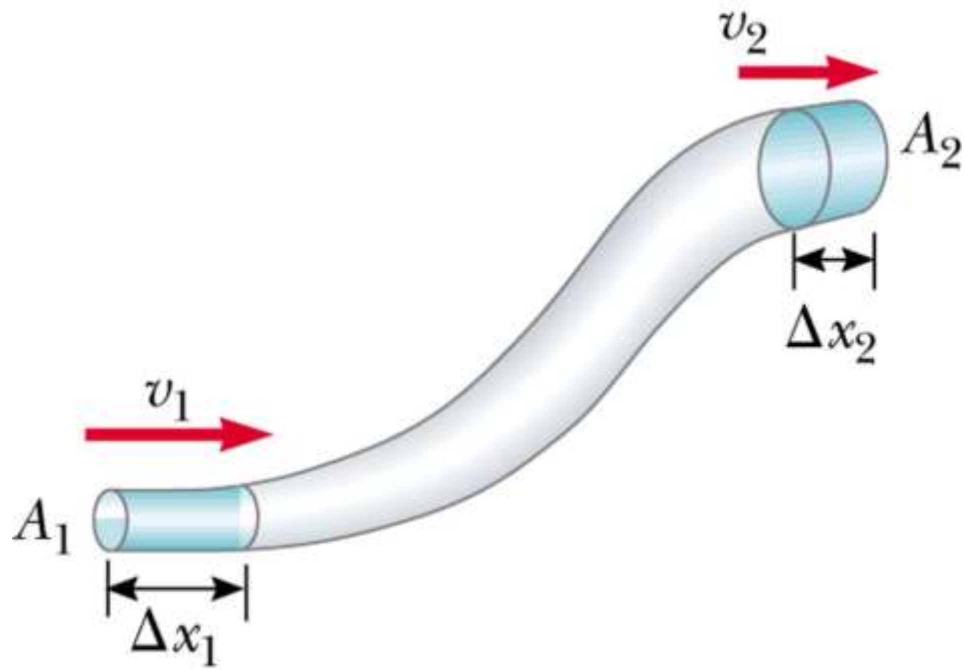
mass density

$$\Delta M = \rho A \Delta x = \rho A v \Delta t$$

Mass that passes a point in pipe during time Δt

Eq. of Continuity

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$



(a)

The volume of the blue region is the AREA times the length.

Length is velocity times time

Density is mass per volume

Putting it all together you have MASS FLOW RATE.

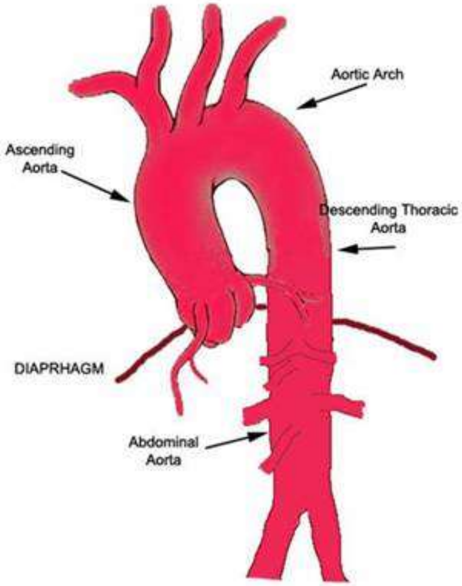
The first thing you MUST understand is that MASS is NOT CREATED OR DESTROYED! IT IS CONSERVED.

Using the Mass Flow rate equation and the idea that a certain mass of water is constant as it moves to a new pipe section:

We have the Fluid Flow Continuity equation

Example

The speed of blood in the aorta is 50 cm/s and this vessel has a radius of 1.0 cm. If the capillaries have a total cross sectional area of 3000 cm^2, what is the speed of the blood in them?



$$A_1 v_1 = A_2 v_2$$

$$\pi r_1^2 v_1 = A_2 v_2$$

$$\pi (1)^2 (50) = (3000) v_2$$

$v_2 =$ 0.052 cm/s

Example 9.11

Water flows through a 4.0 cm diameter pipe at 5 cm/s. The pipe then narrows downstream and has a diameter of of 2.0 cm. What is the velocity of the water through the smaller pipe?

20 cm/s

Daniel Bernoulli

- 1700 – 1782
- Swiss physicist
- Published *Hydrodynamica*
  - Dealt with equilibrium, pressure and speeds in fluids
  - Also a beginning of the study of gasses with changing pressure and temperature

Bernoulli's Equation

- As a fluid moves through a region where its speed and/or elevation above the Earth's surface changes, the pressure in the fluid varies with these changes
- The relationship between fluid speed, pressure and elevation was first derived by Daniel Bernoulli

