KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)

SUBJECT : **PROPERTIES OF MATTER AND ACCOUSTICS**
SEMESTER : **I** **SUBJECT CODE**: **18PHU102**
CLASS : **I B.Sc.PHYSICS**

Scope: This paper gives a brief introduction about the different physical properties of matter which are relevant to daily life applications, like elasticity, surface tension, viscosity etc. Gravitational potential is an improtant parameter as far as matter is concerned.

Objectives: To give an introduction about the different properties of matter, and their different states.

UNIT-I

Kinetic Theory of gases: Assumption of Kinetic theory of gases, pressure of an ideal gas (no derivation), Boyel's law, Charles' law, Reganults law, Avagadro law, Kinetic interpretation of Temperature, Ideal Gas equation, Degree of freedom, Law of equipartition of energy and is application for specific heat of gases, Real gases, Vander wall's equation, Brownian motion(Qualitative).

UNIT-II

Elasticity: Hooke's law- Stress-strain diagram - Elastic moduli-Relation between elastic constants- Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants- Work done in stretching & work done in twisting a wire- Twisting couple on a cylinder- Determination of Rigidity modulus by static torsion- Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η & by Searles method.

UNIT-III

Surface tension: Surface tension and Surface energy- Pressure difference across a spherical surface- Pressure difference across a curved surface - Angle of contact - Angle of contact for water in a glass - Vapour pressure over a flat and curved surface - Variation of Surface tension with temperature - Jaegar's method - Quincke's method.

UNIT-IV

Viscosity: Streamline flow and Turbulent flow - Stoke's law - Stoke's method for the coefficient of viscosity - Poiseuille's method for the coefficient of viscosity - correction to Poiseuille's equation - Ostwald's viscometer - Variation of viscosity with temperature and pressure - Friction and Lubrication - Searle's viscometer - Viscosity of gases - Modification of Poiseuille's formula for gases - Rankine's method for determining the coefficient of viscosity of a gas.

UNIT-V

Intensity and Loudness of sound – decibels – Intensity level – Laws of Transverse Vibrations – Melde's String – Sonometer.

ULTRASONICS

Ultrasonics – Production of ultrasonic wave – Piezoelectric crystal method – Magnetostriction method – Properties – detection – Applications.

Suggested Readings

1. Mathur. D.S, 11th edition 2010, Elements of properties of matter, S. Chand .& company, New Delhi
2. A text book of Sound – Subramanyam and Brijlal – Vikas publishing House Pvt. Ltd, II Edition 1982.
3. Murugesan. R, Revised edition 2004, Properties of matter, S. Chand & Company, New Delhi.

4. Brijlal and N. Subramanyam, 1st edition 2004, Properties of matter, S. Chand & Company, NewDelhi.
5. Mathur.D.S., 2004 edition, Mechanics, S. Chand & Company, New Delhi.
6. Uppadahayay. J. C., 2003, Properties of Matter, Ram Prakash and Sons, Agra.
7. Katie Dicker 1st edition 2011 properties of matter Wind Mills book Ltd
8. A text book of Sound – Khanna and Bedi Atma Ram & Son's, New Delhi

UNIT-I
SYLLABUS

Kinetic Theory of gases: Assumption of Kinetic theory of gases, pressure of an ideal gas (no derivation), Boyel's law, Charles' law, Reganults law, Avagadro law, Kinetic interpretation of Temperature, Ideal Gas equation, Degree of freedom, Law of equipartition of energy and is application for specific heat of gases, Real gases, Vander wall's equation, Brownian motion(Qualitative).

INTRODUCTION

Kinetic theory of gases is about the study of Molecular behaviour of gases which leads to the understanding of macroscopic properties of the gases such as their pressure, volume, temperature, density, kinetic energy in terms of temperature, etc. The movement of molecules is random and complicated. The number of molecules is very large in a sample of gas and it is difficult to apply the laws of Mechanics to each and every molecule independently. However to understand the macroscopic properties of a gas, the individual molecules are not important. The laws of Mechanics can be applied statistically to the whole gas. This approach made the Kinetic theory of gases simple. In gases, the molecules are quite far away compared to their sizes and interactions between them are very weak compared to liquids and solids. This further simplifies the mathematical difficulties.

Ideal Gas Equation

The gases at low pressures and at temperature far above their condensation point obeys the following relation between their pressure P, volume V and temperature T,

$$PV = nRT$$

Here, n - is the number of moles and R = 8.314 J/mol.K. R is called Universal Gas Constant. Gases which obey the eqn(1) are called ideal gases.

The above relation can be verified by performing a simple experiment. Let us take a baloon filled with a gas of mass ‘m’ at thermal equilibrium. If the balloon is squeezed from one end, the gas is forced to take a smaller volume and its pressure increases.

Postulates of Kinetic Theory of Gases

The following assumptions are made in developing Kinetic theory of gases. We will show that the Kinetic theory of gases developed with these assumptions explain the macroscopic properties of the materials.

1. All gases consist of some basic units called molecules. The molecules are made up of single or group of atoms depending on the chemical nature of the gas.
2. The molecules move in random direction with random speed.
3. The molecules undergo collisions among themselves and to the walls of the container. These collisions are perfectly elastic. The collision time is very small compared to the average time spent by a molecule between two collisions.
4. The size of the molecule is very small compared to the average intermolecular distance. Molecules do not exert any force among themselves or to the walls except during collision.
5. The molecules obey Newton's Law of Motion.
6. The number of gas molecules is so large that at every position of infinitesimal volume of the container, the density and distribution of different physical parameters are same. The above parameters are also independent of direction and time at a steady state.
7. Pressure Exerted by an Ideal Gas

8. Let us consider an ideal gas in a cubic container of edge length ‘L’ as shown in Fig.1. S_1 and S_2 are the two surfaces of the cube normal to x-axis.

The surfaces of the container are perfectly elastic. Take a molecule with an average velocity v, whose components along x, y and z directions are v_x,v_y and v_z. If the molecule undergoes collision with surface S_1, it’s x-component of velocity v_x reverses and there is no effect on the v_y and v_z. It is as per the assumption of the elastic collision. The change in momentum of the molecule

,

$$\Delta p = p_2 - p_1 = (-m v_x) - (m v_x) = -2 m v_x$$

where m is the mass of each molecule.

If the reversed molecule collides with S_2 and comes back to S_1 without undergoing any other collision except on these two walls, the time spent by the molecule between two consecutive

collision at S_1 is

$$\frac{2L}{v_x}$$

The number of collisions of the molecule with S_1 per unit time $= \frac{v_x}{2L}$

Kinetic Energy and Temperature

From the basic laws of the the thermodynamics, we know that the change in temperature of the system is associated with the change in internal energy. Thus higher the temperature of the system, larger the internal energy. We can show that the internal energy is related to kinetic energy and there is a direct relation between kinetic energy and temperature of a gas as described below. The pressure exerted by the gas on the wall of the cubic container is reproduced below,

$$P = \frac{1}{3}\rho \mathrm{v}_{rms}^{2}$$

Multiplying by the volume, V on both sides,

$$\begin{aligned} PV &= \frac{1}{3}\rho V \mathrm{v}_{rms}^{2} \\ &= \frac{1}{3} M \mathrm{v}_{rms}^{2} \end{aligned}$$

$$PV = \frac{1}{3} m N \mathrm{v}_{rms}^{2}$$

using ideal gas equation

\ $$PV = N k_B T$$,

$$k_B T = \frac{1}{3} m \mathrm{v}_{rms}^{2} = \frac{2}{3}\,\frac{1}{2} m \mathrm{v}_{rms}^{2}$$

Regnault’s Law

Regnault’s Law states that the specific heat capacity of a gas at constant pressure (C_p) and the specific heat capacity of a gas at constant volume (C_v) do not change with change in pressure and temperature. According to this law, C_p and C_v values of a gas remain constant.

Avogadro’s Law

Avogadro’s Law states that equal volumes of different perfect gases, at the same temperature and pressure, contain equal number of molecules.

Mathematically,

V/n = Constant

where,

V = Volume of gas, and

n = Amount of substance of the gas

Boyle’s Law

Boyle studied the compressibility of gases in 1660. In his experiments he observed "At a fixed temperature, the volume of a gas is inversely proportional to the pressure exerted by the gas. Boyle’s Law states that in a constant temperature or Isothermal process, the volume of a given mass of a gas varies inversely as its absolute pressure.

Mathematically,

PV = Constant or $V \propto 1/P$ or $p \propto 1/V$

where,

P= Absolute pressure of the gas, and

V = Volume of the gas

Consider the box full of moving gas molecules.The particles have the same energy (temperature) throughout. As the box gets smaller, they have a smaller distance to travel before they collide with the walls, and thus the time between collisions gets increasingly smaller. In a given amount of time the partials hit the walls more, which results in a greater amount of pressure. The amount of moles is clearly constant, as we are not adding or subtracting particles from the box. Another way of looking at this is that as the pressure increases, it drives the particles together. These compacted particles now occupy less volume. In order to compare a gas where either pressure or volume vary, we can combine the equations $P_1V_1= k$ and $P_2V_2= k$. Because k is constant for both values of pressure and volume,

P1V1=P2V2

This equation for Boyle's law is helpful when solving problems.

A cylinder with a piston and a gas is immersed in a bath (e.g. water). The purpose of the bath is to have a ready heat source to maintain the temperature of the gas constant throughout the experiment. A mass is placed on top of the piston which results in a pressure on the gas. The gas volume is measured and 1/V vs P data point plotted. The mass is increased and the new 1/V vs P data point plotted. This is continued over several larger masses. to see what happens place the mouse cursor over the image.

The straight line implies

$P\alpha$ 1/V

or

PV=constant

Which is Boyle's law.

Charle’s Law

Charles studied the compressibility of gases nearly a century after Boyle. In his experiments he observed "At a fixed pressure, the volume of a gas is proportional to the temperature of the gas."

Charle’s Law states that in a constant pressure or Isobaric process, the volume of a given mass of a gas varies directly with its temperature.

Mathematically,

$V \propto T$ or $V/T = \text{Constant}$

where,

V = Volume of the gas, and

T = Temperature of the gas

According to Charles' law, gases will expand when heated. The temperature of a gas is really a measure of the average kinetic energy of the particles. As the kinetic energy increases, the particles will move faster and want to make more collisions with the container. However, remember that in order for the law to apply, the pressure must remain constant. The only way to do this is by increasing the volume. This idea is illustrated by the comparing the particles in the small and large boxes.

Both particles leave at and return at the same time, but since the red ball travels a longer distance, it must be moving faster and have more energy. You can see that as the temperature and kinetic energy increase, so does the volume. Also note how the pressure remains constant. Both boxes experience the same number of collisions in a given amount of time. For Charles' Law, you can write the combined equation

$V1/T1=V2/T2$

A cylinder with a piston and a gas is immersed in a bath (e.g. water). A mass is placed on top of the piston which results in a pressure on the gas. This mass is held constant which means that the pressure on the gas is constant. The gas volume is measured as the temperature is increased and V vs T data point plotted. This is continued over a large range of temperatures. To see what happens place the mouse cursor over the image.

The straight line implies

$t(^0C) = bV - 273.15$

which suggests we define a new temperature T (the kelvin temperature scale) as

$T = t(^0C) + 273.15$
which leads to
$V \alpha T$

Which is Charle's law (P and n constant)

Example: In the experiment above the initial volume and temperature of the gas is 0.5L, 5 0C. Assuming the pressure and moles of gas is constant, what is the volume of the gas if the temperature is increased to 80 0C? Let T1 and V1 be the initial temperature and volume and let T2, V2 be the final temperature and volume. Then according to Charles law,

$V1/T1 = \text{constant} = V2/T2$

$V2 = V1\, T2/T1$

The Pressure Law (Gay-Lussac's Law)

The pressure law states that the values for temperature and pressure of a gas are directly related. As the temperature of a gas increases, so will the average speed and kinetic energy of the particles. This relationship is expressed in the following equation,

$P/T=k$

where P is the pressure of the particles on the container, T is the temperature in Kelvin, and k is a constant. At constant volume, this results in more collisions and thereby greater pressure the container. Because the value of k is the same for differing values of pressure and temperature, the pressure law can be written

$P1/T1=P2/T2$

Real Gases

Kinetic theory assumes that all gases behave ideally; however, we know that this is not the case. Obviously real gas particles do occupy space and attract each other. These properties become apparent at low temperatures or high pressures. Usually the particles have enough kinetic energy that they whiz by each other without being affected by the push or pull of neighboring molecules. However, at low temperatures the molecules have very little kinetic energy and move around much slower, so there is time for static forces to take hold. At very high pressures, the molecules of a gas become so tightly packed that their volume is significant compared to the overall volume. Also note that before a gas ever reaches absolute zero, it will condense to a liquid.

Law of equipartition of energy : specific heats of gases

According to the law of equipartition of energy the total energy is distributed uniformly among all possible energy modes (i.e. translational, rotational and vibrational). The energy per molecule for all modes is kT/2, where k is the Boltzmann constant and T is the absolute temperature.

Relation between the specific heat and R:

i. **Monatomic** Gas:

The total energy of the molecule of a monatomic gas (He, Ne, Ar) for three degrees of freedom are $\frac{3}{2}KT$, it is because it has three degrees of freedom and no other modes of motion. Thus for one mole of a substance, the number of molecules are equal to N the Avogadro's number, thus the total energy is given by

$$U=\frac{3}{2}KTN=\frac{3}{2}RT$$

Thus, the molar specific heat of a gas at V = constant is given by

$$C_V=\frac{dU}{dT}=\frac{3}{2}R$$

Also

$$C_p=C_V+R$$

$$C_p=\frac{5}{2}R$$

C_p is molar specific heat at constant pressure

g, the ratio of two specific heats (ratio of specific heat at constant pressure to the specific heat at constant volume)

$$\gamma=\frac{Cp}{C_V}=\frac{5}{3}=1.67$$

Diatomic

The total energy of the molecule of a diatomic gas (O_2, N_2) for five degrees of freedom are $\frac{5}{2}KT$, it is because it has five (3 – translational and 2 – rotational) degrees of freedom and no other modes of motion. Thus, for 1 mole of diatomic gas the total energy of the gas is

$$U=\frac{5}{2}KTN=\frac{5}{2}RT$$

Thus, the molar specific heat at V = Constant is given by

$$C_v=\frac{dU}{dT}=\frac{5}{2}R$$

Als $C_p=C_v+R$

$$C_p=\frac{5}{2}R+R=\frac{7}{2}R$$

g, thus the ratio of specific heats (ratio of specific heat at constant pressure to the specific heat at constant volume)

$$\gamma=\frac{C_p}{C_v}=\frac{7}{5}=1.4$$

Polyatomic Gas:

The total energy of the molecule of a polyatomic gas (3 – translational, 3 – rotational and unknown number of vibrational modes, say b) can be given in accordance with the law of equipartition of energy. For 1 mole of polyatomic gas the total energy of the gas is

$$U=\left(\frac{3}{2}KT+\frac{3}{2}KT+bKT\right)N$$

Thus, the molar specific heat at V = Constant is given by

$$C_v=(3+b)R$$

And, the molar specific heat at P = Constant is given by

$$Cp = (4 + b)R$$

Therefore,

$$\gamma = \frac{Cp}{C_v} = \frac{(4 + b)}{(3 + b)}$$

Van der Waals Equation

The Van der Waals equation is an equation similar to the Real Gas Law, but includes two constants, a and b, to account for deviations from ideal behavior.

The van der Waals equation is:

$[P + (n^2a/V^2)](V - nb) = nRT$

Where:

- P - pressure,
- V - volume,
- n - number of moles,
- T - temperature,
- R - ideal gas constant. If the units of P, V, n and T are atm, L, mol and K, respectively, the value of R is 0.0821
- a and b - constants, which are chosen to fit experiment as closely as possible to individual gas molecule.

When the volume, temperature and the number of moles of the gas molecule are known, the pressure can be calculated:

$P = [nRT/(V - nb)] - n^2a/V^2$

To calculate Volume:

To calculate the volume of a real gas, V in term n^2a/V^2 can be approximated as: nR/TP

as ideal gas. Then, V can be calculated as:

$V = nR^3T^3/(PR^2T^2+aP^2) + nb$

The van der Waals constants a and b of molecular N^2 is 1.390000 and 0.039100, respectively.

To calculate Pressure:

According to the van der Waals equation,

$P = nRT/(V - nb) - n^2a/V^2$

Example:

$P = 1.500 \times 0.0821 \times 3.000\times10^2 / (2.000 - 1.500 \times 0.039100) - (1.500)^2 \times 1.390000 /(2.000)^2$

$= 1.825\times10$ atm

Pressure

The force exerted per unit area of surface, typical pressure units are ATM, mmHg and kPa.

Volume

The measurement of space taken by a substance, it is length cubed, typical units are L, mL and m3.

Temperature

A measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees designated on a standard scale. Typical units are K, F and C.

Density

The mass of the object divided by its volume. Typical units are g/mL and kg/m3.

Formula Weight / Molecular Weight (MW)

The formula weight of a compound is the sum of all the atomic weights of the elements present in the formula of the compound. Some text also refers it to formula mass. Typical unit is g/mol.

Mass and Mole

Mass is the amount of a substance in grams, also called weight.

Gas Constant (R)

The constant that appears in the ideal gas equation (PV=nRT). It is usually expressed as 0.08206 L x atm/K x mol or 8.314 J/K x mol.

Molality

The number of moles of solute dissolved in one kilogram of solvent.

Molarity

The number of moles of solute in one liter of solution.

Brownian motion

Brownian motion is the random movement of particles in a fluid due to their collisions with other atoms or molecules. Brownian motion is also known as pedesis, which comes from the Greek word for "leaping". Even though a particle may be large compared with the size of atoms and molecules in the surrounding medium, it can be moved by the impact with many tiny, fast-moving masses. Brownian motion may be considered a macroscopic (visible) picture of a particle influenced by many microscopic random effects.

Brownian motion takes its name from the Scottish botanist Robert Brown, who observed pollen grains moving randomly in water. He described the motion in 1827 but was unable to explain it. While pedesis takes its name from Brown, he was not actually the first person to describe it. The Roman poet Lucretius describes the motion of dust particles around the year 60 BC, which he used as evidence of atoms.

The transport phenomenon remained unexplained until 1905 when Albert Einstein published a paper that explained the pollen was being moved by the water molecules in the liquid. As with Lucretius, Einstein's explanation served as indirect evidence of the existence of atoms and molecules. Keep in mind, at the turn of the 20th century, the existence of such tiny units of matter was only a matter of theory. In 1908, Jean Perrin experimentally verified Einstein's hypothesis, which earned Perrin the 1926 Nobel Prize in Physics "for his work on the discontinuous structure of matter".

The mathematical description of Brownian motion is a relatively simple probability calculation, of importance not just in physics and chemistry, but also to describe other statistical phenomena. The first person to propose a mathematical model for Brownian motion was Thorvald N. Thiele in a paper on the least squares method, published in 1880. A modern model is the Wiener process, named in honor of Norbert Wiener, who described the function of a continuous-time stochastic process. Brownian motion is considered a Gaussian process and a Markov process with continuous path occurring over continuous time.

Explanation of Brownian Motion

Because the movements of atoms and molecules in a liquid and gas is random, over time, larger particles will disperse evenly throughout the medium. If there are two adjacent regions of matter and region A contains twice as many particles as region B, the probability that a particle will leave region A to enter region B is twice as high as the probability a particle will leave region B to enter A. Diffusion, the movement of particles from a region of higher to lower concentration, can be considered a macroscopic example of Brownian motion.

Any factor that affects the movement of particles in a fluid impacts the rate of Brownian motion. For example, increased temperature, increased number of particles, small particle size, and low viscosity increase the rate of motion.

Examples of Brownian Motion

Most examples of Brownian motion are transport processes that are also affected by larger currents, yet also exhibit pedesis.

Examples include:

- The motion of pollen grains on still water
- Movement of dust motes in a room (although largely affected by air currents)
- Diffusion of pollutants in air
- Diffusion of calcium through bones
- Movement of "holes" of electrical charge in semiconductors

Importance of Brownian Motion

The initial importance of defining and describing Brownian motion was that it supported the modern atomic theory.

Today, the mathematical models that describe Brownian motion are used in math, economics, engineering, physics, biology, chemistry, and a host of other disciplines.

Brownian Motion vs Motility

It can be difficult to distinguish between movement due to Brownian motion and movement due to other effects. In biology, for example, an observer needs to be able to tell whether a specimen is moving because it is motile (capable of movement on its own, perhaps due to cilia or flagella) or because its subject to Brownian motion. Usually, it's possible to differentiate between the processes because Brownian motion appears jerky, random, or like a vibration. True motility often as a path or else the motion is twisting or turning in a specific direction.

POSSIBLE QUESTIONS

PART-B(2 Marks)

1. Define ideal gas.

2. State Boyel's law

3. State Charles' law.

4. State Reganults law.

5. State Avagadro law

6. Write note on Degree of freedom

7. What is Real gas?

8. What is Brownian motion?

9. Write Ideal Gas equation.

PART-C(6 Marks)

1. Explain Law of equipartition of energy and is application for specific heat of gases.

2. Explain Vander wall's equation

3. Explain Brownian Motion.

4. Explain Kinetic interpretation of Temperature

5. Explain pressure of an ideal gas

6. State and explain Boyel's law, Charles' law, Reganults law, Avagadro law

7. Write short note on Real gases, Vander wall's equation, Brownian motion.

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Questions	Option 1	Option 2	Option 3	Option 4	Answer
A vapor does not become a gas as long as degree of superheat is	$< 100^0C$	$< 50^0C$	$<150^0C$	None	None
A vapor does not become a gas as long as degree of superheat is	$< 100^0C$	$< 50^0C$	$<150^0C$	None	None
Mathematical form of isothermal process is	$pv^n = C$	$pv^\gamma = C$	$Pv =C$	None	$Pv =C$
Mathematical form of adiabatic process is	$pv^n = C$	$pv^\gamma = C$	$Pv =C$	None	$pv^n = C$
Mathematical form of isentropic process is	$pv^n = C$	$pv^\gamma = C$	$Pv =C$	None	$pv^\gamma = C$
Mathematical form of isobaric process is	$p/v^n = C$	$p/v^\gamma = C$	$V/T =C$	None	$V/T =C$
Perfect gas equation is	$pV=R_gT$	$pV = mR_gT$	PV	$pV=nR_gT$	$pV = mR_gT$
. Perfect gas equation is	$pV=R_UT$	$pV = mR_UT$	$pV=nR_UT$	PV	$pV=nR_U T$
The internal energy of a gas is a function of	T	V	p	R	T
The molar volume is	22.41 m^3/kg at N.T.P.	22.41 m^3/kg bar at N.T.P.	22.41 m3/kg mole at N.T.P.	33.25	22.41 m3/kg mole at N.T.P.
A polytropic process is represented by	$(pV)^n=C$	$pV^n = C$	$pv^\gamma = C$	None	$pV^n = C$
What are standard temperature and pressure conditions?	0 K and 760 mm of Hg	0^0C and 760 mm of Hg	0^0C and 1 mm of Hg	None	0^0C and 760 mm of Hg

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

What are normal temperature and pressure conditions?	0 K and 760 mm of Hg	$0^{DEGREE}C$ and 760 mm of Hg		300C and 760 mm of Hg	0^0C and 760 mm of Hg
What will be the pressure at constant temperature when the volume becomes three times?	Pressure will become three times	Pressure will become one third	Pressure will remain the same	None	Pressure will become one third
Which gas will have the largest number of moles under the same conditions of temperature and pressure?	CH_4	C_2H_6	NH_4	NH	CH_4
. The gas constant R_g is equal to the	Universal gas constant, R_U	R_U X Molecular weight	R_U/Molecular weight	None	R_U/Molecular weight
Real gases do not react as expected	ideal gas	noble gas	non-ideal gas	inert gas	ideal gas
The force of attraction and repulsion in gaseous molecule is	present	absent	slight	huge	absent
The metal which can be melted even by the warmth of human palm is	gallium	indium	aluminum	tungsten	gallium
The state of matter with fixed volume which can be compressed slightly is	solid	liquid	gas	D. All of Above	liquid
The particles of gas are	randomly arranged	far apart	freely moving	All of Above	which obeys the law pv = RT

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

What is an ideal gas?	which obeys the law pv = RT	which obeys the law p = vR / T	which obeys the law pv = R / T	none of the above	which obeys the law pv = RT
The sum of partial volumes of all gases in a mixture is equal to	less than the total volume of the mixture	the total volume of the mixture	more than the total volum	cannot predict	the total volume of the mixture
In a mixture of ideal gases of volume *V* and temperature *T*, what is the pressure exerted by each individual gas if it occupies the total volume *V* alone at temperature *T*called?	individual pressure	divided pressure	partial pressure	total pressure	total pressure
What is reduced property of a substance?	critical property of a substance minus existing property of the same substance	existing property of a substance minus critical property of the same substance	ratio of critical property to existing property of the same substance	ratio of existing property to critical property of the same substance	ratio of existing property to critical property of the same substance
In high pressure condition, the real gases conform more closely with	van der Waals equation	ideal gas equation	both a. and b.	none of the above	van der Waals equation
In which condition can real gas closely obey the ideal gas equation?	pressure is very small and temperature is very high	pressure is very high and temperature is very low	both pressure and temperature are very high	both pressure and temperature are very low	

