UNIT-V

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.

Calculate the value of R from the gas equation PV = RT (OR) Calculate the universal gas constant of given gas, given one gram molecule of at gas at N.T.P. occupies a volume of 22.4 litres.

AT N.T.P. Pressure P $= 0.76$m of Hg

$= 0.76 \times 13.6 \times 10^3 \times 9.8$

Volume V $= 22.4$ litres

$= 22.4 \times 10^{-3} m^3$

Temperature T $= 273$ K

Gas equation PV = RT

R = PV/T

$$= \frac{0.76 \times 13.6 \times 10^3 \times 9.8 \times 22.4 \times 10^{-3}}{273}$$

Universal gas constant R $= 8.31 \ JK^{-1}$ per gram mole (or) R = $8310 \ JK^{-1}$ per k. mole

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. A gas consists of large number of tiny, rigid particles called molecules.
2. The gas molecules are identical in all respects, like mass, size, etc.
3. The molecules are perfectly elastic spheres.
4. The molecules are in random motion and travel with all possible velocities in all possible directions.
5. The molecules collide with each other and also with the walls of the container.
6. Between two successive collisions, the molecules travel in the straight line.
7. The average distance between two successive collisions is called the mean free path.
8. The time of collision is negligible when compared to the time taken by the molecule to travel its mean free path.
9. The volume of the molecules is negligible when compared to the volume of the gas.
10. The force of attraction between the molecules is negligible.

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,

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

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

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

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,

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

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
VαT

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 = constant= V2/T2

So

V2 = V1 T2/T1

= 0.5 L x 353K/278K

=0.63L

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

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

Therefore,

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

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:

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

= 1.825x10 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. In microbiology, motility can be confirmed if a sample inoculated in a semisolid medium migrates away from a

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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	$pV=nR_UT$
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

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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

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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	

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The volume occupied by one number of unit mol of gas is called as	molecular volume	mol volume	molar volume	none of the above	molecula r 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 numerical ly 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

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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^2T	M^2LT	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

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Mass of solid sphere ___________	4/3 πρR^3	4πρR^3	2/3 πρR^3	1/3 πρR^3	4/3 πρR^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

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_0$L0$L, start subscript, 0, end subscript along the direction of the stress, *i.e.* \epsilon=\Delta L/L_0$\epsilon=\Delta L/L0$.

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

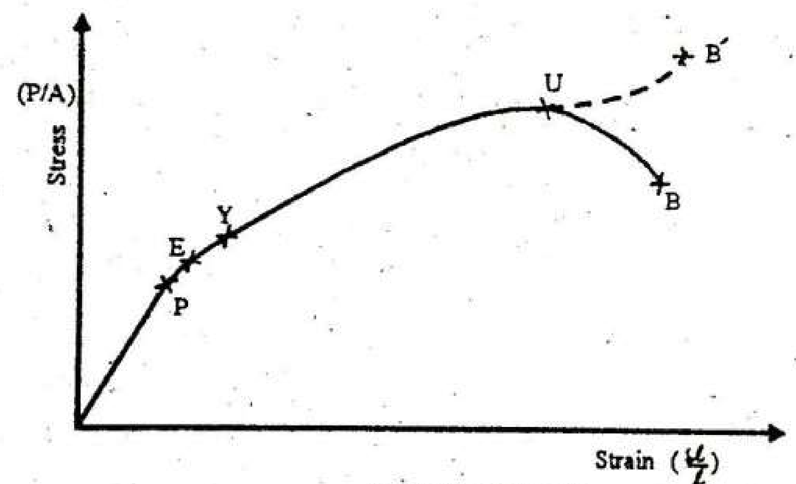
Strain
Strain is a measure of the deformation produced by the stress.

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 = 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.