Bernoulli's Equation: derivation

Consider a volume ΔV of mass ΔM of incompressible fluid,

$$\Delta KE = \frac{1}{2}Mv_2^2 - \frac{1}{2}Mv_1^2$$

$$= \frac{1}{2}\rho\Delta V v_2^2 - \frac{1}{2}\rho\Delta V v_1^2$$

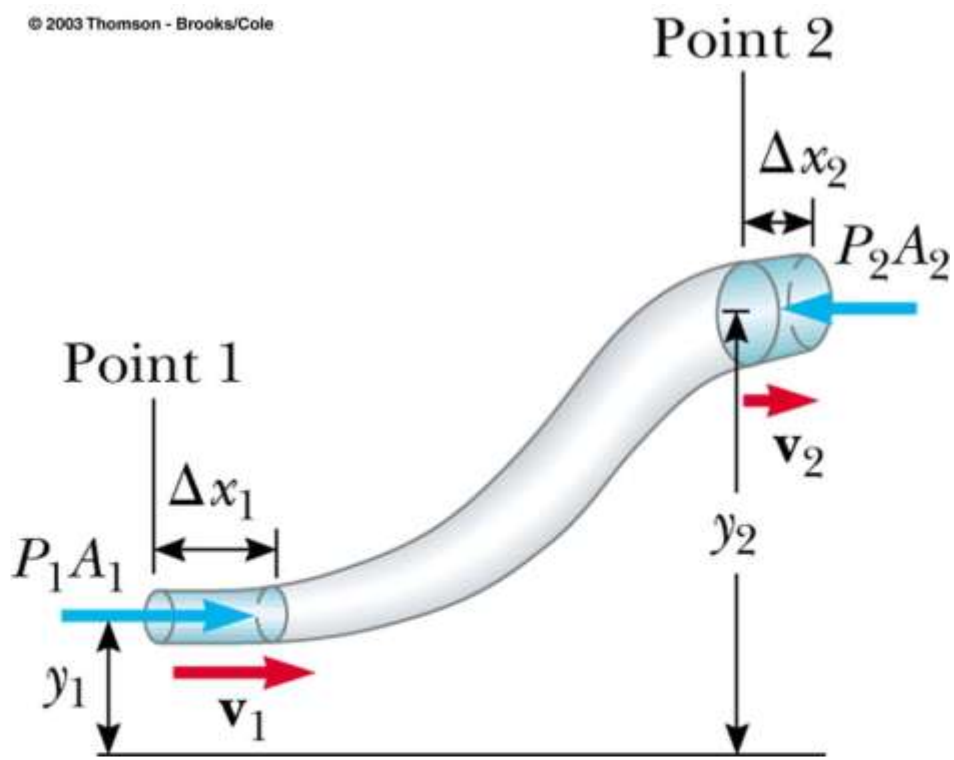
$$\Delta PE = Mgy_2 - Mgy_1$$

$$= \rho\Delta V g y_2 - \rho\Delta V g y_1$$

$$W = F_1\Delta x_1 - F_2\Delta x_2$$

$$= P_1 A_1 \Delta x_1 - P_2 A_2 \Delta x_2$$

$$= P_1\Delta V - P_2\Delta V$$



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

Bernoulli's Equation

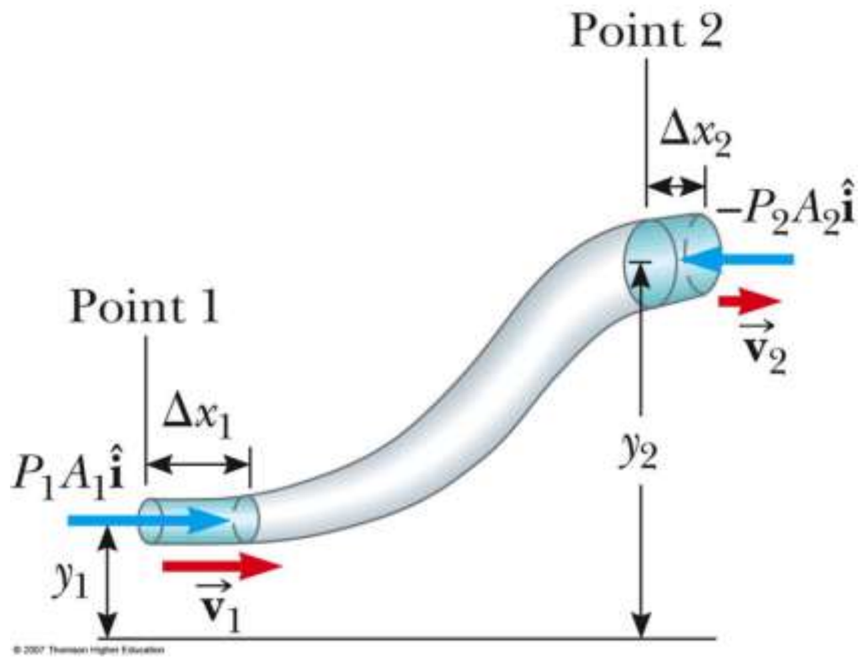
$$P + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$$

Sum of P, KE/V and PE/V is constant

How can we derive this?

Bernoulli's Equation, 2

- Consider the two shaded segments
- The volumes of both segments are equal
- The net work done on the segment is $W = (P_1 - P_2)\,V$
- Part of the work goes into changing the kinetic energy and some to changing the gravitational potential energy



Bernoulli's Equation, 3

- The change in kinetic energy:
  - $\Delta K = \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$
  - There is no change in the kinetic energy of the unshaded portion since we are assuming streamline flow
  - The masses are the same since the volumes are the same

Bernoulli's Equation, 4

- The change in gravitational potential energy:
  - $\Delta U = mgy_2 - mgy_1$
- The work also equals the change in energy
- Combining:
  - $(P_1 - P_2)V = \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2 + mgy_2 - mgy_1$

Bernoulli's Equation, 5

- Rearranging and expressing in terms of density:

$$P_1 + \tfrac{1}{2}\rho v_1^2 + mgy_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + mgy_2$$

