Wrocław University of Science and Technology

Physics

JZL1001913C

summer semester

2020/2021

Wednesday, 18:20 - 19:50

Friday, 18:20 - 19:50

virtual room (ZOOM)

Sylwia Majchrowska

sylwia.majchrowska@pwr.edu.pl

https://majsylw.netlify.app/

room 213, building L-1

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Outline

- Introduction - Physics rules the world
- Motion phenomena - Kinematics
- Motion phenomena - Dynamics
- Rotational motion
- Harmonic motion
- Gravitational field
- Relativistic phenomena
- Basics of Thermodynamics
- Principles of Thermodynamics
- **Fluids Statics**
- Electrostatics
- Electric current
- Magnetic field
- Vibrations and electromagnetic waves
- Optics
- Quantum nature of radiation
- Nuclear Physics

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Thermodynamics

- short rewiev

Pressure $P = F/S$	Unit 1 Pascal $=1N/m^2$
Heat capacity **<value depends on materia>**	Unit J/kg/K
Heat $Q = mc\Delta T$	Unit 1 kg * J/kg/K * K = = J
Heat of change $Q = m\Delta T$	Unit 1 kg * J/kg = J

Quantities:

- Temperature
- Pressure
- Heat
- Specific heat capacity
- Heat of fusion/vaporation

The ideal gas law

$$PV = nRT$$

Process	Important point to remember
isothermal	Constant T, $\Delta U = 0$, $Q=W$
isovolumetric(isochoric)	Constant V, $W = 0$, $\Delta U=Q$
Isobaric	Constant P,$\Delta U = Q- (-P\Delta V)$
adiabatic	Nothing is Constant, $Q = 0$, $\Delta U= -W$

Laws of thermodynamics – short review

The laws of thermodynamics govern the way energy is transferred from one state to another. They are:

- ***First law of thermodynamics***: When energy moves into or out of a system, the systems internal energy changes in accordance with the law of conservation of mass.
- ***Second law of thermodynamics***: The state of the entropy of the entire universe, as an isolated system, will always increase over time.
- ***Third law of thermodynamics***: Entropy of a perfect crystal at absolute zero is zero.

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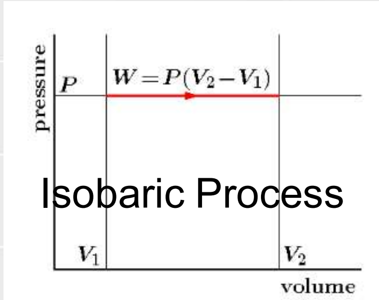
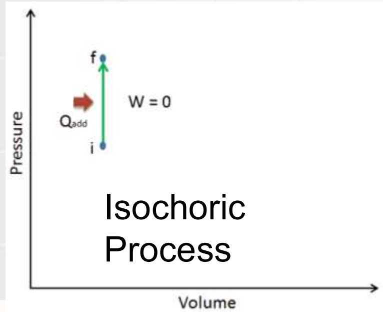
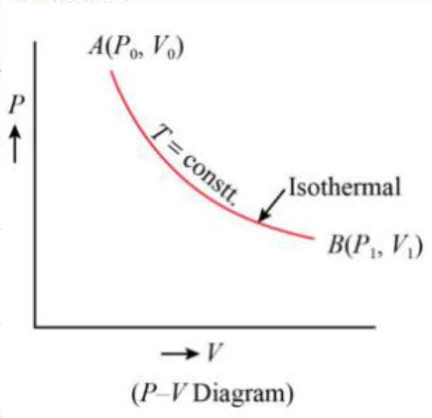
Thermodynamic Processes

