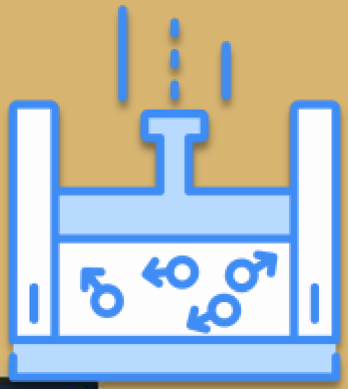
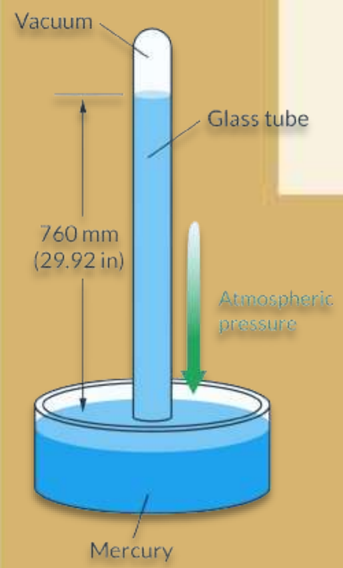
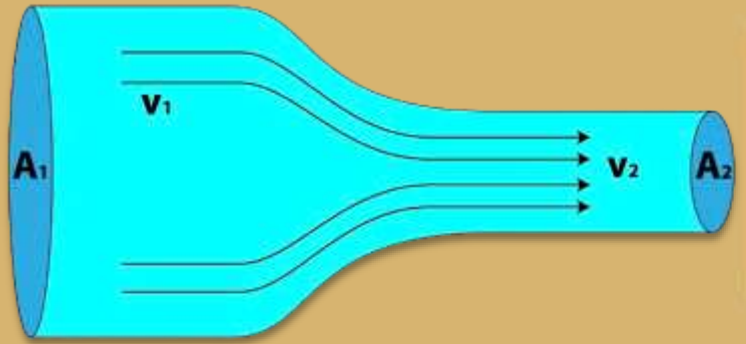
$$A1.V1 = A2.v2$$

$$Q = m.c.\Delta t$$



PHYSICS REVISION





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Physics lo 8

Concepts :

- Fluids
- Pressure
- Manometer
- Pressure gauge
- Units of pressure
- Effect of atmospheric pressure on boiling point of water
- Change in atmospheric pressure with altitude
- Pressure difference and force
- Archimedes Principle
- pascal principle

Fluids

Fluid: any liquid or gas or generally any material that cannot sustain a tangential, or shearing force when at rest and undergoes a continuous change in shape when subjected to such stress.

Types of fluid:

- Fluids statics: It is the mechanism of fluids at rest or non-motion, and the pressure in fluids exerted by fluids on anybody.
- Fluids dynamics: It involves the study of the flow of fluids in motion. Popular branches like aerodynamics and hydrodynamics are part of fluid dynamics.

Properties of fluid:

1. Density: Density is basic property, the quantity of something per unit volume density expressed in g/cm3 or kg / m3 (Density = mass/volume)
2. Relative density: the ratio between density of substance to density of water at the same temperature So R.D = density of substance / density of water (has no unit)
3. Pressure: It is the perpendicular force acting in the object’s surface per unit area. Pressure is a scalar quantity.

p = F/ A Units: N/m2 OR Pascal OR J/m3 OR

Pressure

Pressure increases as we go down into the water. To calculate the pressure of an object inside a liquid:

- Open container: P= ρgh + Pa
- Closed container: P= ρgh

Manometer: a device to measure pressures of a gas. a U shaped tube of glass filled with some liquid.

Use:-

1. Measures the pressure of gas (gauge pressure) enclosed in a reservoir.
2. . Measure the difference between the pressure the enclosed gas and the atmospheric pressure.

Cases of opened manometer:-

First case: P1=P2

P gas=Pa

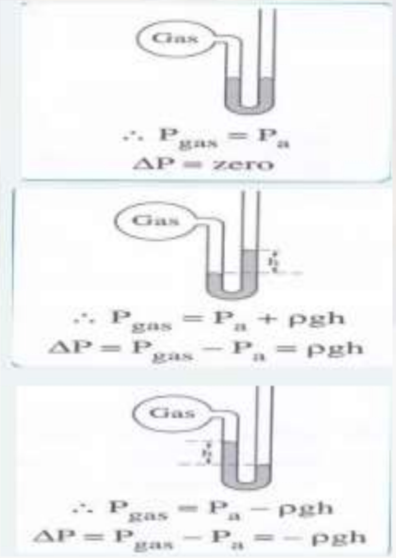
Second case: P1=P2

P gas =Pa + ρgh   (P gas = Pa + h)

Third case: P1=P2

P gas = Pa – ρgh

(P gas = Pa – ρgh)



First case

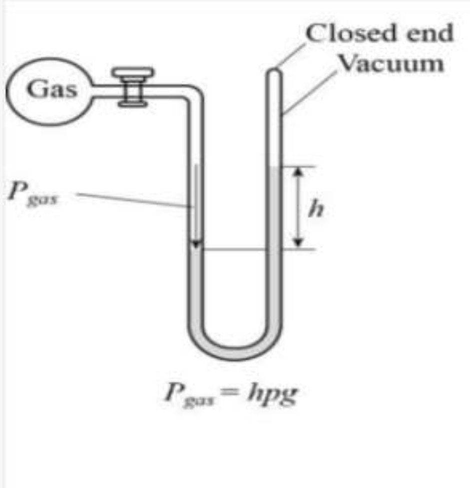
Second case

Third

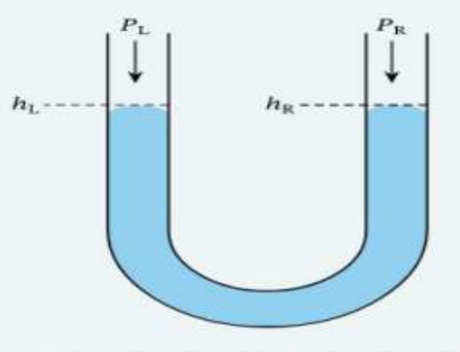
Closed manometer:

There is not atmospheric pressure.

P gas= ρgh

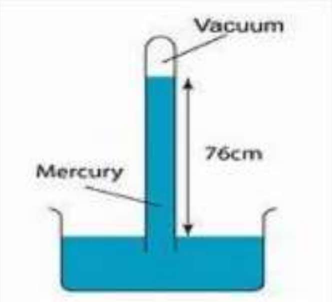


- At same level: Pg= ρgh
- When P>Pa then: Pg=Pa + ρgh=ρa + h
- When: Pg=Pa- ρgh=Pa-h



Barometer:-

Measure atmospheric pressure. Contains mercury because it has high density(13600kg/m3). We can't use water (low density need h=10.4meter) the density of water is 13.6 times smaller than that of mercury, that means we would require a 13.6 times taller column of water than that of mercury to measure same pressure difference.



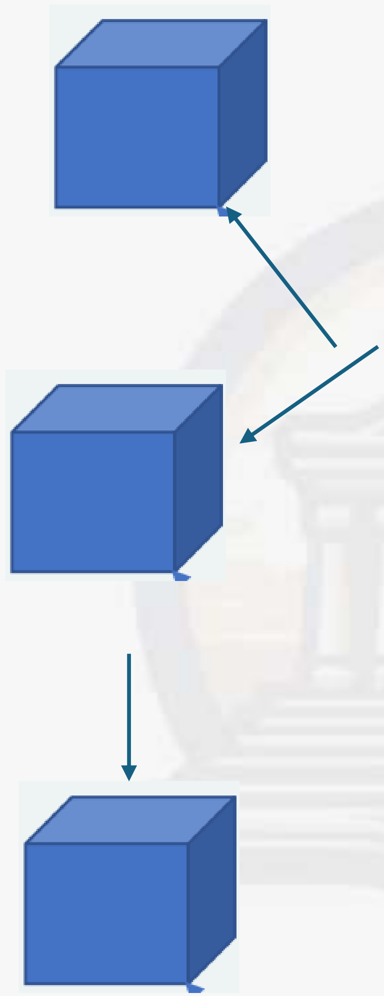
Pressure at its base bottom:-

$P = \rho g h$ $F = \rho h g \times A$ (ρ of water = 1000 kg/m^3)

Pressure at vertical side (face):-

$P = 1/2\, \rho g h$ $F = 1/2\, \rho g h \times A$

Pressure at upper side = zero



Units of atmospheric pressure:

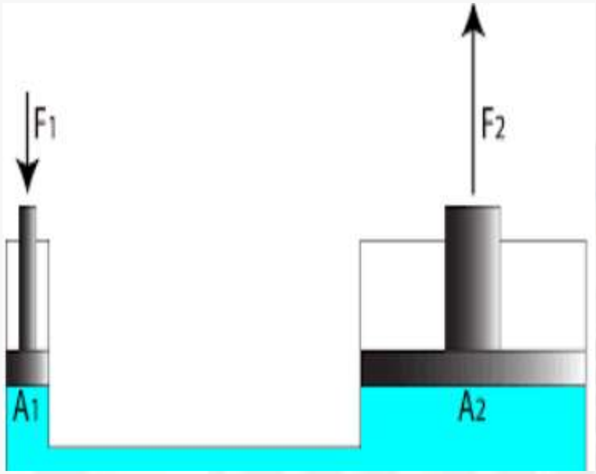
- $1\ atm = 1.013 \times 10^5\ N/m^2$ (Pascal)
- $1\ atm = 76\ cm.\ Hg$
- $1\ atm = 1.013\ Bar$
- $1\ atm = 0.76\ m.\ Hg$
- $1\ atm = 760\ mm.\ Hg\ [Torr.]$

Difference between pressure and force

Force	Pressure
The push and pull action resulting in acceleration of the object	Force acting upon a certain area and acted upon something perpendicular to its surface
Its unit is Newton and is represented by N	Its unit is Pascal and is represented as Pa
The instrument to measure force is called as dynamometer	It instrument to measure pressure is called as manometer
Force is a vector quantity which means it also has direction	Pressure is a scalar quantity which means it does not have direction
Force can be acted upon on the face, edges, side or vertices of the object	Pressure only acts on the surface or face of the object
Velocity of object can be changed with the application of force in one direction	Pressure on the object won't change the direction of the object.