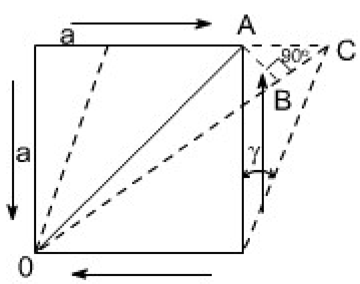
$K = p/\varepsilon_v$

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

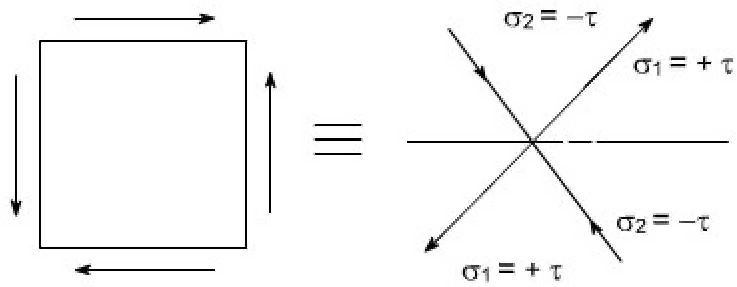
Thus, the strain on diagonal $= \frac{a\gamma}{2a} = \frac{\gamma}{2}$

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

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

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

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.

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

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

if $\gamma = 0.5$ $K = \infty$

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

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

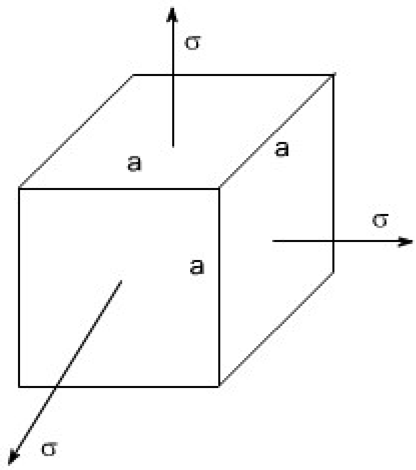
$\epsilon_v = 0$ if $\gamma = 0.5$

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

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

or

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

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

if $\gamma = 0.5$; $K = \infty$

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

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

hence if = 0.5, the value of K becomes infinite, rather than a zero value of E and the volumetric strain is zero or in otherwords, the material becomes incompressible

Futher, it may be noted that under condition of simple tension and simple shear, all real materials tend to experience displacements in the directions of the applied forces and Under hydrostatic loading they tend to increase in volume. In otherwords the value of the elastic constants E, G and K cannot be negative

Therefore, the relations

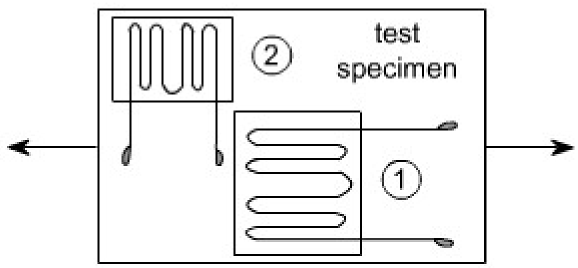
E = 2 G (1 +)

E = 3 K (1   )

Yields $-1 \leq \nu \leq 0.5$

In actual practice no real material has value of Poisson's ratio negative . Thus, the value of cannot be greater than 0.5, if however   0.5 than ϵ_v = ve, which is physically unlikely because when the material is stretched its volume would always increase.

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.

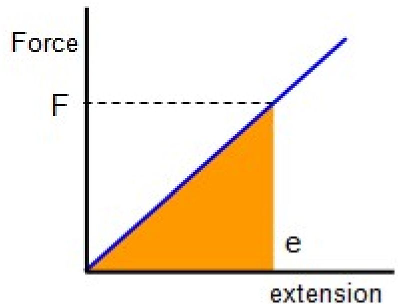


Figure 1(a)

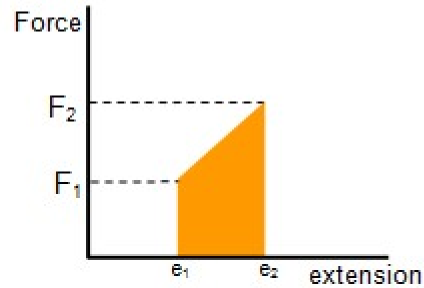


Figure 1(b)

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 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.