- short review



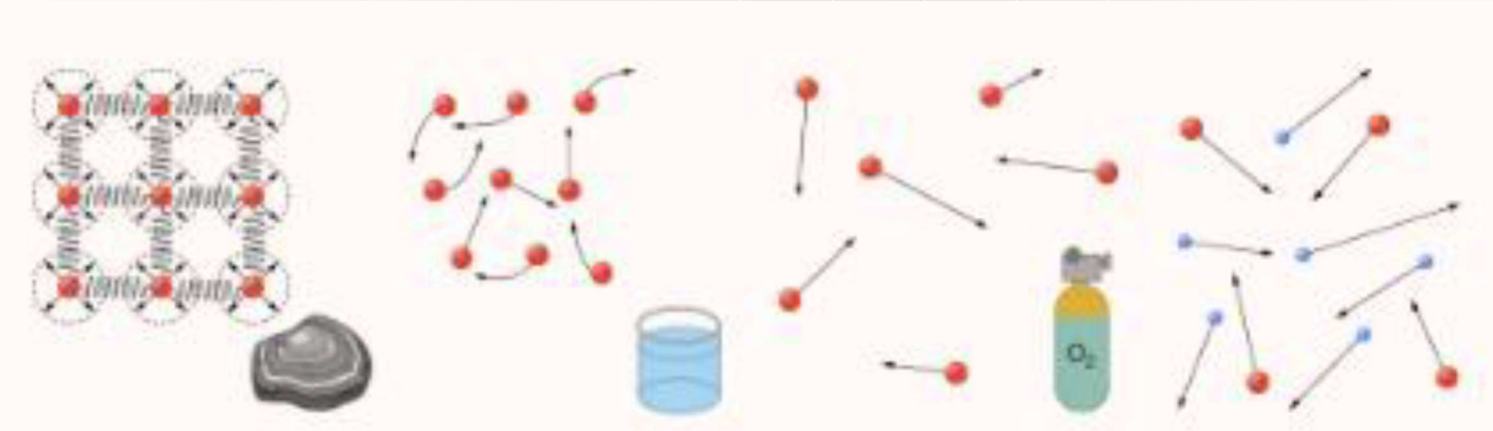


Isobaric	Constant pressure $$W = P\Delta V$$
Isochoric	Constant volume $$W = 0$$
Isothermal	Constant temperature $$Q = W$$
Adiabatic	No heat transfer $$Q = 0$$



Mechanical Properties of Fluids

A fluid is a substance that has no fixed shape. Liquids and Gases can flow and are therefore called fluids. Fluids yield easily to external pressure. In this classes, we will learn about various Mechanical Properties of Fluids like Viscosity and Surface Tension.



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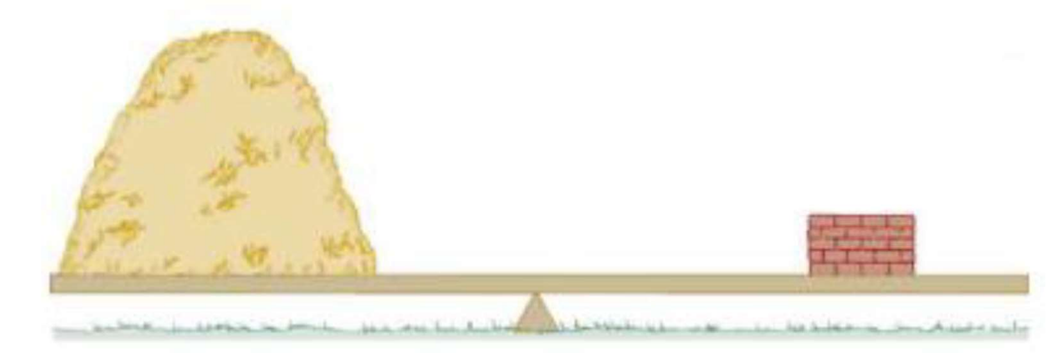
Density

DENSITY

Density is mass per unit volume.

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

where ρ is the symbol for density, m is the mass, and V is the volume occupied by the substance.



A ton of feathers and a ton of bricks have the same mass, but the feathers make a much bigger pile because they have a much lower density.

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Density - dependence of state of the matter

Substance	$\rho(10^3\ \mathrm{kg/m^3}$ or $\mathrm{g/mL})$	Substance	$\rho(10^3\ \mathrm{kg/m^3}$ or $\mathrm{g/mL})$	Substance	$\rho(10^3\ \mathrm{kg/m^3}$ or $\mathrm{g/mL})$
Solids		**Liquids**		**Gases**	
Aluminum	2.7	Water (4°C)	1.000	Air	1.29×10^{-3}
Brass	8.44	Blood	1.05	Carbon dioxide	1.98×10^{-3}
Copper (average)	8.8	Sea water	1.025	Carbon monoxide	1.25×10^{-3}
Gold	19.32	Mercury	13.6	Hydrogen	0.090×10^{-3}
Iron or steel	7.8	Ethyl alcohol	0.79	Helium	0.18×10^{-3}
Lead	11.3	Petrol	0.68	Methane	0.72×10^{-3}
Polystyrene	0.10	Glycerin	1.26	Nitrogen	1.25×10^{-3}
Tungsten	19.30	Olive oil	0.92	Nitrous oxide	1.98×10^{-3}

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Experiment with sugar and salt

A pile of sugar and a pile of salt look pretty similar, but which weighs more? If the volumes of both piles are the same, any difference in mass is due to their different densities (including the air space between crystals). Which do you think has the greater density? What values did you find? What method did you use to determine these values?

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Experiment with sugar and salt

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Salt is about 25% more dense than **sugar**. Therefore a teaspoon of **salt** weighs more than a teaspoon of **sugar** by almost 25%.

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Example 1

A reservoir has a surface area of 50.0 km^2 and an average depth of 40.0 m. What mass of water is held behind the dam? (See Figure for a view of a large reservoir—the Three Gorges Dam site on the Yangtze River in central China.)