Pascal principal

P1 = P2
F1/A1 = F2/A2



Applications of pascal’s law:-
Hydraulic Lift: It works based on the principle of equal pressure transmission throughout a fluid (Pascal’s Law).

Archimedes’ principle

Archimedes’ principle Formula

- $F_b = \rho \times g \times Volume$

Apparent weight= Weight of object (in the air) – Thrust force (buoyancy)

- $F_g - F_b$ (Buoyant Force) = apparent weight

Archimede cases 1) on floating:

$F_b = F_g = \rho_{liquid} * g * v_{immersed} = \rho_{solid} * g * v_{total}$

ρ = density

v = volume

g = gravity

Case 1

Case 2

2) Floating with additional part: $F_b = F_{g(solid)} + F_{g(odd)} = \rho_{liquid} * g * v_{immersed} = \rho_{solid} * g * v_{total}$

$F_b = F_{g(solid)} + F_{g(odd)} = \rho_{liquid} * g * v_{immersed} = \rho_{solid} * g * v_{total}$

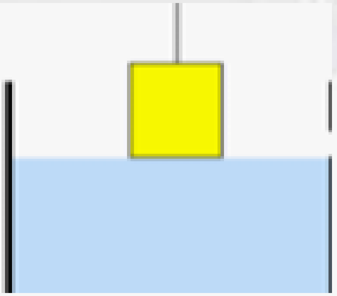
3)Tension force acting on it above : $F_b + F_t = F_g$ $F_t = F_g - F_b$ $F_t = \rho_{solid} * g * v_{total} - \rho_{liquid} * g * v_{total}$

$F_b + F_t = F_g$

$F_t = F_g - F_b$

$F_t = \rho_{solid} * g * v_{total} - \rho_{liquid} * g * v_{total}$

Case 3

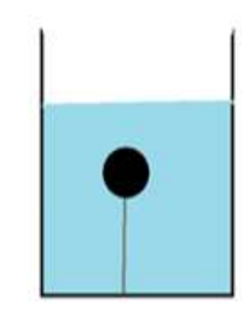


(4)Tension force acting on it down :

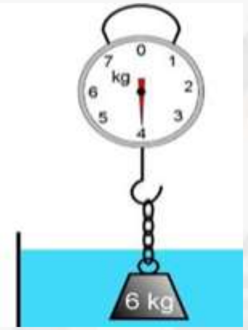
Ft + Fg =Fb

Ft = Fb – Fg

Ft = ρliquid*g*v total – ρsolid*g*v total

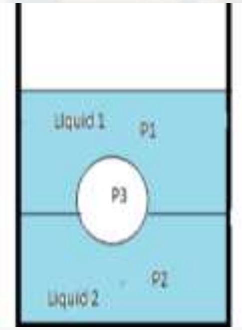


(5) Fb = Fg (air) – Fg (liquid)



(6) Ball into two liquids:

Fb1+Fb2 =Fg



Test bank

(1) A large stone is resting on the bottom of the swimming pool, The normal force of the bottom of the pool on the stone is equal to the:

A .weight of the stone .

b .weight of the water displaced.

C .sum of the weight of the stone and the weight of the displaced water.

d. difference between the weight of the stone and the weight of the displaced water.

ANS: D

(2) A stonecutter's chisel has an edge area of 0.50 cm2. If the chisel is struck with a force of 45 N, what is the pressure exerted on the stone?

a.9 000 Pa

b.90 000 Pa

c.450 000 Pa

d.900 000 Pa

ANS: D

(3)). When water freezes, it expands about nine percent. What would be the pressure increase inside your automobile engine block if the water in there froze? (The bulk modulus of ice is 2.0 · 109 Pa, and 1 atm = 1.0 · 105 Pa.)

a.18 atm

b.270 atm

c.1 080 atm

d.1 800 atm

ANS: D

(4) The correct arrangement of the measuring units of the atmospheric pressure starting from the smallest unit is that labeled

A- Bar – atmosphere – pascal – torr

B- torr – pascal – bar – atmosphere

C- pascal – atmosphere –bar – torr

D- pascal – torr - Bar – atmosphere

ANS: D

(5) The atmospheric pressure increases as

A- the moisture in air increases

B- the height above sea level increases

C- the temperature of air rises

D- moving on surface of earth towards the equator

ANS: A

(6) A water manometer connected to a gas supply a small difference in height between the two liquid levels is noticed. How could you make this difference greater to be measured easier?

A- Use water manometer a with narrow tube

B- add more water into the manometer tube

C- use mercury manometer, instead of water manometer

D- use oil manometer, instead of water manometer

ANS: D

(7) Which of the following quantities has the same S.I. unit as that of pressure?
a) Work
b) Energy / Velocity
c) Energy / Displacement
d) mass X (velocity)2/Volume
ANS: D
(8)) Pressure is a vector quantity. True or False?
a) True
b) False
ANS: B
(9) The dimension of coefficient of viscosity is
a. M1L-1T-1
b. M-1L1T-1
c. M-1L1T1
d. M-1L-1T1
ANS: A
(10) A hydraulic press allows large masses to be lifted with small forces as a result of which principle?
A) Pascal's
B) Bernoulli's
C) Archimedes'
D) Huygens'
E) Newton's
Ans: A

General properties of fluids

- **Density :** is the mass of a substance per unit volume. Typical units are kg/m^3.

***ρ*=m/v**

- **Specific volume :**

of a substance is the volume per unit mass of the substance. Standard unit is m^3 /kg or m^3 · kg -1

- **Specific Weight (Weight Density)**

The specific weight of a fluid is designated by the Greek symbol γ (gamma) and is generally defined as the weight per unit volume. The units for gamma are N/m^3 in the SI systems, respectively.

➢Relative Density (Specific Gravity)

The relative density of any fluid is defined as the ratio of the density of that fluid to the density of the standard fluid. For liquids we take water as a standard fluid with density ρ=1000 kg/m^3. For gases we take air or O_2 as a standard fluid with density, ρ=1.293 kg/m^3.

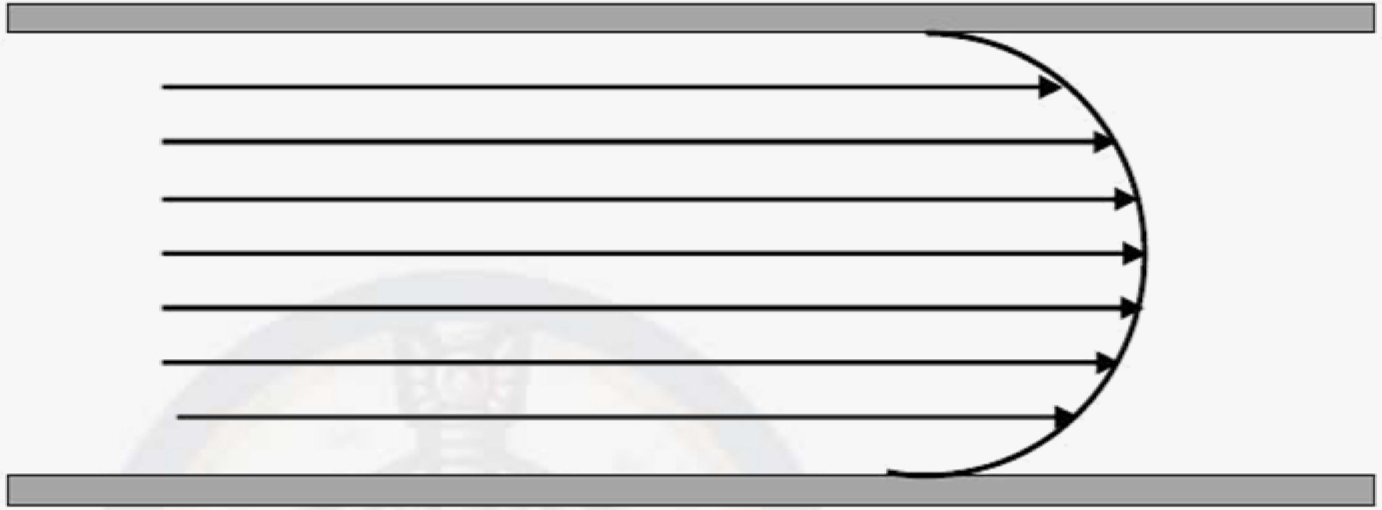
➢Viscosity

The **viscosity** of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness"; for example, honey has a much higher viscosity than water.
Viscosity is a property of the fluid which opposes the relative motion between the two surfaces of the fluid in a fluid that are moving at different velocities.

Types of fluid flow

When fluid is in motion, its flow can be characterized as being one of two main types.