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

The volume occupied by one number of unit mol of gas is called as	molecular volume	mol volume	molar volume	none of the above	molecular volume
What is the formula for number of kg moles (n) of a gas? If,	n = m . μ	n = m / μ	n = μ / m	m=n	n = m / μ
What is a mole of a substance?	One mole has a mass numerically equal to half the molecular weight of the substance	One mole has a mass numerically equal to the molecular weight of the substance	One mole has a mass numerically equal to double the molecular weight of the substance	none of the above	One mole has a mass numerically equal to the molecular weight of the substance
Fixed volumes is a characteristic of	liquids	solids	gases	Both A and B	Both A and B
Melting and boiling points of ___________ are always above room temperature	solids	liquids	gases	all of these	solids
Particles are farthest apart in	. solids	liquids	gases	all of these	gases
Greatest energy is found in the particles of the	solids	liquids	gases	diffusing particles	gases

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

liquids may become vapors	upon boiling only	without boiling	at a temperature below the boiling point of a liquid	at a temperature above the boiling point of a liquid	at a temperature below the boiling point of a liquid
Substances which transform from solid into a gas directly, are called as	Amphoteric oxides	basic oxides	sublimations	neutral oxides	sublimations
A constant temperature at which a pure liquid changes into a gas is called	latent heat of vaporization	depression in freezing point	boiling point	melting point	boiling point
No fixed volume" is a characteristic of	liquids	solids	gases	aqueous solutions	gases
Which below is NOT a state of matter?	plasma		solid	liquid	water
Which state of matter is found in stars and ha electron-less atoms?	plasma	water	solid	liquid	plasma
Which below has both a definite shape and volume?	plasma	water	solid	liquid	solid
The particles of the solid	spin	VIBRATE	moving along	both A and B	both A and B
Unit of moment of inertia___________	Kgm^{-2}	Kgm^{-1}	Kgm	Kgm^{2}	Kgm^{2}
Dimensional formula for I ______________	ML^{2}	MLT^{2}	$ML^{2}T$	$M^{2}LT$	ML^{2}
Area of a ring in circular disc____________	2πxdx	2xdx	πxdx	2πx	2πxdx
Moment of inertia of a solid sphere ___________	$2/5\ MR^{2}$	$1/5\ MR^{2}$	$2/3MR^{2}$	$5/2\ MR^{2}$	$2/5\ MR^{2}$

Enable | Enlighten | Enrich
KARPAGAM
ACADEMY OF HIGHER EDUCATION
(Deemed to be University)
(Established Under Section 3 of UGC Act, 1956)

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT I :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Mass of solid sphere ___________	$4/3\ \pi\rho R^3$	$4\pi\rho R^3$	$2/3\ \pi\rho R^3$	$1/3\ \pi\rho R^3$	$4/3\ \pi\rho R^3$
Volume of hollow sphere _____________	(4/3)(R32-R31)	(4)π(R32-R31)	(1/3)π(R32-R31)	(4/3)π(R31-R32)	(4/3)π(R32-R31)
Unit of g ____________	ms^{-2}	ms^{2}	s^{-2}	m^{-2}	ms^{-2}
Value of g_______	9.8	8.9	98.8	0.98	9.8
Uniform velocity is called___________________	critical velocity	terminal velocity	coefficient of viscosity	streamline flow	terminal velocity

UNIT-II

SYLLABUS

Elasticity: Hooke's law- Stress-strain diagram - Elastic moduli-Relation between elastic constants-Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants- Work done in stretching & work done in twisting a wire- Twisting couple on a cylinder- Determination of Rigidity modulus by static torsion- Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η & by Searles method

Elasticity, ability of a deformed material body to return to its original shape and size when the forces causing the deformation are removed. A body with this ability is said to behave (or respond) elastically.

To a greater or lesser extent, most solid materials exhibit elastic behaviour, but there is a limit to the magnitude of the force and the accompanying deformation within which elastic recovery is possible for any given material. This limit, called the elastic limit, is the maximum stress or force per unit area within a solid material that can arise before the onset of permanent deformation. Stresses beyond the elastic limit cause a material to yield or flow. For such materials the elastic limit marks the end of elastic behaviour and the beginning of plastic behaviour. For most brittle materials, stresses beyond the elastic limit result in fracture with almost no plastic deformation.

The elastic limit depends markedly on the type of solid considered; for example, a steel bar or wire can be extended elastically only about 1 percent of its original length, while for strips of certain rubberlike materials, elastic extensions of up to 1,000 percent can be achieved. Steel is much stronger than rubber, however, because the tensile force required to effect the maximum elastic extension in rubber is less (by a factor of about 0.01) than that required for steel. The elastic properties of many solids in tension lie between these two extremes.

The different macroscopic elastic properties of steel and rubber result from their very different microscopic structures. The elasticity of steel and other metals arises from short-range interatomic forces that, when the material is unstressed, maintain the atoms in regular patterns. Under stress the atomic bonding can be broken at quite small deformations. By contrast, at the microscopic level, rubberlike materials and other polymers consist of long-chain molecules that uncoil as the material is extended and recoil in elastic recovery. The mathematical theory of elasticity and its application to engineeringmechanics is concerned with the macroscopic response of the material and not with the underlying mechanism that causes it.

In a simple tension test, the elastic response of materials such as steel and bone is typified by a linear relationship between the tensile stress (tension or stretching force per unit area of cross section of the material), σ, and the extension ratio (difference between extended and initial lengths divided by the initial length), e. In other words, σ is proportional to e; this is expressed $\sigma = Ee$, where E, the constant of proportionality, is called Young's modulus. The value of E depends on the material; the ratio of its values for steel and rubber is about 100,000. The equation $\sigma = Ee$ is known as Hooke's law and is an example of a constitutive law. It expresses, in terms of macroscopic quantities, something about the nature (or constitution) of the material. Hooke's law applies essentially to one-dimensional deformations, but it can be extended to more general (three-dimensional) deformations by the introduction of linearly related stresses and strains (generalizations of σ and e) that account for shearing, twisting, and volume changes. The resulting generalized Hooke's law, upon which the linear theory of elasticity is based, provides a good description of the elastic properties of all materials, provided that the deformations correspond to extensions not exceeding about 5 percent. This theory is commonly applied in the analysis of engineering structures and of seismic disturbances.

The elastic limit is in principle different from the proportional limit, which marks the end of the kind of elastic behaviour that can be described by Hooke's law, namely, that in which the stress is proportional to the strain (relative deformation) or equivalently that in which the load is proportional to the displacement. The elastic limit nearly coincides with the proportional limit for some elastic materials, so that at times the two are not distinguished; whereas for other materials a region of nonproportional elasticity exists between the two.

The linear theory of elasticity is not adequate for the description of the large deformations that can occur in rubber or in soft human tissue such as skin. The elastic response of these materials is nonlinear except for very small deformations and, for simple tension, can be represented by the constitutive law $\sigma = f(e)$, where $f(e)$ is a mathematical function of e that depends on the material and that approximates to Ee when e is very small. The term nonlinear means that the graph of σ plotted against e is not a straight line, by contrast with the situation in the linear theory. The energy, $W(e)$, stored in the material under the action of the stress σ represents the area under the graph of $\sigma = f(e)$. It is available for transfer into other forms of energy—for example, into the kinetic energy of a projectile from a catapult.

The stored-energy function $W(e)$ can be determined by comparing the theoretical relation between σ and e with the results of experimental tension tests in which σ and e are measured. In this way, the elastic response of any solid in tension can be characterized by means of a stored-energy function. An important aspect of the theory of elasticity is the construction of specific forms of strain-energy function from the results of experiments involving three-dimensional deformations, generalizing the one-dimensional situation described above.

Strain-energy functions can be used to predict the behaviour of the material in circumstances in which a direct experimental test is impractical. In particular, they can be used in the design of components in engineering structures. For example, rubber is used in bridge bearings and engine mountings, where its elastic properties are important for the absorption of vibrations. Steel beams, plates, and shells are used in many structures; their elastic flexibility contributes to the support of large stresses without material damage or failure. The elasticity of skin is an important factor in the successful practice of skin grafting. Within the mathematical framework of the theory of elasticity, problems related to such applications are solved. The results predicted by the mathematics depend critically on the material properties incorporated in the strain-energy function, and a wide range of interesting phenomena can be modeled.

When a force is placed on a material, the material stretches or compresses in response to the force. We are all familiar with materials like rubber which stretch very easily.

In mechanics, the force applied per unit area is what is important, this is called the *stress* (σsigma). The extent of the stretching/compression produced as the material responds to stress in called the *strain* (epsilonϵ). Strain is measured by the ratio of the difference in length \Delta LΔLdelta, L to original length L_0L0L, start subscript, 0, end subscript along the direction of the stress, *i.e.* \epsilon=\Delta L/L_0ϵ=$\Delta L/L$0.

Every material responds differently to stress and the details of the response are important to engineers who must select materials for their structures and machines that behave predictably under expected stresses.

For most materials, the strain experienced when a small stress is applied depends on the tightness of the chemical bonds within the material. The stiffness of the material is directly related to the chemical structure of the material and the type of chemical bonds present. What happens when the stress is removed depends on how far the atoms have been moved. There are broadly two types of deformation:

1. ***Elastic deformation***. When the stress is removed the material returns to the dimension it had before the load was applied. The deformation is reversible, non-permanent.
2. ***Plastic deformation***. This occurs when a large stress is applied to a material. The stress is so large that when removed, the material does not spring back to its previous dimension. There is a permanent, irreversible deformation. The minimal value of the stress which produces plastic deformation is known as the *elastic limit* for the material.

Any spring should be designed and specified such that it only ever experiences elastic deformation when built into a machine under normal operation.

Hooke's law

When studying springs and elasticity, the 17th century physicist Robert Hookenoticed that the stress vs strain curve for many materials has a linear region. Within certain limits, the force required to stretch an elastic object such as a metal spring is directly proportional to the extension of the spring. This is known as Hooke's law and commonly written:

\boxed{F=-kx}$F=-kx$

Where FFF is the force, xxx is the length of extension/compression and kkk is a constant of proportionality known as the *spring constant* which is usually given in\mathrm{N/m}N/m.

Though we have not explicitly established the direction of the force here, the negative sign is customarily added. This is to signify that the *restoring force* due to the spring is in the opposite direction to the force which caused the displacement. Pulling down on a spring will cause an extension of the spring **downward**, which will in turn result in an **upward** force due to the spring.

Stress and strain
Every stress produces a strain

Stress
The previous comment is true for elastic properties as well. A stress is a measure of the cause of the deformation produced by a force:

Stress = Force per unit area the units for stress are Nm-2 or Pa.

Breaking stress
The maximum stress that a material can stand before it breaks is called the breaking stress. There are two types of breaking stress

(a) compressive breaking stress - the maximum squashing stress before fracture
(b) tensile breaking stress - the maximum stretching stress before fracture

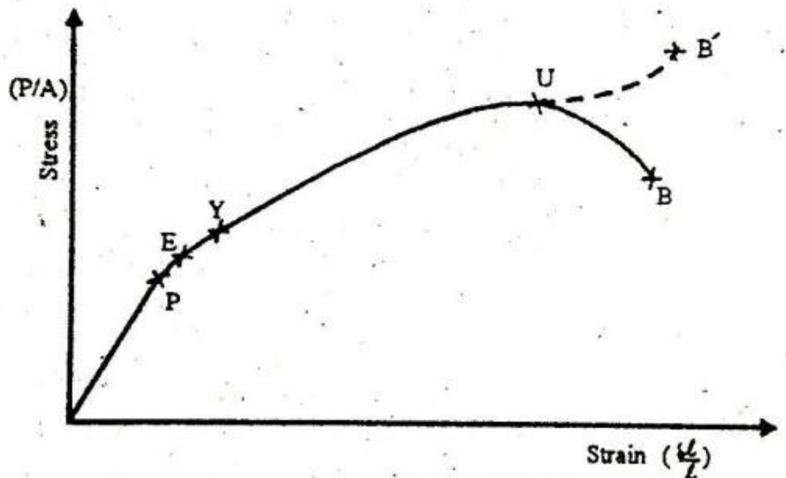
Strain
Strain is a measure of the deformation produced by the stress.

Strain = change in size/original size

Strain has no units as it is simply a ratio of two similar quantities

Stress Strain Curve Explanation

Stress strain curve is a behavior of material when it is subjected to load. In this diagram stresses are plotted along the vertical axis and as a result of these stresses, corresponding strains are plotted along the horizontal axis. As shown below in the stress strain curve.



Stress-Strain Curve

From the diagram one can see the different mark points on the curve. It is because, when a ductile material like mild steel is subjected to tensile test, then it passes various stages before fracture.

These stages are;

1. Proportional Limit
2. Elastic Limit
3. Yield Point

4. Ultimate Stress Point
5. Breaking Point

PROPORTIONAL LIMIT

Proportional limit is point on the curve up to which the value of stress and strain remains proportional. From the diagram point **P** is the called the proportional limit point or it can also be known as limit of proportionality. The stress up to this point can be also be known as proportional limit stress.

Hook’s law of proportionality from diagram can be defined between point**OP**. It is so, because **OP** is a straight line which shows that Hook’s law of stress strain is followed up to point **P**.

ELASTIC LIMIT

Elastic limit is the limiting value of stress up to which the material is perfectly elastic. From the curve, point **E** is the elastic limit point. Material will return back to its original position, If it is unloaded before the crossing of point **E**. This is so, because material is perfectly elastic up to point **E**.

YIELD STRESS POINT

Yield stress is defined as the stress after which material extension takes place more quickly with no or little increase in load. Point **Y** is the yield point on the graph and stress associated with this point is known as yield stress.

ULTIMATE STRESS POINT

Ultimate stress point is the maximum strength that material have to bear stress before breaking. It can also be defined as the ultimate stress corresponding to the peak point on the stress strain graph. On the graph point **U** is the ultimate stress point. After point **U** material have very minute or zero strength to face further stress.

BREAKING STRESS (POINT OF RUPTURE)

Breaking point or breaking stress is point where strength of material breaks. The stress associates with this point known as breaking strength or rupture strength. On the stress strain curve, point **B** is the breaking stress point.

Young's Modulus or Modulus of Elasticity: It is the ratio between compressive stress and compressive strain or tensile stress and tensile strain. It is denoted by 'E'. Its units are GN/m^2.

$E = \text{stress/stain} = \sigma/\varepsilon = \sigma_t/\varepsilon_t = \sigma_c/\varepsilon_c$

Modulus of Rigidity or Shear Modulus of Elasticity: It is the ratio of shear stress (τ) to shear strain (γ). It is represented by 'C', 'N' or 'G'. Its units are GN/m^2.

C, N or G = τ/γ

Bulk Modulus or Volume Modulus of elasticity: It is defined as the ratio of applied pressure (on each face of solid cube) to volumetric strain. It is represented by 'K'. Its units are GN/m^2.

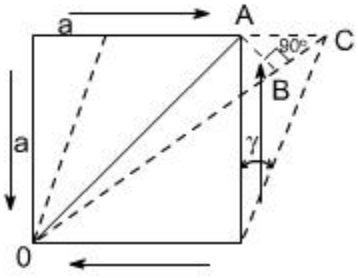
$K = p/\varepsilon_v$

RELATION AMONG ELASTIC CONSTANTS

Relation between E, G and □ :

Let us establish a relation among the elastic constants E,G and □. Consider a cube of material of side 'a' subjected to the action of the shear and complementary shear stresses as shown in the figure and producing the strained shape as shown in the figure below.

Assuming that the strains are small and the angle A C B may be taken as 45^0.



Therefore strain on the diagonal OA

= Change in length / original length

Since angle between OA and OB is very small hence OA □ OB therefore BC, is the change in the length of the diagonal OA

Thus, strain on diagonal OA $= \frac{BC}{OA}$

$$= \frac{AC\cos 45^0}{OA}$$

$$OA = \frac{a}{\sin 45^0} = a.\sqrt{2}$$

hence strain $= \frac{AC}{a\sqrt{2}} . \frac{1}{\sqrt{2}}$

$$= \frac{AC}{2a}$$

but AC = $a\gamma$

where γ = shear strain

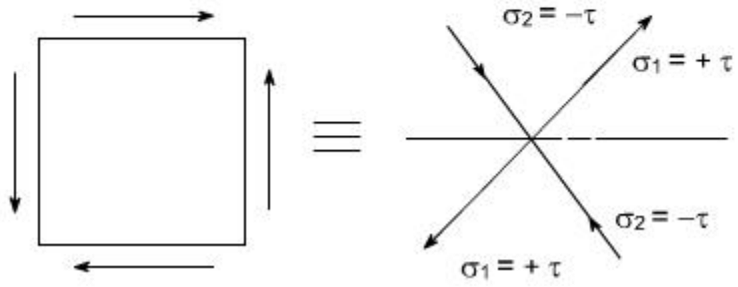
Thus, the strain on diagonal $= \frac{a\gamma}{2a} = \frac{\gamma}{2}$

From the definition

$$G = \frac{\tau}{\gamma} \text{ or } \gamma = \frac{\tau}{G}$$

thus, the strain on diagonal $= \frac{\gamma}{2} = \frac{\tau}{2G}$

Now this shear stress system is equivalent or can be replaced by a system of direct stresses at 45^0 as shown below. One set will be compressive, the other tensile, and both will be equal in value to the applied shear strain.



Thus, for the direct state of stress system which applies along the diagonals:

$$\text{strain on diagonal} = \frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E}$$

$$= \frac{\tau}{E} - \mu\frac{(-\tau)}{E}$$

$$= \frac{\tau}{E}(1+\mu)$$

equating the two strains one may get

$$\frac{\tau}{2G} = \frac{\tau}{E}(1+\mu)$$

$$\text{or} \qquad \boxed{E = 2G(1+\mu)}$$

We have introduced a total of four elastic constants, i.e E, G, K and □. It turns out that not all of these are independent of the others. Infact given any two of then, the other two can be found.

$$\text{Again} \quad E = 3K(1-2\gamma)$$

$$\Rightarrow \frac{E}{3(1-2\gamma)} = K$$

$$\text{if } \gamma = 0.5 \;\; K = \infty$$

$$\epsilon_v = \frac{(1-2\gamma)}{E}(\epsilon_x + \epsilon_y + \epsilon_z) = 3\frac{\sigma}{E}(1-2\gamma)$$

$$(\text{for } \epsilon_x = \epsilon_y = \epsilon_z \text{ hydrostatic state of stress})$$

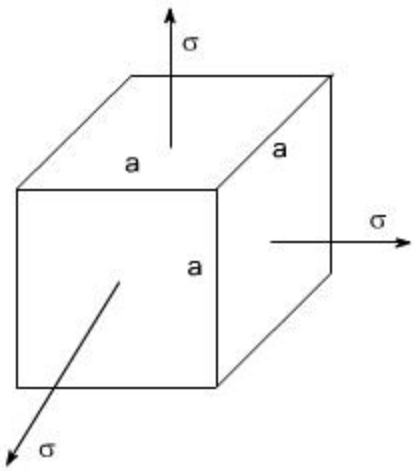
$$\epsilon_v = 0 \text{ if } \gamma = 0.5$$

irrespective of the stresses i.e, the material is incompressible.

When □ = 0.5 Value of k is infinite, rather than a zero value of E and volumetric strain is zero, or in other words, the material is incompressible.

Relation between E, K and □ :

Consider a cube subjected to three equal stresses □ as shown in the figure below



The total strain in one direction or along one edge due to the application of hydrostatic stress or volumetric stress □ is given as

$$= \frac{\sigma}{E} - \gamma\frac{\sigma}{E} - \gamma\frac{\sigma}{E}$$

$$= \frac{\sigma}{E}(1-2\gamma)$$

volumetre strain = 3.linear strain

volumetre strain = $\epsilon_x + \epsilon_y + \epsilon_z$

or thus, $\epsilon_x = \epsilon_y = \epsilon_z$

volumetric strain = $3\frac{\sigma}{E}(1-2\gamma)$

By definition

$$\text{Bulk Modulus of Elasticity (K)} = \frac{\text{Volumetric stress}(\sigma)}{\text{Volumetric strain}}$$

or

$$\text{Volumetric strain} = \frac{\sigma}{k}$$

Equating the two strains we get

$$\frac{\sigma}{k} = 3.\frac{\sigma}{E}(1-2\gamma)$$

$$\boxed{E = 3K(1-2\gamma)}$$

Relation between E, G and K :

The relationship between E, G and K can be easily determained by eliminating □ from the already derived relations

E = 2 G (1 + □) and E = 3 K (1 □ □)

Thus, the following relationship may be obtained

$$\boxed{E = \frac{9\,GK}{(3K + G)}}$$

Relation between E, K and □ :

From the already derived relations, E can be eliminated

$$E = 2G(1 + \gamma)$$
$$E = 3K(1 - 2\gamma)$$

Thus,we get

$$3k(1 - 2\gamma) = 2G(1 + \gamma)$$

therefore

$$\gamma = \frac{(3K - 2G)}{2(G + 3K)}$$

or

$$\boxed{\gamma = 0.5(3K - 2G)(G + 3K)}$$

Engineering Brief about the elastic constants :

We have introduced a total of four elastic constants i.e E, G, K and □. It may be seen that not all of these are independent of the others. Infact given any two of them, the other two can be determined. Futher, it may be noted that

$$E = 3K(1-2\gamma)$$

or

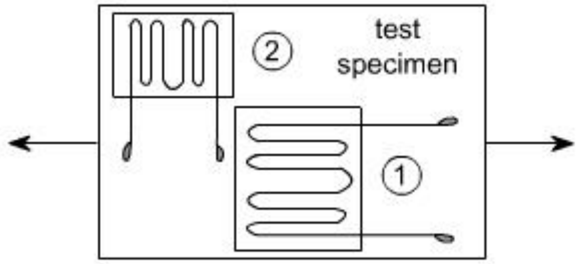
$$K = \frac{E}{(1-2\gamma)}$$

$$\text{if } \gamma = 0.5;\ K = \infty$$

$$\text{Also } \epsilon_v = \frac{(1-2\gamma)}{E}(\sigma_x + \sigma_y + \sigma_z)$$

$$= \frac{(1-2\gamma)}{E}.3\sigma \text{ (for hydrostatic state of stress i.e } \sigma_x = \sigma_y = \sigma_z = \sigma \text{)}$$

Determination of Poisson's ratio: Poisson's ratio can be determined easily by simultaneous use of two strain gauges on a test specimen subjected to uniaxial tensile or compressive load. One gage is mounted parallel to the longitudnal axis of the specimen and other is mounted perpendicular to the longitudnal axis as shown below:



Definition of Poisson's ratio

Poisson's ratio is the ratio of transverse contraction strain to longitudinal extension strain in the direction of stretching force. Tensile deformation is considered positive and compressive deformation is considered negative. The definition of Poisson's ratio contains a minus sign so that normal materials have a positive ratio. Poisson's ratio, also called Poisson ratio or the Poisson coefficient, or coefficient de Poisson, is usually represented as a lower case Greek nu, n. If your browser does not interpret Symbol font properly, Greek nu, n may instead look like a bold face Latin **n**.

$n = - e_{trans} / e_{longitudinal}$

Strain e is defined in elementary form as the change in length divided by the original length.

$e = DL/L.$

Poisson's ratio: relation to elastic moduli in isotropic solids

Poisson's ratio is related to elastic moduli K (also called B), the bulk modulus; G as the shear modulus; and E, Young's modulus, by the following (for isotropic solids, those for which properties are independent of direction). The elastic moduli are measures of stiffness. They are ratios of stress to strain. Stress is force per unit area, with the direction of both the force and the area specified. See Sokolnikoff Ref. [1]; also further details.

$n = (3K - 2G)/(6K + 2G)$

$E = 2G(1 + n)$

$E = 3K(1 - 2 n)$

Further interrelations among elastic constants for isotropic solids are as follows. B is the bulk modulus.

$$B = \frac{E}{3(1-2\nu)}, B = \frac{GE}{3(3G-E)}$$

$$\nu = \frac{E}{2G} - 1, \nu = \frac{3B-2G}{6B+2G}, \nu = \frac{1}{2} - \frac{E}{6B}$$

$$E = 2G(1+\nu)$$

$$E = 3B(1-2\nu) = \frac{9GB}{3B+G}.$$

$$C_{1111} = B + \frac{4}{3}G$$

$$C_{1111} = E\frac{1-\nu}{(1+\nu)(1-2\nu)}$$

The theory of isotropic linear elasticity allows Poisson's ratios in the range from -1 to 1/2 for an object with free surfaces with no constraint. Physically the reason is that for the material to be stable, the stiffnesses must be positive; the bulk and shear stiffnesses are interrelated by formulae which incorporate Poisson's ratio. Objects constrained at the surface can have a Poisson's ratio outside the above range and be stable.

Elastic energy stored in a stretched wire

When a person jumps up and down on a trampoline it is clear that the bed of the trampoline stores energy when it is in a state of tension. This energy is converted to kinetic and potential energy of the jumper when the tension is removed.