Preassure

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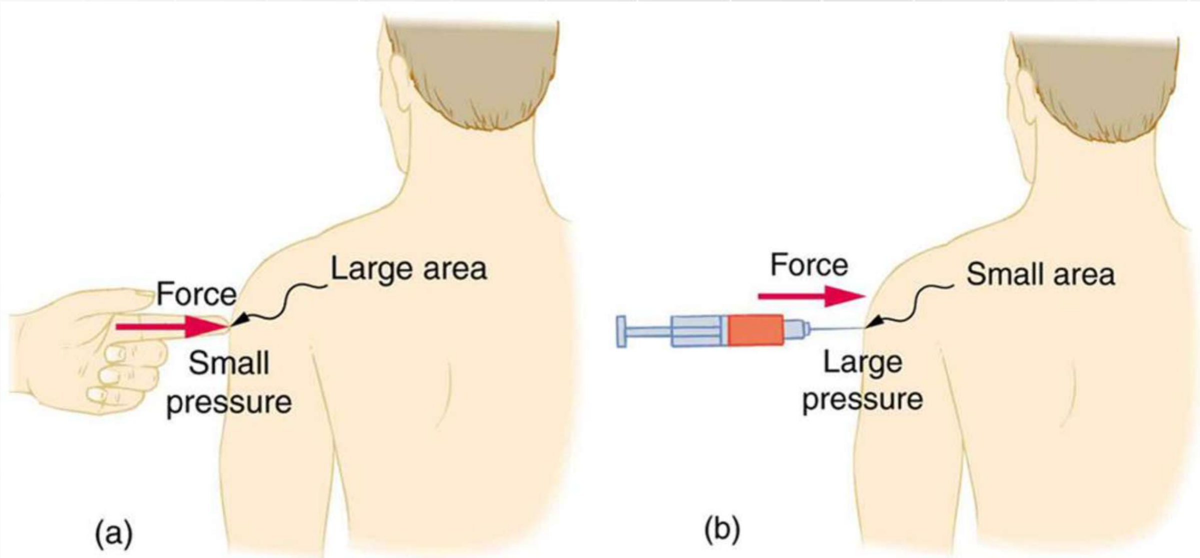
PRESSURE

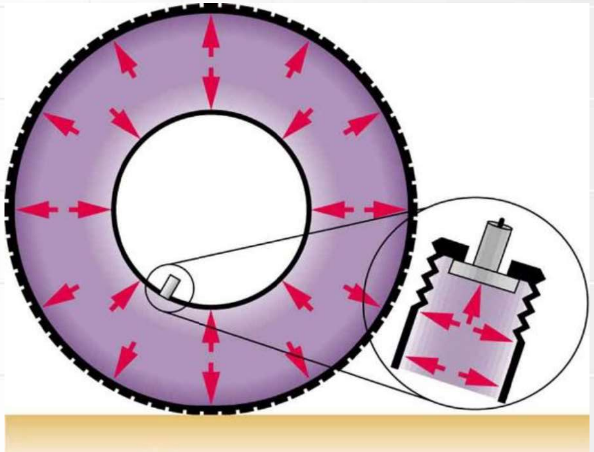
Pressure is defined as the force divided by the area perpendicular to the force over which the force is applied, or

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



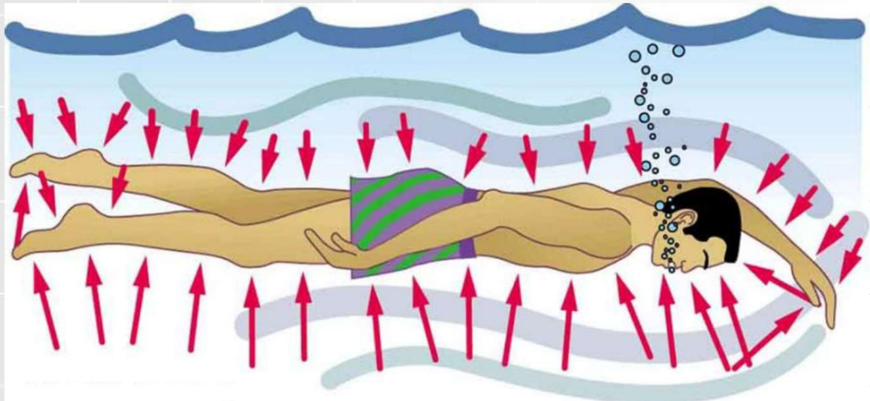
(a) While the person being poked with the finger might be irritated, the force has little lasting effect. (b) In contrast, the same force applied to an area the size of the sharp end of a needle is great enough to break the skin.

Preassure - examples



Pressure inside this tire exerts forces perpendicular to all surfaces it contacts. The arrows give representative directions and magnitudes of the forces exerted at various points. Note that static fluids do not exert shearing forces.