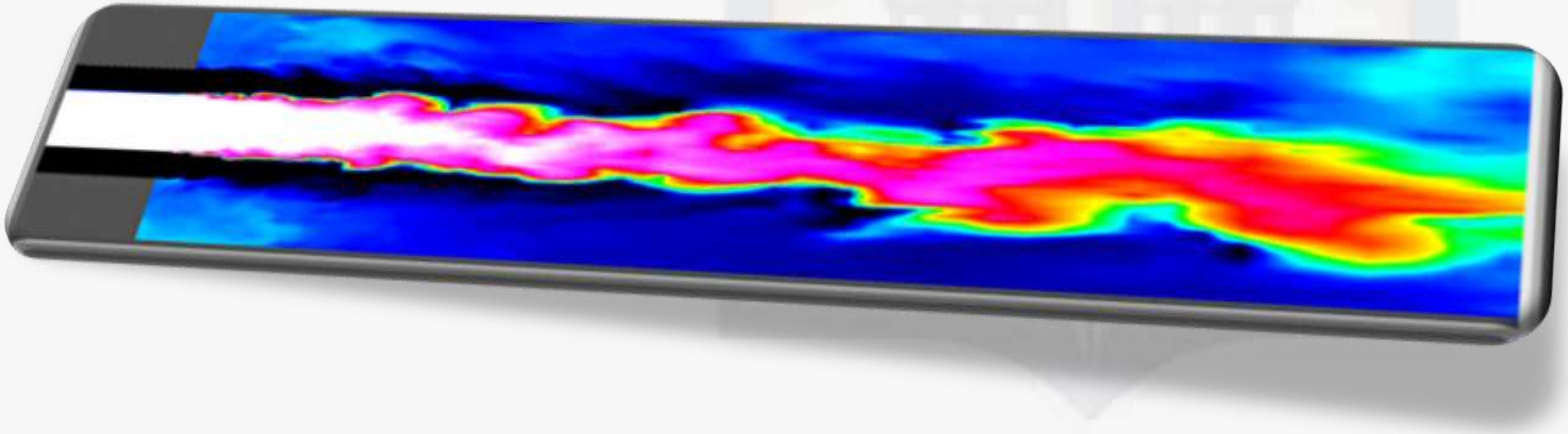
1. **Turbulent**
2. **laminar**



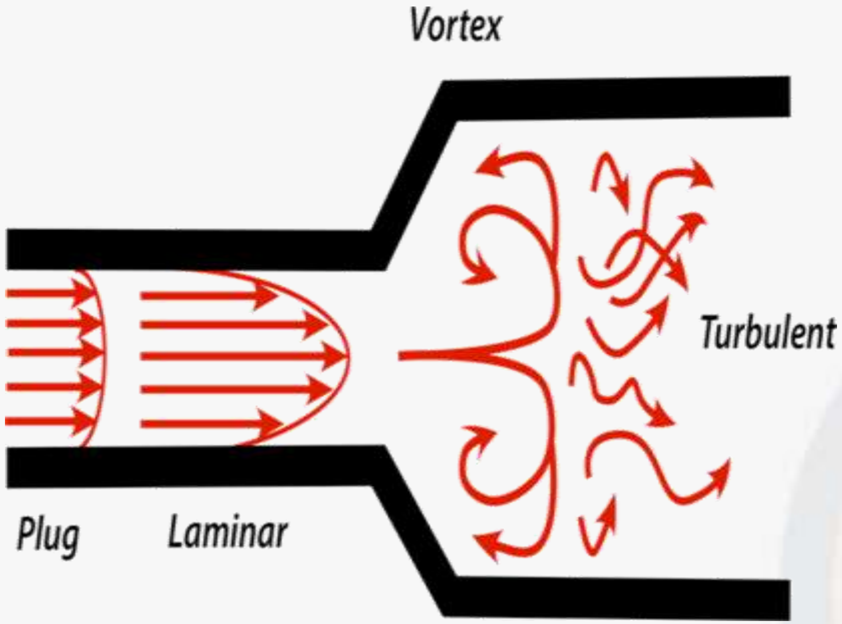
The flow is said to be
steady, or laminar,
if each particle of the fluid
follows a smooth path such
that the paths that is parallel
to any other path like layers of different
particles never cross each
other, In steady flow, every fluid particle arriving at a given point in space
has the same velocity.

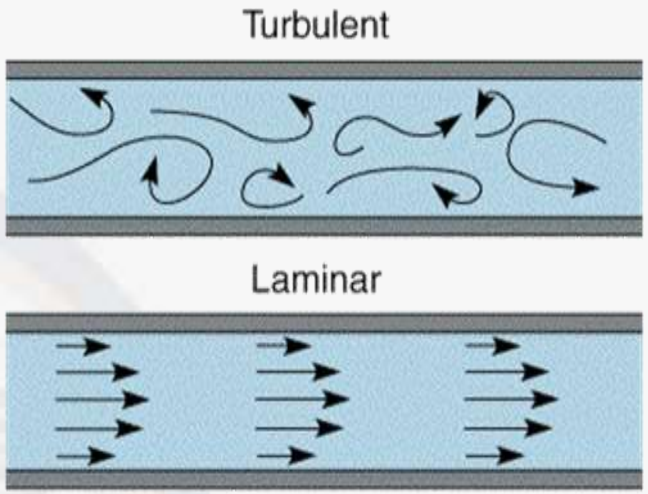
turbulent

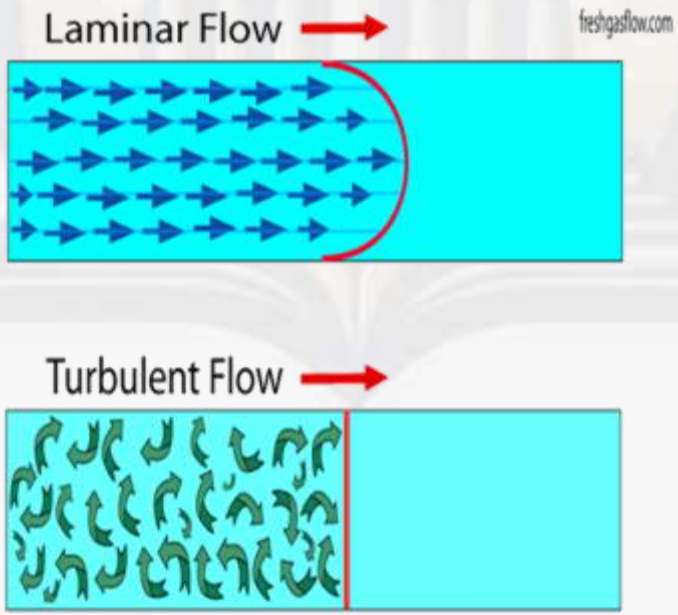
- In contrast, the flow of a fluid becomes irregular, or *turbulent*, above a certain velocity or under conditions that can cause abrupt changes in velocity, fluid flow becomes **turbulent**.
- Irregular motions of the fluid, called *eddy currents*, are characteristic of turbulent flow.



Laminar VS Turbulent



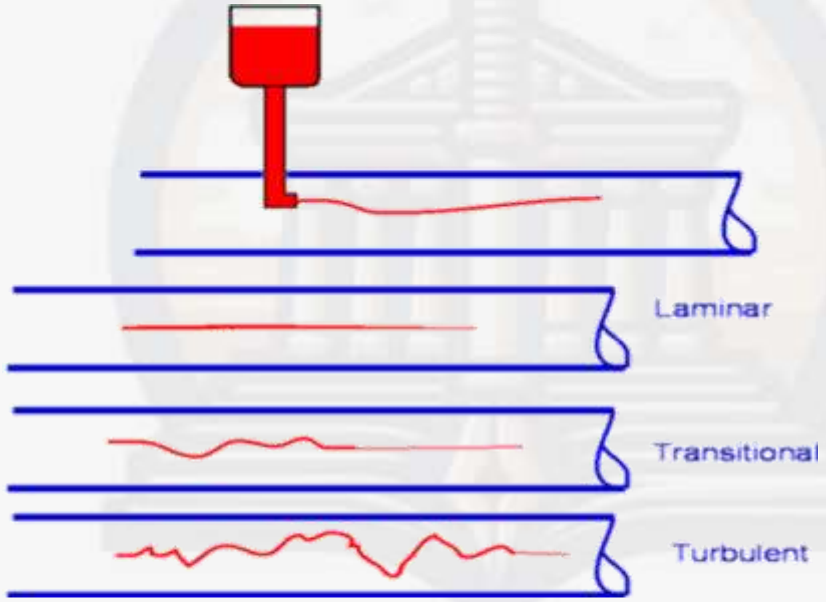




Identify the type of flow

Reynolds Number

- The **Reynolds Number** is used to predict the transition from laminar to turbulent of flow, and used in the scaling of similar but different-sized flow situations, such as between an aircraft model in a wind tunnel and the full size version.



Reynolds Number

$$\mathrm{Re} = \frac{\rho u L}{\mu} = \frac{u L}{\nu}$$

where:

ρ is the density of the fluid (SI units: kg/m3)

u is the velocity of the fluid with respect to the object (m/s)

L is a characteristic linear dimension (m)

μ is the dynamic viscosity of the fluid (Pa· s or N· s/m2 or kg/(m· s)

ν is the kinematic viscosity of the fluid ν = μ / ρ (m2/s)

The Reynolds Number can be used to determine if flow is laminar, transient or turbulent. The flow is

laminar - when *Re* < *2300*

transient - when *2300* < *Re* < *4000*

turbulent - when *Re* > *4000*

➢Example - Calculating Reynolds Number:

A Newtonian fluid with a dynamic or absolute viscosity of 0.38 Ns/m2 and a specific gravity of 0.91 flows through a 25 mm diameter pipe with a velocity of 2.6 m/s.