- This is Bernoulli's Equation and is often expressed as

$$P + \tfrac{1}{2}\rho v^2 + \rho gy = constant$$

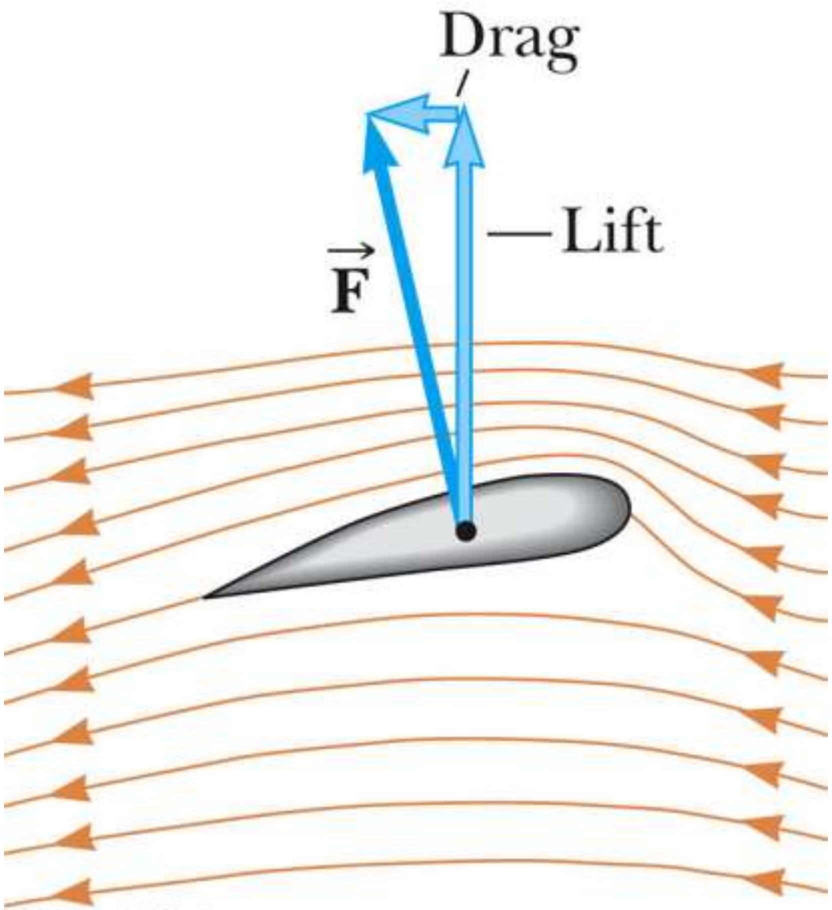
- When the fluid is at rest, this becomes $P_1 - P_2 = \rho gh$ which is consistent with the pressure variation with depth we found earlier

Bernoulli's Equation, Final

- The general behavior of pressure with speed is true even for gases
  - As the speed increases, the pressure decreases

Applications of Fluid Dynamics

- Streamline flow around a moving airplane wing
- *Lift* is the upward force on the wing from the air
- *Drag* is the resistance
- The lift depends on the speed of the airplane, the area of the wing, its curvature, and the angle between the wing and the horizontal

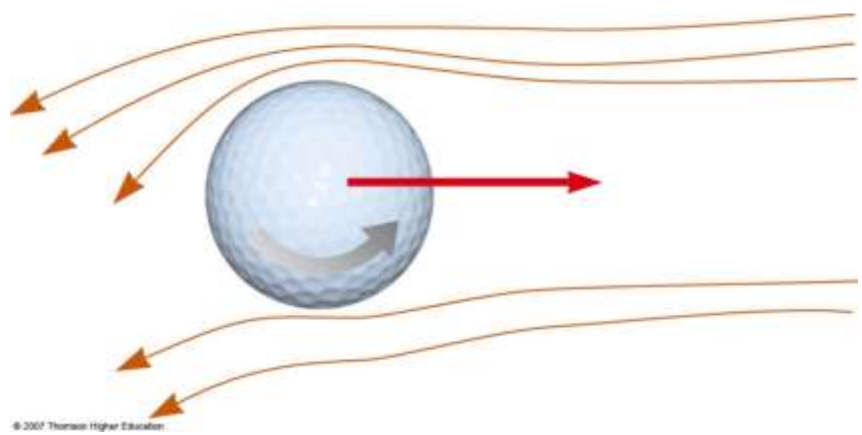


Lift – General

- In general, an object moving through a fluid experiences lift as a result of any effect that causes the fluid to change its direction as it flows past the object
- Some factors that influence lift are:
  - The shape of the object
  - The object's orientation with respect to the fluid flow
  - Any spinning of the object
  - The texture of the object's surface

Golf Ball

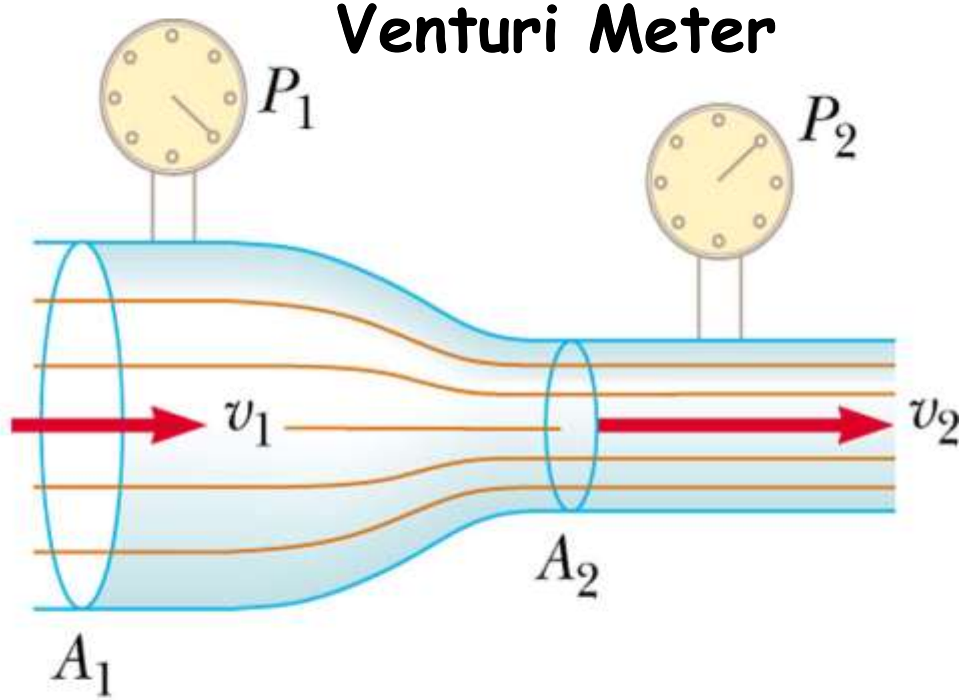
- The ball is given a rapid backspin
- The dimples increase friction
  - Increases lift
- It travels farther than if it was not spinning



Example 9.12

A very large pipe carries water with a very slow velocity and empties into a small pipe with a high velocity. If P_2 is 7000 Pa lower than P_1, what is the velocity of the water in the small pipe?