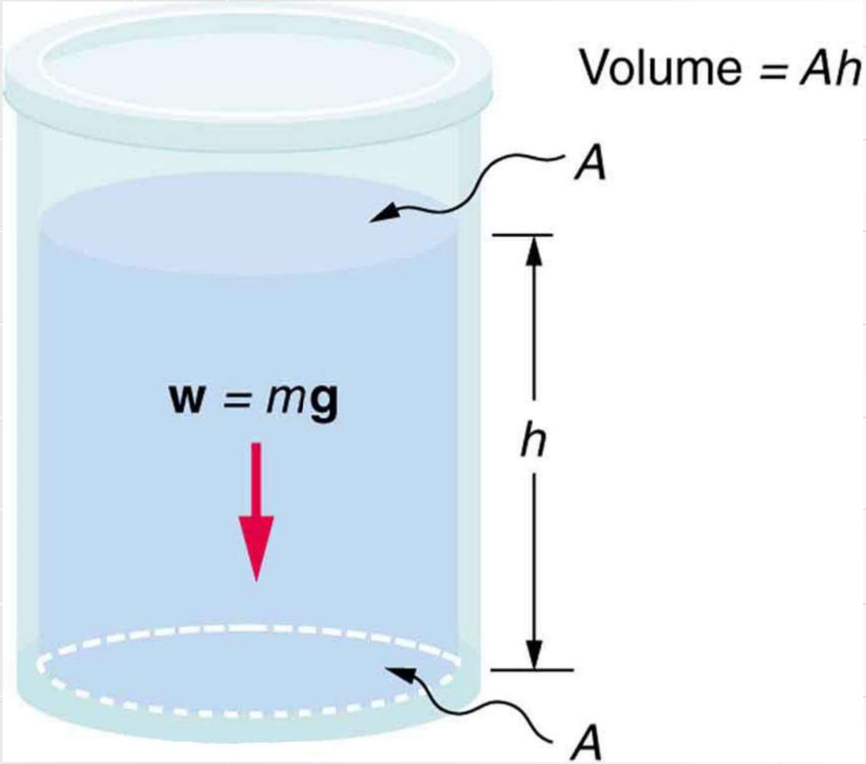
Pressure is exerted on all sides of this swimmer, since the water would flow into the space he occupies if he were not there. The arrows represent the directions and magnitudes of the forces exerted at various points on the swimmer. Note that the forces are larger underneath, due to greater depth, giving a net upward or buoyant force that is balanced by the weight of the swimmer.



https://phet.colorado.edu/en/simulation/legacy/gas-properties

Variation of Pressure with Depth in a Fluid

The bottom of this container supports the entire weight of the fluid in it. The vertical sides cannot exert an upward force on the fluid (since it cannot withstand a shearing force), and so the bottom must support it all.



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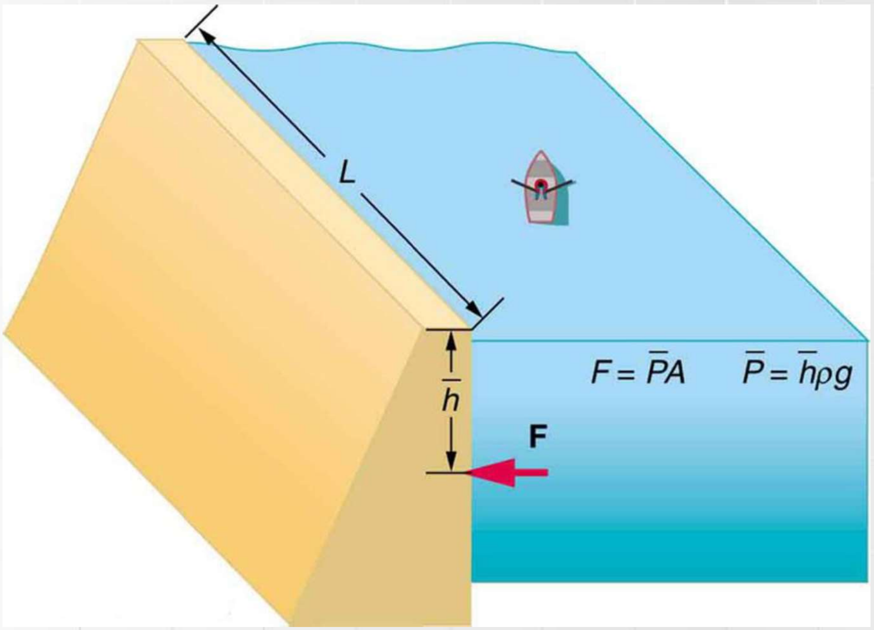
Example 2

Now we will now consider the pressure and force acting on the dam retaining water. The dam is 500 m wide, and the water is 80.0 m deep at the dam.

(a) What is the average pressure on the dam due to the water?

(b) (b) Calculate the force exerted against the dam and compare it with the weight of water in the dam (previously found to be 1.96×10^{13}N).

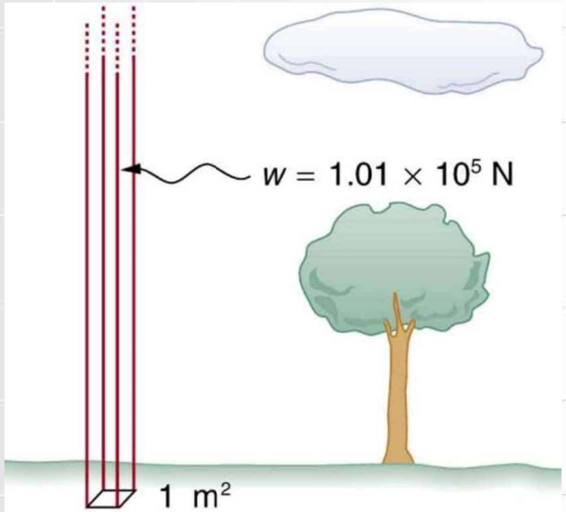


Atmospheric pressure

Atmospheric pressure is another example of pressure due to the weight of a fluid, in this case due to the weight of air above a given height. The atmospheric pressure at the Earth's surface varies a little due to the large-scale flow of the atmosphere induced by the Earth's rotation (this creates weather "highs" and "lows"). However, the average pressure at sea level is given by the standard atmospheric pressure P_{atm}, measured to be

$$1\ \text{atmosphere (atm)} = P_{\text{atm}} = 1.01 \times 10^5\ \text{N/m}^2 = 101\ \text{kPa}$$