Solution:-

The density can be calculated using specific gravity like

ρ = 0.91 (1000 kg/m3 = 910 kg/m3

The Reynolds Number can then be calculated using equation (1) like

Re = (910 kg/m3) (2.6 m/s) (25 mm) (10-3 m/mm) / (0.38 Ns/m2)

= 156 ((kg m / s2)/N) = 156 ~ Laminar flow

Turbulence at high velocities and Reynolds number

- The flow becomes turbulence and chaotic after exceeding a certain critical velocity the way to find out this critical velocity is:

- V critical = R*η/2ρf*r → radius of tube

Reynolds no

eta or viscosity coefficient Of fluid

This gives you the first critical speed where you would except turbulence

R gives you a way to predict what is the first speed where you might excepts turbulence and therefore the first speed where you might except

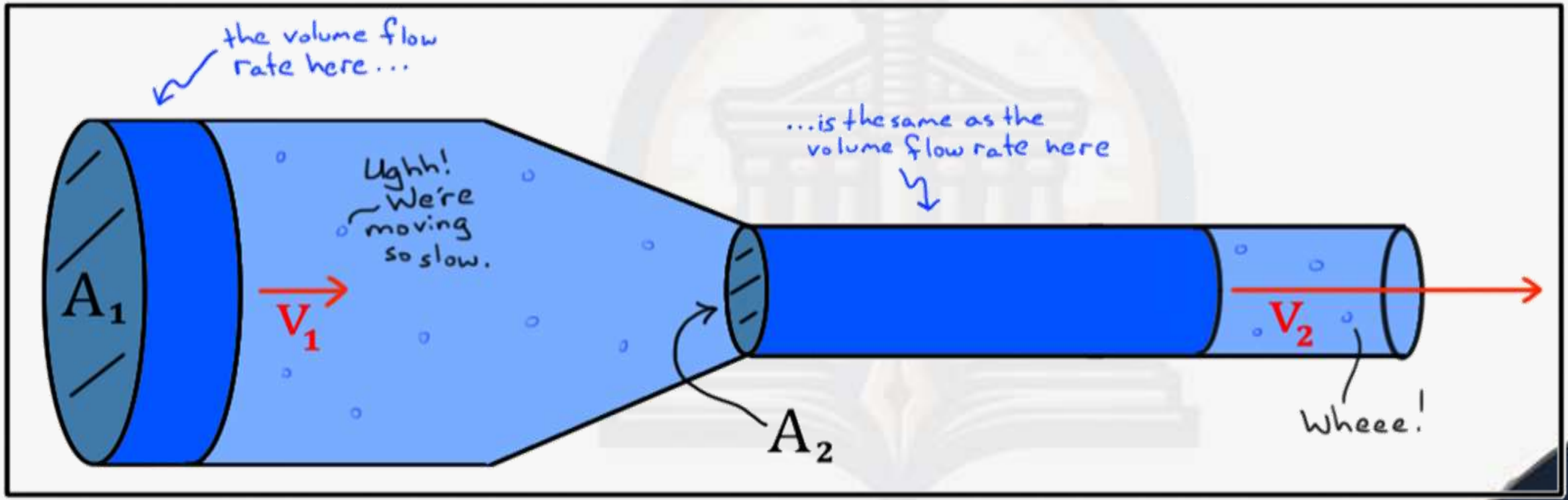
Ideal fluids in motion

- Because the motion of real fluids is very complex and not fully understood we make some simplifying assumptions in our approach. In our simplification model of **ideal fluid flow,** we make the following four assumptions:
- **1. The fluid is non viscous.** In a non viscous fluid, internal friction is neglected. An object moving through the fluid experiences no viscous force.
- **2. The flow is steady.** In steady (laminar) flow, all particles passing through a point have the same velocity.
- **3. The fluid is incompressible.** The density of an incompressible fluid is constant.
- **4. The flow is irrotational.** In irrotational flow, the fluid has no angular momentum about any point. If a small paddle wheel placed anywhere in the fluid does not rotate about the wheel's center of mass, the flow is irrotational

Volume flow rate

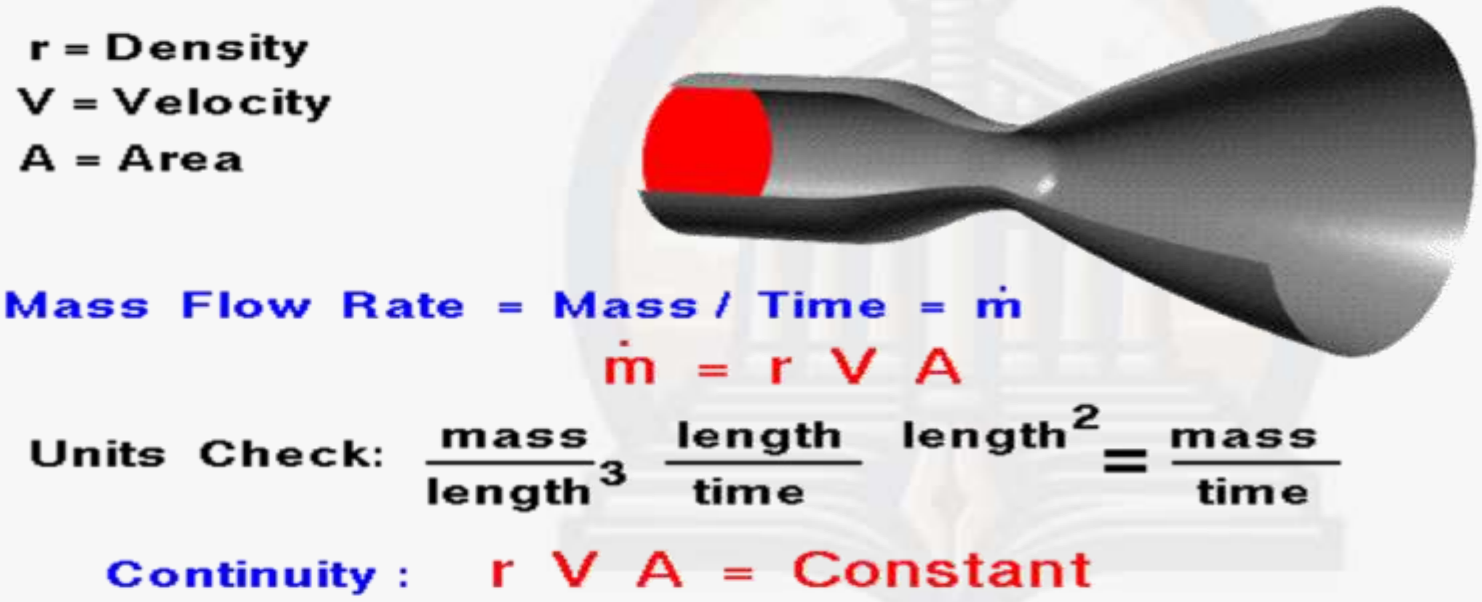
➢ *RV* is the **volume flow rate** of the fluid (volume past a given point per unit time). Its SI unit is the cubic meter per second (m3/s). If the density p of the fluid is uniform

$$RV = Av = \text{constant (volume flow rate)}$$



Mass flow rate

- $Rm = \rho RV = \rho Av$ a constant (mass flow rate).
- The SI unit of mass flow rate is the kilogram per second (kg/s). From previous EQ we can say that the mass that flows into the tube segment at each second must be equal to the mass that flows out of that segment each second.



PRINCIPLES OF FLUID FLOW

➢ **The continuity equation:**

➢ You may have noticed that you can increase the speed of the water emerging from a garden hose by partially closing the hose opening with your thumb. Apparently the speed *v* of the water depends on the cross-sectional area through which the water flows.

➢ The relation between cross-sectional area and velocity called continuity equation.

Continuity Equation

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

Same, incompressable, fluid so roe drops out!

$$A_1 v_1 = A_2 v_2$$

Imagine that an ideal fluid flows into one end of a pipe and out the other end, as shown in Figure.

- The diameter of the pipe is different at each end, How does the speed of fluid flow change as the fluid passes through the pipe?

- Because mass is conserved and because the fluid is incompressible so *m1* must equal the mass flowing out of the top of the pipe, *m2*, during any given time interval

- *So*

$$m1 = m2$$

$m = \rho V$ and by using the formula for the volume of a cylinder, $V = A\Delta x$.

$$\rho 1V1 = \rho 2V2$$

$$\rho 1A1\Delta x1 = \rho 2A2\Delta x2$$

$\Delta x = v\Delta t$

$$\rho 1A1v1\Delta t = \rho 2A2v2\Delta t$$

the density in the two ends and the time interval are the same then:

$$A1v1 = A2v2$$

- Note in the continuity equation that *A1* and *A2* can represent any two different cross-sectional areas of the pipe, not just the ends. This equation implies that the fluid speed is faster where the pipe is narrow and slower where the pipe is wide.

- The product *Av*, which has units of volume per unit time, is called the flow rate. The flow rate is constant throughout the pipe.

- The continuity equation explains an effect you may have observed as water flows slowly from a faucet, as shown in Figure.

- Because the water speeds up due to gravity as it falls, the stream narrows, satisfying the continuity equation

Bernoulli equation & law of conservation of energy

- Bernoulli's principle is a statement about how the speed of a fluid relates to the pressure of the fluid.

- BERNOULLI'S PRINCIPLE

 The pressure in a fluid decreases as the fluid's velocity increases.

- So within a horizontal water pipe that changes diameter, regions where the water is moving fast will be under less pressure than regions where the water is moving slow.

Bernoulli's Principle

Theory - Equation

$$P_1 + \frac{1}{2}\rho V_1{}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2{}^2 + \rho g h_2$$

Where (in SI units)

P= static pressure of fluid at the cross section
ρ= density of the flowing fluid
g= acceleration due to gravity;
v= mean velocity of fluid flow at the cross section
h= elevation head of the center of the cross section with respect to a datum.

Law of conservation of energy

- In physics, the law of conservation of energy states that the total energy of an isolated system remains constant—it is said to be *conserved* over time. Energy can neither be created nor destroyed; rather, it transforms from one form to another. In physics, the law of conservation of energy states that the total energy of an isolated system remains constant—it is said to be *conserved* over time. Energy can neither be created nor destroyed; rather, it transforms from one form to another.

Temperature

- A measure of the average kinetic energy of the particles in a substance.
- By turning the dial that controls the electric current delivered to the heating element, you can adjust the element’s temperature.
- As the current is increased, the temperature of the element increases. Similarly, as the current is reduced, the temperature of the element decreases.
- In general, energy must be either added to or removed from a substance to change its temperature.
- The temperature of a substance is proportional to the average kinetic energy of particles in the substance.
- A substance’s temperature increases as a direct result of added energy being distributed among the particles of the substance.

- That temperature will not change as long as conditions remain unchanged in the beaker.
- Increasing the temperature of a gas at constant pressure causes the volume of the gas to increase. This increase occurs not only for gases but also for liquids and solids.
- In general, if the temperature of a substance increases, so does its volume. This phenomenon is known as thermal expansion.
- Different substances undergo different amounts of expansion for a given temperature change.
- The thermal expansion characteristics of a material are indicated by a quantity called the coefficient of volume expansion. Gases have the largest values for this coefficient. Liquids have much smaller values. Solids typically have the smallest coefficient of volume expansion values.
- In general, the volume of a liquid tends to decrease with decreasing temperature. But, the volume of water increases with decreasing temperature in the range between 0°C and 4°C.
- Also, as the water freezes, it forms a crystal that has more empty space between the molecules than does liquid water. This explains why ice floats in liquid water.