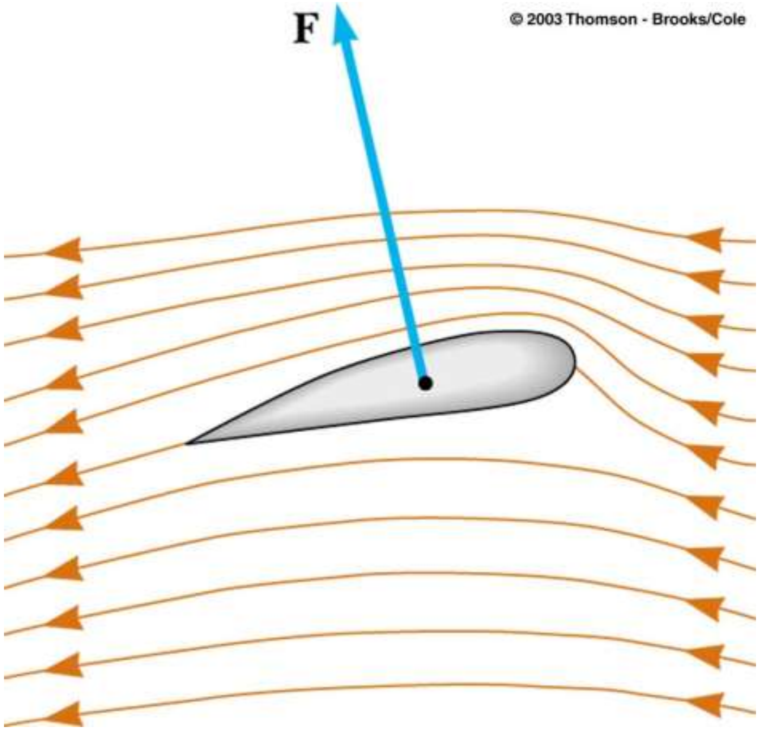
Venturi Meter



3.74 m/s

Applications of Bernoulli's Equation

- Venturi meter
- Curve balls
- Airplanes



Beach Ball & Straws Demos

s Principle

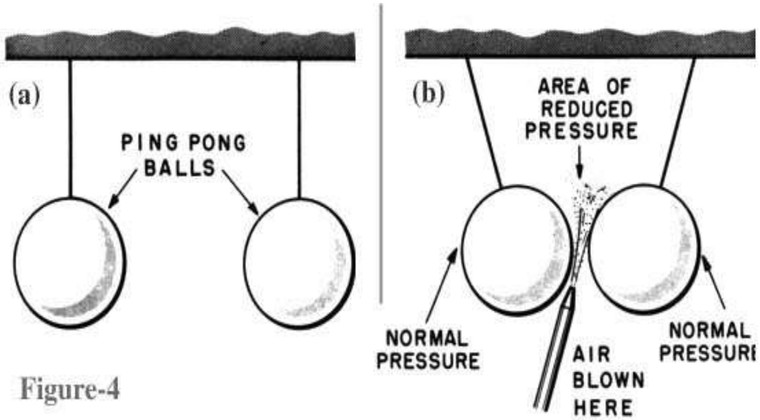
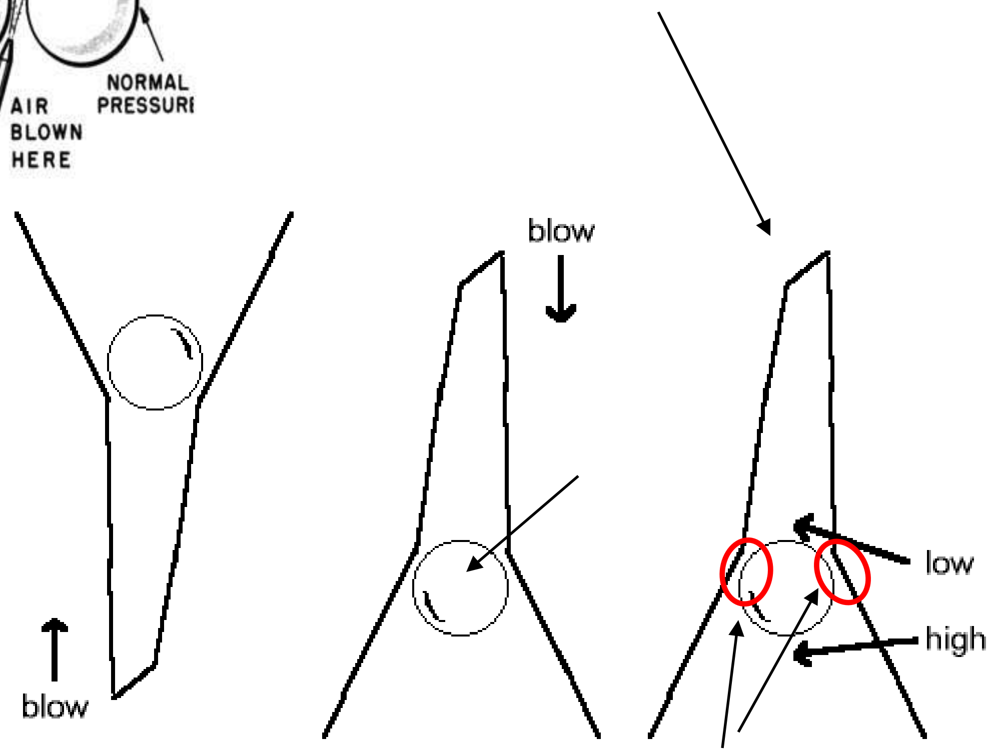
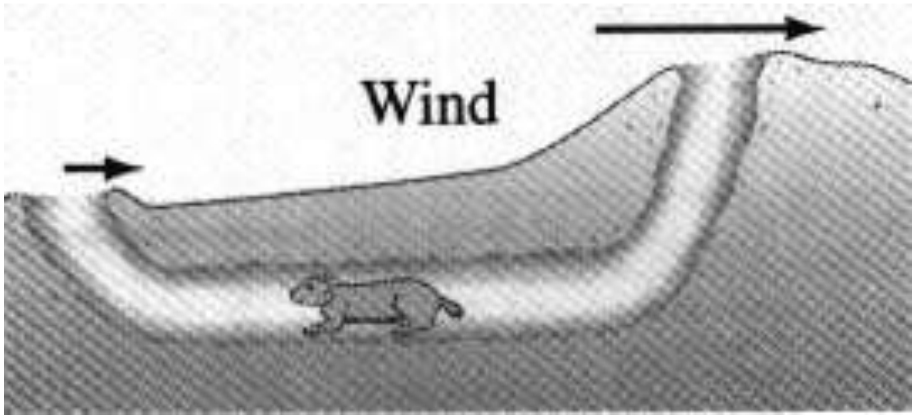