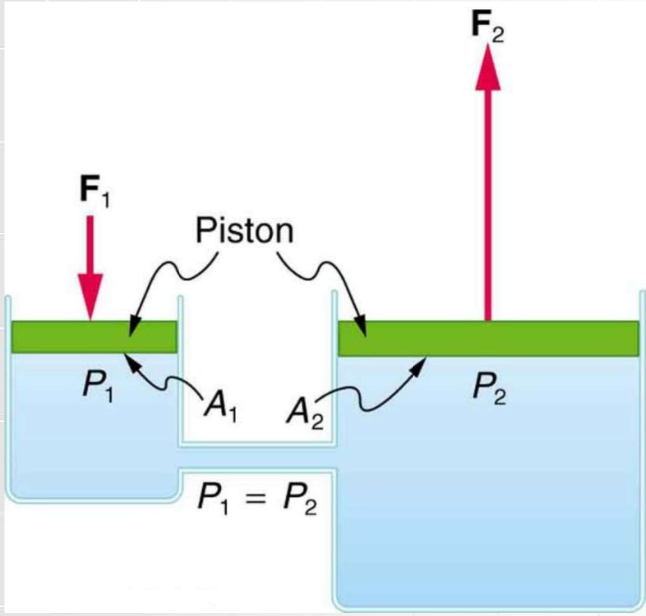
This relationship means that, on average, at sea level, a column of air above $1.00 m^2$ of the Earth's surface has a weight of $1.01 \times 10^5 N$, equivalent to 1 atm .



Pascal's Principle

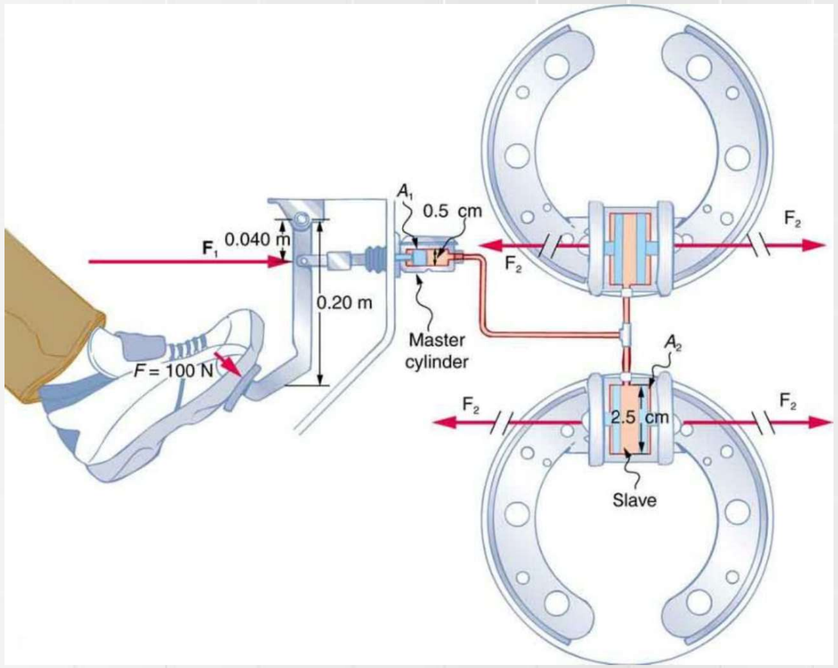
PASCAL'S PRINCIPLE
A change in pressure applied to an enclosed fluid is transmitted undiminished to all portions of the fluid and to the walls of its container.

A typical hydraulic system with two fluid-filled cylinders, capped with pistons and connected by a tube called a hydraulic line. A downward force F_1 on the left piston creates a pressure that is transmitted undiminished to all parts of the enclosed fluid. This results in an upward force F_2 on the right piston that is larger than F_1 because the right piston has a larger area.



Example 3

A force of 100 N is applied to the brake pedal, which acts on the cylinder—called the master—through a lever. A force of 500 N is exerted on the master cylinder. Pressure created in the master cylinder is transmitted to four so-called slave cylinders. The master cylinder has a diameter of 0.500 cm, and each slave cylinder has a diameter of 2.50 cm. Calculate the force F_2 created at each of the slave cylinders.