Measuring Temperature & Temperature scale

- In order for a device to be used as a thermometer, it must make use of a change in some physical property that corresponds to changing temperature, such as the volume of a gas or liquid, or the pressure of a gas at constant volume.
- The most common thermometers use a glass tube containing a thin column of mercury, colored alcohol, or colored mineral spirits.
- When the thermometer is heated, the volume of the liquid expands. (The cross-sectional area of the tube remains nearly constant during temperature changes.) The change in length of the liquid column is proportional to the temperature change.
- The temperature scales most widely used today are the Fahrenheit, Celsius, and Kelvin scales. The Fahrenheit scale is commonly used in the United States. The Celsius scale is used in countries that have adopted the metric system and by the scientific community worldwide

Celsius and Fahrenheit temperature measurements can be converted to each other using this equation.

$$T_F = 9 / 5\ T_C + 32.0$$

Fahrenheit temperature =9 / 5 ×Celsius temperature+32.0

The number 32.0 in the equation indicates the difference between the ice point value in each scale. The point at which water freezes is 0.0 degrees on the Celsius scale and 32.0 degrees on the Fahrenheit scale.

A temperature difference of one degree is the same on the Celsius and Kelvin scales. The two scales differ only in the choice of zero point. Thus, the ice point (0.00°C) equals 273.15 K, and the steam point (100.00°C) equals 373.15 K. The Celsius temperature can therefore be converted to the Kelvin temperature by adding 273.15.

$$T = T_C + 273.15$$

Kelvin temperature =Celsius temperature +273.15

Kelvin temperatures for various physical processes can range from around 1 000 000 000 K (109 K),which is the temperature of the interiors of the most massive stars, to less than 1 Which is slightly cooler than the boiling point of liquid helium.

The temperature 0 K is often referred to as absolute zero. Absolute zero has never been reached, although laboratory experiments have reached temperatures of just a half-billionth of a degree above absolute zero.

Heat

- The energy transferred between objects because of a difference in their temperatures.
- The word heat is sometimes used to refer to the process by which energy is transferred between objects because of a difference in their temperatures.
- From a macroscopic viewpoint, energy transferred as heat tends to move from an object at higher temperature to an object at lower temperature.
- If the energy exchange between two objects at equal temperature, then the quantity of energy transferred from the first one to the other is the same as the energy transferred from the second one to the other. The net energy transferred between the two objects is zero.
- This reveals the difference between temperature and heat. The atoms of all objects are in continuous motion, so all objects have some internal energy. Because temperature is a measure of that energy, all objects have some temperature.
- Heat, on the other hand, is the energy transferred from one object to another because of the temperature difference between them. When there is no temperature difference between a substance and its surroundings, no net energy is transferred as heat

- Because heat, like work, is energy in transit, all heat units can be converted to joules, the SI unit for energy.
- Heat is indicated by the symbol Q.
- Thermal conduction: can be understood by the behavior of atoms in a metal. As the skillet is heated, the atoms nearest to the burner vibrate with greater energy.
- These vibrating atoms jostle their less energetic neighbors and transfer some of their energy in the process.
- Gradually, iron atoms farther away from the element gain more energy. The rate of thermal conduction depends on the properties of the substance being heated.
- A few examples of heat sources are the sun, friction, chemical reactions and the earth. The sun is a natural heat source that is renewable and that can be converted into electricity.

Thermal energy

- Thermal energy is energy possessed by an object or system due to the movement of particles within the object or the system.
- Because thermal energy is due to the movement of particles, it is a type of kinetic energy, which is the energy due to motion. Thermal energy results in something having an internal temperature
- heat is the term we use to refer specifically to the transfer of thermal energy from one object or a system to another, transfer being the key.
- The thermal energy is the energy possessed within the object or within the system due to movement of particles. They're different - heat and thermal energy.
- Unlike other forms of energy, thermal energy is difficult to convert to other forms of energy.

Conduction, Convection and Radiation

Heat can travel from one place to another in three ways: Conduction, Convection and Radiation. Both conduction and convection require matter to transfer heat.

CONDUCTION:

Conduction is the transfer of heat between substances that are in direct contact with each other. The better the conductor, the more rapidly heat will be transferred.

Metal is a good conduction of heat. Conduction occurs when a substance is heated, particles will gain more energy, and vibrate more. These molecules then bump into nearby particles and transfer some of their energy to them.

This then continues and passes the energy from the hot end down to the colder end of the substance.

CONVECTION:

Thermal energy is transferred from hot places to cold places by convection.

Convection occurs when warmer areas of a liquid or gas rise to cooler areas in the liquid or gas.

Cooler liquid or gas then takes the place of the warmer areas which have risen higher. This results in a continuous circulation pattern.

Water boiling in a pan is a good example of these convection currents. Another good example of convection is in the atmosphere. The earth's surface is warmed by the sun, the warm air rises and cool air moves in.

RADIATION:

Radiation is a method of heat transfer that does not rely upon any contact between the heat source and the heated object as is the case with conduction and convection.

Heat can be transmitted through empty space by thermal radiation often called infrared radiation. This is a type electromagnetic radiation . No mass is exchanged and no medium is required in the process of radiation.

Examples of radiation is the heat from the sun, or heat released from the filament of a light bulb.

The heat capacity

The heat capacity of a defined system is the amount of heat (usually expressed in calories, kilocalories, or joules) needed to raise the system's temperature by one degree (usually expressed in Celsius or Kelvin).
It is expressed in units of thermal energy per degree temperature.

Heat capacity = mass x specific heat x change in temperature

$$Q = mc\,\Delta T$$

Q = heat capacity, J
m = mass, g
c = specific heat of object, J/(g-ºC)
ΔT = change in temperature, ºC

Specific heat capacity

The specific heat capacity of a substance is defined as the energy required to change the temperature of 1 kg of that substance by 1°C.

Every substance has a unique specific heat capacity. This value tells you how much the temperature of a given mass of that substance will increase or decrease, based on how much energy is added or removed as heat.

$$c_p = Q / m \Delta T$$

specific heat capacity = energy transferred as heat / mass ×change in temperature

The subscript p indicates that the specific heat capacity is measured at constant pressure. Maintaining constant pressure is an important detail when determining certain thermal properties of gases, which are much more affected by changes in pressure than are solids or liquids. Note that a temperature change of 1°C is equal in magnitude to a temperature change of 1 K, so ΔT gives the temperature change in either scale.

The equation for specific heat capacity applies to both substances that absorb energy from their surroundings and those that transfer energy to their surroundings.
When the temperature increases, ΔT and Q are taken to be positive, which corresponds to energy transferred into the substance. Likewise, when the temperature decreases, ΔT and Q are negative and energy is transferred from the substance.

To measure the specific heat capacity of a substance, it is necessary to measure mass , temperature change, and energy transferred as heat. Mass and temperature change are directly measurable, but the direct measurement of heat is difficult. However, the specific heat capacity of water (4.186 kJ/kg•°C) is well known, so the energy transferred as heat between an object of unknown specific heat capacity and a known quantity of water can be measured. If a hot substance is placed in an insulated container of cool water, energy conservation requires that the energy the substance gives up must equal the energy absorbed by the water.
Although some energy is transferred to the surrounding container, this effect is small and will be ignored in this discussion.

Energy conservation can be used to calculate the specific heat capacity, $c_{p,x}$, of the substance (indicated by the subscript x),as follows:

energy absorbed by water =energy released by the substance

$$Q_w = -Q_x$$

$$c_{p,w} m_w \Delta T_w = -c_{p,x} m_x \Delta T_x$$

For simplicity, a subscript w will always stand for “water "in problems involving specific heat capacities. As discussed earlier, the energy gained by a substance is expressed as a positive quantity, and the energy released is expressed as a negative quantity.

The first equation above can be rewritten as $Q_w + Q_x = 0$,which shows that the net change in energy transferred as heat equals zero.

Note that ΔT equals the final temperature minus the initial temperature. This approach to determining a substance’s specific heat capacity is called Calorimetry and devices that are used for making this measurement are called calorimeters.

A calorimeter also contains both a thermometer to measure the final temperature of substances at thermal equilibrium and a stirrer to ensure the uniform mixture of energy throughout the water.

Blackbody radiation

- The radiation emitted by a blackbody, which is a perfect radiator and absorber and emits radiation based only on its temperature.
- All objects emit electromagnetic radiation. This radiation, which depends on the temperature and other properties of an object, typically consists of a continuous distribution

of wavelengths from the infrared, visible, and ultraviolet portions of the spectrum.

- The distribution of the intensity of the different wavelengths varies with temperature. At low temperatures, radiation wavelengths are mainly in the infrared region. So, they cannot be seen by the human eye.
- As the temperature of an object increases, the range of wavelengths given off shifts into the visible region of the electromagnetic spectrum.
- Most objects absorb some incoming radiation and reflect the rest. An ideal system that absorbs all incoming radiation is called a blackbody.
- Physicists study blackbody radiation by observing a hollow object with a small opening.
- The system is a good example of how a blackbody works; it traps radiation.

The light given off by the opening is in equilibrium with light from the walls of the object, because the light has been given off and reabsorbed many times.

- A blackbody refers to an opaque object that emits thermal radiation.
- A perfect blackbody is one that absorbs all incoming light and does not reflect any. At room temperature, such an object would appear to be perfectly black (hence the term blackbody). However, if heated to a high temperature, a blackbody will begin to glow with thermal radiation.

Solar collectors:

- They transform solar radiation into heat and transfer that heat to a medium (water, solar fluid, or air). Then solar heat can be used for heating water, to back up heating systems or for heating swimming pools.
- The heart of a solar collector is the absorber, which is usually composed of several narrow metal strips.
- The carrier fluid for heat transfer flows through a heat-carrying pipe, which is connected to the absorber strip.
- In plate-type absorbers, two sheets are sandwiched together allowing the medium to flow between the two sheets. Absorbers are typically made of copper or aluminum.
- Absorbers are usually black, as dark surfaces demonstrate a particularly high degree of light absorption.