Similarly, when a piece of elastic in a catapult is stretched energy is stored in it, and when the catapult is fired this energy is convened into the kinetic energy of the projectile.

What actually happens within some of the materials mentioned in the examples may be quite complex, but we can calculate the energy stored in a stretched metal wire where Hooke's law is obeyed as follows.

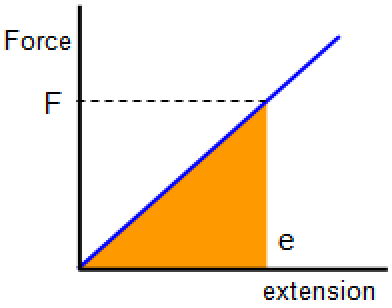


Figure 1(a)

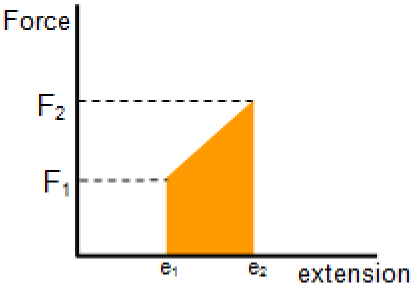


Figure 1(b)

Let the wire be of unstretched length L and let a force F produce an extension e. (Assume that the elastic limit of the wire has not been exceeded and that no energy is lost as heat.) Consider Figure 1(a). The work done a the force is Fs but in this case the force varies from 0 at the start to F at the end when the wire is stretched by an amount e. Therefore:

Work done on the wire during stretching = average force x extension = ½ Fe

But the work done by F is equal to the energy gained by the wire. Therefore:
work done = average force x extension = ½ Fe

Therefore:
work done = energy stored = ½ Fe = ½ EAe2/L

And this energy is the shaded area of the graph.
If the extension is increased from e1 to e2 then the extra energy stored is given by:
Energy stored = ½ F[e2 – e1] = ½ EA[e22 – e12]/L

This is the shaded area on the graph in Figure 1(b), and in general the energy stored in an extension is the area below the line in the force-extension graph. It can also be shown that: Energy stored per unit volume of a specimen = ½ stress x strain

Example

Calculate the energy stored in a 2 m long copper wire of cross-sectional area 0.5 mm2 if a force of 50 N is applied to it. [Young modulus for copper = 1.2x1011 Pa]

Energy stored = ½ Fe

Extension (e) = FL/EA = 50 x 2/[1.2x1011x0.5x10-6] = 1.67 mm

Therefore energy stored = ½ x 50 x 1.67x10-3 = 0.04 J

The action of the arrester wire that halts a plane when it lands on the deck of an aircraft carrier is not due to the elastic stretching of the wire. Although as the plane lands the wire does stretch a little virtually all of the plane's kinetic energy is converted to heat energy in a pair of large disc brakes.

However the energy stored in a rubber band can be used to get a very rough idea of the speed of a paper pellet when fired! Air resistance and the heat energy produced in stretched rubber must both be taken into account in this case.

If the wire has been extended beyond the elastic limit and then the force removed the extension is only partially recoverable. Energy is therefore lost due to heat and this phenomenon is known as hysteresis. The force-extension curve for the wire will follow the line OAB on the graph

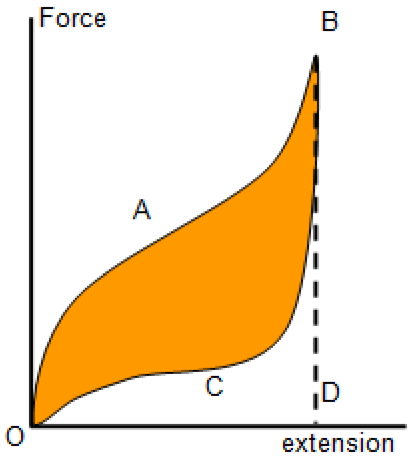


Figure 2

in Figure 2, where the area OABDO is the energy input, OCBD the recoverable energy and the shaded area OABCO represents the energy converted to heat within the specimen. The larger this area the bigger is the energy loss due to hysteresis.

The effect of hysteresis is usually very small for metals, but is noticeable for polythene, glass and rubber. You can easily investigate this using a rubber band. By simply stretching it and then holding it against your lips you can detect a rise in temperature.

Twisting Couple

A pair of forces F, equal in magnitude, but oppositely directed, and displaced by perpendicular distance constitute a couple. It can also be defined as a system of forces with a resultant moment but without any force acting on it. The resultant moment of a couple is called as torque.

Definition of Torsion: Consider a shaft rigidly clamped at one end and twisted at the other end by a torque T = F.d applied in a plane perpendicular to the axis of the bar such a shaft is said to be in torsion

Twisting Couple of a Cylindrical Object

Let us consider a cylindrical object subjected to torsion. This cylinder is having length l metres and let R be the radius of the cylinder. Since the cylinder is subject to torsion, which is essentially a rotation at the movable end while nothing happens to the fixed end of the cylinder, a twisting couple is accompanied by a restoring couple inside the cylinder. It is required to imagine that this cylinder consists of many coaxial cylinders and one such cylinder is having radius s and thickness d. Let GH be a parallel line to the central axis EF and now, when the cylinder is twisted, the line GH is twisted through an angle j, so that the shearing angle is GFC.

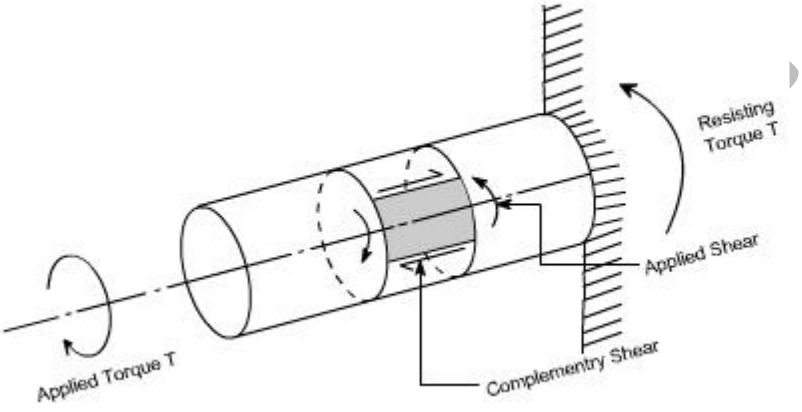
Here we are basically interested to derive an equation between the relevant parameters

Relationship in Torsion: $\frac{T}{J} = \frac{\tau}{r} = \frac{G.\theta}{l}$

1 st Term: It refers to applied loading ad a property of section, which in the instance is the polar second moment of area.

2 nd Term: This refers to stress, and the stress increases as the distance from the axis increases.

3 rd Term: it refers to the deformation and contains the terms modulus of rigidity & combined term (q / l) which is equivalent to strain for the purpose of designing a circular shaft to with stand a given torque we must develop an equation giving the relation between Twisting moments max m shear stain produced and a quantity representing the size and shape of the cross – sectional area of the shaft.



Refer to the figure shown above where a uniform circular shaft is subjected to a torque it can be shown that every section of the shaft is subjected to a state of pure shear, the moment of resistance developed by the shear stresses being every where equal to the magnitude, and opposite in sense, to the applied torque. For the purpose of deriving a simple theory to describe the behavior of shafts subjected to torque it is necessary make the following base assumptions.

Assumption:

(i) The materiel is homogenous i.e of uniform elastic properties exists throughout the material.

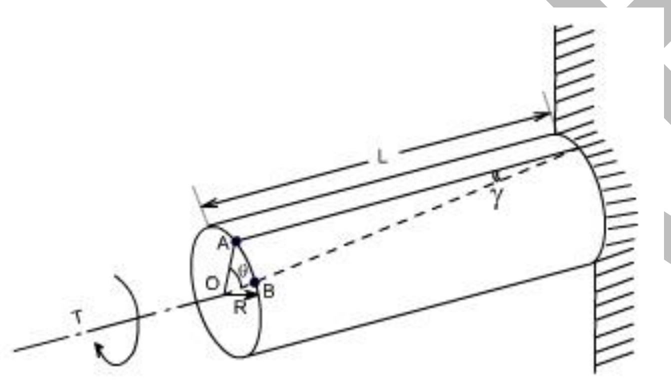
(ii) The material is elastic, follows Hook's law, with shear stress proportional to shear strain.

(iii) The stress does not exceed the elastic limit.

(iv) The circular section remains circular

(v) Cross section remain plane.

(vi) Cross section rotate as if rigid i.e. every diameter rotates through the same angle.



Consider now the solid circular shaft of radius R subjected to a torque T at one end, the other end being fixed Under the action of this torque a radial line at the free end of the shaft twists through an angle q , point A moves to B, and AB subtends an angle ‘ g ' at the fixed end. This is then the angle of distortion of the shaft i.e the shear strain.

Since angle in radius = arc / Radius

arc AB = Rq

= L g [since L and g also constitute the arc AB]

Thus, g = Rq / L (1)

From the definition of Modulus of rigidity or Modulus of elasticity in shear

$$G = \frac{\text{shear stress}(\tau)}{\text{shear strain}(\gamma)}$$

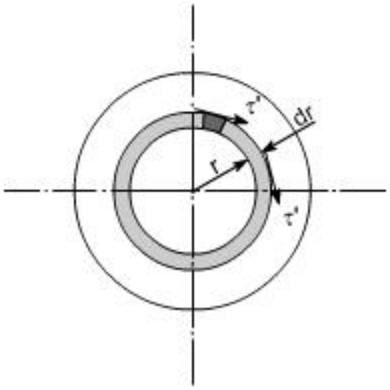
where γ is the shear stress set up at radius R.

Then $\frac{\tau}{G} = \gamma$

Equating the equations (1) and (2) we get $\frac{R\theta}{L} = \frac{\tau}{G}$

$\frac{\tau}{R} = \frac{G\theta}{L}\left(= \frac{\tau'}{r}\right)$ where τ' is the shear stress at any radius r.

Stresses: Let us consider a small strip of radius r and thickness dr which is subjected to shear stress t'.



= stress x area

= t' x 2p r dr (approximately)

This force will produce a moment or torque about the center axis of the shaft.

= t' . 2 p r dr . r

= 2 p t' . r^2. dr

The total torque T on the section, will be the sum of all the contributions. $T = \int_0^R 2\pi\tau' r^2 dr$

Since t' is a function of r, because it varies with radius so writing down t' in terms of r from the equation (1).

i.e $\tau' = \frac{G\theta . r}{L}$

we get $T = \int_0^R 2\pi \frac{G\theta}{L} . r^3 dr$

$T = \frac{2\pi G\theta}{L}\int_0^R r^3 dr$

$= \frac{2\pi G\theta}{L} . \left[\frac{R^4}{4}\right]_0^R$

$= \frac{G\theta}{L} . \frac{2\pi R^4}{4}$

$= \frac{G\theta}{L} . \frac{\pi R^4}{2}$

$= \frac{G\theta}{L} . \left[\frac{\pi d^4}{32}\right]$ now substituting R = d/2

$= \frac{G\theta}{L} . J$

since $\frac{\pi d^4}{32} = J$ the polar moment of inertia

or $\frac{T}{J} = \frac{G\theta}{L}$ ......(2)

if we combine the equation no.(1) and (2) we get $\boxed{\frac{T}{J} = \frac{\tau'}{r} = \frac{G.\theta}{L}}$

Where

T = applied external Torque, which is constant over Length L;

J = Polar moment of Inertia

$$= \frac{\pi d^4}{32} \text{ for solid shaft}$$

$$= \frac{\pi(D^4 - d^4)}{32} \text{ for a hollow shaft.}$$

[D = Outside diameter ; d = inside diameter]

G = Modules of rigidity (or Modulus of elasticity in shear)

q = It is the angle of twist in radians on a length L.

Tensional Stiffness: The tensional stiffness k is defined as the torque per radius twist

i.e, k = T / q = GJ / L

Power Transmitted by a shaft : If T is the applied Torque and w is the angular velocity of the shaft, then the power transmitted by the shaft is

$$P = T.\omega = \frac{2\pi NT}{60} = \frac{2\pi NT}{60.10^3} \text{kw}$$

where N= rpm

What is Torsional Oscillation?

A body suspended by a thread or wire which twists first in one direction and then in the reverse direction, in the horizontal plane is called a torsional pendulum.The first torsion pendulum was developed by Robert Leslie in 1793.

A simple schematic representation of a torsion pendulum is given below,

The period of oscillation of torsion pendulum is given as,

$$T = 2\pi\sqrt{\frac{I}{C}} \dots\dots\dots\dots (1)$$

Where I=moment of inertia of the suspended body; C=couple/unit twist

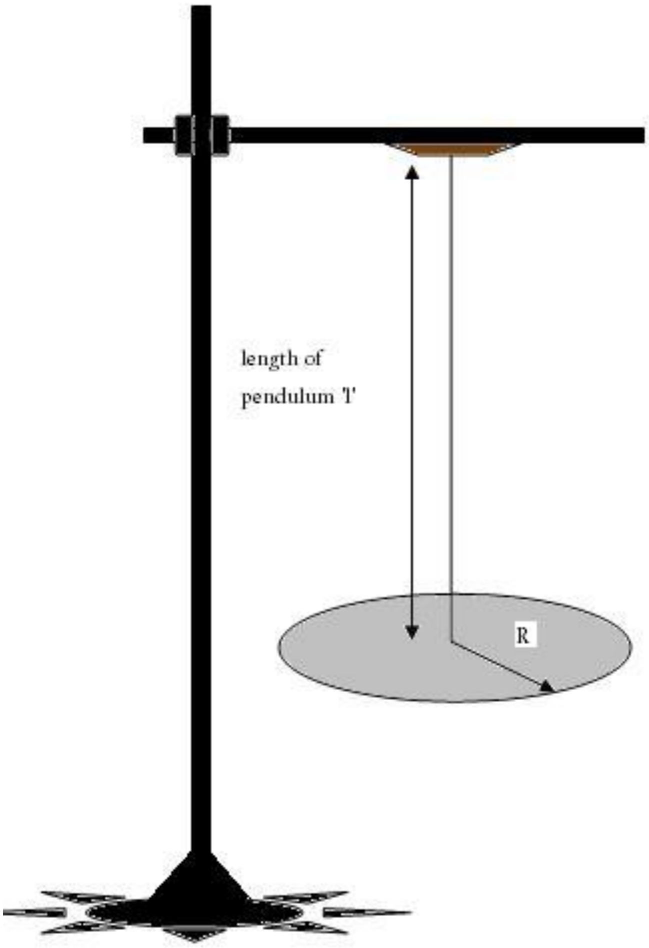
But we have an expression for couple per unit twist C as,

$$C = \frac{1}{2}\frac{\pi n r^4}{l} \dots\dots\dots\dots [2]$$

Where l =length of the suspension wire; r=radius of the wire; n=rigidity modulus of the suspension wire

Substituting (2) in (1) and squaring,we get an expression for rigidity modulus for the suspension wire as

$$n = \frac{8\pi I l}{r^4 T^2} \dots\dots\dots\dots (A)$$



We can use the above formula directly if we calculate the moment of inertia of the disc,I as (1/2)MR^2.

Now,let I_0 be the moment of inertia of the disc alone and I_1 & I_2 be the moment of inertia of the disc with identical masses at distances d_1&d_2 respectively.If I_1 is the moment of inertia of each identical mass about the vertical axis passing through its centre of gravity, then

$$I_1 = I_0 + 2\ I^1 + 2md_1{}^2 \dots\dots\dots\dots (3)$$

$$I_2 = I_0 + 2I^1 + 2md_2{}^2 \dots\dots\dots\dots (4)$$

$$I_2 - I_1 = 2m(d_2{}^2 - d_1{}^2) \dots\dots\dots (5)$$

But from equation (1) ,

$$T_0{}^2 = 4\pi^2 \frac{I_0}{C} \dots\dots\dots\dots\dots\dots\dots\dots (6)$$

$$T_1{}^2 = 4\pi^2 \frac{I_1}{C} \dots\dots\dots\dots\dots\dots\dots\dots (7)$$

$$T_2{}^2 = 4\pi^2 \frac{I_2}{C} \dots\dots\dots\dots\dots\dots\dots\dots (8)$$

$$T_2{}^2 - T_1{}^2 = \frac{4\pi^2}{C}(I_2 - I_1) \dots\dots\dots (9)$$

Where T_0,T_1,T_2 are the periods of torsional oscillation without identical mass,with identical pass at position d_1,d_2 respectively.

Dividing equation (6) by (9) and using (5),

$$\frac{T_0{}^2}{(T_2{}^2 - T_1{}^2)} = \frac{I_0}{[I_2 - I_1]} = \frac{I_0}{2m(d_2{}^2 - d_1{}^2)} \dots\dots\dots (10)$$

Therefore,The moment of inertia of the disc,

$$I_0 = 2m\left(d_2{}^2 - d_1{}^2\right)\frac{T_0{}^2}{\left(T_2{}^2 - T_1{}^2\right)} \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Now substituting equation (2) and (5) in (9),we get the expression for rigidity modulus 'n' as,

$$n = \frac{16\pi m\left(d_2{}^2 - d_1{}^2\right)}{r^4}\left(\frac{l}{T_2{}^2 - T_1{}^2}\right) \ldots\ldots\ldots\ldots (12)$$

Applications of Torsional Pendulum:

1.The working of " Torsion pendulum clocks " (shortly torsion clocks or pendulum clocks), is based on torsional oscillation.

2.The freely decaying oscillation of Torsion pendulum in medium(like polymers),helps to determine their characteristic properties.

3.New researches, promising the determination of frictional forces between solid surfaces and flowing liquid environments using forced torsion pendulums.

Young's Modulus by Searle's Method

Consider a wire of length LL and diameter dd. Let length LL increases by an amount ll when wire is pulled by a longitudinal force FF. The Young's modulus of the material of a wire is given by,

Y=StressStrain=F/Al/L=4FLπd

Y=StressStrain=F/Al/L=4FLπd

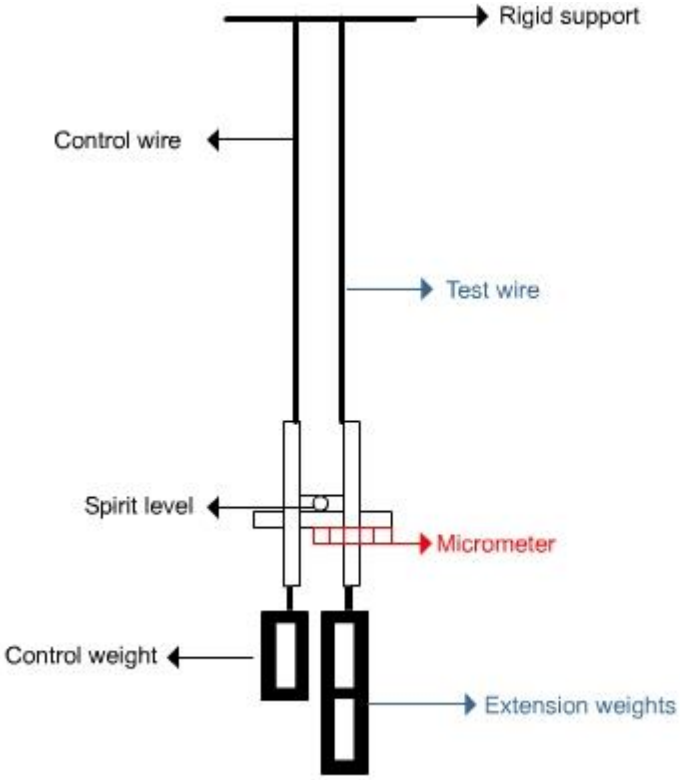
In Searle's method, the parameters Lis measured by a scale, d is measured by a screw gauge, ll is measured by a Micrometer or Vernier scale, and F is specified weight. Differentiate the expression for Yto get the error in measured Y,

ΔY=ΔL+2Δd+Δll,ΔYY=ΔLL+2Δdd+Δll,

where ΔL, Δd, and Δl are errors in measurement of L, d, and l, respectively. Generally, these errors are given by least count of the measuring instrument.

Experimental Setup and Procedure

The Searle's apparatus consists of two wires (control wire and test wire) of equal length attached to a rigid support. Both control and test wires are attached to the other ends by a horizontal bar supporting a spirit level. The bar is hinged to the control wire so that when the test wire is extended due to the addition of weights on the side of the test wire, the spirit level is tilted by a small amount. We can remove any tilt of the spirit level and restore it to the horizontal position by turning the screw of a micrometer, which is positioned on the test wire side and making the bar mounted spirit level travel in the desired direction.



The test procedure is,

1. Measure the initial length L of the wire by a scale and diameter d of the wire by a screw gauge.
2. Adjust the spirit level so that it is in the horizontal position by turning the micrometer. Record the micrometer reading to use it as the reference reading.
3.
4. Load the test wire with a further weight. The spirit level is tilted due to elongation of test wire.

5. Adjust the micrometer screw to restore the spirit level into the horizontal position. Subtract the first micrometer reading from the second micrometer reading to obtain the extension ll of the test wire.
6. Calculate stress and strain from the formulae.

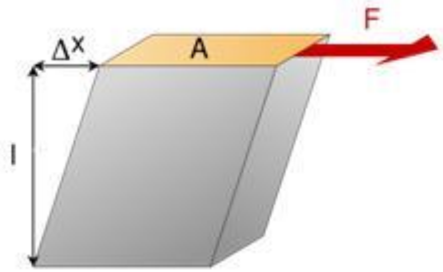
Repeat above steps by increasing load on the test wire to obtain more values of stresses and strains.

Plot the above values on stress strain graph; it should be a straight line. Determine the value of the slope Y.

Determination of Rigidity modulus by static torsion

Shear modulus, or rigidity modulus *n* is defined as the ratio of stress *F/A* to strain *Δx/l* when a shearing force *F* is applied to a rigid block of height *l* and area *A*. *Δx* is the deformation of the block, and

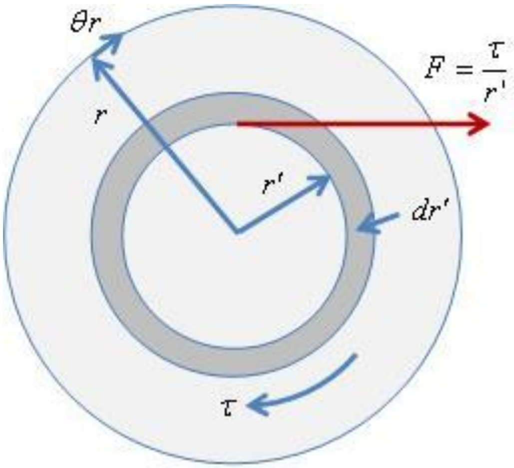
$$n = \frac{F/A}{\Delta x/l}$$



This is similar to what happens when a torque *τ* is applied to a rigid rod of length *l* and radius *r*. Looking at the cross-section of the rod, consider a ring of width *dr'* at radius *r'* , which will have area *2πr'dr'*, with force applied tangentially. The weighted average force over the cross-sectional area *A* of the rod is then

$$\frac{1}{A}\int_0^r \frac{\tau}{r'} 2\pi r' dr' = \frac{1}{\pi r^2} 2\pi r \tau = \frac{2\tau}{r}$$

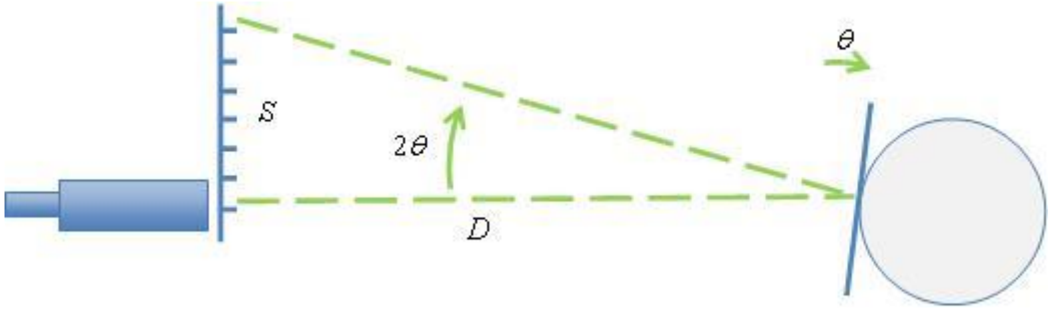
If the torque deforms the rod by twisting it through a small angle θ, the deformation distance (corresponding to Δx) at the outside edge of the rod is approximately θr. The definition of the rigidity modulus n becomes



$$n = \frac{F/A}{\Delta x/l} = \frac{\frac{2\tau}{r}/\pi r^2}{\theta r/l} = \frac{2\tau l}{\pi r^4 \theta}$$

In our apparatus the torque τ is supplied by hanging a weight of mass M from a string wound round a pulley of radius R, so $\tau = MgR$ and our definition of rigidity modulus $n$becomes

$$n = \frac{2MgR}{\pi r^4}\frac{l}{\theta}$$



Now suppose we mount a small mirror on the rod at distance l from its fixed end, and look at a centimeter scale in the mirror through an adjacent telescope, both at distance D from the mirror. When the rod deforms and the mirror rotates through a small angle θ , we look at a point on the scale a distance approximately $S=2D\theta$ from the original point, which was aligned with the telescope. We can measure D and S and substitute $\theta = S/2D$ in our definition of rigidity modulus n, to get

$$n = \frac{4MgR}{\pi r^4}\frac{lD}{S}$$

Application:

Engineers consider the value of shear modulus when selecting materials for shafts, which are rods that are subjected to twisting torques.