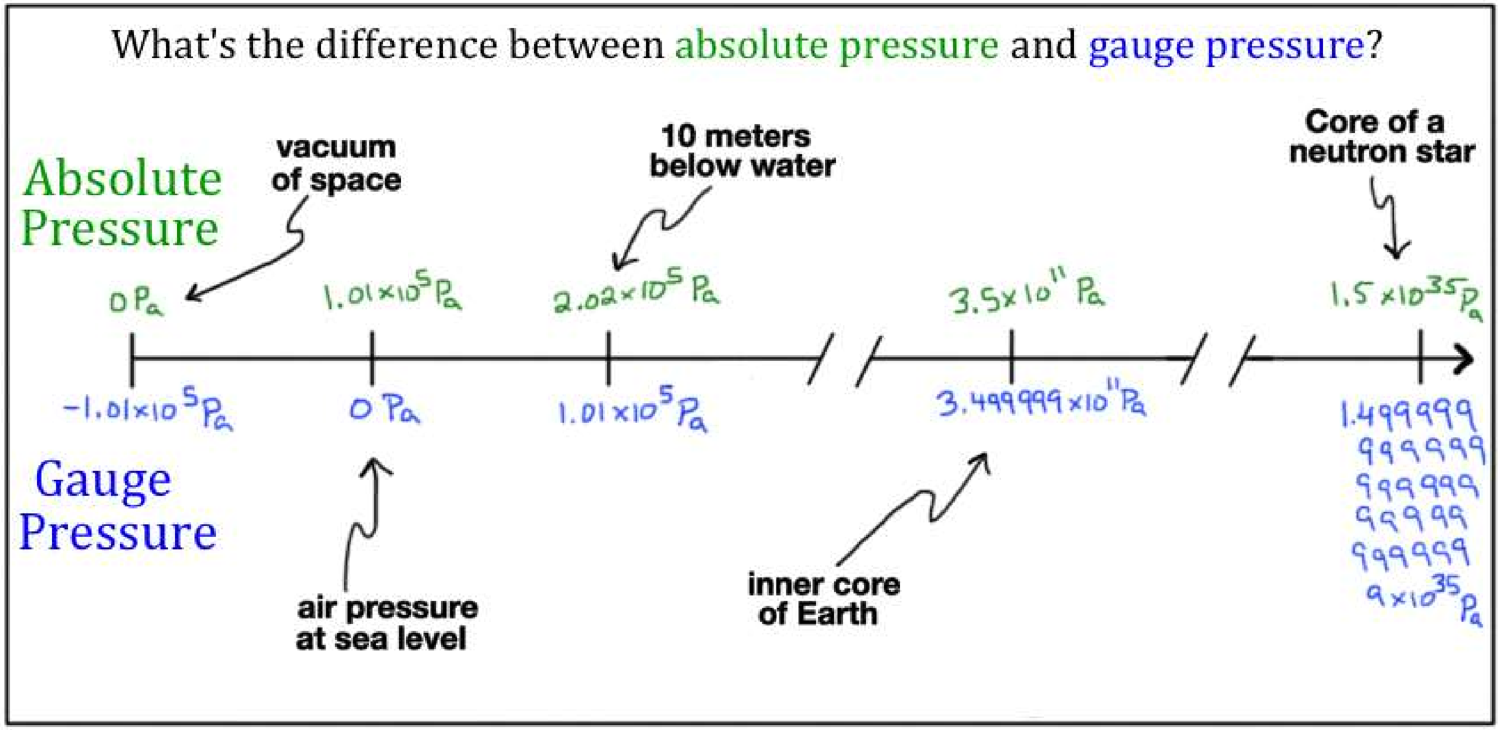


Gauge pressure

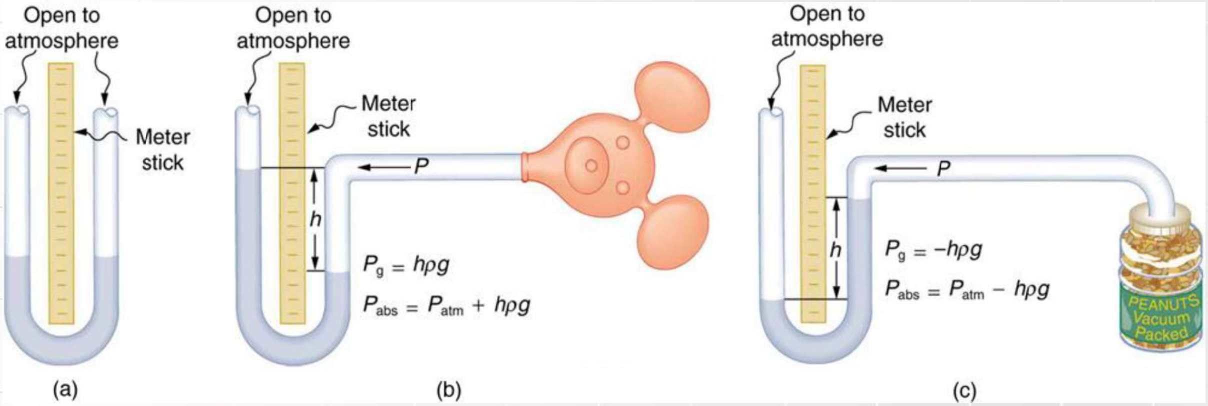
Gauge pressure is the pressure relative to atmospheric pressure. Gauge pressure is positive for pressures above atmospheric pressure, and negative for pressures below it.