Figure-4

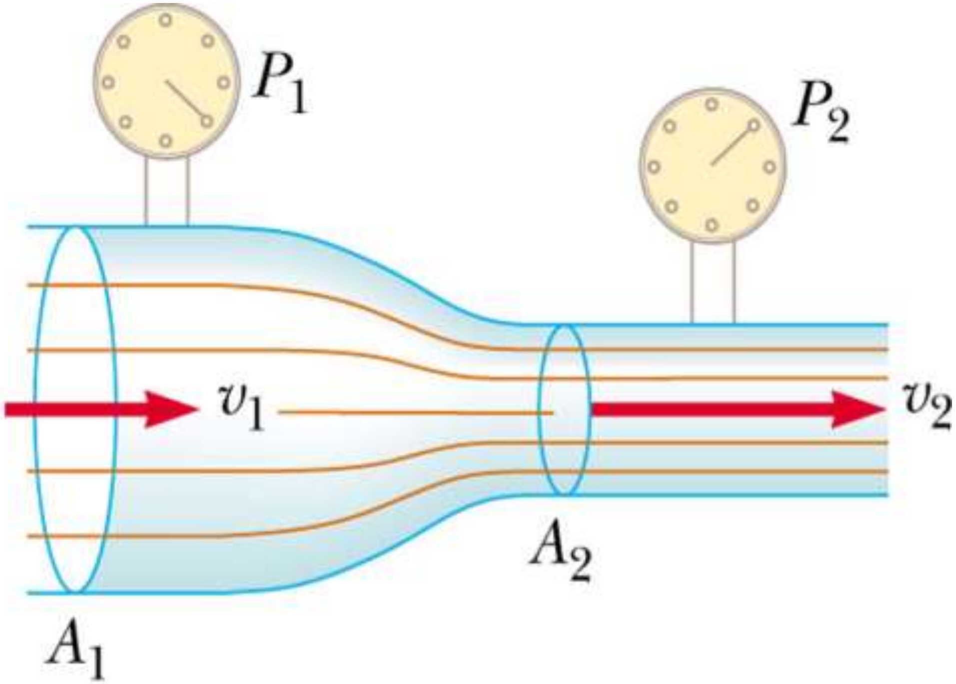


Bernoulli's Principle



One end of a gopher hole is higher than the other causing a constriction and low pressure region. Thus the air is constantly sucked out of the higher hole by the wind. The air enters the lower hole providing a sort of air re-circulating system effect to prevent suffocation.