POSSIBLE QUESTIONS

PART B - (2 marks)

1. Define Elasticity

2. Define strain

3. Define Rigidity modulus

4. Define Young’s modulus

5. Define Bulk modulus

6. Define Poisson’s Ratio.

7. State Hooke’s law

PART C - (6 marks)

1. Derive the expression for Elastic moduli and Relation between elastic constants.

2. Determine the Rigidity modulus and moment of inertia by Searles method .

3. Determination of Rigidity modulus by static torsion.

4. Explain Twisting couple on a cylinder.

5. Explain Work done in stretching & work done in twisting a wire.

6. Derive the expression for Poisson's ratio in terms of elastic constants

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT II :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

QUESTION	opt1	opt2	opt3	opt4	Answer
___________ law in simple says that strain is directly proportional to stress.	Kepler's	Hooke's	Newton's	Stoke's	Hooke's
__________ is defined as the restoring force per unit area.	strain	stress	slip	dislocation	stress
The ratio of change in length to original length is called __________.	shearing strain	volume strain	tensile strain	longitudinal strain	longitudinal strain
The property of a body to regain its original state on removal of the applied forces is called __________.	plasticity	elasticity	Pseudoelasticity	viscoelasticity	elasticity
The ratio of the change in any dimension to its original value is called __________.	strain	stress	slip	dislocation	strain
The ratio of change in angle to original angle is called __________.	longitudinal strain	shearing strain	tensile strain	volume strain	shearing strain
The ratio of change in volume to original volume is called _________.	longitudinal strain	shearing strain	tensile strain	volume strain	volume strain
_________ is defined as the ratio of longitudinal stress to longitudinal strain within elastic limits.	Young's modulus	rigidity modulus	bulk modulus	dynamic modulus	Young's modulus
_________ is defined as the ratio of tangential stress to shearing strain.	Young's modulus	rigidity modulus	bulk modulus	dynamic modulus	Rigidity modulus
_________ is defined as the ratio of volume stress to volume strain.	Young's modulus	rigidity modulus	bulk modulus	dynamic modulus	Bulk modulus
Mathematically, Hooke's law states that F = ______________	- kx	kx	k/x	k/x	- kx

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT II :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

____________ exhibits linear-elastic behavior in most engineering applications.	Steel	Iron	carbon	chromium	Steel
__________ is generally regarded as a "non-hookean" material because its elasticity is stress dependent and sensitive to temperature and loading rate.	Steel	rubber	iron	carbon	rubber
Most materials have Poisson's ratio values ranging between ____________.	0.0 and 0.5	0.0 and 0.1	0.0 and 0.05	0.5 and 1.0	0.0 and 0.5
Rubber has a Poisson ratio of nearly ____________.	0.5	0.1	0.2	0.3	0.5
A perfectly incompressible material deformed elastically at small strains would have a Poisson's ratio of exactly __________.	0.2	0.3	0.4	0.5	0.5
A beam is a ____________ that is capable of withstanding load primarily by resisting bending.	structural element	inline element	interface element	linear element	structural element
A ____________ is a beam supported on only one end.	cantilever	pile	pillar	stay	cantilever
______________ are the most ubiquitous structures in the field of microelectromechanical systems (MEMS).	Cantilevered beams	piles	pillars	stays	Cantilevered beams
An early example of a MEMS cantilever is the _________, an electromechanical monolithic resonator.	Resonistor	Sensor	Actuator	Accelerometers	Resonistor
___________ cantilevers are commonly fabricated from silicon (Si), silicon nitride	MEMS	AFM	deck	roof	MEMS

(SiN), or polymers.					
Without cantilever transducers, ________________ would not be possible.	atomic force microscopy	scanning electron microscopy	transmission electron microscopy	scanning tunneling microscopy	atomic force microscopy
_______________ cantilevers are also finding application as radio frequency filters and resonators.	MEMS	AFM	deck	roof	MEMS
The _____________ cantilevers are commonly made as unimorphs or bimorphs.	MEMS	AFM	deck	roof	MEMS
In solid mechanics, ___________ is the twisting of an object due to an applied torque.	torsion	stress	strain	shear	torsion
_________ modulus describes the material's response to linear strain.	Young's	shear	bulk	dynamic	Young's
The _________ modulus describes the material's response to uniform pressure.	Young's	shear	bulk	dynamic	bulk
The ___________ modulus describes the material's response to shearing strains.	Young's	shear	bulk	dynamic	shear
______________ materials such as wood and paper exhibit differing material response to stress or strain when tested in different directions.	Anisotropic	isotropic	bi isotropic	quasi isotropic	Anisotropic
The _________ modulus of metals measures the resistance to glide over atomic planes in	Young's	shear	bulk	dynamic	shear

crystals of the metal.					
In solid mechanics, ___________ modulus is also known as the tensile modulus.	Young's	shear	bulk	dynamic	Young's
The __________ modulus calculates the change in the dimension of a bar made of an isotropic elastic material under tensile or compressive loads.	Young's	shear	bulk	dynamic	Young's
_____________ modulus is not always the same in all orientations of a material.	Young's	shear	bulk	dynamic	Young's
The _________ modulus of a substance measures the substance's resistance to uniform compression.	Young's	shear	bulk	dynamic	bulk
It is possible to measure the __________ modulus using powder diffraction under applied pressure.	Young's	shear	bulk	dynamic	bulk
The inverse of the bulk modulus gives a substance's __________.	compressibility	Susceptibility	permeability	Permittivity	compressibility
The _________ modulus of an object is defined as the slope of its stress-strain curve in the elastic deformation region.	elastic	Young's	shear	bulk	elastic
_________ is the force causing the deformation divided by the area to which the force is applied.	stress	strain	deformation	bending	stress

Enable | Enlighten | Enrich
KARPAGAM
ACADEMY OF HIGHER EDUCATION
(Deemed to be University)
(Established Under Section 3 of UGC Act, 1956)

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT II :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

__________ is the ratio of the change caused by the stress to the original state of the object.	stress	strain	deformation	bending	strain
The ___________ modulus is an extension of Young's modulus to three dimensions.	Young's	shear	bulk	dynamic	bulk
Two soap bubbles have radii in the ratio of 4:3. What is the ratio of work done to below these bubbles?	4;3	16:09	9:16	3:04	16:09
At critical temperature, the surface tension of a liquid	Is zero	Is infinity	Is the same as that at any other temperature	Can not be determined	Is zero
Out of the following. Which one is not an example of capillary action?	Ploughing of the field	Absorption of ink in a blotting paper	Floating of wood on the surface of water	Rise of oil in the wick of a lam	Floating of wood on the surface of water
A capillary tube is placed vertically in a liquid. If the cohesive force is less than the adhesive force, then	The meniscus will be convex upwards	The liquid will wet the solid	The angle of contact will be obtuse	The liquid will drip in the capillary tube	The liquid will wet the solid
If the surface of a liquid is plane, then the angle of contact of the liquid with the walls of container is	Acute angle	Obtuse angle	90°	0°	0°
The surface of water in contact with glass wall is	Plane	concave	convex	curved	concave

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT II :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

A liquid is kept in a glass vessel. If the liquid solid adhesive force between the liquid and the vessel is very weak as compared to the cohesive force in the liquid, then the shape of the liquid surface near the solid should be	Concave	Convex	Horizontal	Almost vertical	Convex
The height of a liquid in a fine capillary tube	Increases with an increase in the density of a liquid	Decreases with a decrease in the diameter of the tube	Decreases with an increase in the surface tension	Increases as the effective value of acceleration due to gravity is decreased	Increases as the effective value of acceleration due to gravity is decreased
When a soap bubble is charged	It contracts	It expands	It does not undergo any change in size	None of these	It expands
If common salt is dissolved in water, then the S.T. of salt water is	Increased	Decreased	Not changed	First decreases and then increases	Increased
In a capillary tube, fall of liquid is possible when angle of contact is	Acute angle	Obtuse angle	Obtuse angle	0°	Obtuse angle
Water can rise up to a height of 12 cm in a capillary tube. If the tube is lowered to keep only 9 cm above the water level then the water at the upper end of the capillary will	Overflow	From a convex surface	From a flat surface	From a concave surface	From a flat surface
A square frame of length L is immersed in soap solution and taken out. The force	TL	2TL	4TL	8TL	8TL

experienced by the square plate is					
A drop of oil is placed on the surface of water. Which of the following statement is correct?	It will remain on it as a sphere	It will spread as a thin layer	It will partly be as spherical droplets and partly as thin film	It will float as distorted drop on the water surface.	It will spread as a thin layer
Plants get water through the roots because of	Capillarity	Viscosity	Gravity	Elasticity	Capillarity
The pressure just below the meniscus of water	Is greater than just above it	Is less than just above it	Is same as just above it	Is always equal to atmospheric pressure.	Is less than just above it
Potential energy of a molecule on the surface of a liquid is as compare to another molecule inside of the liquid is	more	less	medium	zero	more
Rain drops are spherical because of	Gravitational force	Surface tension	Air resistance	Low viscosity of water	Surface tension
For a water does not wet a glass rod, the angle of contact is	Obtuse	Acute	0°	90°	Obtuse

UNIT III

SYLLABUS

Surface tension: Surface tension and Surface energy- Pressure difference across a spherical surface- Pressure difference across a curved surface -- Quincke's method, Angle of contact - Angle of contact for water in a glass - Vapour pressure over a flat and curved surface - Variation of Surface tension with temperature - Jaegar's method.

Surface tension

Surface tension is measured as the energy required to increase the surface area of a liquid by a unit of area. The surface tension of a liquid results from an imbalance of intermolecular attractive forces, the **cohesive forces** between molecules:

- A molecule in the bulk liquid experiences cohesive forces with other molecules in all directions.
- A molecule at the surface of a liquid experiences only net inward cohesive forces.

Adhesive Forces

Forces of attraction between a liquid and a solid surface are called **adhesive forces**. The difference in strength between cohesive forces and adhesive forces determine the behavior of a liquid in contact with a solid surface.

- Water does not wet waxed surfaces because the cohesive forces within the drops are stronger than the adhesive forces between the drops and the wax.
- Water wets glass and spreads out on it because the adhesive forces between the liquid and the glass are stronger than the cohesive forces within the water.

Surface tension is a phenomenon in which the surface of a liquid, where the liquid is in contact with gas, acts like a thin elastic sheet. This term is typically used only when the liquid surface is in contact with gas (such as the air). If the surface is between two liquids (such as water and oil), it is called "interface tension."

Surface tension is also viewed as the result of forces acting in the plane of the surface and tending to minimize its area. On this basis, surface tension is often expressed as an amount of force exerted in the surface perpendicular to a line of unit length. The unit then isnewtons per metre, which is equivalent to joules per square metre.

Causes of Surface Tension

Various intermolecular forces, such as Van der Waals forces, draw the liquid particles together.

Along the surface, the particles are pulled toward the rest of the liquid, as shown in the picture to the right.

Surface tension (denoted with the Greek variable gamma) is defined as the ratio of the surface force F to the length d along which the force acts:

gamma = F / d

Units of Surface Tension

Surface tension is measured in SI units of N/m (newton per meter), although the more common unit is the cgs unit dyn/cm (dyne per centimeter).

In order to consider the thermodynamics of the situation, it is sometimes useful to consider it in terms of work per unit area. The SI unit, in that case, is the J/m^2(joules per meter squared). The cgs unit is erg/cm^2.

These forces bind the surface particles together. Though this binding is weak - it's pretty easy to break the surface of a liquid after all - it does manifest in many ways.

Examples of Surface Tension

Drops of water. When using a water dropper, the water does not flow in a continuous stream, but rather in a series of drops.

The shape of the drops is caused by the surface tension of the water. The only reason the drop of water isn't completely spherical is because of the force of gravity pulling down on it. In the absence of gravity, the drop would minimize the surface area in order to minimize tension, which would result in a perfectly spherical shape.

Insects walking on water. Several insects are able to walk on water, such as the water strider. Their legs are formed to distribute their weight, causing the surface of the liquid to become depressed, minimizing the potential energy to create a balance of forces so that the strider can move across the surface of the water without breaking through the surface. This is similar in concept to wearing snowshoes to walk across deep snowdrifts without your feet sinking.

Needle (or paper clip) floating on water. Even though the density of these objects is greater than water, the surface tension along the depression is enough to counteract the force of gravity pulling down on the metal object. Click on the picture to the right, then click "Next," to view a force diagram of this situation or try out the Floating Needle trick for yourself.

Anatomy of a Soap Bubble

When you blow a soap bubble, you are creating a pressurized bubble of air which is contained within a thin, elastic surface of liquid. Most liquids cannot maintain a stable surface tension to create a bubble, which is why soap is generally used in the process ... it stabilizes the surface tension through something called the Marangoni effect.

When the bubble is blown, the surface film tends to contract.

This causes the pressure inside the bubble to increase. The size of the bubble stabilizes at a size where the gas inside the bubble won't contract any further, at least without popping the bubble.

In fact, there are two liquid-gas interfaces on a soap bubble - the one on the inside of the bubble and the one on the outside of the bubble. In between the two surfaces is a thin film of liquid.

The spherical shape of a soap bubble is caused by the minimization of the surface area - for a given volume, a sphere is always the form which has the least surface area.

Pressure Inside a Soap Bubble

To consider the pressure inside the soap bubble, we consider the radius R of the bubble and also the surface tension, gamma, of the liquid (soap in this case - about 25 dyn/cm).

We begin by assuming no external pressure (which is, of course, not true, but we'll take care of that in a bit). You then consider a cross-section through the center of the bubble.

Along this cross section, ignoring the very slight difference in inner and outer radius, we know the circumference will be 2pi R. Each inner and outer surface will have a pressure of gamma along the entire length, so the total. The total force from the surface tension (from both the inner and outer film) is, therefore, 2gamma (2pi R).

Inside the bubble, however, we have a pressure p which is acting over the entire cross-section pi R^2, resulting in a total force of p(pi R^2).

Since the bubble is stable, the sum of these forces must be zero so we get:

2 gamma (2 pi R) = p(pi R ^{2})

or

p = 4 gamma / R

Obviously, this was a simplified analysis where the pressure outside the bubble was 0, but this is easily expanded to obtain the difference between the interior pressure p and the exterior pressure p_e:
p - p_e = 4 gamma / R

Pressure in a Liquid Drop

Analyzing a drop of liquid, as opposed to a soap bubble, is simpler. Instead of two surfaces, there is only the exterior surface to consider, so a factor of 2 drops out of the earlier equation (remember where we doubled the surface tension to account for two surfaces?) to yield:

$p - p_e = 2\ \text{gamma} / R$

Contact Angle

Surface tension occurs during a gas-liquid interface, but if that interface comes in contact with a solid surface - such as the walls of a container - the interface usually curves up or down near that surface. Such a concave or convex surface shape is known as a meniscus

The contact angle, theta, is determined as shown in the picture to the right.

The contact angle can be used to determine a relationship between the liquid-solid surface tension and the liquid-gas surface tension, as follows:

$\text{gamma}_{ls} = - \text{gamma}_{lg} \cos \text{theta}$

where

- gamma_{ls} is the liquid-solid surface tension
- gamma_{lg} is the liquid-gas surface tension
- theta is the contact angle

One thing to consider in this equation is that in cases where the meniscus is convex (i.e. the contact angle is greater than 90 degrees), the cosine component of this equation will be negative which means that the liquid-solid surface tension will be positive.

If, on the other hand, the meniscus is concave (i.e. dips down, so the contact angle is less than 90 degrees), then the cos theta term is positive, in which case the relationship would result in a negative liquid-solid surface tension!

What this means, essentially, is that the liquid is adhering to the walls of the container and is working to maximize the area in contact with solid surface, so as to minimize the overall potential energy.

Capillarity

Another effect related to water in vertical tubes is the property of capillarity, in which the surface of liquid becomes elevated or depressed within the tube in relation to the surrounding liquid. This, too, is related to the contact angle observed.

If you have a liquid in a container, and place a narrow tube (or capillary) of radiusr into the container, the vertical displacement y that will take place within the capillary is given by the following equation:

y = (2 gamma $_{lg}$ cos theta) / (dgr)

where

- y is the vertical displacement (up if positive, down if negative)
- gamma$_{lg}$ is the liquid-gas surface tension
- theta is the contact angle
- d is the density of the liquid
- g is the acceleration of gravity
- r is the radius of the capillary

surface energy

The energy associated with the intermolecular forces at the interface between two media the surface energy per unit area equals the surface tension — called also free surface energy.

Surface energy = Energy/Area= Newton/m= Joule/m^2

Excess pressure inside a liquid drop and a bubble:

Consider a small water drop. The drop doesn't collapse because of the surface tension which is given by

σ = F/L

where,
σ is the surface tension of the liquid

F is the force per unit length

L is the line over which the force acts

If the drop doesn't collapse, it implies that the pressure within the drop is greater than that outside. The extra pressure (p) is given by subtracting the outside pressure (p_o) from the inside pressure (p_i),

$p_o = p_i – p_o$

Outside Force = p x surface area of the drop

$(p_i – p_o) \times 4\pi r^2$

where,
r is the radius of the drop

To satisfy the usual tendency for increasing surface area,

$dW = \text{Outside Force} = (p_i – p_o) \times 4\pi r^2.dr$

Work done by the excess pressure is stored in the form of potential energy.
Increase in P.E.

= surface tension x increase in surface area.

$= \sigma \times [4\pi(r + dr)^2 – 4\pi r^2]$

$= \sigma \times 8\pi r.dr$ (after neglecting extremely small terms)

dW = increase in P.E.

This implies that,

$(p_i – p_o) \times 4\pi r^2.dr = \sigma \times 8\pi r.dr$

$(p_i – p_o) = 2\sigma/r$

$p = 2\sigma/r$

For a bubble have two free surfaces, like soap bubles,

$p = 4\sigma/r$

Pressure difference across a liquid surface

If the free surface of a liquid is plane, then the surface tension acts horizontally (Fig. a). It has no component perpendicular to the horizontal surface. As a result, there is no pressure difference between the liquid side and the vapour side.

If the surface of the liquid is concave (Fig. b), then the resultant force R due to surface tension on a molecule on the surface act vertically upwards. To balance this, an excess of pressure acting downward on the concave side is necessary. On the other hand if the surface is convex (Fig. c), the resultant R acts downward and there must be an excess of pressure on the concave side acting in the upward direction.

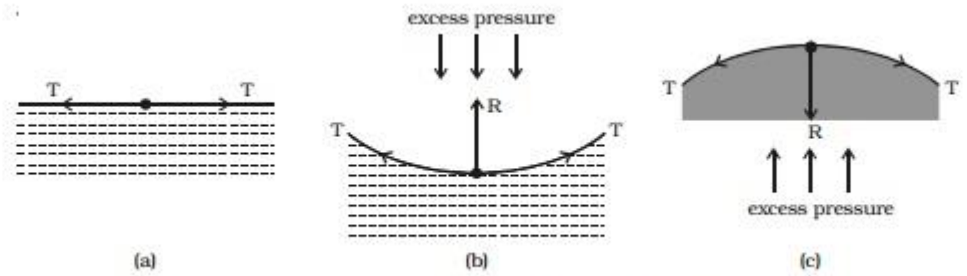


Fig. Excess of pressure across a liquid surface

Thus, there is always an excess of pressure on the concave side of a curved liquid surface over the pressure on its convex side due to surface tension.

Excess pressure inside a liquid drop

Consider a liquid drop of radius r. The molecules on the surface of the drop experience a resultant force acting inwards due to surface tension. Therefore, the pressure inside the drop must be greater than the pressure outside it. The excess of pressure P inside the drop provides a force acting outwards perpendicular to the surface, to balance the resultant force due to surface tension. Imagine the drop to be divided into two equal halves. Considering the equilibrium of the upper hemisphere of the drop, the upward force on the plane face ABCD due to excess pressure P is $P \pi r^2$ (Fig.).

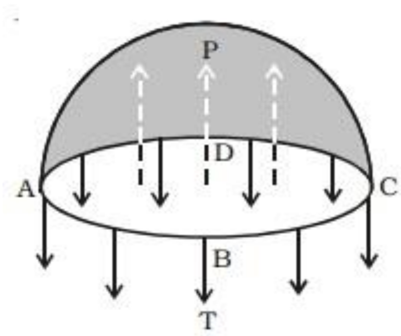


Fig. Excess pressure inside a liquid drop

If T is the surface tension of the liquid, the force due to surface tension acting downward along the circumference of the circle ABCD is T 2πr.
At equilibrium, $P\pi r^2 = T\,2\pi r$
$P = 2T/r$

Excess pressure inside a soap bubble

A soap bubble has two liquid surfaces in contact with air, one inside the bubble and the other outside the bubble. Therefore the force due to surface tension = 2 � 2πrT

∴ At equilibrium, P πr 2 = 2 � 2πrT

$P=4T/r$

Thus the excess of pressure inside a drop is inversely proportional to its radius i.e $P \propto 1/r$. As $P \propto 1/r$. the pressure needed to form a very small bubble is high. This explains why one needs to blow hard to start a balloon growing. Once the balloon has grown, less air pressure is needed to make it expand more.

The Angle of Contact

The angle between the meniscus and the containing walls of a column of liquid measured from the vertical wall below the surface of the liquid to the position of the tangent to the meniscus at its point of contact with the wall.

When the free surface of a liquid comes in contact with a solid, it becomes curved near the place of contact. The free surface of water curves upward when it touches a vertical glass surface. On the other hand, the free surface of mercury curves downwards when it touches the vertical glass surface.

The angle between the tangent at the liquid surface at the point of contact and the solid surface inside the liquid is called the angle of contact for a given pair of solid and liquid. It is represented by θ

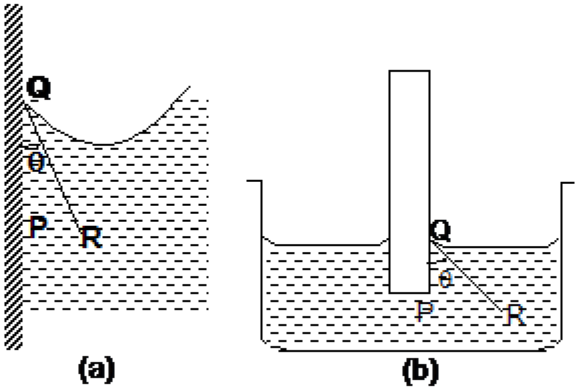


Fig. Angle of contact

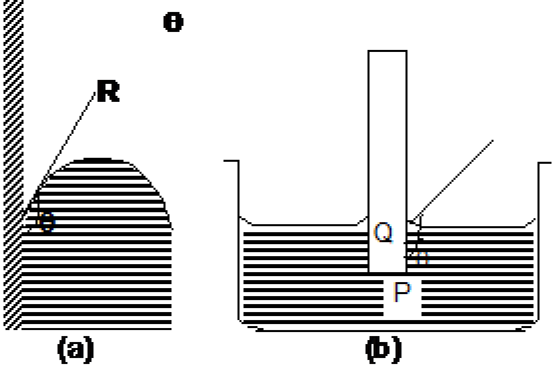


Fig. Angle of contact

The angle of contact remains the same whether the liquid is contained in a glass vessel or a glass plate is inserted in the liquid or a drop of given liquid rests on the glass.

In other words, the angle of contact does not depend on the manner of contact.

In Figs. , QR is the tangent drawn at the point of contact. The angle RQP which the tangent makes with the portion QP of the plate inside water is called the angle of contact.

When a liquid has concave meniscus, the angle of contact is acute. When it has a convex meniscus, the angle of contact is obtuse.

For pure water and perfectly clean glass, the angle of contact is 0°. For ordinary water and glass, it lies between 8° and 18°. For pure water and pure silver, the angle of contact is 90°. When pure water is put in pure silver vessel, the surface of water is flat.

The angle of contact of water with greased glass surface may be obtuse. The angle of contact of water with chromium may be as high as 160°. The angle of contact of mercury (exposed to air) with lass glass is nearly 138°.

Vapour pressure over a flat and curved surface

Consider the forces that are holding a water drop together for a flat and a curved surface. The forces on the hydrogen bonding in the liquid give a net inward attractive force to the molecules on the boundary between the liquid and the vapor. The net inward force, divided by the distance along the surface, is called **surface tension, σ**. Its units are N/m or J/m^2.

If the surface is curved, then the amount of bonding that can go on between any one water molecule on the surface and its neighbors is reduced. As a result, there is a greater probability that any one water molecule can escape from the liquid and enter the vapor phase. Thus, the evaporation rate increases. The greater the curvature, the greater the chance that the surface water molecules can escape. Thus, it takes less energy to remove a molecule from a curved surface than it does from a flat surface.