ABSOLUTE PRESSURE

Absolute pressure is the sum of gauge pressure and atmospheric pressure.



Pressure measurement



In routine blood pressure measurements, an inflatable cuff is placed on the upper arm at the same level as the heart.

An open-tube manometer has one side open to the atmosphere. (a) Fluid depth must be the same on both sides, or the pressure each side exerts at the bottom will be unequal and there will be flow from the deeper side. (b) A positive gauge pressure $P_g = h\rho g$ transmitted to one side of the manometer can support a column of fluid of height h. (c) Similarly, atmospheric pressure is greater than a negative gauge pressure P_g by an amount $h\rho g$. The jar's rigidity prevents atmospheric pressure from being transmitted to the peanuts.

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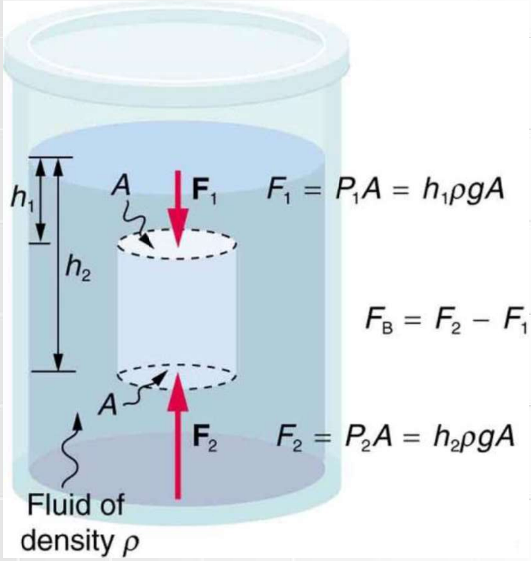
Example 4

Intravenous infusions are usually made with the help of the gravitational force. Assuming that the density of the fluid being administered is 1.00 g/ml, at what height should the IV bag be placed above the entry point so that the fluid just enters the vein if the blood pressure in the vein is 18 mm Hg above atmospheric pressure? Assume that the IV bag is collapsible.

Archimedes principle

BUOYANT FORCE
The buoyant force is the net upward force on any object in any fluid.



According to this principle the buoyant force on an object equals the weight of the fluid it displaces. In equation form, Archimedes' principle is

$F_B = w_{fl}$,

where F_B is the buoyant force and w_{fl} is the weight of the fluid displaced by the object.

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Example 5

(a) Calculate the buoyant force on 10,000 metric tons $(1.00\times10^7 kg)$ of solid steel completely submerged in water, and compare this with the steel's weight.

(b) What is the maximum buoyant force that water could exert on this same steel if it were shaped into a boat that could displace $1.00\times10^5 m^3$ of water?

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Cohesion and Adhesion

Attractive forces between molecules of the same type are called **cohesive forces**. Liquids can, for example, be held in open containers because cohesive forces hold the molecules together. Attractive forces between molecules of different types are called **adhesive forces**. Such forces cause liquid drops to cling to window panes, for example. In this section we examine effects directly attributable to cohesive and adhesive forces in liquids.

Gauge pressure P inside a spherical bubble:

$$P = \frac{4\gamma}{r}$$

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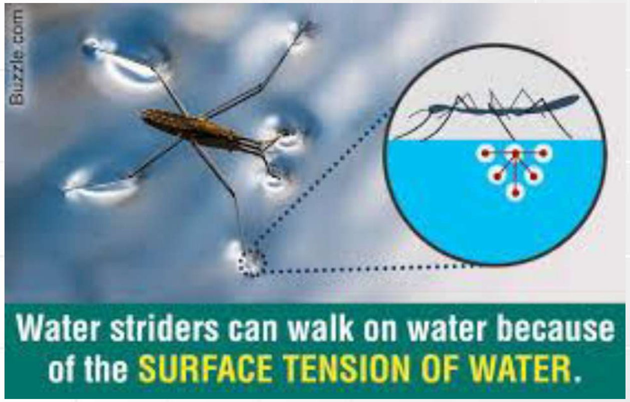
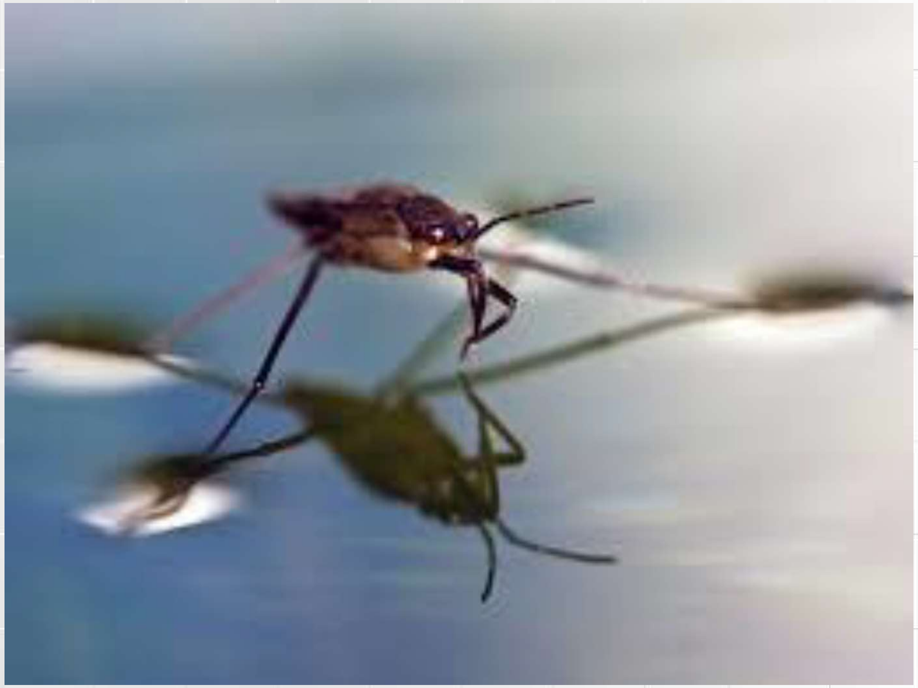
Surface Tension