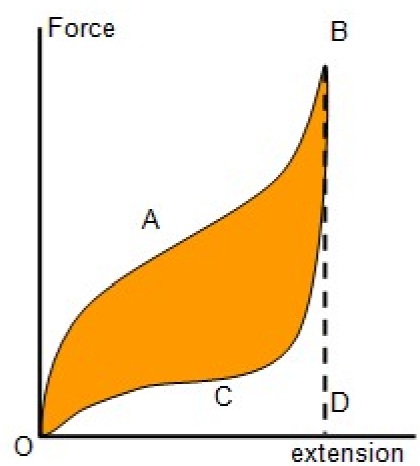


Figure 2

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.

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.

From the diagram HC is = sq = lj or j = s l q ;

Rigidity modulus h = Shearing stress Shearing strain

Hence, h ¥ shearing strain = hj = h qs

But shearing stress = Shearing force Area over which the force acts Shearing force = shearing stress ¥ area over which the force acts.

But the area over which the force acts = p (s + ds) 2 – p s 2 This area is equal to px2 + 2psds + πds 2 – ps 2 (ds 2 term is neglected since it is very small). Thus, we get, Area over which force acts = 2πsds. The shearing force F = h qs l ¥ 2πsds = 2phq 2 l s sd (1.58) The moment of the force about the axis EF of the cylinder Force ¥ Perpendicular distance. 2phq 2 l s sd ¥ s = 2phq 3 l s sd (1.59) The moment of this force on the entire cylinder of radius r is obtained by integrating the Eq. (1.59) between the limits s = 0 to s = r. Hence, the twisting couple, T = 0 2 3 r l s s Ú phq d i.e., T = 2πhq = s r 4 0 4 È Î Í ˘ ˚ ˙ Applying the limits, we have, T = phq 2 4 l r (1.60) In the above expression, if q = 1 radian, then, we get, Twisting couple per unit twist T = ph 2 4 l r © Oxford University Press. All rights reserved. Oxford University Press Properties of Matter 21 This is the twisting couple required to produce a twist of unit radian in a cylinder is called as torsional rigidity for a material of the cylinder. Special case In the hollow cylinder case, we have, for a cylinder of length l and inner radius r1 and outer radius r2, twisting couple of the cylinder T¢ = 2 1 phq 2 l s s r r È Î Í ˘ ˚ Ú ˙ d = (r2 4 – r1 4) and hence the couple per unit twist of the cylinder = T¢ = ph 2l (r2 4 – r1 4), assuming q = 1 radian.

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,

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

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

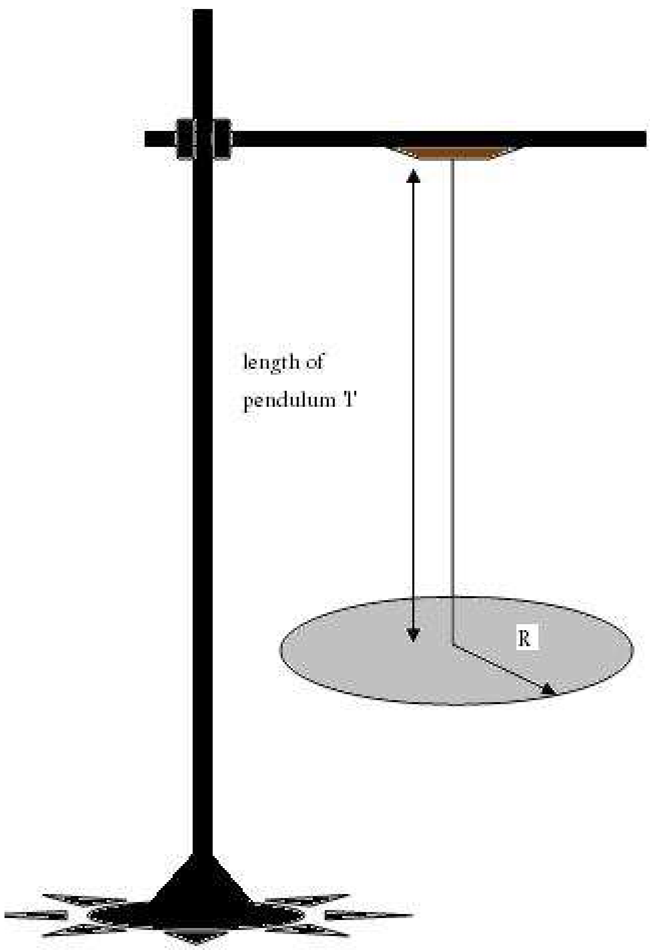
But we have an expression for couple per unit twist C as,