Kelvin Equation

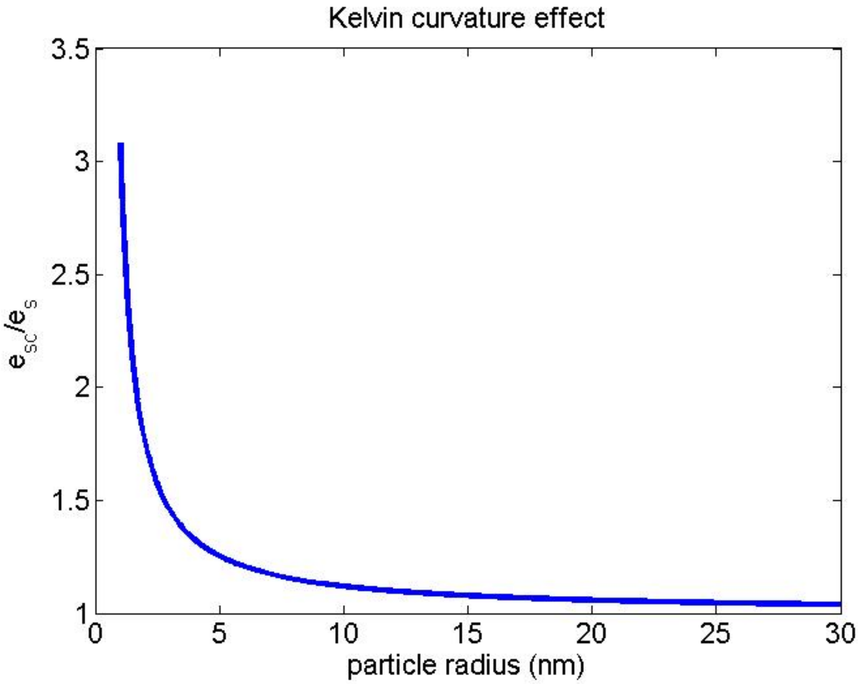
$$e_{sc}(T) = e_s(T) \cdot \exp\left(\frac{2\sigma}{n_L \cdot R^* \cdot T \cdot r}\right.$$

where e_{sc} is the equilibrium vapor pressure over *a* curved surface of pure water, e_s is the equilibrium vapor pressure over a flat surface of pure water, both of which are functions of temperature, althoughe_{sc} is also a function of the drop radius, n_L is the number of moles per volume of water (55.5 moles L^{-1}).R^* is the molar gas constant, σ is the water surface tension, and r is the radius of the drop.

$$\left(\frac{2\sigma}{n_L \cdot R^*}\right) = 3.3x10^{-7}\, m\, K^{-1}$$

Since the evaporation is much, much greater over a curved surface, the condensation must also be much, much greater in order to keep condensation = evaporation, which is required for saturation (i.e., equilibrium). Thus, the saturation vapor pressure over a curved surface is much greater than the saturation vapor pressure over a flat surface of pure water.

When we plot this equation, we get the following figure:



Dependence of ratio of the saturation vapor pressure over a curved surface to saturation vapor pressure over a flat surface on the drop radius.

The rapid increase in equilibrium vapor pressure for particles that have radii less than 10 nm. Of course, all small clusters of water vapor and CCN start out at this small size and grow by adding water.

The Kelvin Equation can be approximated by expanding the exponential into a series:

$$e_{sc}(T) = e_s(T)\cdot\left(1+\frac{2\sigma}{n_L\cdot R^*\cdot T\cdot r_d}\right) = e_s(T)\cdot\left(1+\frac{a_K}{r_d}\right), \quad where\ a_K = \frac{2\sigma}{n_L\cdot R^*\cdot T}$$ [5.8]

Variation of surface tension with temperature- **Jaeger's method**

A method of determining surface tension of a liquid in which one measures the pressure requiredt o cause air to flow from a capillary tube immersed in the liquid.

As might be expected, the coefficient of surface tension decreases with increasing temperature. It becomes zero at the critical temperature.

The variation of surface tension with temperature can be studied by Jaeger's method using the apparatus shown in Figure 1.

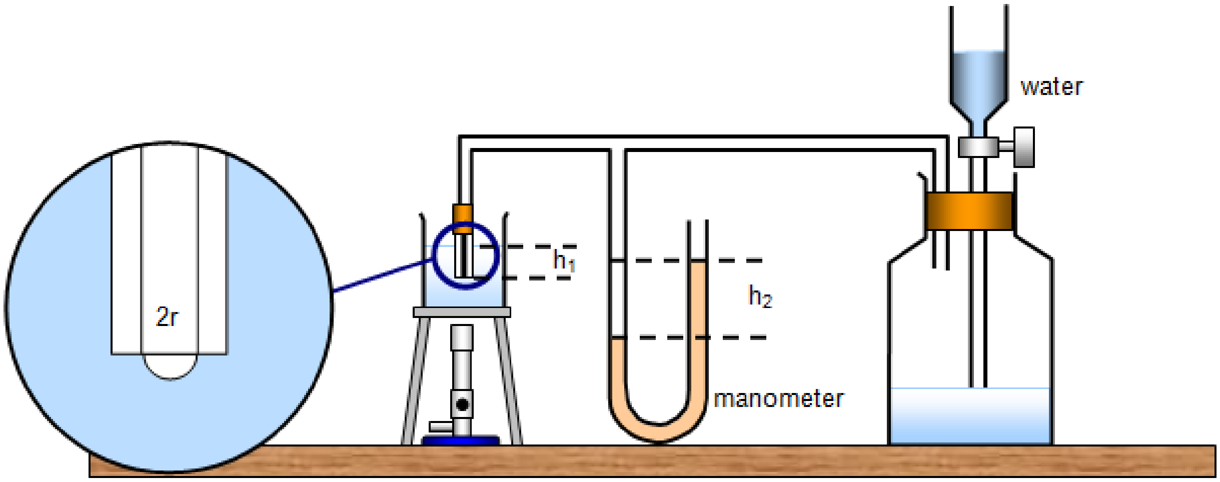


Figure 1

Water is allowed to drip slowly into the large flask, so forcing bubbles of air out of the capillary tube which dips into a beaker of water. The lower end of the capillary tube is a depth h_1 below the water surface. It can be shown that the bubble will break free from the end of the tube when its radius is equal to the internal radius of the tube.

Using a manometer the total pressure within the apparatus may be found; this is equal to the hydrostatic pressure ($h_1\rho_1 g$) plus the excess pressure within the air bubble due to the surface tension of the water. The total pressure is given by the equation:

$$h2r2g = h1r1g + 2T/r$$

where ρ_1 is the density of water, ρ_2 the density of the liquid in the manometer, r the radius of the capillary tube and h_2 the difference in levels within the manometer. The coefficient of surface tension of the water (T) can therefore be found.

Heating the water enables the value of T to be determined at a range of temperatures.

Surface tension: Surface tension and Surface energy- Pressure difference across a spherical surface- Pressure difference across a curved surface -- Quincke's method, Angle of contact - Angle of contact for water in a glass - Vapour pressure over a flat and curved surface - Variation of Surface tension with temperature - Jaegar's method.

POSSIBLE QUESTIONS

PART B - (2 marks)

1. Surface tension

2. Surface energy

3. Angle of contact

4.Write Kelvin Equation

5.Explain two applications of surface tension

6.List out the advantages of Jaeger's method.

7. List out the advantages of Quincke's method

PART C - (6 marks)

1. Explain and derive the expression for pressure difference across a spherical surface

2. Explain and derive the expression for pressure difference across a curved surface

3. Describe an experiment to determine the surface tension by Quincke's method

4. Explain and derive the expression for the vapour pressure over a flat and curved surface

5. Describe an experiment to determine the surface tension by Jaegar's method

6. Define Angle of contact and find out the Angle of contact for water in a glass

7. Describe an experiment to determine the surface tension of water by capillary rise method.

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT III :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Question	OPT 1	OPt2	OPT3	OPT4	Answer
Fundamental property of a liquid _________________	viscosity	surface tension	velocity	force	surface tension
Unit of surface tension ________________________	Nm^{-1}	Nm	m	N	Nm^{-1}
Surface tension is the ratio of force to ________	length	mass	density	volume	length
Molecular forces are of ___________ types	4	5	3	2	2
Range of molecular attraction is of the order ______________	1/10^{9}	1/10^{8}	1/10^{7}	1/10^{2}	1/10^{9}
The potential energy per unit area of the surface film is called as	surface tension	force	surface energy	none of theabove	surface energy
The surface of the liquid under tension behaves like_____________	plastic	stretched elastic membrane	rubber	none of theabove	stretched elastic membrane
Force of attraction between same substance is called________________	adhesive	cohesive	force	K.E	cohesive
Adhesive forcce is the force of attraction between ______________ substance	same	4	different	none of theabove	different
The angle of contact for most liquid and glass is __________	> 90	<90	90	180	<90
The angle of contact for mercury and glass is __________	180	240	140	360	140
Angle of contact independent of _________________________ solid to liquid surface	nature of solid	nature of liquid	angle of inclination	nature of gas	angle of inclination

If the free surface of the liquid is plane the resultant force due to S.T. on molecule is ___	upward	0	downward	middle	0
If the free surface of the liquid is concave the resultant force due to S.T. on molecule is ___	upward	0	downward	middle	upward
If the free surface of the liquid is plane the resultant force due to S.T. on molecule is ___	upward	0	downward	middle	downward
Jaegars method based on the principle that the pressure inside an air bubble in liquid is _________ than prressure of liquid	equal	smaller	greater	may be gteater or smaller	greater
Liquids are of _____________ types	2	3	4	6	2
Example for unassociated liquid__________	CCl_4	CCl	Cl	benzene and CCl_4	benzene and CCl_4
The surface tension of an unassociated liquid is found to _______________ with rise in temperature	increase	decrease	remains same	may be increase	decrease
The best relation connecting S.T. and temperature is __________	osmosis	Eotvos	none of these	viscosity	Eotvos
Etovos formula was later modified by _______________	ramsay	shields	both	Einstein	both
Waves having smaller wavelength than critical value is called _________________	osmosis	ripples	surface tension	Surface energy	ripples
Rayleigh's method depend on the measurement of the __________ of ripples	velocity	wavelength	length	mass	wavelength

Rayleigh's method perfectly clean liquid is placed in a large ________ dish	circle	flat	rectangle	square	flat
An electrically maintained tuning fork of large frequency about ______________is held in position above the liquid	200	100	300	40	100
In Rayleigh's method a dipper of polished _________________ is attached to lower prong	Ag	Al	Hg	Ag or Al	Ag or Al
Glass plate is arrange horizontallyon a small table with the help of __________ in quinckes method	prism	spirit level	screw	none of theabove	spirit level
When the S.T acts vertically upwards has no component along ______________	horizontal	vertical	diagonal	middle	horizontal
In quinckes method the angle of contact=______________	90-α	180-α	360-α	α	180-α
The apparatus used for the determination of surface tension of a liquid is	Oedometer	Stalagmometer	Consolidometer	Cappilary tube	Stalagmometer
Stalagmometer is cleaned to remove grease with the help of	Chromic acid	Sulphuric acid	Distilled water	Tartaric acid	Chromic acid
The surface tension of water at 250C is	90.0 dynes/cm	45.63 dynes/cm	82.5 dynes/cm	72.14 dynes/cm	72.14 dynes/cm
On increasing the temperature, the kinetic energy of the liquid molecules	Increases	Decreases	Remains constant	None of the mentioned	Increases
Shapes of drops of liquid are spherical because of	Viscosity	Conductivity	Absorption	Surface tension	Surface tension
On increasing the temperature, the surface tension of the liquid	Increases	Decreases	Remains constant	None of the mentioned	Decreases

Kerosene in the wick of lantern rises up because	Of negligible viscosity	The diffusion of the oil through the wick	Of the surface tension of the oil	Wick attracts the kerosene	Of the surface tension of the oil
At the boiling point of water, its surface tension	Is infinite	Is zero	Is the same as that at room temperature	Is maximum	Is zero
Nacl dissolved (added) in to water than it surface tension is	Increases	Decreases	Remains constant	None of the mentioned	Increases
Out of the following, which is not an example of capillary action	Absorption of ink in blotting paper	Floating of wood on water surface	Rise of oil wick of a lamp	Ploughing of the field	Floating of wood on water surface
The surface of water in contact with glass wall is	Plane	Convex	Concave	Either convex or concave	Concave
More liquid rises in a thin tube because of	Larger value of radius	Larger value of surface tension	Smaller value of S.T.	Smaller value of radius	Smaller value of radius
A spherical liquid drop of radius R is divided into eight equal droplets. If surface tension is T, then the work done in this process will be	2 p R2 T	3 p R2 T	4 p R2 T	2 p R T2	4 p R2 T
Excess pressure inside a soap bubble is	Inversely proportional to its radius	Directly proportional to its radius	Directly proportional to square roots of its radius	Independent of its radius	Inversely proportional to its radius
When a liquid rises inside a capillary tube, the weight of the liquid in the tube is supported	By atmospheric pressure	Partly by atmospheric pressure and partly by surface tension	Entirely by the force due to surface tension	Partly by the force due to surface tension	Entirely by the force due to surface tension

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT III :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

When two capillary tube of different diameters are dipped vertically the rise of the liquid is	Same in both the tubes	More in tube of larger diameter.	Less in tube of smaller diameter	More in the tube of smaller diameter	More in the tube of smaller diameter
Two drops of a liquid are merged to from a single drop. In this process	Energy is released	Energy is absorbed	Energy is remains constant	First ‘B’ then ‘C’	Energy is released
A liquid is kept in a glass beaker. Which molecules of the liquid have the highest potential energy?	Molecules at the bottom of the beaker	Molecules near the centre of the liquid	Molecules lying at half the depth of the liquid and touching the walls of the beaker	Molecules lying in the surface film	Molecules lying in the surface film
Van der Waals derived an expression for the ‘pressure defect’, if the observed pressure is denoted as ‘p’ and volume is denoted as ‘V’, the gas pressure in the bulk of the gas is equal to:	$p + a/V$; where a: constant for the particular gas	$p + a/(V^2)$; where a: constant for the particular gas	$p + (a \times V)$; where a: constant for the particular gas	$p + (a \times V^2)$; where a: constant for the particular gas	$p + a/(V^2)$; where a: constant for the particular gas
Which of the following contribute to the reason behind the origin of surface tension?	only cohesive forces	only adhesive forces	neither cohesive forces nor adhesive forces	both cohesive forces and adhesive forces	both cohesive forces and adhesive forces
f the surface tension is given as 0.0049 N/m, what will be the value of m (in mg) such that the wire remains in equilibrium?	0.1	1	10	100	100
The rise in the level of a liquid in a tube is h. If half the amount is poured outside, what will be the new rise in liquid level?	0	h/2	h	2h	h

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT III :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

For liquid fluids will capillarity rise (or fall) increase or decrease with rise in temperature.	Increase	Decrease	Remain constant	First decrease then increase	Decrease
The angle of contact for liquid on a solid surface is the angle between:	he tangent to the liquid surface at the point of contact and the solid surface	the tangent to the solid surface at the point of contact and the liquid surface		none of the above	he tangent to the liquid surface at the point of contact and the solid surface
When impurity is added to a liquid, its surface tension	decreases	first decreases and then increases	increases	remains same	decreases
If drops and bubbles do not collapse under the effect of gravity, it indicates that	pressure inside the drop is greater than outside	pressure inside the drop is lower than outside it	Surface tension is low	Viscosity is large	pressure inside the drop is greater than outside
By which phenomenon does the water rise from roots to leaves of plants?	Capillary action	Surface Tension	Bernoulli's Theorem	Viscosity	Capillary action
Water rises through a height h in a capillary tube of internal radius (r). if T is the S.T. of water, then the pressure difference between the liquid level in the container and the lowest point of the concave meniscus is	T/r	r/T	2T/r	remains same	2T/r
A number of small drops of mercury coalesce adiabatically to form a single drop. The temperature of drop	Increases	Is infinite	Remains unchanged	May decrease or increase depending upon size	May decrease or increase depending upon size
When there are no external forces, the shape of a liquid drop is determined by	Surface tension of the liquid	Density of liquid	Viscosity of liquid	Temperature of air only	Surface tension of the liquid

When the angle of contact between a solid and a liquid is 90°, then	Cohesive force > Adhesive force	Cohesive force < Adhesive force	Cohesive force = Adhesive force	Cohesive force >> Adhesive force	Cohesive force = Adhesive force

Viscosity: Streamline flow and Turbulent flow - Stoke's law - Stoke's method for the coefficient of viscosity - Poiseuille's method for the coefficient of viscosity - correction to Poiseuille's equation - Ostwald's viscometer - Variation of viscosity with temperature and pressure - Friction and Lubrication - Searle's viscometer - Viscosity of gases - Modification of Poiseuille's formula for gases - Rankine's method for determining the coefficient of viscosity of a gas.

Viscosity:

Viscosity is the quantity that describes a fluid's resistance to flow. Fluids resist the relative motion of immersed objects through them as well as to the motion of layers with differing velocities within them.

Viscosity is the property of a fluid by virtue of which an internal resistance comes into play when the liquid is in motion, and opposes the relative motion between its different layers. Thus, it is the resistance of a fluid to flow.

When liquid flows over flat surface, a backward viscous force acts tangentially to every layer. This force depends upon the area of the layer, velocity of the layer, and the distance of the layer from the surface.

$$F \alpha A \frac{\mathrm{d}v}{\mathrm{d}x}$$

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

Where η is the **coefficient of viscosity** of the liquid.

Factors affecting viscosity

Viscosity is first and foremost a function of material. The viscosity of water at 20 ℃ is 1.0020 millipascal seconds (which is conveniently close to one by coincidence alone). Most ordinary liquids have viscosities on the order of 1 to 1,000 mPa s, while gases have viscosities on the order of 1 to 10 μPa s. Pastes, gels, emulsions, and other complex liquids are harder to summarize. Some fats like butter or margarine are so viscous that they seem more like soft solids than like flowing liquids. Molten glass is extremely viscous and approaches infinite viscosity as it solidifies. Since the process is not as well defined as true freezing, some believe (incorrectly) that glass may still flow even after it has completely cooled, but this is not the case. At ordinary temperatures, glasses are as solid as true solids.

From everyday experience, it should be common knowledge that viscosity varies with temperature. Honey and syrups can be made to flow more readily when heated. Engine oil and hydraulic fluids thicken appreciably on cold days and significantly affect the performance of cars and other machinery during the winter months. In general, the viscosity of a simple liquid decreases with increasing temperature. As temperature increases, the average speed of the molecules in a liquid increases and the amount of time they spend "in contact" with their nearest neighbors decreases. Thus, as temperature increases, the average intermolecular forces decrease. The actual manner in which the two quantities vary is nonlinear and changes abruptly when the liquid changes phase.

Viscosity is normally independent of pressure, but liquids under extreme pressure often experience an increase in viscosity. Since liquids are normally incompressible, an increase in pressure doesn't really bring the molecules significantly closer together. Simple models of molecular interactions won't work to explain this behavior and, to my knowledge, there is no generally accepted more complex model that does. The liquid phase is probably the least well understood of all the phases of matter.

While liquids get runnier as they get hotter, gases get thicker. (If one can imagine a "thick" gas.) The viscosity of gases increases as temperature increases and is approximately proportional to the square root of temperature. This is due to the increase in the frequency of intermolecular collisions at higher temperatures. Since most of the time the molecules in a gas are flying freely through the void, anything that increases the number of times one molecule is in contact with another will decrease the ability of the molecules as a whole to engage in the coordinated movement. The more these molecules collide with one another, the more disorganized their motion becomes. Physical models, advanced beyond the scope of this book, have been around for nearly a century that adequately explain the temperature dependence of viscosity in gases. Newer models do a better job than the older models. They also agree with the observation that the viscosity of gases is roughly independent of pressure and density. The gaseous phase is probably the best understood of all the phases of matter.

Streamline flow

The flow of a liquid is said to be steady, streamline or laminar if every particle of the liquid follows exactly the path of its preceding particle and has the same velocity of its preceding particle at every point.

Let abc be the path of flow of a liquid and v1, v2 and v3 be the velocities of the liquid at the points a, b and c respectively. During a streamline flow, all the particles arriving at 'a' will have the same velocity v_1 which is directed along the tangent at the point 'a'. A particle arriving at b will always have the same velocity v_2. This velocity v_2 may or may not be equal to v_1. Similarly all the particles arriving at the point c will always have the same velocity v_3. In other words, in the streamline flow of a liquid, the velocity of every particle crossing a particular point is the same.

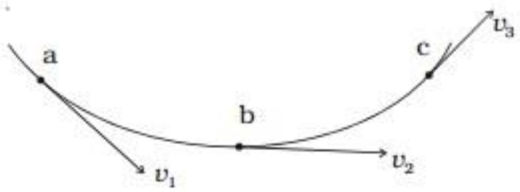


Fig. Steamline flow

The streamline flow is possible only as long as the velocity of the fluid does not exceed a certain value. This limiting value of velocity is called critical velocity.

Turbulent flow

When the velocity of a liquid exceeds the critical velocity, the path and velocities of the liquid become disorderly. At this stage, the flow loses all its orderliness and is called turbulent flow. Some examples of turbulent flow are :

(i) After rising a short distance, the smooth column of smoke from an incense stick breaks up into irregular and random patterns.

(ii) The flash - flood after a heavy rain.

Critical velocity of a liquid can be defined as that velocity of liquid upto which the flow is streamlined and above which its flow becomes turbulent.

Stoke’s Law

Stoke’s law was established by an English scientist Sir George G Stokes (1819-1903).

When a spherical body moves down through an infinite column of highly viscous liquid, it drags the layer of the liquid in contact with it. As a result, the body experiences a retarding force.

Then according to Stokes law, the viscous drag force,

$$F = 6\pi\eta r v\,,$$

where, r - Radius of the spherical body

v - Velocity of the spherical body

It gives the relationship between retarding force and velocity. When viscous force plus buoyant force becomes equal to force due to gravity, the net force becomes zero. The sphere then descends with a constant terminal velocity (v_t).

Now,

$$6\pi\eta r v = \frac{4}{3}\pi r^3(\rho - \sigma)g$$

where, ρ - Density of the liquid

σ - Density of the spherical body

Stoke's method for the coefficient of viscosity:

Real fluid has a certain amount of internal friction, which is called **viscosity**. Viscosity exists in both liquids and gases, and is essentially the frictional force between the adjacent layers of fluid as the layers move past one another. In liquids, viscosity appears due to the cohesive forces between the molecules. In gases, it arises from collisions between the molecules.

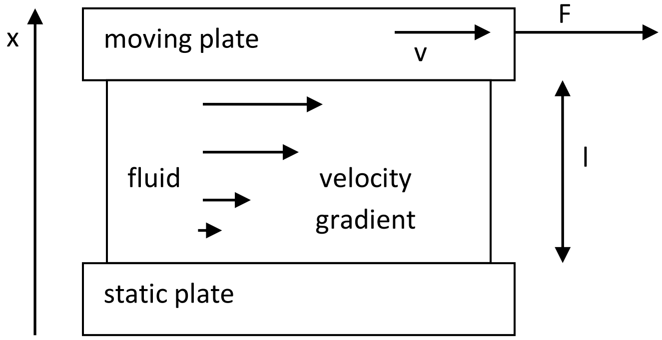


Fig. 1 Experiment setup for obtaining of viscosity coefficient

Different fluids posses different amounts of viscosity: syrup is more viscous than water; grease is more viscous than the engine oil; liquids in general are much more viscous than gases. The viscosity of different fluids can be expressed quantitatively by the coefficient of viscosity, η (the Greek lowercase letter eta), which could be defined using the following experiment. A thin layer of fluid is placed between two flat plates. One plate is static and the other is made to move (Fig. 1). The fluid directly in contact with each plate is held to the surface by the adhesive force between the molecules of the liquid and those of the plate. Thus the upper surface of the fluid moves with the same speed v as the upper plate, whereas the fluid in contact with the stationary plate remains stationary. The stationary layer of fluid retards the flow of the layer just above it, which in turn retards the flow of the next layer, and so on. Thus the velocity varies continuously from *0* to *v*, as shown. The increase in velocity divided by the distance over which the change is made - equal to *v/l* - is called the velocity gradient. To move the upper plate requires a force, which you can verify by moving a flat plate across the puddle of syrup on the table. For a given fluid, it is found that the required force *F*, is proportional to the area of a fluid in contact with each plate *A*, and to the speed *v*, but is inversely proportional to the separation *l*, of the plates, what comes down to the following relation: $F \propto vA/l$. For different fluids, the more viscous the fluid, the greater is the required force. Hence the proportionality constant for this equation is defined as the **coefficient of viscosity**, **η**:

$$\vec{F} = \eta \cdot \frac{A\vec{v}}{l}$$

Solving for η, we find $\eta = Fl/vA$. The SI unit for η is $N \cdot s/m^2 = Pa \cdot s$. In the CGS system, the unit is $dyne \cdot s/cm^2$ and the unit is called a poise (P). Viscosities are often given in centipoise[*] (

$1\text{cP} = 10^{-2}\,\text{P}$). Viscosity is a function of the temperature – for example a hot engine oil is less viscous than the cold one.