Example 9.13a

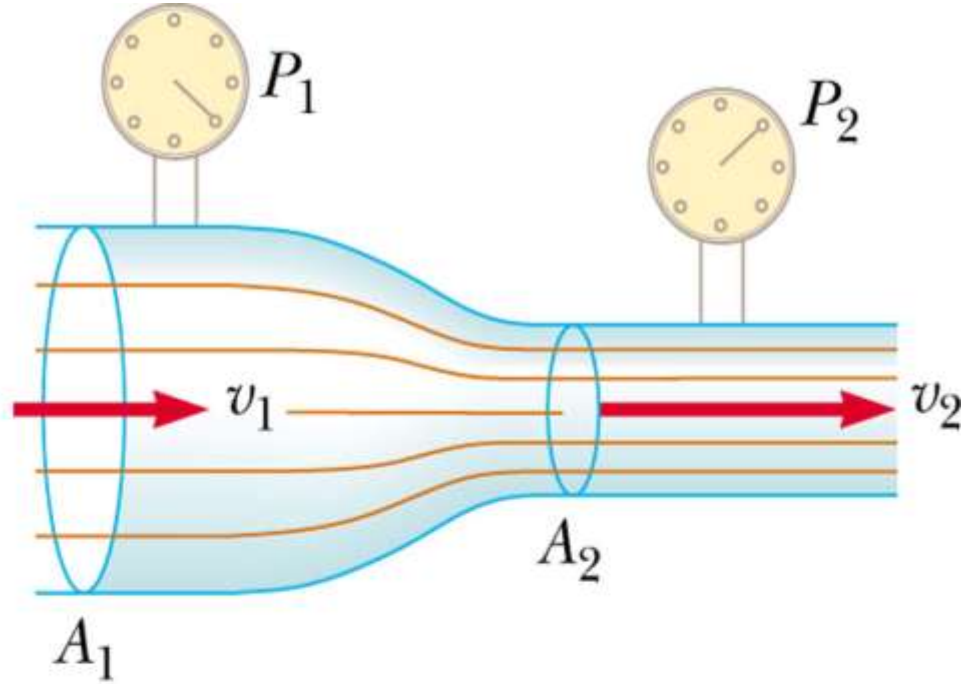


Consider an ideal incompressible fluid, choose >, < or =

ρ_1 ______ ρ_2

a) =
b) <
c) >

Example 9.13b

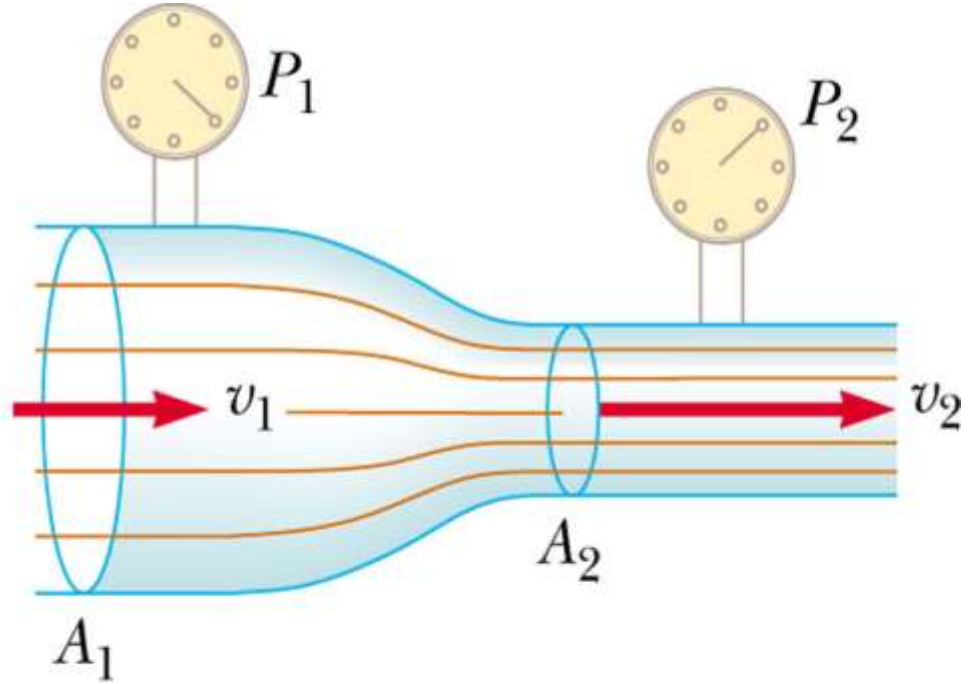


Consider an ideal incompressible fluid,
choose >, < or =

Mass that passes "1" in one second
______ mass that passes "2" in one second

a) =
b) <
c) >

Example 9.13c

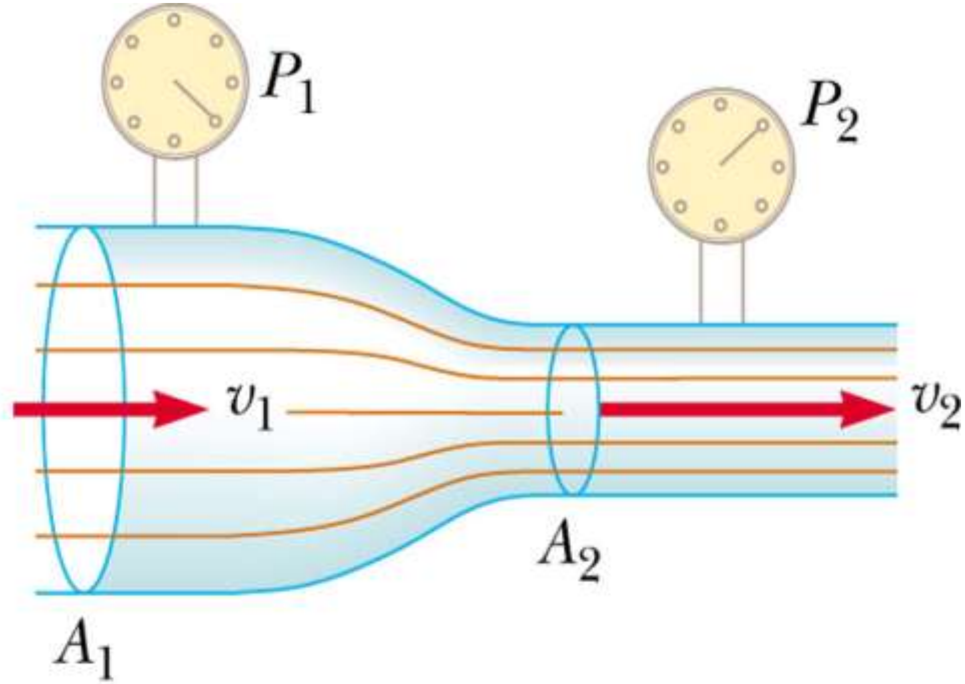


Consider an ideal incompressible fluid,
choose >, < or =

v_1 ______ v_2

a) =
b) <
c) >

Example 9.13d



Consider an ideal incompressible fluid, choose >, < or =

P_1 _____ P_2

a) =
b) <
c) >

Example 9.14

Water drains out of the bottom of a cooler at 3 m/s, what is the depth of the water above the valve?