- The level of absorption indicates the amount of short-wave solar radiation being absorbed that means not being reflected.
- As the absorber warms up to a temperature higher than the ambient temperature, it gives off a great part of the accumulated solar energy in form of long-wave heat rays. The ratio of absorbed energy to emitted heat is indicated by the degree of emission.
- In order to reduce energy loss through heat emission, the most efficient absorbers have a selective surface coating. This coating enables the conversion of a high proportion of the solar radiation into heat, simultaneously reducing the emission of heat.
- Galvanically applied selective coatings include black chrome, black nickel, and aluminum oxide with nickel. Relatively new is a titanium-nitride-oxide layer, which is applied via steam in a vacuum process.
- The cost of making power from sunlight has been steadily decreasing, leading to many uses that affect you in your daily life.
- Solar batteries provide electric power outdoors, on your desktop, and in the depths of space. Electricity from solar plants supplies commercial-grade power, reducing dependence on coal and natural gas.

- A small solar panel provides enough power to light up a the stop signs or message boards used in construction work. Other types of solar-powered signs include speed limit signs and radar-driven speed warnings.
- Solar rooftop collectors use heat gathered from sunlight for hot water and building heat.
- Satellites use solar cells to convert sunlight into electrical energy, powering sophisticated on-board radio and computer equipment and affecting your daily life through satellite radio, television and weather forecasting.
- Some desktop and pocket calculators have miniature solar panels built into them, providing energy to run the electronics inside.
- Several companies now offer solar-powered recharge stations that let you use the sun to power your portable electronics.
- Some are small enough to fit in your pocket and can only generate enough electricity to recharge smaller devices like cell phones.
- Others are much larger and can provide electricity to power-hungry electronics like laptop computers.

Natural sources of heat: sun, geothermal

- Natural sources of heat energy can be found in plant and animal products, fossil fuels, the sun and from within the Earth.
- The sun is Earth's major external source of heat energy. The sun's energy travels to Earth as electromagnetic radiation.
- The amount of radiation we receive depends on the time of day and season, but it is constantly enough heat energy to support life.
- Geothermal energy comes from within the Earth.
- The heat is produced within Earth's core, which is made of solid iron surrounded by molten lava. The core is hotter than the surface of the sun.
- The energy is produced by the radioactive decay of particles of rocks, creating the magma. People use geothermal heat by utilizing hot springs or underground water to heat homes and buildings.

Latent heat

- The energy per unit mass that is transferred during a phase change of a substance.
- To understand the behavior of a substance undergoing a phase change, you need to consider the changes in potential energy.
- Potential energy is present among a collection of particles in a solid or in a liquid in the form of attractive bonds. These bonds result from the charges within atoms and molecules. Potential energy is associated with the electric forces between these charges.
- Phase changes result from a change in the potential energy between particles of a substance.
- When energy is added to or removed from a substance that is undergoing a phase change, the particles of the substance rearrange themselves to make up for their change of energy. This rearrangement occurs without a change in the average kinetic energy of the particles.
- The energy that is added or removed per unit mass is called abbreviated as L.

Note that according to this definition, the energy transferred as heat during a phase change simply equals the mass multiplied by the latent heat, as follows:

$$\mathbf{Q = mL}$$

During melting, the energy that is added to a substance equals the difference between the total potential energies for particles in the solid and the liquid phases.

This type of latent heat is called the heat of fusion. During vaporization, the energy that is added to a substance equals the difference in the potential energy of attraction between the liquid particles and between the gas particles.

In this case, the latent heat is called the heat of vaporization. The heat of fusion and the heat of vaporization are abbreviated as L_f and L_v, respectively

Physics Lo 11

Thermodynamic

Conservation of thermal energy

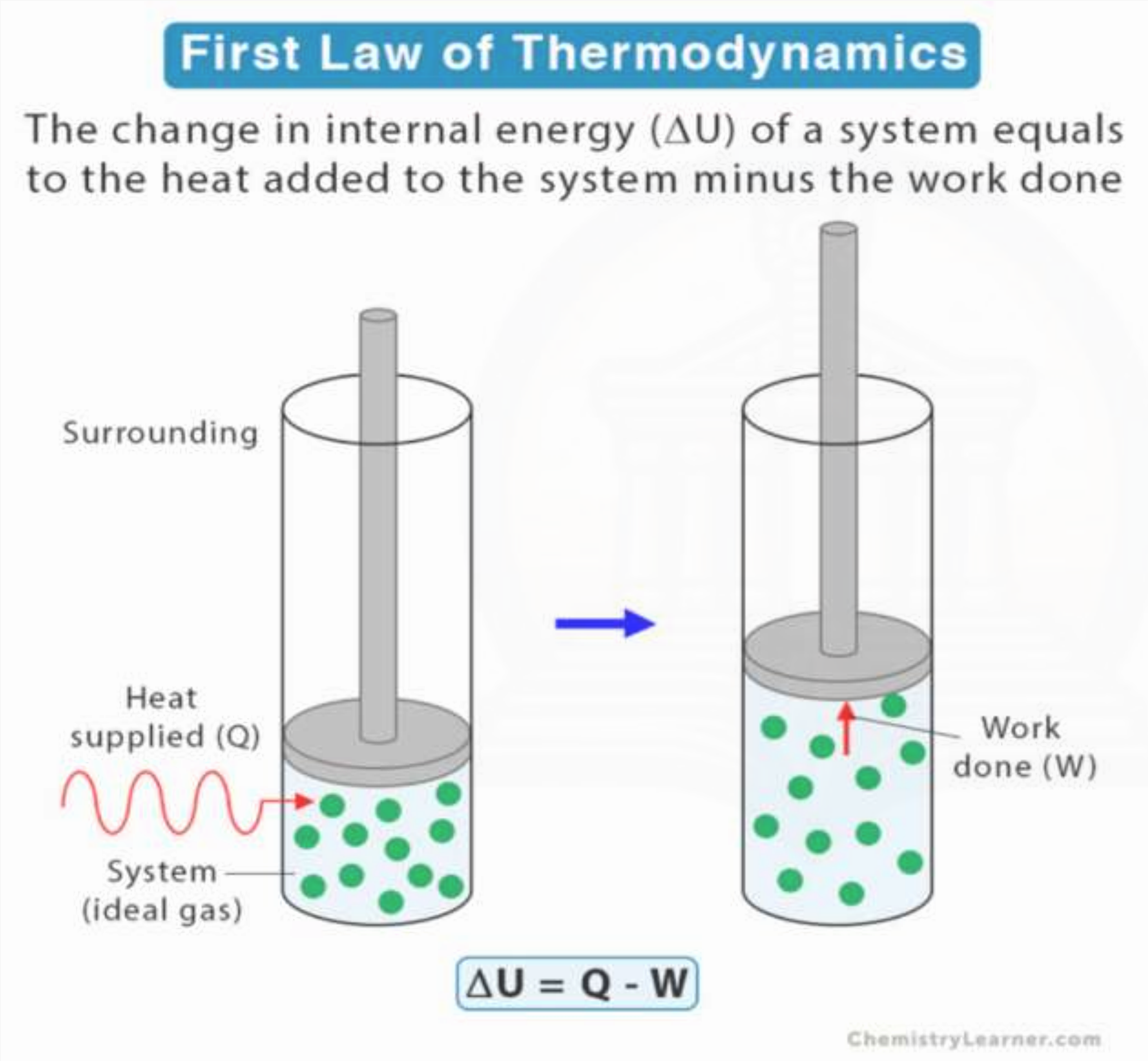
Firstly, Conservation of thermal energy(The first law of thermodynamics):
conservation of energy: a fundamental law of physics and chemistry stating that the total
energy of an isolated system is constant despite internal changes.
The law of conservation of energy states that the amount of energy is neither created nor destroyed.
Heat added to a system must be either taken out or used for work, or else the system's internal energy increases.
Energy can't be created or destroyed, only converted between forms.
When heat is added to an ideal gas, it can be used for work or increase the gas's internal energy.
In an isolated system, the total energy remains constant.
Internal energy is related to a system's molecular motion and interactions and depends on its mass.
Specific energy (internal energy per unit mass) is independent of mass
Intensive property.
Understanding thermal energy conservation helps predict energy transfers in physical systems.
For an ideal gas, internal energy depends only on temperature.

Ideal Gas

Properties of an ideal gas
No intermolecular forces, infinitely small, etc.

- There is no ideal gas in the real world, but some gases come closer than others:
- The gas molecules are small.
- The gas molecules have very weak intermolecular forces.
- The gas molecules are very hot, so they move quickly around and don't interact with each other much.
- The gas is at low pressure, so the molecules have a lot of space between them.

First law of thermodynamics



The first law of thermodynamic

The internal energy (U) of a system includes kinetic energy from molecular motion and potential energy from molecular vibrations or electric motion.

Heat (Q) is the amount of energy transferred to or from an object, calculated as $Q = mC\Delta T$, where m is mass, C is specific heat capacity, and ΔT is temperature change.

Work involves a force causing displacement; it can be done on a system (externally) or by a system (expansion against external pressure), impacting internal energy.

Different forms of potential energy exist (e.g., gravitational, electric), and the specific type affecting a system's internal energy depends on the system.

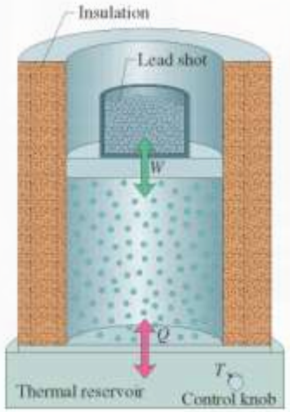
Heat and work

Heat and Work

A force acting on a system can heat it up (or cool it down), by working on it.

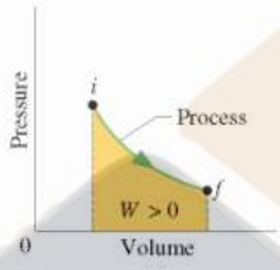
A change in temperature produced in a system can be used to produce mechanical work.