Determination of coefficient of viscosity of water by Poiseuille's flow method

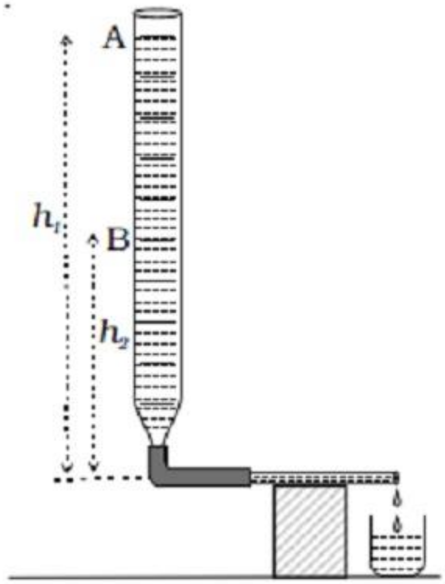


Fig. Determination of coefficient of viscosity by Poiseuille's flow

Poiseuille's equation

Poiseuille investigated the steady flow of a liquid through a capillary tube. He derived an expression for the volume of the liquid flowing per second through the tube.

Consider a liquid of co-efficient of viscosity η flowing, steadily through a horizontal capillary tube of length l and radius r. If P is the pressure difference across the ends of the tube, then the volume *V* of the liquid flowing per second through the tube depends on η, *r* and the pressure gradient p/l.

(i.e) $V \alpha \eta^x r^y (P/l)^z$

$V=k \eta^x r^y (P/l)^z$

where k is a constant of proportionality. Rewriting equation (1) in terms of dimensions,

$[L^3T^{-1}] = [ML^{-1} T^{-1}]^x [L]^y[ML^{-1}T^{-2} / L]^z$

Equating the powers of L, M and T on both sides we get x = -1, y = 4 and z = 1

Substituting in equation (1),

$V= kPr^4/ \eta l$

Experimentally k was found to be equal to π/ 8

$V = \pi Pr^4 / 8 \eta l$

This is known as Poiseuille's equation.

Determination of coefficient of viscosity of water by Poiseuille's flow method

A capillary tube of very fine bore is connected by means of a rubber tube to a burette kept vertically. The capillary tube is kept horizontal as shown in Fig.. The burette is filled with water and the pinch - stopper is removed. The time taken for water level to fall from A to B is noted. If V is the volume between the two levels A and B, then volume of liquid flowing per second is V/t. If l and r are the length and radius of the capillary tube respectively, then

$V/t = \pi Pr^4 / 8 \eta$

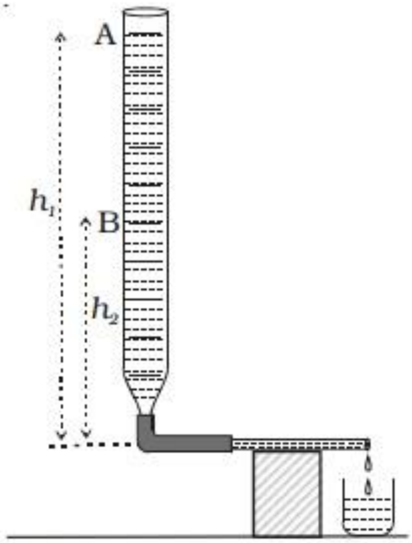


Fig. Determination of coefficient of viscosity by Poiseuille's flow]

If ρ is the density of the liquid then the initial pressure difference between the ends of the tube is $P_1 = h_1\rho g$ and the final pressure difference $P_2 = h_2\rho g$. Therefore the average pressure difference during the flow of water is P where

$P = (P_1 + P_2)/2$

$=[(h1+h2)/2]hg$

Substituting in equation (1), we get

$V/t = \pi h\rho gr^4 / 8l\eta$

or

$\eta = \pi h\rho gr^4 t / 8lV$

Viscosity - Practical applications

The importance of viscosity can be understood from the following examples.

(i) The knowledge of coefficient of viscosity of organic liquids is used to determine their molecular weights.

(ii) The knowledge of coefficient of viscosity and its variation with temperature helps us to choose a suitable lubricant for specific machines. In light machinery thin oils (example, lubricant oil used in clocks) with low viscosity is used. In heavy machinery, highly viscous oils (example, grease) are used.

The Ostwald viscometer

A viscometer (also called viscosimeter) is an instrument used to measure the viscosity of a fluid. For liquids with viscosities which vary with flow conditions, an instrument called a rheometer is used. Thus, a rheometer can be considered as a special type of viscometer.Viscometers only measure under one flow condition.

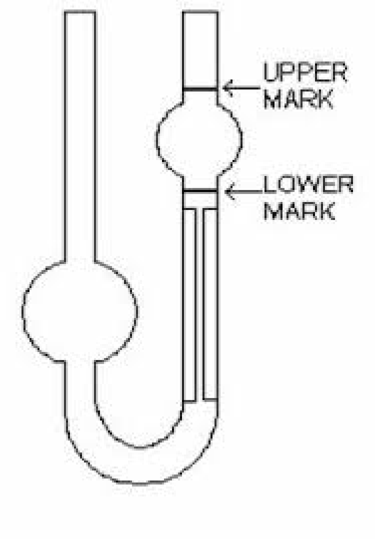
In general, either the fluid remains stationary and an object moves through it, or the object is stationary and the fluid moves past it. The drag caused by relative motion of the fluid and a surface is a measure of the viscosity. The flow conditions must have a sufficiently small value of Reynolds number for there to be laminar flow.

At 20.00 °C, the dynamic viscosity (kinematic viscosity × density) of water is 1.0038 mPa·s and its kinematic viscosity(product of flow time × factor) is 1.0022 mm^2/s. These values are used for calibrating certain types of viscometers.

These devices are also known as glass capillary viscometers or Ostwald viscometers, named afterWilhelm Ostwald. Another version is the Ubbelohde viscometer, which consists of a U-shaped glass tube held vertically in a controlled temperature bath. In one arm of the U is a vertical section of precise narrow bore (the capillary). Above there is a bulb, with it is another bulb lower down on the other arm. In use, liquid is drawn into the upper bulb by suction, then allowed to flow down through the capillary into the lower bulb. Two marks (one above and one below the upper bulb) indicate a known volume. The time taken for the level of the liquid to pass between these marks is proportional to the kinematic viscosity. Most commercial units are provided with a conversion factor, or can be calibrated by a fluid of known properties.

The time required for the test liquid to flow through a capillary of a known diameter of a certain factor between two marked points is measured. By multiplying the time taken by the factor of the viscometer, the kinematic viscosity is obtained.

Such viscometers can be classified as direct flow or reverse flow. Reverse flow viscometers have the reservoir above the markings and direct flow are those with the reservoir below the markings. Such classifications exist so that the level can be determined even when opaque or staining liquids are measured, otherwise the liquid will cover the markings and make it impossible to gauge the time the level passes the mark. This also allows the viscometer to have more than 1 set of marks to allow for an immediate timing of the time it takes to reach the 3rd mark, therefore yielding 2 timings and allowing for subsequent calculation of Determinability to ensure accurate results. The use of two timings in one viscometer in a single run is only possible if the sample being measured has Newtonian properties. Otherwise the change in driving head which in turn changes the shear rate will produce a different viscosity for the two bulbs.



Variation of viscosity with temperature and pressure

- Temperature affects the viscosity.

- The viscosity of liquids decreases when the temperature increases, while the viscosity of gases increases with the increase of temperature.

- This is due to reason that the viscous forces in a fluid are due to cohesive forces and molecular momentum transfer.

- In liquids the cohesive forces are more important than the molecular momentum transfer, due to closely packed molecules and with the increase in temperature, the cohesive forces decrease with the result of decreasing viscosity.

- But in gases, molecular momentum transfer is more important than the cohesive forces. Molecular momentum transfer increases with the increase in temperature and hence viscosity of a gas increases.

- For ordinary pressure, viscosity is independent of pressure and depends upon temperature only.
- The relation between viscosity and temperature for liquids and gases are:

(i) For liquids, $\mu = \mu_0 (1/ 1+ At + Bt^2)$

where μ = Viscosity of liquids at t^0C, in poise

μ_0 = Viscosity of liquids at 0^0C, in poise

A, B = Constants for the liquid

For water, $\mu_0 = 1.79 \times 10^{-3}$ poise, $A = 33.68 \times 10^{-3}$ and $B = 22.1 \times 10^{-3}$

The equation shows that with the increase of temperature, the viscosity decreases.

(ii) For gases, $\mu = \mu_0 + \alpha t - \beta t^2$

where for air $\mu_0 = 0.17 \times 10^{-6}$, $\alpha = 0.056 \times 10^{-6}$, $\beta = 0.1189 \times 10^{-9}$

The equation shows that with the increase of temperature, the viscosity increases.

FRICTION

Some times there is screeching sound while using a pulley or hand pump. Friction is a force. Whatever work we do, friction works opposite to our force. When we apply a force to move something, the friction opposes our force and there is no motion. When our force is greater than the friction force, the object starts moving. The parts where there is friction, they wear out fast. A smooth surface shows lots of uneven and rough surface under a microscope. When these rough parts rub on each other, it results in friction. Oiling and greasing reduces friction and wear & tear of parts. When there is dust or foreign particles in the area of contact, friction and wear & tear are high and rapid. To prevent this, we must first clean the friction area and put oil or grease there.

Webster defines friction as the "rubbing of one body against another," and as "resistance to relative motion between two bodies in contact." Friction can be beneficial. As we overcome this resistance to motion between two objects in contact, heat is generated. This heat is what warms our hands or starts a fire. Friction is also the principle behind the braking systems we find on our automobiles. In fact, once we were able to get a car moving there would be nothing to stop it without friction except the effects of gravity or other objects.

However, friction can also be our enemy. The heat generated as the result of friction can cause damage. Because contact is required to generate friction, wear in the areas of contact can occur. This can lead to material failures, overheating and the formation of wear deposits.

Although there are many ways to reduce friction, the most common way is through the use of a fluid or a semi-fluid material. The key characteristic of such materials is that they are not readily compressible. Fluid and semi-fluid materials allow us to minimize component contact or eliminate contact altogether. These fluids are commonly referred to as **lubricants**

Advantages of Friction

Friction is not always bad. Sometimes we require friction. For example: 1) While walking friction helps us. If we put oil on the floor, we will fall down due to slippery floor. We need friction to be able to walk. 2) It is commonly seen that in muddy area the wheel of a truck slips round and round because there is no friction between the tyres and ground. 3) Flour mill works because of friction between belt and wheel. 4) Bicycle can be stopped by putting on a brake, which works because there is friction. 5) When we tie a knot in a rope, it is the friction which holds the knot. Thus friction is useful to some extent but it will reduce the efficiency of work.

Factors affecting Friction

The intensity of friction depends on following factors: i) The area involved in friction. ii) The pressure applied on the surfaces. Force = Pressure ´ Area Frictional force will increase, if the area of contact will increase or if pressure applied on the surface increased.

Methods to reduce Friction

i) Polish the contact surface.

ii) Put oil or grease so that it fills in the small gaps of the flat parts. iii) Use ball bearings to reduce area of contact between rotating parts.

LUBRICATION

Following methods can be used to reduce friction: Oil is either thin or viscous. It depends upon SAE No. of oil. (SAE means Society of Automotive Engineers). If we use very viscous oil, it does not reach all the parts. Very thin oil will flows away easily and gets wasted. Grease is used in such cases. It is generally used around ball-bearing. Normal grease or oil is never used where there is high pressure, high temperature and high speed. Special lubricants are used in such cases. In cold season the oil becomes thick and in hot season it becomes thin. Therefore selection of lubrication also depends on the season. It is always advisable to refer operating manual of the equipment before selecting the lubricant.

TYPES OF LUBRICATION

There are three types of lubrication or lubrication situations that can exists between two surfaces separated by a lubricant. Whether or not these situations occur is dependent upon the ability of the lubricant to provide adequate protection to the moving surfaces.

Between two rolling and/or sliding surfaces, a thicker pressurized film can be generated by the movement of the surfaces (at their respective velocities). The non-compressible nature of this film separates the surfaces and prevents any metal-to-metal contact. The condition in which surfaces are completely separated by a continuous film of lubricating fluid is commonly referred to as **Hydrodynamic** or **Full Fluid Film Lubrication.**

Although hydrodynamic lubrication is the ideal lubrication scenario, in many situations it cannot be maintained. Hydrodynamic lubrication is limited by the lubricant's viscosity, the rotation speed or RPM and by component loading. An increase in speed or viscosity increases oil film thickness. An increase in load decreases oil film thickness.

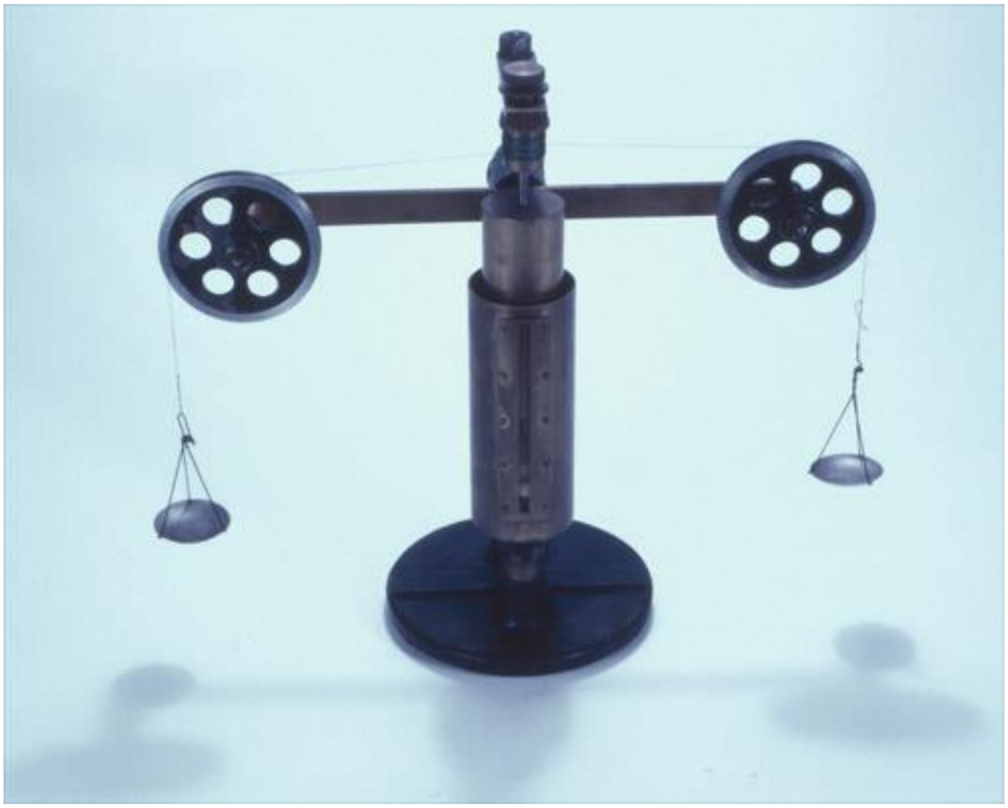
Boundary Lubrication is a condition in which the lubricant film becomes too thin to provide total surface separation. This may be due to excessive loading, low speeds or a change in the fluid's characteristics. In such a case, contact between surface asperities (or peaks and valleys) occurs. Friction reduction and wear protection is then provided via chemical compounds rather than through properties of the lubricating fluid.

The third type lubrication situation is known as **Elastohyrodynamic Lubrication** (EHD or EHL). This situation occurs as pressure or load increases to a level where the viscosity of the lubricant provides a higher shear strength than the metal surface that it supports. As a result, the metal surfaces deform elastically in preference to the highly pressurized lubricant. This increases the contact area and decreases the effectiveness of the lubricant.

To minimize friction, an effective lubricant should be able to handle the pressures and speeds of the surfaces it will separate.

Searle's Viscometer

Searle’s method involves a rotating inner cylinder partially immersed in the sample fluid contained in the outer cylinder. The inner cylinder is under a constant, known, torque provided by two weights connected to a spool on the inner cylinder via a pair of pulleys. When the weights are released, the angular velocity of the cylinder increases until it reaches a stage where the resistive force due to the viscosity of the fluid equals the force due to the weights and the angular velocity remains constant. By measuring this velocity, we can calculate the viscosity of the fluid. The apparatus which we used also featured a water jacket around the outer cylinder through which water of varying temperatures could be pumped. This helped us to maintain a constant temperature in the oil (avoiding the effects of frictional heating) and also enabled us to investigate the effects of temperature on the viscosity. The water was pumped through from an adequately large reservoir which could be heated using an electronic element.



Although it featured it own thermomenter it was imprecise for our 2 purposes and so the temperature was taken using a seperate electric thermometer. The reservoir was mixed by a paddle connected to an electric motor to ensure even heating. The depth of immersion of the inner cylinder can be adjusted by loosening a screw and working the outer cylinder up or down around the inner cylinder. The inner cylinder had a scale etched onto it calibrated in millimetres allowing us to easily obtain the correct depth. The baffle plate below the inner cylinder prevents the fluid in the area below from rotating with the cylinder and causing an unwanted whirlpool effect. All diameters were measured using calipers and masses were measured using the Sartorus balance in the level 2 laboratory. Because it is difficult to measure the outer cylinder width directly, the width was calculated by taking the diameter of the entire apparatus and substracting the width of the water jacket.

Viscosity of Gases

The viscosity of a gas can be thought of as a measure of its resistance to flow and is measured in the CGS unit Poise = dyne sec/cm2. The viscosity of gases near room temperature are in the centi Poise range, so that is a commonly used unit. Gas viscosity is only weakly dependent on pressure near atmospheric pressure. It is primarily a function of temperature, and can be modeled in terms of temperature with the input of experimental reference measurements. Note that as an engineering quantity, the temperatures used are in the Rankine scale.

Gas viscosity can be modeled by Sutherland's formula:

$$\mu = \mu_0 \left(\frac{a}{b}\right)\left[\frac{T}{T_0}\right]^{3/2}$$

$$a = 0.555T_0 + C$$

$$b = 0.555T + C$$

μ = viscosity in centiPoise at temperature T

μ_0 = reference viscosity in centiPoise at reference temperature T_0

T = temperature in degrees Rankine

T_0 = reference temperature in degrees Rankine

C = Sutherland's constant

Rankine's method for determining the coefficient of viscosity of a gas.

POSSIBLE QUESTIONS

PART B - (2 marks)

1.Define viscosity

2. What is Streamline flow?

3. What is Turbulent flow?

4.Write Poiseuille's equation.

5.Define Friction.

6.What is Lubrication?

7.State Stoke's law.

PART C - (6 marks)

1. Explain Stoke’s method for the coefficient of viscosity.

2. Explain Poiseuille’s method for the coefficient of viscosity .

3. Explain Rankine’s method for determining the coefficient of viscosity of a gas.

4.Explain the operation of Ostwald’s viscometer.

5. Explain the operation of Searle’s viscometer.

6.Write short note on Streamline flow and Turbulent flow

7.Explain Variation of viscosity with temperature and pressure.

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Questions	Option1	Option2	Option3	Option4	Answer
When two paralel layers of a liquid are moving with different velocities, they experience___________	tangential force	viscous force	vortex motion	coefficient of viscosity	tangential force
The viscous force is proportional to ___________	surface area	velocity gradient	both 1 and 2	none of the above	both 1 and 2
Unit of 'h' is____________	Nsm^{-2}	Ns	m^{-1}	Nsm^{2}	Nsm^{-2}
Dimension of [h] ______________	$ML^{-1}T^{-1}$	MLT^{-1}	$ML^{-1}T$	MLT	$ML^{-1}T^{-1}$
The velocity of the liquid does not exceed a limiting value called ____________	Crtical velocity	tangential force	streamline flow	turbulent flow	Crtical velocity
Turbulent motion is also known as____________	velocity gradient	tangential force	viscous force	vortex motion	vortex motion
The corrections are applied in poiseuille's equation for____________	pressure head	length of tube	none of the above	both 1 and 2	both 1 and 2
The effective length of the tube ________________ during the correction in poiseuille's eaquation	decreased	increased	remains same	may be increased or decreased	increased
Volume of liquid flowing per second___________________	m/(r.t)	m/(r+t)	m(r.t)	m/(p.t)	m/(r.t)
The radius of the capillary tube is determined using ______________________	optical microscope	travelling microscope	ostwald's viscometer	none of the above	travelling microscope

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

r1/r2 is determined by ____________________	Poiseuille's equation	ostwald's viscometer	Hare's apparatus	none of the above	Hare's apparatus
Variation of viscosity of a liquid with temperature is studied by ______________	Ostwald's viscometer	Hare's apparatus	tangential force	poiseuille's equation	Ostwald's viscometer
Pressure is proportional to ____________________	mass of the liquid	volume of the liquid	density of the liquid	none of the above	density of the liquid
Which is the highly vicous liquid_______________	castor oil	ginger oil	coconut oil	none of the above	castor oil
Uniform velocity is called_____________________	critical velocity	terminal velocity	coefficient of viscosity	streamline flow	terminal velocity
Viscous force experienced by a falling sphere must depend on______________	terminal velocity of ball	radius of ball	coefficient of viscosity of liqiud	all the above	all the above
Dimension of viscous force_______________	MLT	MLT^{-1}	$ML^{-1}T$	MLT^{-2}	MLT^{-2}
Dimensiom of r	L	L^{-1}	L^{-2}	L^{2}	L
k is a _______________________	Rydberg's constant	Reynolds number	viscosity	dimensionless constant	dimensionless constant
Experimental value of k is_______________	6/p	6p	p/6	3p	6p
In deriving stokes formula there is no _______________	Eddy currents	whirlpools	viscosity	terminal velocity	Eddy currents

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Which method is suitable for measuring coefficient of viscosity of highly viscous liquid?	Stoke's method	Ostwald's viscometer	Searle's viscometer	rotating cylinder method	Stoke's method
Termial velocity = _______________	x/t	x+t	x*t	x-t	x/t
The viscosity of the liquid ______________ with temperature	decreased	increased	remains same	may be increased or decreased	decreased
The viscosity of ether at 20°C increases by only __________for an increase of 500 atmosphere pressure	65%	60%	6%	66%	60%
When two solid surfaces in contact move relative to each other, friction opposes ___________________	relative motion	vortex motion	translation motion	rotational motion	relative motion
Friction is reduced by using __________	rod	lubricants	oil	none of the above	lubricants
Lubricant is a ________________	gas	liquid	solid	both 2 and 3	both 2 and 3
Searle's viscometer is used to find _________________	viscous force	surface tension	coefficient of viscosity	density	coefficient of viscosity
In Searle's viscometer the space between the cylinders is filled with _____________	liquid	solid	plasma	gas	liquid
The velocity of the liquid increases from __________ to maximum	45	0	90	-45	0

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

In Searles viscometer the negative side of the length axis gives bottom correction of __________	l	k	b	m	k
Poiseuille's formula is not applicable to ________	solid	liquid	gas	plasma	gas
Density of the gas varies directly with _________	mass	volume	pressure	length	pressure
The negative sign indicates the pressure decreases with ________ in x	increase	decrease	reamains same	none of the above	increase
In Rankine's method the pressure difference between the ends of the capillary tube is caused by _______	alumnium pellet	mercury pellet	manganese pellet	iron pellet	mercury pellet
In light machinery thin oils with _______- viscosity are used	high	low	0	moderate	low
The viscosity of water decreases with _____________	pressure	volume	gas	density	pressure
The viscosity of all the liquids other than water _________________- with pressure	0	decrease	increases	same	increases
Which of the following is a highly viscous oil?	clock oil	grease	coconut oil	water	grease
___________ is the force resisting the relative motion of solid surfaces, fluid layers, or material elements sliding against each other.	Friction	Drag	Wear	Tire	Friction
_______ friction resists relative lateral motion of two solid surfaces in contact.	Dry	fluid	lubricated	skin	Dry
__________ friction describes the friction between layers within a viscous fluid that are moving relative	Dry	fluid	lubricated	skin	fluid

to each other.					
___________ friction is a case of fluid friction where a fluid separates two solid surfaces.	Dry	fluid	lubricated	skin	lubricated
________ friction is a component of drag, the force resisting the motion of a solid body through a fluid.	Dry	fluid	lubricated	skin	skin
_________ friction is the force resisting motion between the elements making up a solid material while it undergoes deformation.	Internal	fluid	lubricated	skin	Internal
Friction is a component of the science of ________.	tribology	Terotechnology	nanotribology	microtribiology	tribology
__________friction is friction between two solid objects that are not moving relative to each other.	Static	dry	skin	fluid	Static
The maximum value of static friction, when motion is impending, is sometimes referred to as ________.	limiting friction	static friction	skin friction	dry friction	limiting friction
A _________ is an instrument that measures friction on a surface.	tribometer	optical microscope	scanning electron microscope	optical interferometry	tribometer
A _______ is a mechanical device, by convention understood to be rotating, which provides driving force to another mechanism when required.	clutch	brake	clamp	flywheel	clutch