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

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

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



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

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

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

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

But from equation (1) ,

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

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

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

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

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),

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

Therefore,The moment of inertia of the disc,

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

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

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

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

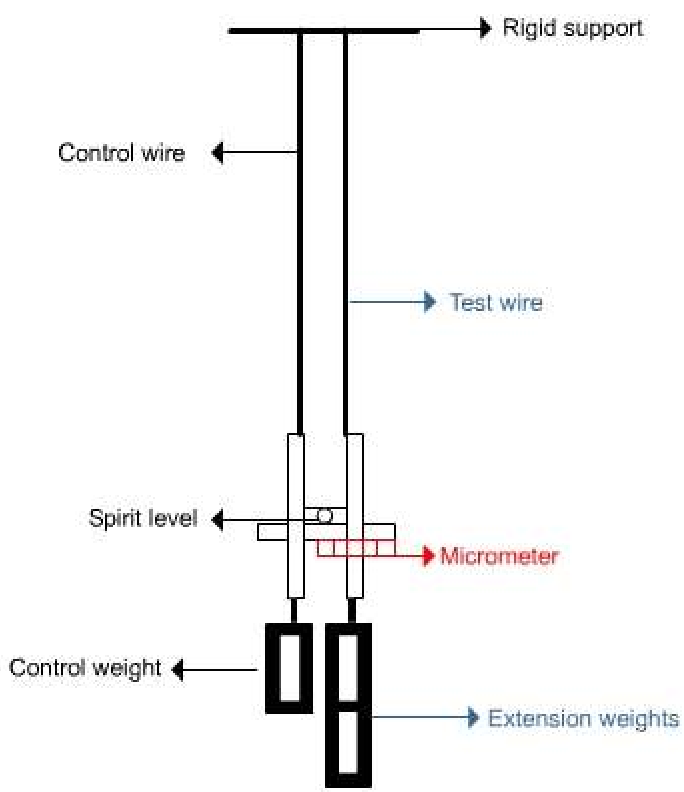
Y=StressStrain=F/Al/L=4FLπd

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. Load the test wire with a further weight. The spirit level is tilted due to elongation of test wire.
4. 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.
5. Calculate stress and strain from the formulae.

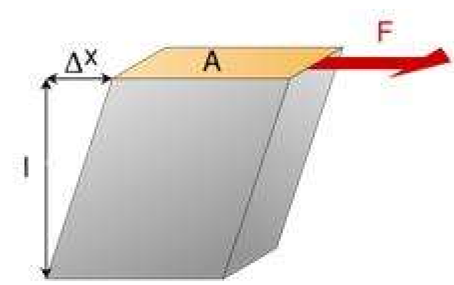
Repeat above steps by increasing load on the test wire to obtain more values of stresses and strains.

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

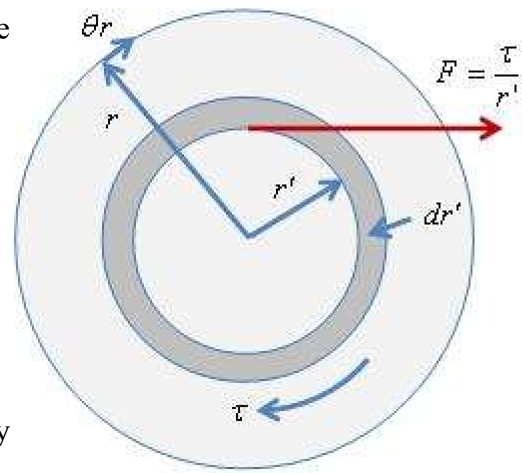
$$n = \frac{F/A}{\Delta x/l}$$



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 $2\pi r'dr'$, with force applied tangentially. The weighted average force over the cross-sectional area A of the rod is then