Cohesive forces between molecules cause the surface of a liquid to contract to the smallest possible surface area. This general effect is called **surface tension**. Molecules on the surface are pulled inward by cohesive forces, reducing the surface area. Molecules inside the liquid experience zero net force, since they have neighbors on all sides.





Surface tension γ is defined to be the force F per unit length L exerted by a stretched liquid membrane:

$$\gamma = \frac{F}{L}$$

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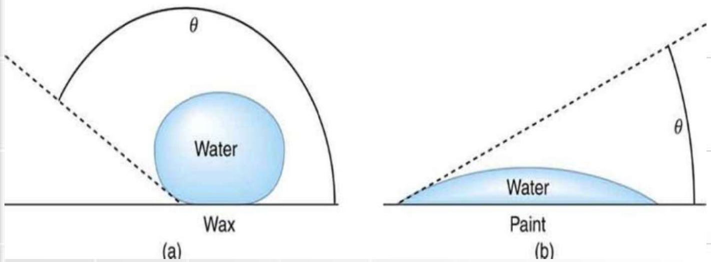
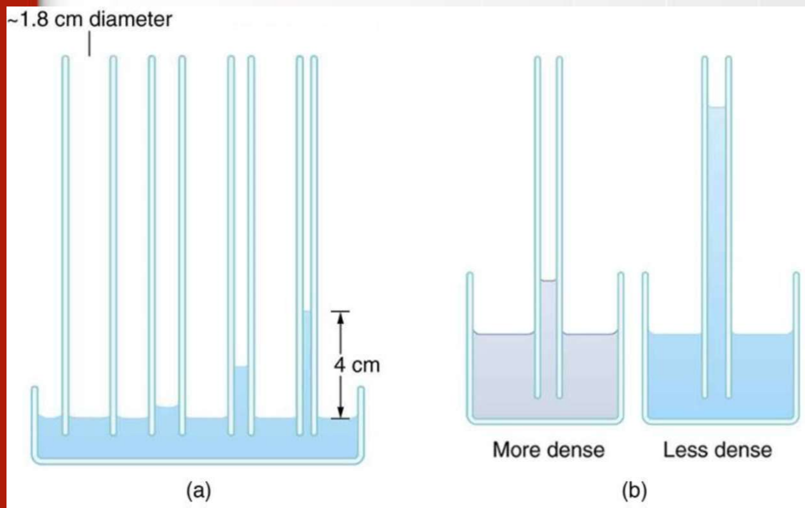
Capillary Action

The contact angle θ is directly related to the relative strength of the cohesive and adhesive forces. The larger the strength of the cohesive force relative to the adhesive force, the larger θ is, and the more the liquid tends to form a droplet. The smaller θ is, the smaller the relative strength, so that the adhesive force is able to flatten the drop.



$$h = \frac{2\gamma\cos\theta}{\rho g r}$$



One important phenomenon related to the relative strength of cohesive and adhesive forces is **capillary action**—the tendency of a fluid to be raised or suppressed in a narrow tube, or *capillary tube*. This action causes blood to be drawn into a small-diameter tube when the tube touches a drop.

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Example 6

Can capillary action be solely responsible for sap rising in trees? To answer this question, calculate the radius of a capillary tube that would raise sap 100m to the top of a giant redwood, assuming that sap's density is 1050 kg/m^3, its contact angle is zero, and its surface tension is the same as that of water at 20.0^o C .

The height to which a liquid will rise as a result of capillary action is given by $h = \frac{2\gamma \cos\theta}{\rho g r}$, and every quantity is known except for r.

Fluid statics

All right. So if you go to our website today, you will find I've assigned some problems and you should try to do them. They apply to this chapter.