At any point in the process, the system (gas) will have temperature T, pressure p and volume V.



$$dW = Fds = pAds = pdV$$

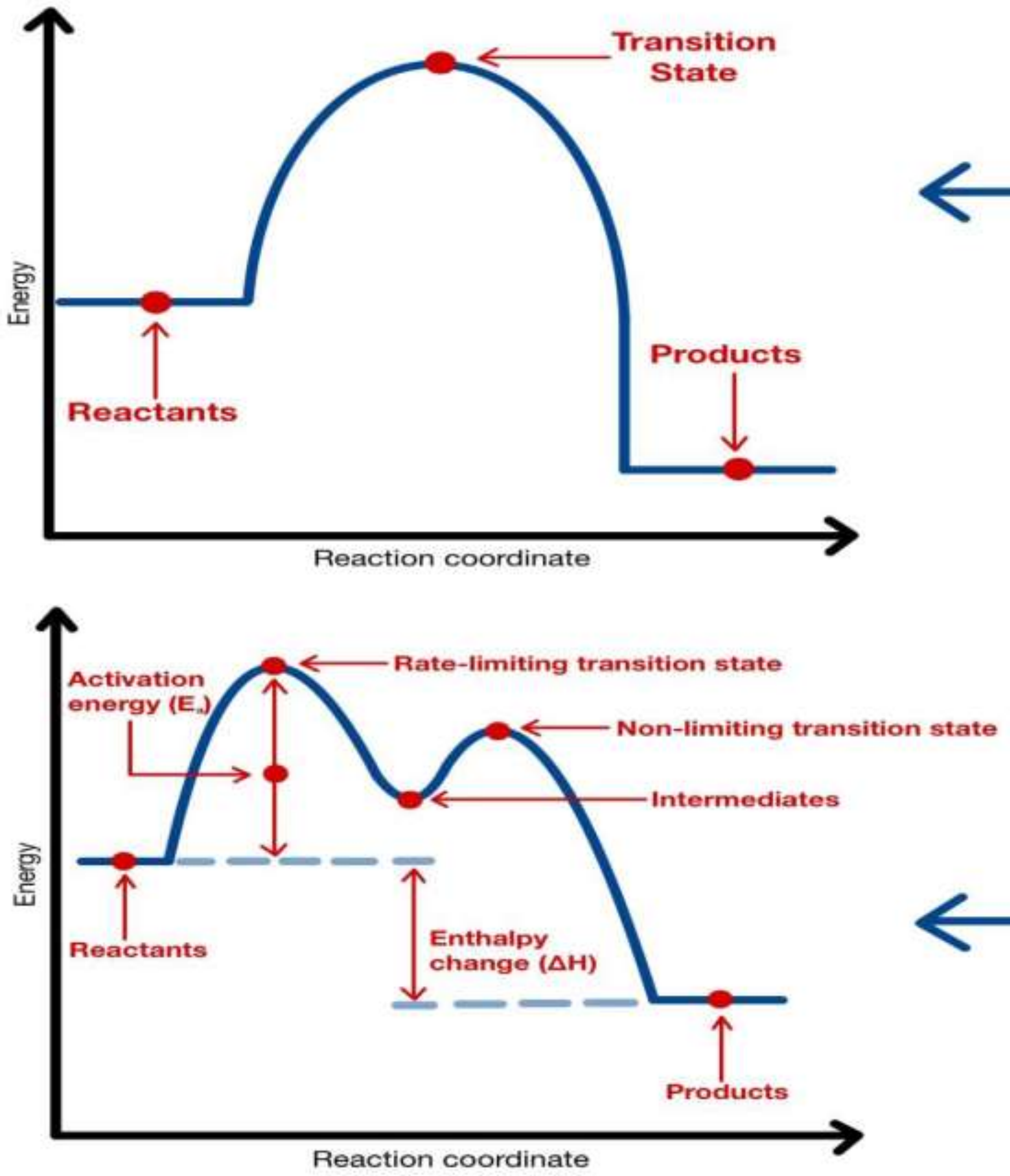
$$W = \int_{V_i}^{V_f} pdV$$



Heat added to system and work cases

- $Q > 0$: Heat added to the system.
- $Q < 0$: Heat removed from the system.
- $Q = 0$: No heat transfer.
- $W > 0$: System does work (expands), volume (v) increases, and dv (change in volume) is positive.
- $W < 0$: Work done on the system (compression), volume decreases, and dv is negative.
- $W = 0$: No work done, volume remains constant.

Energy Graphs



Energy diagrams can range from simple to more complex depending on what is being studied as well as what information is expected

Calculate work

The work done during a thermodynamic

Process The area under the curve.

$W = P\Delta V$ (why) :
$W = F\Delta x$
$W = PA\Delta x$
$W = P(A\Delta x)$
$W = P\Delta V$

Internal energy

- ΔU is constant when the start and endpoint are the same, regardless of the path.

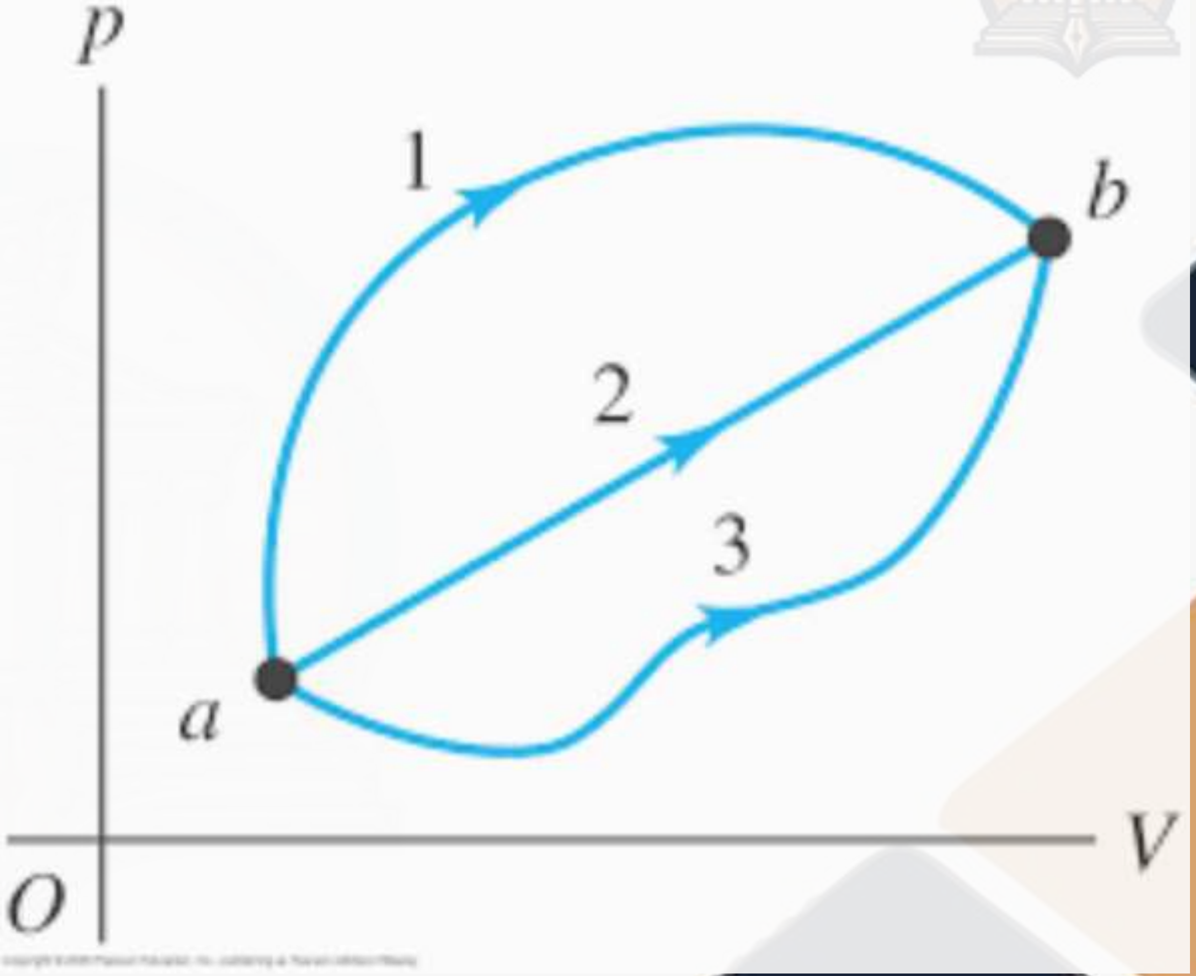
- Changing the path alters the work done.

- Temperature increase leads to U increase, so V (volume) is positive.

- Temperature decrease leads to U decrease, so V is negative.

- To increase U, work done on the system is negative or heat is positive.

- To decrease U, work done on the system is positive or heat is negative.



Low-temperature physics

- Low-temperature physics, or cryogenics, focuses on studying materials at temperatures below 123 Kelvin (K).
- Achieving low temperatures involves removing energy from a substance.
- Absolute zero, at 0 Kelvin, marks the lowest point on the thermodynamic temperature scale.
- The Kelvin scale is preferred for measuring low temperatures, unlike Celsius and Fahrenheit scales.
- Very low temperatures lead to fascinating phenomena like superconductivity, superfluidity, and Bose-Einstein condensation.

Cryogenics

- Cryogenics deals with extremely low temperatures, typically between -150 to -273°C, which is extremely cold.

- When gases are cooled to these temperatures, they transform into liquids, which is the focus of cryogenics.

- At such low temperatures, materials exhibit interesting behaviors: some become superconductors, conducting electricity with zero resistance, while others become superfluids, flowing without friction.

- Cryogenics finds applications in various fields like science, medicine, and engineering. For instance, it's used for freezing and preserving biological samples, cooling magnets in medical devices, and powering rocket engines.

- Commonly used gases in cryogenics include oxygen, nitrogen, hydrogen, and helium, which are cooled to very low temperatures to induce their liquid state.

Uses of Cryogenics

1- cryosurgery: It is used in surgical techniques that involve the use of extreme cold to destroy or remove abnormal tissues, such as tumors or warts, by using liquid nitrogen or argon gas on the target cells.