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

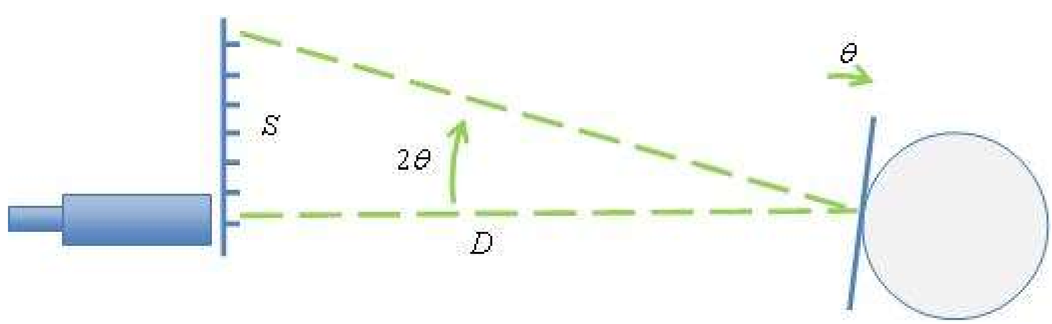
If the torque deforms the rod by twisting it through a small angle θ, the deformation distance (corresponding to Δx) at the outside edge of the rod is approximately θr. The definition of the rigidity modulus n becomes



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

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.

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DEPARTMENT OF PHYSICS

UNIT I :(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

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____________ 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

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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

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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

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power. Ocean Bio-mass.

Wind Energy:

Source of wind energy

- Atmosphere – a layer of gases that may surround a material body of sufficient mass, and that is held in place by the gravity of the body.
- Wind – the flow of gases on a large scale. Wind is composed of:
- Air – the gas found in the Earth's atmosphere. Air is mainly composed of nitrogen, oxygen, and argon, which together constitute the major gases of the atmosphere.
- Gas – one of the three classical states of matter (the others being liquid and solid).
- Motion – change in position of an object (including particles) with respect to time. Motion is typically described in terms of velocity, acceleration, displacement and time. Flow is a type of motion.

History of wind energy

- History of wind power – has been used as long as humans have put sails into the wind.
- Maritime history – The Ancient Egyptians had knowledge to some extent of sail construction.[1]
- History of sails – The earliest known depictions of sails are from ancient Egypt around 3200 BC, where reed boats sailed upstream against the River Nile's current.
- Age of Sail – the period in which international trade and naval warfare were dominated by sailing ships, lasting from the 16th to the mid 19th century.

Wind power

Wind power – conversion of wind energy into a useful form of energy.

- Variable renewable energy – any source of renewable energy that is not continuously available due to some factor outside direct control. The variable source may be quite predictable, for example, tidal power, but cannot be dispatched to meet the demand of a power system.
- Environmental impact of wind power – relatively minor compared to the environmental impact of traditional energy sources. Wind power consumes no fuel, and emits no air pollution, unlike fossil fuel power sources.
- Wind power forecasting – estimating the expected production of wind farms.
- Wind resource assessment – the process by which wind power developers estimate the future energy production of a wind farm.

Types of wind power

- Wind turbine – a turbine that converts wind energy into mechanical energy.
- Windmill – a machine which converts the energy of wind into rotational energy by means of vanes called sails or blades.
- Wind pump – a windmill used for pumping water, either as a source of fresh water from wells, or for draining low-lying areas of land.
- Sail – any type of surface intended to move a vessel, vehicle or rotor by being placed in a wind – in essence a propulsion wingWind power