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

A ____________ is a load device which is generally used for measuring the power output of an engine.	dynamometer	clutch	tachometer	speedometer	dynamometer
___________ dynamometers are the oldest kind, and consist of some sort of mechanical breaking device, often a belt or frictional “shoe” which rubs a rotating hub or shaft.	Dry friction	Hydraulic	Eddy current	Engine	Dry friction
________ dynamometers are basically hydraulic pumps where the impeller is spun by the engine.	Hydraulic	Eddy current	Engine	Dry friction	Hydraulic
When the dynamometer is connected to the vehicles drive wheels it is called a _________ Dynamometer.	Chassis	Eddy current	Engine	Dry friction	Chassis
If the dynamometer is connected to the engine’s output shaft it is referred to as an _________ Dynamometer.	Engine	Chassis	Eddy current	Dry friction	Engine
A __________ can also be used to determine the torque and power required to operate a driven machine such as a pump.	dynamometer	clutch	tachometer	speedometer	dynamometer
The eddy current dynamometer was invented by Martin and Anthony Winther in the year _________.	1931	1932	1933	1944	1931
In dynamometer, RPM stands for ____________.	Revolutions Per Minute	Rounds Per Minute	Radiation Portal Monitor	Rate Per Minute	Revolutions Per Minute
__________ dynamometers are typically limited to lower RPM due to heat dissipation issues.	Powder	engine	chassis	Eddy current	Powder

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

__________ are useful in the development and refinement of modern day engine technology.	Dynamometers	Clutchs	Electric motors	Engines	Dynamometers

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Questions	Option1	Option2	Option3	Option4	Answer
When two paralel layers of a liquid are moving with different velocities, they experience__________	tangential force	viscous force	vortex motion	coefficient of viscosity	tangential force
The viscous force is proportional to __________	surface area	velocity gradient	both 1 and 2	none of the above	both 1 and 2
Unit of 'h' is___________	Nsm^{-2}	Ns	m^{-1}	Nsm^{2}	Nsm^{-2}
Dimension of [h] _____________	$ML^{-1}T^{-1}$	MLT^{-1}	$ML^{-1}T$	MLT	$ML^{-1}T^{-1}$
The velocity of the liquid does not exceed a limiting value called ___________	Crtical velocity	tangential force	streamline flow	turbulent flow	Crtical velocity
Turbulent motion is also known as___________	velocity gradient	tangential force	viscous force	vortex motion	vortex motion
The corrections are applied in poiseuille's equation for___________	pressure head	length of tube	none of the above	both 1 and 2	both 1 and 2
The effective length of the tube _______________ during the correction in poiseuille's eaquation	decreased	increased	remains same	may be increased or decreased	increased
Volume of liquid flowing per second__________________	m/(r.t)	m/(r+t)	m(r.t)	m/(p.t)	m/(r.t)
The radius of the capillary tube is determined using ______________________	optical microscope	travelling microscope	ostwald's viscometer	none of the above	travelling microscope

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

r1/r2 is determined by ___________________	Poiseuille's equation	ostwald's viscometer	Hare's apparatus	none of the above	Hare's apparatus
Variation of viscosity of a liquid with temperature is studied by ______________	Ostwald's viscometer	Hare's apparatus	tangential force	poiseuille's equation	Ostwald's viscometer
Pressure is proportional to ___________________	mass of the liquid	volume of the liquid	density of the liquid	none of the above	density of the liquid
Which is the highly vicous liquid_______________	castor oil	ginger oil	coconut oil	none of the above	castor oil
Uniform velocity is called____________________	critical velocity	terminal velocity	coefficient of viscosity	streamline flow	terminal velocity
Viscous force experienced by a falling sphere must depend on______________	terminal velocity of ball	radius of ball	coefficient of viscosity of liqiud	all the above	all the above
Dimension of viscous force_______________	MLT	MLT^{-1}	$ML^{-1}T$	MLT^{-2}	MLT^{-2}
Dimensiom of r	L	L^{-1}	L^{-2}	L^{2}	L
k is a ______________________	Rydberg's constant	Reynolds number	viscosity	dimensionless constant	dimensionless constant
Experimental value of k is_______________	6/p	6p	p/6	3p	6p
In deriving stokes formula there is no _______________	Eddy currents	whirlpools	viscosity	terminal velocity	Eddy currents

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Which method is suitable for measuring coefficient of viscosity of highly viscous liquid?	Stoke's method	Ostwald's viscometer	Searle's viscometer	rotating cylinder method	Stoke's method
Termial velocity = _______________	x/t	x+t	x*t	x-t	x/t
The viscosity of the liquid ______________ with temperature	decreased	increased	remains same	may be increased or decreased	decreased
The viscosity of ether at 20°C increases by only __________for an increase of 500 atmosphere pressure	65%	60%	6%	66%	60%
When two solid surfaces in contact move relative to each other, friction opposes ____________________	relative motion	vortex motion	translation motion	rotational motion	relative motion
Friction is reduced by using ___________	rod	lubricants	oil	none of the above	lubricants
Lubricant is a ________________	gas	liquid	solid	both 2 and 3	both 2 and 3
Searle's viscometer is used to find _________________	viscous force	surface tension	coefficient of viscosity	density	coefficient of viscosity
In Searle's viscometer the space between the cylinders is filled with _____________	liquid	solid	plasma	gas	liquid
The velocity of the liquid increases from ___________ to maximum	45	0	90	-45	0

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

In Searles viscometer the negative side of the length axis gives bottom correction of __________	l	k	b	m	k
Poiseuille's formula is not applicable to ________	solid	liquid	gas	plasma	gas
Density of the gas varies directly with _________	mass	volume	pressure	length	pressure
The negative sign indicates the pressure decreases with ________ in x	increase	decrease	reamains same	none of the above	increase
In Rankine's method the pressure difference between the ends of the capillary tube is caused by _______	alumnium pellet	mercury pellet	manganese pellet	iron pellet	mercury pellet
In light machinery thin oils with _______- viscosity are used	high	low	0	moderate	low
The viscosity of water decreases with _____________	pressure	volume	gas	density	pressure
The viscosity of all the liquids other than water _________________- with pressure	0	decrease	increases	same	increases
Which of the following is a highly viscous oil?	clock oil	grease	coconut oil	water	grease
___________ is the force resisting the relative motion of solid surfaces, fluid layers, or material elements sliding against each other.	Friction	Drag	Wear	Tire	Friction
_______ friction resists relative lateral motion of two solid surfaces in contact.	Dry	fluid	lubricated	skin	Dry
__________ friction describes the friction between layers within a viscous fluid that are moving relative	Dry	fluid	lubricated	skin	fluid

to each other.					
___________ friction is a case of fluid friction where a fluid separates two solid surfaces.	Dry	fluid	lubricated	skin	lubricated
________ friction is a component of drag, the force resisting the motion of a solid body through a fluid.	Dry	fluid	lubricated	skin	skin
_________ friction is the force resisting motion between the elements making up a solid material while it undergoes deformation.	Internal	fluid	lubricated	skin	Internal
Friction is a component of the science of ________.	tribology	Terotechnology	nanotribology	microtribiology	tribology
__________friction is friction between two solid objects that are not moving relative to each other.	Static	dry	skin	fluid	Static
The maximum value of static friction, when motion is impending, is sometimes referred to as ________.	limiting friction	static friction	skin friction	dry friction	limiting friction
A _________ is an instrument that measures friction on a surface.	tribometer	optical microscope	scanning electron microscope	optical interferometry	tribometer
A _______ is a mechanical device, by convention understood to be rotating, which provides driving force to another mechanism when required.	clutch	brake	clamp	flywheel	clutch

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT IV :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

A ____________ is a load device which is generally used for measuring the power output of an engine.	dynamometer	clutch	tachometer	speedometer	dynamometer
___________ dynamometers are the oldest kind, and consist of some sort of mechanical breaking device, often a belt or frictional “shoe” which rubs a rotating hub or shaft.	Dry friction	Hydraulic	Eddy current	Engine	Dry friction
________ dynamometers are basically hydraulic pumps where the impeller is spun by the engine.	Hydraulic	Eddy current	Engine	Dry friction	Hydraulic
When the dynamometer is connected to the vehicles drive wheels it is called a _________ Dynamometer.	Chassis	Eddy current	Engine	Dry friction	Chassis
If the dynamometer is connected to the engine’s output shaft it is referred to as an _________ Dynamometer.	Engine	Chassis	Eddy current	Dry friction	Engine
A __________ can also be used to determine the torque and power required to operate a driven machine such as a pump.	dynamometer	clutch	tachometer	speedometer	dynamometer
The eddy current dynamometer was invented by Martin and Anthony Winther in the year _________.	1931	1932	1933	1944	1931
In dynamometer, RPM stands for ____________.	Revolutions Per Minute	Rounds Per Minute	Radiation Portal Monitor	Rate Per Minute	Revolutions Per Minute
__________ dynamometers are typically limited to lower RPM due to heat dissipation issues.	Powder	engine	chassis	Eddy current	Powder

___________ are useful in the development and refinement of modern day engine technology.	Dynamometers	Clutchs	Electric motors	Engines	Dynamometers

UNIT-V

SYLLABUS

Intensity and Loudness of sound – decibels – Intensity level – Laws of Transverse Vibrations – Melde's String – Sonometer.

ULTRASONICS

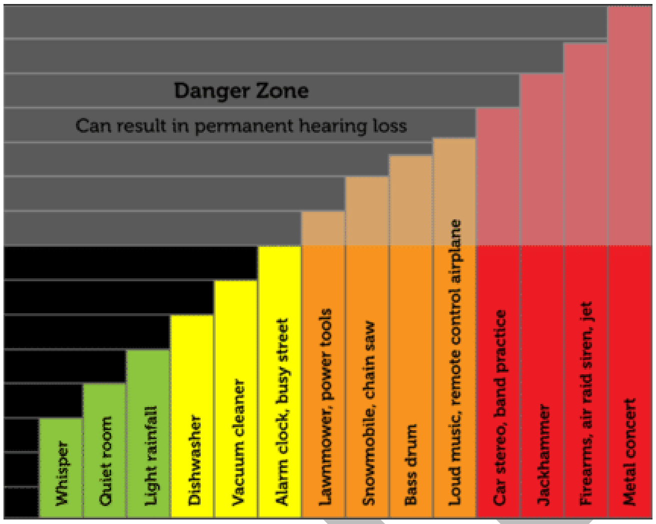
Ultrasonics – Production of ultrasonic wave – Piezoelectric crystal method – Magnetostriction method – Properties – detection – Applications

Intensity and Loudness of sound

Loudness refers to how loud or soft a sound seems to a listener. The loudness of sound is determined, in turn, by the intensity of the sound waves. Intensity is a measure of the amount of energy in sound waves. The unit of intensity is the decibel (dB).

Decibel Levels

The Figure below shows decibel levels of several different sounds. As decibel levels get higher, sound waves have greater intensity and sounds are louder. For every 10-decibel increase in the intensity of sound, loudness is 10 times greater. Therefore, a 30-decibel "quiet" room is 10 times louder than a 20-decibel whisper, and a 40-decibel light rainfall is 100 times louder than the whisper. High-decibel sounds are dangerous. They can damage the ears and cause loss of hearing.



The intensity of sound waves determines the loudness of sounds, but what determines intensity? Intensity results from two factors: the amplitude of the sound waves and how far they have traveled from the source of the sound.

- Amplitude is a measure of the size of sound waves. It depends on the amount of energythat started the waves. Greater amplitude waves have more energy and greater intensity, so they sound louder.
- As sound waves travel farther from their source, the more spread out their energybecomes. You can see how this works in the Figure below. As distance from the sound source increases, the area covered by the sound waves increases. The same amount of energy is spread over a greater area, so the intensity and loudness of the sound is less. This explains why even loud sounds fade away as you move farther from the source.

Laws of Transverse Vibrations

A string is a tight wire. When it is plucked or bowed, progressive transverse waves travel along the wire and is reflect at the fixed ends. These waves superpose with the incident waves and produce a stationary wave in the wire. A progressive sound wave is produced in the surrounding air having a frequency equal to that of the stationary wave in the string.

Modes of Vibration

A stretched string can produce different frequencies. Since the ends are fixed, these are the position of nodes in the wire. When the string is plucked at the middle, an antinode is formed at the middle. This is the simplest mode of vibration and the distance between the consecutive nodes is $\lambda/2$ where λ is the wavelength of the transverse wave in the string.

L or, λ The frequency of vibration is given by $f=\lambda/2=2L=v$

$$\lambda=v2L$$

$$L=\lambda/2$$

$$\text{or,}\lambda=2L$$

The frequency of vibration is given by $f=v$

$$\lambda=v2L$$

where v is the velocity of the transverse wave. This is fundamental frequency or frequency of first harmonic. It is the lowest frequency produced by the vibrating string.

Overtone in Stretched String

If the string is plucked at a point one-quarter of its length from one end, the string vibrates in two segments. This mode of vibration is called the first overtone. This vibration can be also be set when the vibrating antinodes are formed in the string as shown in the figure.

If λ_1 is wavelength and f_1 is the frequency of the resulting stationary wave, we have

L The frequency of the wave,

$$f1=\lambda2+\lambda2=\lambda=v\lambda=vL=2fL=\lambda2+\lambda2=\lambda$$

The frequency of the wave,

$$f1=v\lambda=vL=2f$$

Thus the frequency of the first overtone is two times the fundamental frequency. This is also called second harmonics.If the string is made to vibrate in three segments by touching it at one-third of the length from one end, additional nodes are produced in it.

If λis the wavelength andf2its frequency of the wave, then

Lor,λand the frequency is given by $f2=\lambda2+\lambda2+\lambda2=3\lambda2=2L3=v\lambda=3v2L=3f$

If λ s the wavelength andf2 its frequency of the wave, then

$$L=\lambda2+\lambda2+\lambda2=3\lambda2or,\lambda=2L3$$

and the frequency is given by

$$f2=v\lambda=3v2L=3f$$

Hence, the frequency of second overtone is three times the fundamental frequency which is also called third harmonics. Similarly we can obtain other overtone in the same string with more segments. The ratio of the frequency of string is

$$f:f1:f2:f3:\cdots=1:2:3\ldots f:f1:f2:f3:\cdots=1:2:3\ldots$$

Laws of Transverse Vibration in Stretched String

The velocity of a transverse wave travelling in a stretched string is given by

$$v=T\mu{-}{-}\surd v=T\mu$$

where T is the tension in the stretched string and μ, the mass per unit length. Since the frequency, f = v/2L in fundamental mode, then

$$f=12LT\mu{-}{-}\surd f=12LT\mu$$

From this expression, it follows that there are three laws of transverse vibration of stretched string;

1. The length of length: The fundamental frequency is inversely proportional to the resonating length, L of the string.

$$f\propto 1Lf\propto 1L$$

2. The law of tension: The fundamental frequency is directly proportional to the square root of the stretching force or tension.

$$F \propto T{-}{-}\surd f \propto T$$

3. The law of mass: The fundamental frequency is inversely proportional to the square root of the mass per unit length.

$$f\propto 1\mu{-}{-}\surd f\propto 1\mu$$

Verification of the Laws of Transverse Vibration

These laws can be verified experimentally using a sonometer. This device consists of a wire under tension which is arranged in a hollow wooden board as shown in the figure. The vibration of the wire are passed by the movable bridges to the box and then, to the air inside it.

1. **To verify** $f\propto 1/Lf\propto 1/L$

   To verify this law, take a tuning fork of known frequency, such as 320 Hz. Taking a load of 1 kg on the string, find the resonating length of the wire between the bridges C and D. this is found by using a small paper on the wire. Let L_1 be the resonating length for this tuning fork. The same process is repeated for next tuning fork having a different frequency. Let L_2 resonating length for the second tuning fork. It will be found that the product $f1\times L1=f2\times L2f1\times L1=f2\times L2$ at constant tension on and mass per unit length of the string. This follows that

F∝1LF∝1L

2. **To verify** F∝T−−√F∝T

   To verify this law, a length L of experimental wire AB is fixed between bridges C and D, and load W on it is varied to alter tension T. to measure the frequency of vibration in this wire, an auxiliary wire PQ is used which runs parallel to the experimental wire AB. The tension on this wire is kept constant which is not shown in a figure. The bridges M and N are moved until the note on length l of auxiliary wire between MN is same as that in experimental wire CD. Since the tension in the wire MN is constant, we have f∝1/lf∝1/l. By varying W, the tension I in AB is varied. A graph between 1/l1/l and T−−√T is a straight line passing through the origin, which shows that

   F∝T−−√F∝T

   at constant μ and resonating length.

3. **To verify f∝1/μ−−√f∝1/μ**

   To verify this law, the wires of different diameters and materials are used under same vibrating length and same tension. Parallel to the experimental wire AB, an auxiliary wire PQ with known tension is fixed on the sonometer as shown in a figure. The experimental wire is plucked at the middle between two bridges C and D and the length of the auxiliary wire PQ is set into resonance by varying the position of the bridges M and N on the auxiliary string, let the resonating length of the auxiliary wire be L_1 and the frequency of vibration of the experimental wire is proportional to the length. The second experimental wire is taken with the same load and same vibrating length and the auxiliary wire is again made in resonance with the experimental wire. The resonating length is again noted as L_2. When a graph between 1/L1/L and μ−−√μ is plotted, a straight line is obtained which passes through the origin.

   f∝1/μ−−√

The laws of transverse vibrations of stretched strings are (i) the law of length (ii) law of tension and (iii) the law of mass.

(i) For a given wire tension (T) and linear density (m) are constant, the fundamental frequency of vibration (n) is inversely proportional to the vibrating length ,

i.e. $n \infty 1/l$

or, $nl = \text{constant}$.

(ii) For the length (l) and linear density (m) are constant, the fundamental frequency (n) is directly proportional to the square root of the tension (T),

i.e. $n \infty \sqrt{T}$

or, $n / \sqrt{T} = \text{constant}$.

(iii) For the length (l) and tension (T) are constant, the fundamental frequency (n) varies inversely as the square root of the linear density (m),

i.e. $n \infty 1/\sqrt{m}$

or, $n \sqrt{m} = \text{constant}$.

Melde's String

Melde's experiment is a scientific experiment carried out in 1859 by the German physicist Franz Melde on the standing waves produced in a tense cable originally set oscillating by a tuning fork, later improved with connection to an electric vibrator. Melde’s experiment is ideal to study the behavior of standing waves.

Speed of waves in a stretched string*:* A string means a wire or a fiber which has a uniform diameter and is perfectly flexible. The speed of a wave in a flexible stretched string depends upon the tension in the string and mass per unit length of the string.

$$v = \sqrt{\frac{T}{\mu}}$$

Where the tension T in the string equal to Mg.

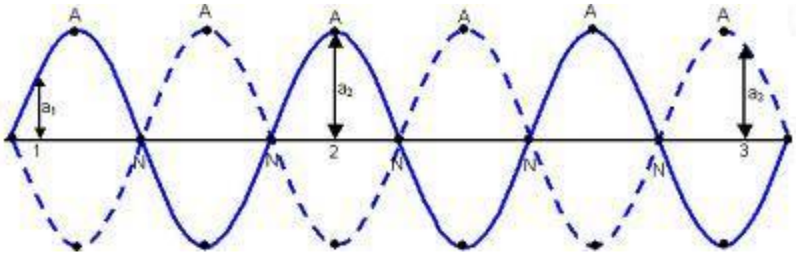
M - Mass suspended and g is acceleration due to gravity.

μ - linear density or mass per unit length of the string.

$$\mu = \frac{m}{L}$$

Where m is the mass of the string and L is the total length of the string.

Vibrations of a stretched string: When the wire is clamped to a rigid support, the transverse progressive waves travel towards each end of the wire. By the superposition of incident and reflected waves, transverse stationary waves are set up in the wire. Since ends of the wire are clamped, there is node N at each end and anti node A in the middle as shown in Fig: 1.



The points of the medium which have no displacements called node*s* and there are some points which vibrate with maximum amplitude called antinodes.

The distance between two consecutive nodes is λ/2, (λ - wavelength). Because l is half a wavelength in the equations,

$$l = \frac{\lambda}{2}$$

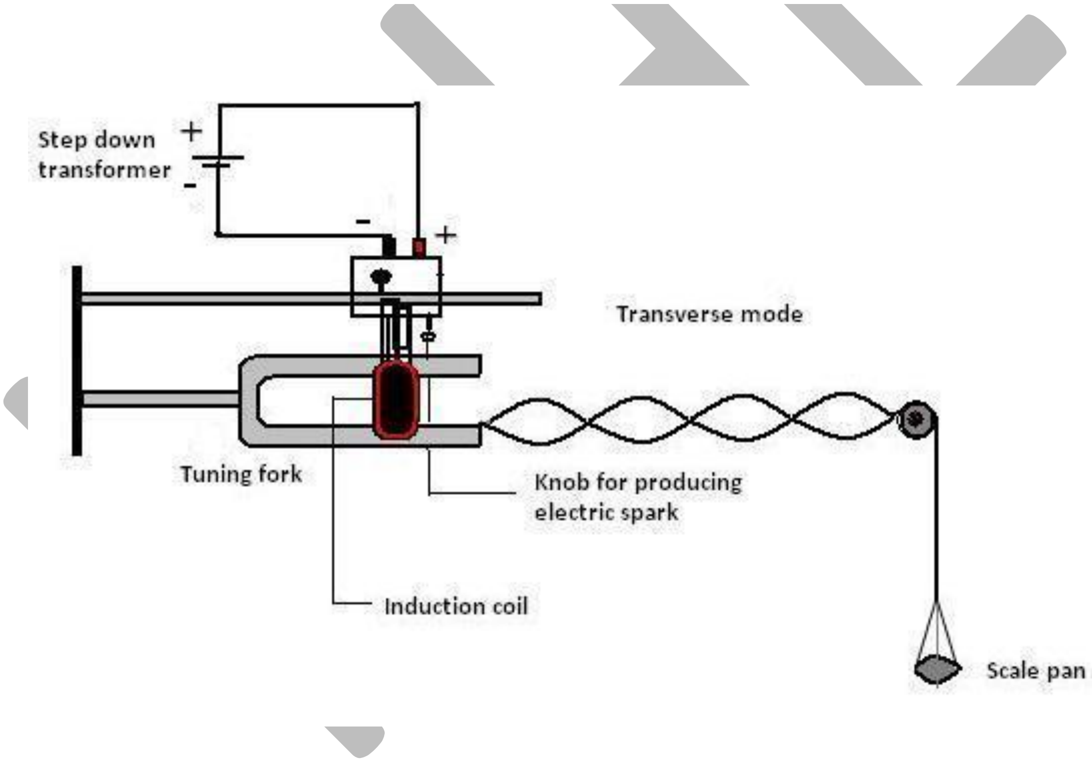
If 'f' be the frequency of vibration the wire,

$$f = \frac{v}{\lambda} = \frac{v}{2l}$$

Substituting the value of ' v ' in equation (4)

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

Transverse drive mode : In this arrangement the vibrations of the prongs of the tuning fork are in the direction perpendicular to the length of the string.



The time, during which the tuning fork completes one vibration, the string also completes one vibration. In this mode, frequency of the string is equal to the frequency of the tuning fork.

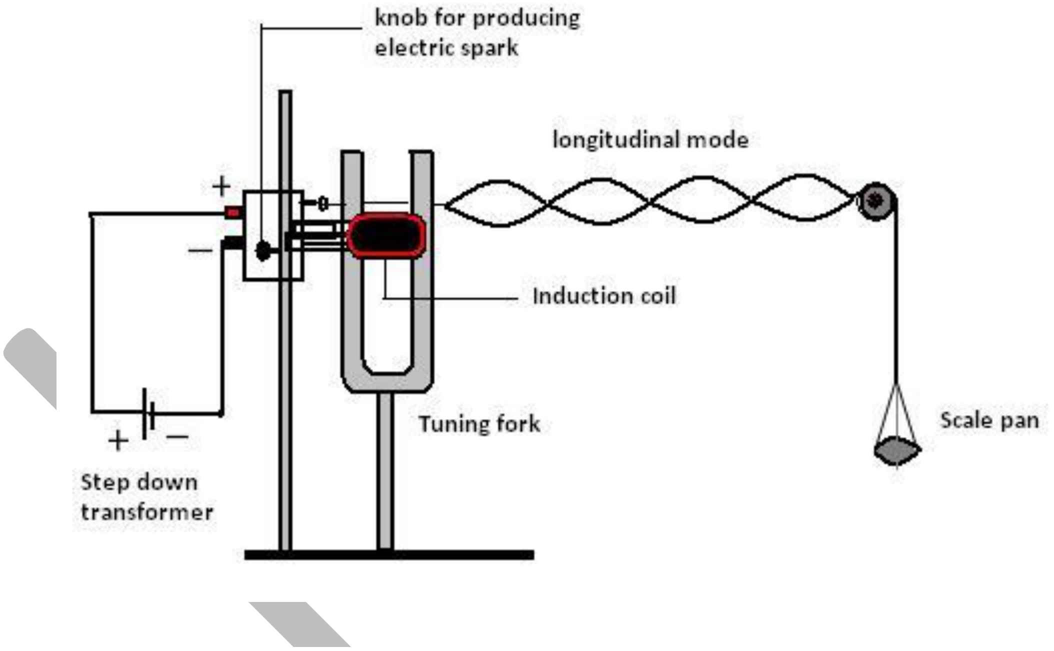
Therefore from equation (5),

Frequency $f = \sqrt{\frac{gM}{4\mu l^2}}$

Where

The total mass M is equal to the mass M' of the weight in the scale pan plus the mass M0 of the scale pane, $M = M' + M_0$.