2- Cryoelectronic: Cryoelectronic explores how electronic devices behave at super cold temperatures, often near absolute zero. These frigid conditions can lead to unique behaviors like superconductivity, with applications in areas like quantum computing.

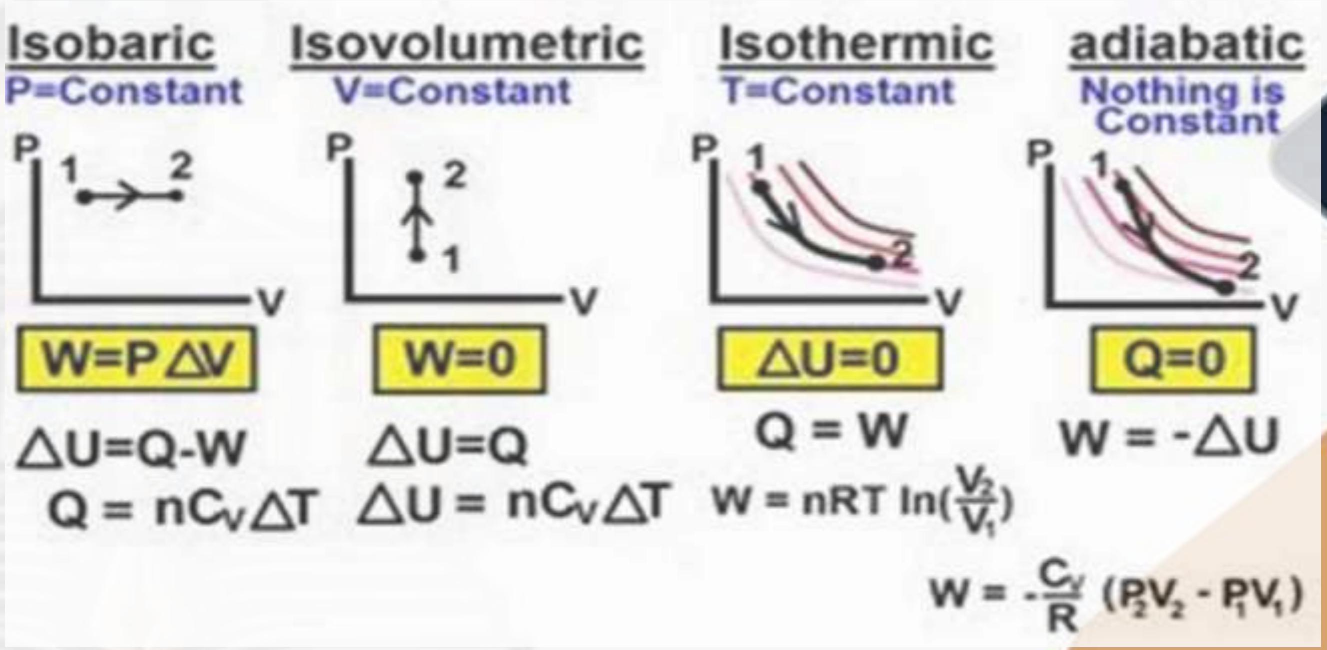
3- Cryobiology: Cryobiology is the study of the effects of low temperatures on organisms

4- used in food preservation

Cryogenics is also used to transport gases that are not typically cryogenic.

Cryotherapy is a medical treatment that involves exposing the body to extremely cold temperatures.

Thermodynamic process



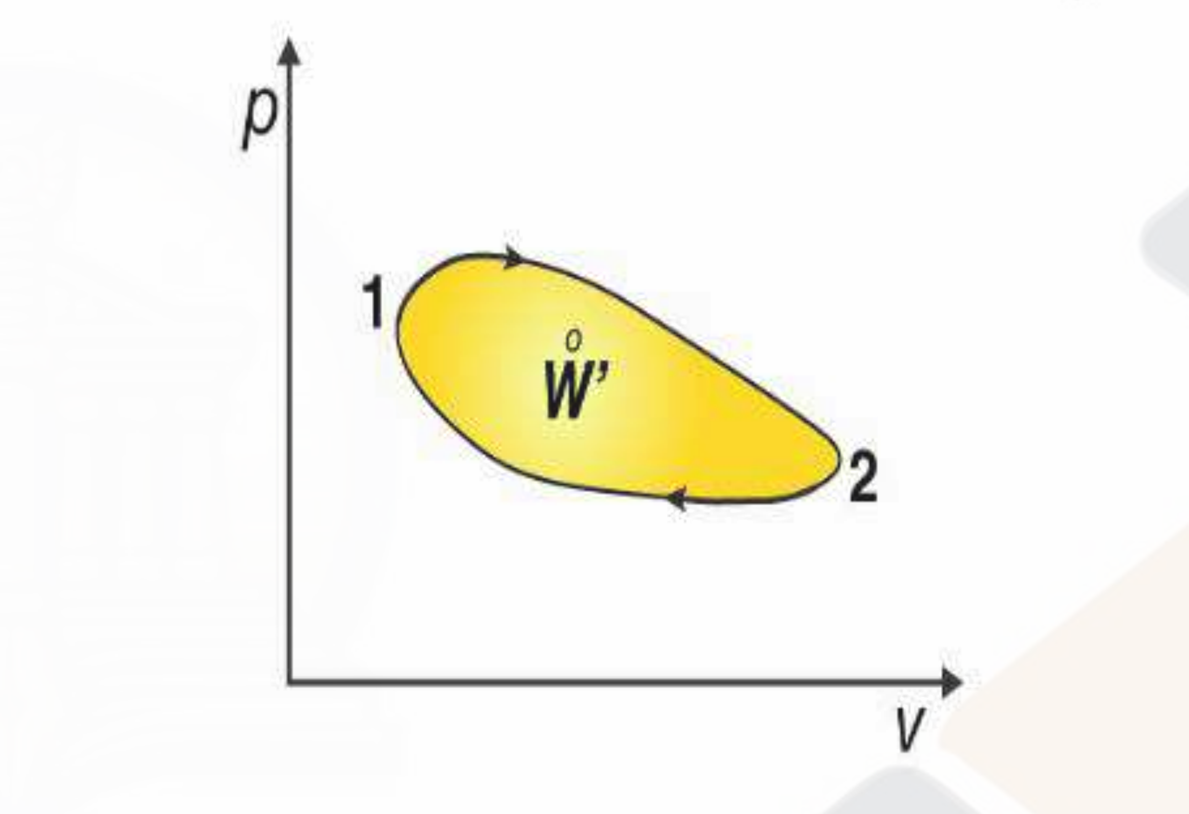
Cyclic process

- A cyclic process returns the system to its initial state after a sequence of changes.

- Internal energy change in a cyclic process is zero.

- Work done by the system equals the heat absorbed.

- Examples include refrigerators and air conditioners.



Questions:

1- According to the first law of thermodynamics, applied to a gas, the increase in the internal energy during any process:
A- equals the heat input minus the work done on the gas
B- equals the heat input plus the work done on the gas
C- equals the work done on the gas minus the heat input
D- equals the work done on the gas multipliers the heat input

Ans: B

2- A system undergoes an adiabatic process in which its internal energy increases by 20 Joule(J).
Which of the following statements is correct?
A- 20 J of work was done on the system
B- 20 J of work was done by the system
C- the system received 20 J of energy as heat
D- the system lost 20 J of energy as heat

Ans : A

3- Which of the following statements is true about an adiabatic process?
A- the energy absorbed as heat equals the work done by the system on its environment
B- the energy absorbed as heat equals the work done by the environment on the system
C- the work done by the environment on the system equals the change in C- internal energy
D- the energy absorbed as heat by the system equals the change in internal energy

Ans: C

4- Which of the following statements is true about an isobaric process?
A- The pressure is constant.
B- The volume is constant.
C- Both The volume and pressure are constant
D- Both temperature and pressure are constant.

Ans: A
5- Which of the following statements is true about an adiabatic process?
A- The system with a constant internal energy.
B- The system gains a lot of thermal energy.
C- The system loses a lot of thermal energy.
D The system neither loses nor gains any heat.

Ans: D

6- An enclosed gas is compressed at a constant temperature. Which of the following mathematical relation is true?
A- The work done (W) = the change in the internal energy (Delta*U)
B- The amount of heat (Q) = the change in the internal energy (Delta*U)
C- The amount of heat (Q) = the work done (W)
D- The amount of heat (Q) = 0

Ans: C
7- An enclosed gas expands from 15 m3 to 25 m3 under the effect of constant pressure of 20 kilopascal. What is the magnitude of the work done by the gas?
LO 1.11
A- 10 kilojoule
B- 20 kilojoule
C- 200 kilojoule
D- 500 kilojoule

Ans: C
8- What will happen when an adiabatic expanding occurs for some gas?
A- The gas' temperature increases.
B. The gas' temperature decreases.
C- The gas gains some of thermal energy.
D- The gas loses some of thermal energy

Ans: B

9- A gas trapped in a container under constant pressures of 2000 Pascal, and allowed to be expanding from 1 m3 to 4 m3, what is the magnitude of the work?
A- 6 Kilo Joule, done by the gas
B- 6 Kilo Joule, done on the gas
C- 8 Kilo Joule, done by the gas
D- 8 Kilo Joule, done on the gas

Ans: A

10- 701 J of heat is absorbed by a system and 394 J of work is done by the system. The change in internal energy for the process is-
1. 307 J
2. −307 J
3. 1095 J
4. −701 J

Ans: A

11- Which of the following are the extensive variables?
a. Internal energy, pressure and volume
b. Pressure, temperature and density
c. Internal energy, volume, total mass
d. Pressure, temperature and volume

Ans: C

12-In an adiabatic process internal energy of gas
a. Increases
b. Become twice
c. Does not change
d. Decreases

Ans: D

13- an open system, for maximum work, the process must be entirely
a. irreversible
b. reversible
c. adiabatic
d. none of the mentioned

Ans: B

14- Minimum work is said to be done when a gas expands
a. Adiabatically
b. Isochorically
c. Isothermally
d. Isobarically

Ans: B

Thank you

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