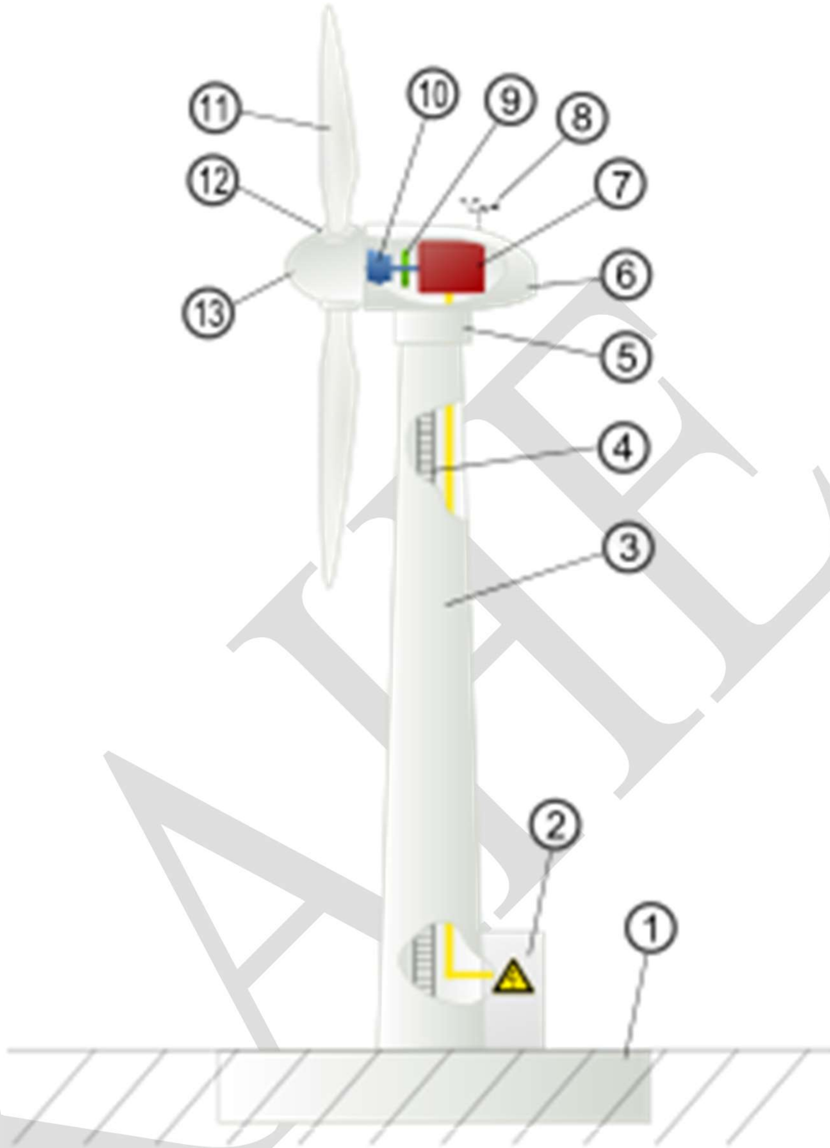
Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Wind power gives variable power which is very consistent from year to year but which has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid, and a lowered ability to supplant conventional production can occur. Power management techniques such as having excess capacity, geographically distributed turbines, dispatchable backing sources, sufficient hydroelectric power, exporting and importing power to neighboring areas, or reducing demand when wind production is low, can in many cases overcome these problems. In addition, weather forecasting permits the electric power network to be readied for the predictable variations in production that occur.

As of 2015, Denmark generates 40% of its electric power from wind, and at least 83 other countries around the world are using wind power to supply their electric power grids. In 2014, global wind power capacity expanded 16% to 369,553 MW. Yearly wind energy production is also growing rapidly and has reached around 4% of worldwide electric power usage, 11.4% in the EU.

3)Wind Turbines:



Typical wind turbine components:

1. Foundation
2. Connection to the electric grid
3. Tower
4. Access ladder
5. Wind orientation control (Yaw control)
6. Nacelle
7. Generator

8. Anemometer
9. Electric or Mechanical Brake
10. Gearbox
11. Rotor blade
12. Blade pitch control
13. Rotor hub

4) Marine energy

Marine energy or marine power (also sometimes referred to as ocean energy, ocean power, or marine and hydrokinetic energy) refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. This energy can be harnessed to generate electricity to power homes, transport and industries.

The term marine energy encompasses both wave power i.e. power from surface waves, and tidal power i.e. obtained from the kinetic energy of large bodies of moving water. Offshore wind power is not a form of marine energy, as wind power is derived from the wind, even if the wind turbines are placed over water.

The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world. Energy from the ocean is also known as hydroelectricity.