45.9 cm

Example

Water circulates throughout the house in a hot-water heating system. If the water is pumped at a speed of 0.50 m/s through a 4.0 cm diameter pipe in the basement under a pressure of 3.0 atm, what will be the flow speed and pressure in a 2.6 cm-diameter pipe on the second floor 5.0 m above?

$$A_1 v_1 = A_1 v_2$$

$$\pi r_1^2 v_1 = \pi r_2^2 v_2$$

$$(0.04)^2 0.50 = (0.026)^2 v_2$$

$v_2 =$ **1.183 m/s**

$$P_o + \frac{1}{2}\rho v_o^2 + \rho g h_o = P + \frac{1}{2}\rho v^2 + \rho g h$$

$$3x10^5 + \frac{1}{2}(1000)(0.50)^2 + (1000)(9.8)(0) = P + \frac{1}{2}(1000)(1.183)^2 + (1000)(9.8)(5)$$

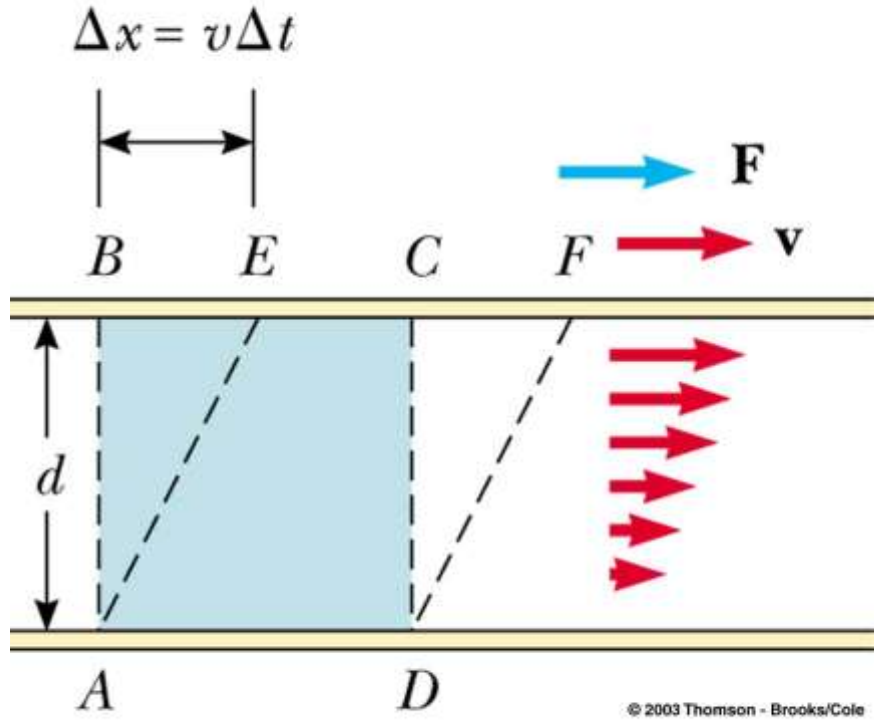
$P =$ **$2.5x10^5$ Pa(N/m^2) or 2.5 atm**

Three Vocabulary Words

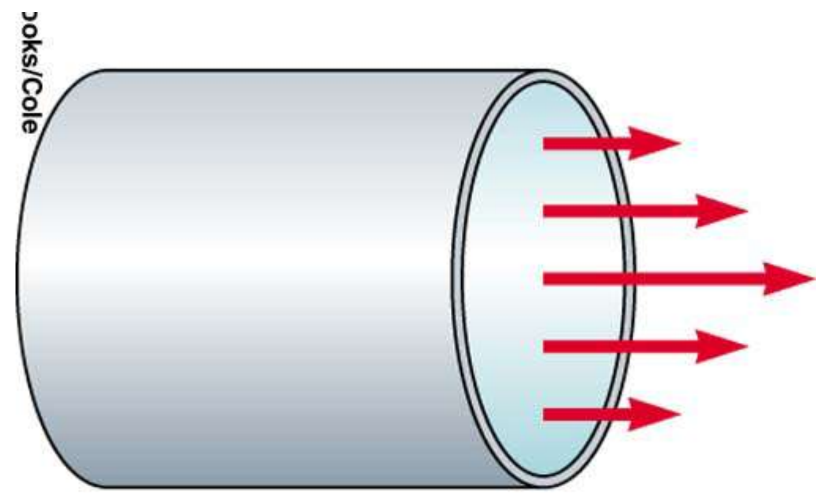
- Viscosity
- Diffusion
- Osmosis

Viscosity

$$F = \eta A \frac{v}{d}$$



- Friction between the layers
- Pressure drop required to force water through pipes (Poiselle's Law)
- At high enough v/d, turbulence sets in