Longitudinal drive mode: In this arrangement the tuning fork is set in such a manner that the vibrations of the prongs are parallel to the length of the string.



he time, during which the tuning fork completes one vibration, the string completes half of its vibration. In this mode, frequency of the fork is twice the frequency of the string.

Frequency $f = \sqrt{\frac{gM}{\mu l^2}}$

Using equation (6) and (7) we can calculate the frequency of electrically maintained tuning fork in two different modes of vibration.

In transverse drive mode the string follows the motion of the tuning fork, up and down, once up and once down per cycle of tuning fork vibration.

However, one cycle of up and down vibration for transverse waves on the string is two cycles of string tension increase and decrease. The tension is maximum both at the loops' maximum up position and again at maximum down position. Therefore, in longitudinal drive mode, since the string tension increases and decreases once per tuning fork vibration, it takes one tuning fork vibration to move the string loop to maximum up position and one to move it to maximum down position. This is two tuning fork vibrations for one up and down string vibration, so the tuning fork frequency is half the string frequency.

Applications

1. Tuning of instruments like guitar.

2. Standing waves in air coloumn, soprano saxophone etc.

3. Human speech analysis.

Sonometers

A Sonometer is a device for demonstrating the relationship between the frequency of the sound produced by a plucked string, and the tension, length and mass per unit length of the string. These relationships are usually called Mersenne's laws after Marin Mersenne (1588-1648), who investigated and codified them. For small amplitude vibration, the frequency is proportional to:

a. the square root of the tension of the string,

b. the reciprocal of the square root of the linear density of the string,

c. the reciprocal of the length of the string.

The usual sonometer is horizontal, like the one below at Kenyon College, and the tension is supplied by the weight of the masses hung on the ends of the wires after they pass over the pulleys. This arrangement has the defect that the strings and bridge cannot be seen by the class.

The vertical sonometer at DePauw University is upright, and tipped back about 3° from the vertical. The differential sonometer was invented by the French acoustical apparatus manufacturer, Marloye, ca. 1840. This has two strings, which may be used to illustrate beats if the two strings have almost the same frequency. If one string has twice the frequency of the other, octaves may be demonstrated. It is in the apparatus collection of Kenyon College in Gambier, Ohio.

Sonometer consists of a hollow rectangular wooden box of more than one meter length, with a hook at one end and a pulley at the other end. One end of a string is fixed at the hook and the other end passes over the pulley. A weight hanger is attached to the free end of the string. Two adjustable wooden bridges are put over the board, so that the length of string can be adjusted.

Production of transverse waves in stretched strings

If a string which is stretched between two fixed points is plucked at its center, vibrations produced and it move out in opposite directions along the string. Because of this, a transverse wave travels along the string.

If a string of length l having mass per unit length m is stretched with a tension T, the fundamental frequency of vibration f is given by;

$$F = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

Laws of transverse vibrations on a stretched string

- Law of Length: The frequency of vibration of a stretched string varies inversely as its resonating length (provided its mass per unit length and tension remain constant.)

$$F \alpha \frac{1}{l}$$

- Law of Tension:The frequency of vibration of a stretched string varies directly as the square root of its tension, (provided its resonating length and mass per unit length of the wire remains constant).

$$F \alpha \sqrt{T}$$

Relation between frequency and length
From the law of length, $f \times l = constant$

A graph between f and 1/l will be a straight line.

Relation between length and tension
From the equation for frequency, $\sqrt{T} / l = constant$

A graph between T and l2 will be a straight line.

ULTRASONICS

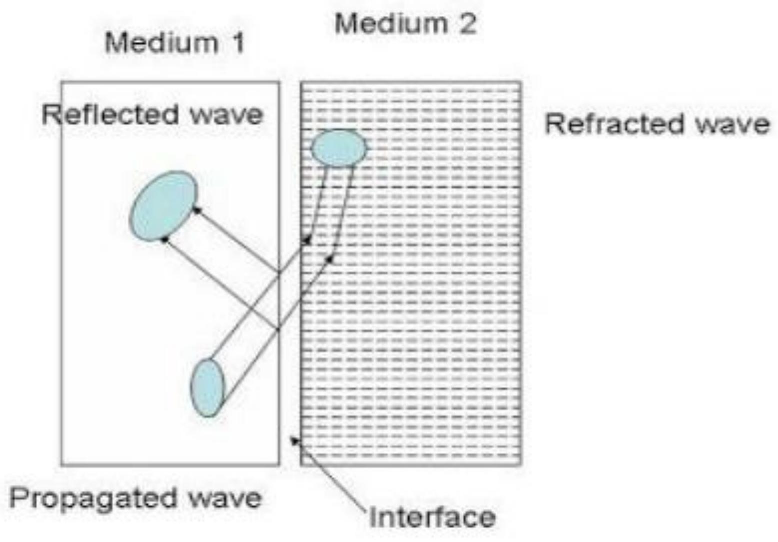
Vibrations upto 20,000 cycles can be heard by human beings and so, the frequency range upto 20KHz is called sonic frequency. Sound waves do not belong to the electromagnetic wave family like heat and light. As such, study of sound waves is not exactly an electronic branch. However most of the ultrasonic sound waves find very valuable industrial applications as flaw direction, submarine communication, electronic soldering and welding. Ultrasonics is today applied in medical diagnosis (echo-scanning) as an alternative to X-ray scanning. Production of ultrasonic sound waves involves use of electronic oscillators called transducers. Use of ultrasonic waves does not involve harmful wave radiation. Radiation is present in other methods for the applications mentioned above. Hence ultrasonics is a welcome substitute for electromagnetic waves in many industrial applications.

Ultrasonic principle:

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.

Properties of ultrasound.

The ultrasonic waves travel in different media with different velocities. In air it travels at 330m/sec. The velocities in liquids and solids range from 1200m/s to 4000m/s respectively. The property of a medium to conduct ultrasonic waves is represented in its acoustic impedance. When ultrasound travels through a homogeneous medium there is not change of velocity or wavelength and hence it essentially continues in a straight line. When the ultrasound beam reaches an interface between two different media, it undergoes reflection and refraction.



Propagation of ultrasound

The reflected wave may be termed as the ultrasonic echo. The echoes produced by large objects with smooth surface are specular echoes. Much energy is returned by these specular echoes. Echoes from small objects with irregular shapes are called scattered echoes. When ultrasound gets reflected irregularly in multiple directions, only a small part of ultrasonic energy returns to the source. Through analysis of reflected waves leads to several useful applications in industry and medicine. The properties of ultrasound are summed up as follows:

Ultrasound 1. Can be directed into a beam. 2. Obeys laws of reflection and refraction. 3. Is reflected by small objects. 4. Permits recording of clear echoes from interface that are approximately 1 mm part.

Properties of ultrasonic waves:

Ultrasonic waves are high frequency waves that have a heating effect. They also have smaller wavelength than all the other waves and they form stationary wave pattern when passing through liquids. The ultrasonic waves have constant velocity in homogeneous medium. Many modes of vibration. High resolution, used for flaw detection. Sonic beam and highly energetic.

1. The ultrasonic waves cannot travel through vacuum.

2. These waves travel with speed of sound in a given medium.

3. Their velocity remains constant in homogeneous media.

4. These waves can weld certain plastics, metals etc.

5. These can produce vibrations in low viscosity liquids.

6. The ultrasonic waves are reflected and refracted just like light waves.

7. As ultrasonic waves cannot travel through vacuum, therefore if these waves travel through a non-homogeneous medium, then at each discontinuity like crack or change in density or presence of impurity etc., the amplitude and thus intensity of ultrasonic waves decreases by some amount. This decrease in intensity of ultrasonic waves as these travel through a medium is called Attenuation. The vacuum in the material causes strong reflection of ultrasonic waves while impurities or discontinuity cause the scattering of ultrasonic waves leading to net decrease in intensity. The attenuation is increased with increase in frequency of ultrasonic waves for a given medium. The intensity of ultrasonic waves decreases exponentially according to the relation.

8. The speed of ultrasonic waves/acoustic waves is more in more dense media.

9. Ultrasound travels through various media including gases, liquids and solids, but cannot travel through a vacuum. The speed of sound varies by the medium it travels through. Sound is likely to travel faster through solids, followed by liquids and gases. For example, the speed of sound in the air is about 340 meters per second (m/s). That in water is about 1530 m/s and that in iron as high as about 5,850 m/s. Another typical property of sound is that its energy is more likely to be lost in gases while it travels through liquids or solids more efficiently.

Production of Ultrasonics by Piezoelectric method

For generating ultrasonic waves of high frequency (about 50 MHz) a generator using the piezoelectric effect is employed. It is found that when crystals of some materials such as quartz, tourmaline, rocksalt etc. are subjected to a mechanical pressure in a certain direction, each charges of opposite sign develop as their faces, normal to the direction of the direction of the applied pressure. This phenomenon is known as the piezoelectric effect.

Referring to figure 1 which is a cross sectional view of a quartz crystal, if pressure is applied along the axis x_2-x_2 electrical charges appear on the faces ab and a'b' conversely if two opposite faces of a crystal are subjected to a potential difference (in order to provide charge on them), a tensile pressure appears on the crystal. This pressure alters the length of the pressure alters the crystal. This pressure alters the length of crystal in that direction. If the applied potential is alternating the crystal, the crystal, the crystal begins to oscillate with a frequency which lies in the ultrasonic range.

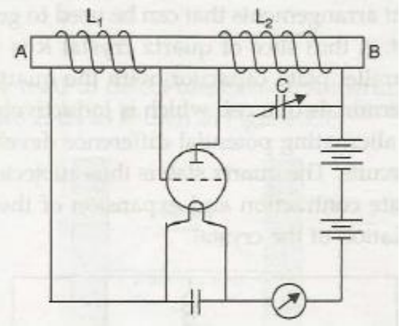


FIGURE1 Cross-sectional view of a quartz crystal. If pressure is applied along the axis X_2-X_2, electric charge appears on the faces ab and a'b'

Figure 2 shows circuit arrangements that can be used to generate ultrasonic waves by using the piezoelectric effect. A thin slice of quartz crystal R is placed between two metal plates A and B to form a parallel plate capacitor, with the quartz crystal as dielectric. The plates are connected to the terminals of a coil which is inductively coupled to the oscillating circuit of a triode valve. An alternating potential difference developed across the condenser plates due to the electrical circuits. The quartz slab is thus subjected to an alternating electric field which produces alternate contraction and expansion of the slab in the perpendicular direction leading to the oscillation of the crystal.

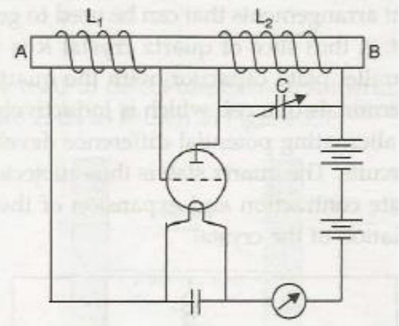


FIGURE 2 Circuit arrangement used to generate ultrasonic waves using piezoelectric effect

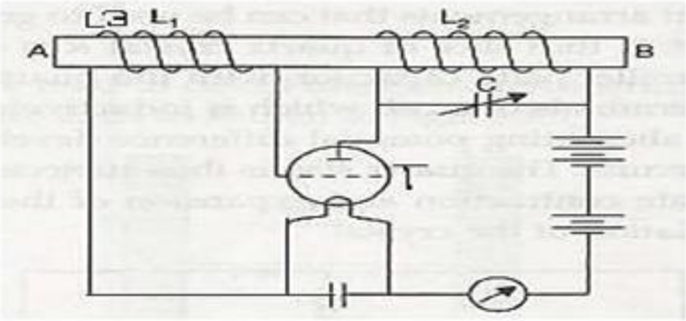
The variable condenser C is adjusted so that the frequency of the oscillatory circuit is equal to the natural frequency of one of the modes of vibration of the crystal. This produces resonant mechanical vibrations in the crystal due to the linear expansion and contraction. If one of the faces of the crystal is placed in contact with some medium in which elastic waves can be propagated, ultrasonic waves are generated.

When a ferromagnetic rod is kept in an alternating magnetic field the rod is set into longitudinal vibrations, this happens due to change in the length of the rod.

This longitudinal vibrations, result in the formation of ultrasonic waves at resonance.

Resonance is the condition at which the frequency of the oscillator match with the natural frequency of rod.

Construction



Working:

1) The rod is initially magnetized by the DC power supply.

2) When the battery is initially switched on the current is induced in the transistor.

3) The transistor is properly biased.

4) Emitter- forward biased, Collector- reverse biased.

5) An emf is induced in coil L1, this induces an emf to coil L2 & a part of it is feed as input to the base. Hence, this feedback system makes transistor operates continuously.

6) The varying frequency can be obtained by altering the capacitance value of condenser.

7) At resonance Ultrasonic waves will be produced.

Natural frequency of rod= Frequency of oscillator circuit

K2lγρ−−√=12πL1C1√K2lγρ=12πL1C1
Where,

K - Fundamental overtone, here K=1

l - length of rod

γ -Youngs'modulus

ρ - density of rod

L1L1 - Inductance
C1C1 - Capacitance
Vv

Ultrasonic detection

Ultrasonic detection is most commonly used in industrial applications to detect hidden tracks, discontinuities in metals, composites, plastics, ceramics, and for water level detection. For this purpose the laws of physics which are indicating the propagation of sound waves through solid materials have been used since ultrasonic sensors using sound instead of light for detection.

Sound is a mechanical wave travelling through the mediums, which may be a solid, or liquid or gas. Sound waves can travel through the mediums with specific velocity depends on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns.

Laws of physics for sound waves

Sound waves are having specific frequencies or number of oscillations per second. Humans can detect sounds in a frequency range from about 20Hz to 20 KHz. However the frequency range normally employed in ultrasonic detection is 100 KHz to 50MHz. The velocity of ultrasound at a particular time and temperature is constant in a medium.

$W = C/F$ (or) $W = CT$

Where W = Wave length

C = Velocity of sound in a medium

F = Frequency of wave

T=Time Period

The most common methods of ultrasonic examination utilize either longitudinal waves or shear waves. The longitudinal wave is a compression wave in which the particle motion is in the same direction of the propagation wave. The shear wave is a wave motion in which the particle motion is perpendicular to the direction of propagation. Ultrasonic detection introduces high frequency sound waves into a test object to obtain information about the object without altering or damaging it in any way. Two values are measured in ultrasonic detection.

The amount of time, taking for the sound to travel through the medium and amplitude of the received signal. Based on velocity and time thickness can be calculated.

Thickness of material = Material sound velocity X Time of Fight

Transducers for Wave Propagation and particle detection

For sending sound waves and receiving echo, ultrasonic sensors, normally called transceivers or transducers will be used. They work on a principle similar to radar that will convert electrical energy into mechanical energy in the form of sound, and vice versa.

The commonly used transducers are contact transducers, angle beam transducers, delay line transducers, immersion transducers, and dual element transducers. Contact transducers are typically used for locating voids and cracks to the outside surface of a part as well as measuring thickness. Angle beam transducers use the principle of reflection and mode conversion to produce refracted shear or longitudinal waves in the test material.

Delay line transducers are single element longitudinal wave transducers used in conjunction with a replaceable delay line. One of the reasons for choosing delay line transducer is that near surface resolution can be improved. The delay allows the element to stop vibrating before a return signal from the reflector can be received.

The major advantages offered by immersion transducers over contact transducers are Uniform coupling reduces sensitivity variations, Reduction in scan time, and increases sensitivity to small reflectors.

Applications involving Ultrasonic detection:

The distance of obstacle or discontinuities in metals is related to velocity of sound waves in a medium through which waves are passed and the time taken for echo reception. Hence the ultrasonic detection can be used for finding the distances between particles, for detecting the discontinuities in metals and for indicating the liquid level.

POSSIBLE QUESTIONS

PART B - (2 marks)

1. Define Intensity

2. Define Loudness of sound

3. Define decibels

4. What is Sonometer.?

5.What are the applications of Ultrasonics?

6. What are the properties of Ultrasonics?

7. Write Ultrasonic principle**.**

PART C - (6 marks)

1. Explain Laws of Transverse Vibrations

2.Explain Magnetostriction method to produce ultrasonic waves

3. Explain Piezoelectric crystal method to produce ultrasonic waves

4.Write short note on Intensity and Loudness of sound

5. Write short note on Properties , detection and Applications of ultrasonic waves

6.Explain Melde's String experiment

7. Explain Sonometer principle.

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Question	OPT1	OPT2	OPT3	OPT4	Answer
Standing waves are produced in 10m long stretched string. If the string vibrates in 5 segments and wave velocity is 20m/s, its frequency is	2Hz	4Hz	5Hz	10Hz	5Hz
If vibrations of a string are to be increased by a factor 2, tension in the string must be made	Half	Twice	Four times	Eight times	Four times
The tension in piano wire is 10N. What should be the tension in the wire to produce a note of double the frequency?	5N	20N	40N	80N	40N
frequency of 1000Hz is to be produced, then required length of string is	62.5cm	50cm	50cm	37.5cm	50cm
The frequency of a tuning fork is 256. It will not resonate with a fork of frequency	256	512	738	768	738
An organ pipe closed at one end has fundamental frequency of 1500Hz. The maximum number of overtones generated by this pipe, which a normal person can hear is	12	9	6	4	9
A tube closed at one end containing air produces fundamental note of frequency 512Hz. If the tube is open at both ends, the fundamental frequency will be	256Hz	768Hz	1024Hz	1280Hz	1024Hz

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

A closed organ pipe and an open pipe of the same length produce four beats per second, when sounded together. If the length of the closed pipe is increased, then the number of beats will	Increase	Decrease	Remain the same	First decrease then remain the same	Increase
At resonance air column of length 20cm resonates with a tuning fork of frequency 450Hz. Ignoring end correction, the velocity of sound in air is	720m/s	820m/s	920m/s	360m/s	360m/s
The technique or method to absorb undesirable sounds by soft and porous surface is called	acoustic protection	unacoustic protection	audible protection	decibel protection	acoustic protection
When sound interacts with materials and boundaries, it displays all the properties of	heat	waves	light	electricity	waves
Both bats and dolphins have the ability to “see” using	electric waves	light waves	heat waves	sound waves	sound waves
Soft materials absorb large amount of	heat energy	light energy	electromagnetic waves	sound energy	sound energy
The echo of sound is more prominent if the surface is	soft	rigid	porous	smooth	rigid
When a wave travels through a medium	particles are transferred from one place to another	energy is transferred in a periodic manner	energy is transferred at a constant speed	none of the above statements is applicable	energy is transferred at a constant speed

PROPERTIES OF MATTER AND ACCOUSTICS

The minimum distance between the source and the reflector, so that an echo is heard is approximately equal to	10m	17m	34m	50m	17m
Bats detect the obstacles in their path by receiving the reflected	infrasonic waves	radio waves	electro-magnetic waves	ultrasonic waves	ultrasonic waves
When sound travels through air, the air particles	vibrate along the direction of wave propagation	vibrate but not in any fixed direction	vibrate perpendicular to the direction of wave propagation	do not vibrate	vibrate along the direction of wave propagation
The frequency of a wave travelling at a speed of 500 ms^{-1} is 25 Hz. Its time period will be	20 s	0.05 s	25 s	0.04 s	
The amplitude of a wave is ______.	the distance the wave moves in one second	the distance the wave moves in one time period of the wave	the maximum distance moved by the medium particles on either side of the mean position	the distance equal to one wave length	the maximum distance moved by the medium particles on either side of the mean position
Which of the following is not a characteristic of a musical sound?	Pitch	Wavelength	Quality	Loudness	Wavelength
The physical quantity, which oscillates in most waves, is	mass	energy	amplitude	wavelength	amplitude

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Sound waves are		partly longitudinal and partly transverse	sometimes longitudinal and sometimes transverse	transverse	longitudinal
The frequency which is not audible to the human ear is	50 Hz	500 Hz	5000 Hz	50000 Hz	50000 Hz
Which of the following will remain unchanged when a sound wave travels in air or in water?	Amplitude	Wavelength	Frequency	Speed	Frequency
A sound source sends waves of 400 Hz. It produces waves of wavelength 2.5 m. The velocity of sound waves is	100 m/s	1000 m/s	10000 m/s	3000 km/s	1000 m/s
The time period of a vibrating body is 0.05 s. The frequency of waves it emits is	5 Hz	20 Hz	200 Hz	2 Hz	20 Hz
A source of frequency of 500 Hz emits waves of wavelength 0.4 m, how long does the waves take to travel 600 m?	3 s	6 s	9 s	12 s	3 s
Sound and light waves both	have similar wavelength	obey the laws of reflection	travel as longitudinal waves	travel through vacuum	obey the laws of reflection
The method of detecting the presence, position and direction of motion of distant objects by reflecting a beam of sound waves is known as	RADAR	SONAR	MIR	CRO	SONAR
The technique used by bats to find their way or to locate food is	SONAR	RADAR	Echolocation	Flapping	Echolocation
An example for mechanical wave.	Radio wave	Light wave	Infrared radiation	Sound wave	Sound wave

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Which of the following quantities is transferred during wave propagation?	Speed	Mass	Matter	Energy	Energy
The vibrations or the pressure variations inside the inner ear are converted into electrical signals by the	cochlea	tympanic membrane	pinna	anvil	cochlea
Basically sound waves are _______________	Voltage signals	Pressure waves	Current	Radiation	Pressure waves
Which of the following is not a character of sensor of sound wave?	Causes no health hazard	They are suitable in harsh environment	They are only suitable in cold environment	They can be used in corrosive environment	They are only suitable in cold environment
SONAR stands for ________________	Sound navigation and ranging	Sound number approximation and ranging	Sound nullifying ranging	None of the mentioned	Sound navigation and ranging
Mosaic regarding sonar is _____________	Surface of sonar	Frequency of sound wave	Pattern of vibrating elements	Depth of sea to which it is applicable	Pattern of vibrating elements
Piezo electric materials are well cut for ______________	Good dimension	Good coupling coefficient	Compact shape of device	Increasing frequency	Good coupling coefficient
Which of the following can be used in sonar?	ADP	Rescelle salt	ADP and Roscelle salt	ADP and Roscelle salt in sealed condition	ADP and Roscelle salt in sealed condition

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Magnetostriction transmitter uses ________________	Electrostrictive phenomena	Horizontal vibration of nickel tube	Longitudinal vibration of nickel tube	All of the mentioned	Longitudinal vibration of nickel tube
Sounds of frequency higher than 20,000 Hz which are inaudible to normal human ear are called	noise	frequency	ultrasonics	amplitude	ultrasonics
Ultrasonic waves carry more	energy	frequency	. heat	both frequency and energy	both frequency and energy
The wavelength of ultrasonic waves is	more than audible sound	less than audible sound	equal to audible sound	greater than light wave	equal to audible sound
The speed of sound varies with	humidity	temperature	both humidity and temperature	heat	both humidity and temperature
o find the speed of sound, we use the relation	v = fλ	f = vλ	lambda = fv	v = f + lambda	v = fλ
Sound waves can be transmitted by any	medium	vacuum	both medium and vacuum	none	medium
As compare to air, the speed of sound in liquids and solids is	lower	faster	equal	zero	faster
he loudness and amplitude of sound varies	directly	inversely	Not related	proportionally	directly
The scale to measure the intensity level of sound is called	vector scale	measuring ruler	bel scale	decibel scale	decibel scale
Echoes maybe heard more than once due to	multiple reflections	single time reflection	refraction	diffraction of waves	multiple reflections

KARPAGAM ACADEMY OF HIGHER EDUCATION
Coimbatore - 641021.
(For the candidates admitted from 2018 onwards)
DEPARTMENT OF PHYSICS

UNIT V :(Objective Type/Multiple choice Questions each Question carries one Mark)
PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

Old people can not hear sounds even above	5,000 Hz	15,000 Hz	10,000 Hz	8,000 Hz	15,000 Hz
The intensity level of the rustling of leaves is	25dB	0dB	10dB	100dB	10dB
he technique or method to absorb undesirable sounds by soft and porous surface is called	acoustic protection	unacoustic protection	audible protection	decibel protection	acoustic protection
A normal human ear can hear a sound only if its frequency lies between	30 Hz to 30,000 Hz	50 Hz to 50,000 Hz	20 Hz to 20,000 Hz	10 Hz to 10,000 Hz	20 Hz to 20,000 Hz
The speed of sound in air is	343ms-1	343ms-2	341ms-1	250ms-1	343ms-1
Which statement is true about the distinction between sound and acoustic energy	Acoustic energy refers only to vibrations through air	Sound requires a perceiver.	Sound is a purely physical quality.	There is no distinction.	Sound requires a perceiver.
The rate at which something vibrates is	intensity	timbre	frequency	decibel	timbre
As _____ increases, pitch increases:	intensity	timbre	frequency	decibel	frequency
Microphones and loudspeakers are examples of:	mixers	transducers	amplifiers	equalizers	transducers

Prepared By-Ambili Vipin,Assistant Professor,Department of Physics