Global potential

There is the potential to develop 20,000–80,000 terawatt-hours (TWh) of electricity generated by changes in ocean temperatures, salt content, movements of tides, currents, waves and swells

Global potential	
Form	**Annual generation**
Tidal energy	>300 TWh
Marine current power	>800 TWh
Osmotic power Salinity gradient	2,000 TWh
Ocean thermal energy Thermal gradient	10,000 TWh
Wave energy	8,000–80,000 TWh
Source: IEA-OES, Annual Report 2007	

Indonesia as archipelagic country with three quarter of the area is ocean, has 49 GW recognized potential ocean energy and has 727 GW theoretical potential ocean energy.

Forms of ocean energy

Renewable

The oceans represent a vast and largely untapped source of energy in the form of surface waves, fluid flow, salinity gradients, and thermal.

Marine and Hydrokinetic (MHK) or marine energy development in U.S. and international waters includes projects using the following devices:

- Wave power converters in open coastal areas with significant waves;
- Tidal turbines placed in coastal and estuarine areas;
- In-stream turbines in fast-moving rivers;
- Ocean current turbines in areas of strong marine currents;
- Ocean thermal energy converters in deep tropical waters.

Strong ocean currents are generated from a combination of temperature, wind, salinity, bathymetry, and the rotation of the Earth. The Sun acts as the primary driving force, causing winds and temperature differences. Because there are only small fluctuations in current speed and stream location with no changes in direction, ocean currents may be suitable locations for deploying energy extraction devices such as turbines.

Ocean currents are instrumental in determining the climate in many regions around the world. While little is known about the effects of removing ocean current energy, the impacts of removing current energy on the far field environment may be a significant environmental concern. The typical turbine issues with blade strike, entanglement of marine organisms and acoustic effects still exists; however, these may be magnified due to the presence of more diverse populations of marine organisms using ocean currents for migration purposes. Locations can be further offshore and therefore require longer power cables that could affect the marine environment with electromagnetic output.

Water typically varies in temperature from the surface warmed by direct sunlight to greater depths where sunlight cannot penetrate. This differential is greatest in tropical waters, making this technology most applicable in water locations. A fluid is often vaporized to drive a turbine that may generate electricity or produce desalinized water. Systems may be either open-cycle, closed-cycle, or hybrid.

Non-renewable

Petroleum and natural gas beneath the ocean floor are also sometimes considered a form of ocean energy. An ocean engineer directs all phases of discovering, extracting, and delivering offshore petroleum (via oil tankers and pipelines,) a complex and demanding task. Also centrally important is the development of new methods to protect marine wildlife and coastal regions against the undesirable side effects of offshore oil extraction.

Marine energy development

The UK is leading the way in wave and tidal (marine) power generation. The world's first marine energy test facility was established in 2003 to kick start the development of the marine energy industry in the UK. Based in Orkney, Scotland, the European Marine Energy Centre (EMEC) has supported the deployment of more wave and tidal energy devices than at any other single site in the world. The Centre was established with around £36 million of funding from the Scottish Government, Highlands and Islands Enterprise, the Carbon Trust, UK Government, Scottish Enterprise, the European Union and Orkney Islands Council, and is the only accredited wave and tidal test centre for marine renewable energy in the world, suitable for testing a number of full-scale devices simultaneously in some of the harshest weather conditions while producing electricity to the national grid.

Clients that have tested at the centre include Aquamarine Power, AW Energy, Pelamis Wave Power, Seatricity, Scottish Power Renewables and Wello on the wave site, and Alstom (formerly Tidal Generation Ltd), ANDRITZ HYDRO Hammerfest, Kawasaki Heavy Industries, Magallanes, Nautricity, Open Hydro, Scot renewables Tidal Power, and Voith on the tidal site.
Leading the €11m FORESEA (Funding Ocean Renewable Energy through Strategic European Action) project, which provides funding support to ocean energy technology developers to access Europe's world-leading ocean energy test facilities, EMEC will welcome a number of wave and tidal clients to their pipeline for testing on site.
Beyond device testing, EMEC also provides a wide range of consultancy and research services, and is working closely with Marine Scotland to streamline the consenting process for marine energy developers. EMEC is at the forefront in the development of international standards for marine energy, and is forging alliances with other countries, exporting its knowledge around the world to stimulate the development of a global marine renewables industry.