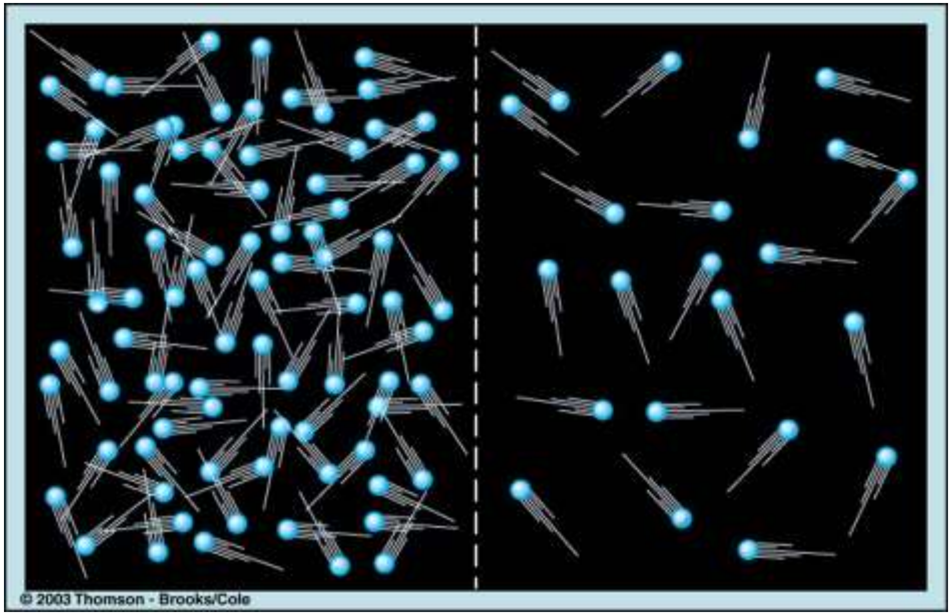


Diffusion

- Molecules move from region of high concentration to region of low concentration
- Fick's Law:

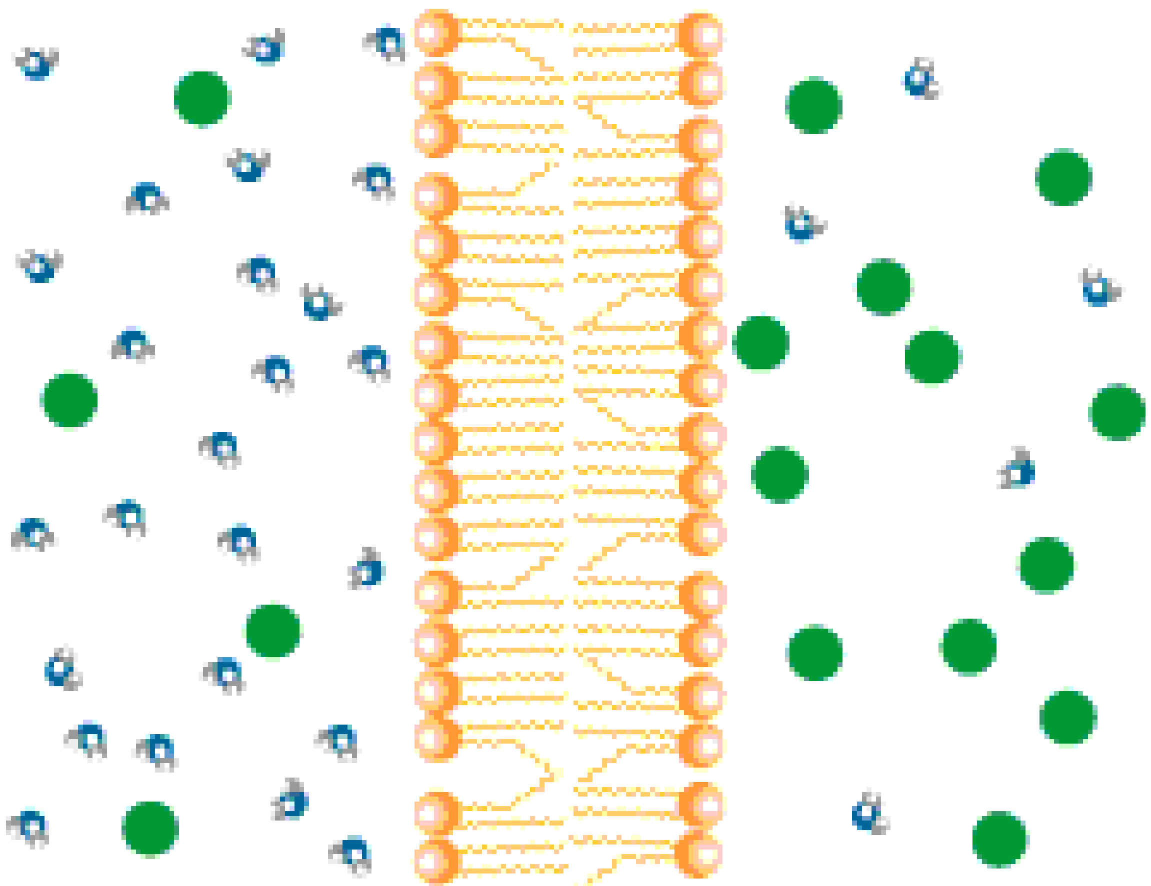
$$Diffusion\ rate = \frac{Mass}{time} = DA\left(\frac{C_2 - C_1}{L}\right)$$

- D = diffusion coefficient



Osmosis

Movement of water through a boundary while denying passage to specific molecules, e.g. salts



Lecture Quiz - Question 1:

A large metal tank is filled with high pressure of Helium, used to fill Helium balloons. Consider how much the tank weighs when it is full, and when empty.

A. The weight is the same full or empty.

B. The empty tank weighs less than the full tank.

C. The tank weighs less when it is full, because Helium is lighter than air.

Lecture - Question 2:

One cubic centimeter of Aluminum weighs 2.7 gms (ρ_{Al}=2.7 gms/cm^3). The Al cube is placed in a beaker of water.

A. The upward buoyant force on the cube equals the downward force (weight).

B. The weight of the displaced water equals the weight of the cube.

C. The weight of the cube is reduced in water do to the buoyant force.

D. The cube floats, because Aluminum is lighter than water.

Lecture - Question 3:

A block of wood is added to a beaker of water. It floats. The beaker rests on a scale that reads its weight.

A. There is no change in weight, because the buoyant force equals the weight of the water.

B. The weight increases by the weight of the block.

C. The weight increases by an amount less than the weight of the block.