Environmental effects

Common environmental concerns associated with marine energy developments include:

- the risk of marine mammals and fish being struck by tidal turbine blades
- the effects of EMF and underwater noise emitted from operating marine energy devices
- the physical presence of marine energy projects and their potential to alter the behavior of marine mammals, fish, and seabirds with attraction or avoidance
- the potential effect on near field and far field marine environment and processes such as sediment transport and water quality.

5) Tidal power:

Sihwa Lake Tidal Power Station, located in Gyeonggi Province, South Korea, is the world's largest tidal power installation, with a total power output capacity of 254 MW.

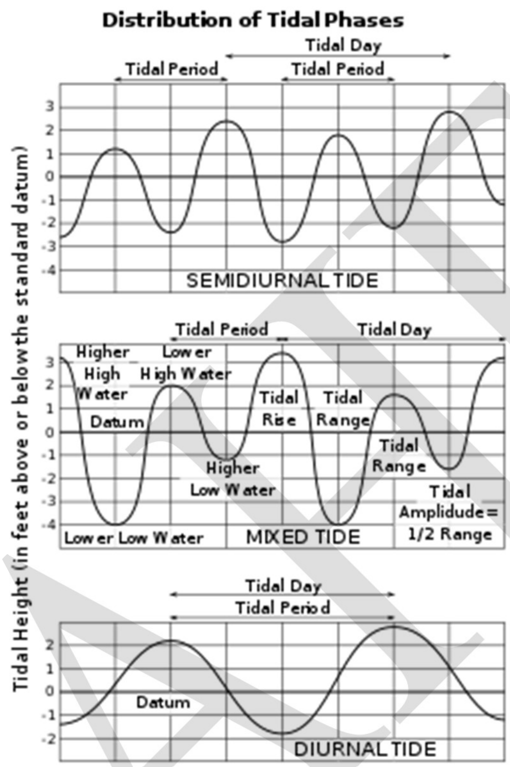
Tidal power or **tidal energy** is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.

Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels.

Historically, tide mills have been used both in Europe and on the Atlantic coast of North America. The incoming water was contained in large storage ponds, and as the tide went out, it turned waterwheels that used the mechanical power it produced to mill grain. The earliest occurrences date from the Middle Ages, or even from Roman times. The process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe in the 19th century.

The world's first large-scale tidal power plant was the Rance Tidal Power Station in France, which became operational in 1966. It was the largest tidal power station in terms of output until Sihwa Lake Tidal Power Station opened in South Korea in August 2011. The Sihwa station uses sea wall defense barriers complete with 10 turbines generating 254 MW.

Generation of tidal energy



Variation of tides over a day

Tidal power is taken from the Earth's oceanic tides. Tidal forces are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the water level is created, causing a temporary increase in sea level. When the sea level is raised, water from the middle of the ocean is forced to move toward the shorelines, creating a tide. This occurrence takes place in an unfailing manner, due to the consistent pattern of the moon's orbit around the earth. The magnitude and character of this motion reflects the changing positions of the Moon and Sun relative to the Earth, the effects of Earth's rotation, and local geography of the sea floor and coastlines.

Tidal power is the only technology that draws on energy inherent in the orbital characteristics of the Earth–Moon system, and to a lesser extent in the Earth–Sun system. Other natural energies exploited by human technology originate directly or indirectly with the Sun, including fossil fuel, conventional hydroelectric, wind, biofuel, wave and solar energy. Nuclear energy makes use of Earth's mineral deposits of fissionable elements, while geothermal power taps the Earth's internal heat, which comes from a combination of residual heat from planetary accretion (about 20%) and heat produced through radioactive decay (80%).

A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation. Because the Earth's tides are ultimately due to gravitational interaction with the Moon and Sun and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy resource. Movement of tides causes a loss of mechanical energy in the Earth–Moon system: this is a result of pumping of water through natural restrictions around coastlines and consequent viscous dissipation at the seabed and in turbulence. This loss of energy has caused the rotation of the Earth to slow in the 4.5 billion years since its formation. During the last 620 million years the period of rotation of the earth (length of a day) has increased from 21.9 hours to 24 hours in this period the Earth has lost 17% of is rotational energy. While tidal power will take additional energy from the system, the effect is negligible and would only be noticed over millions of years.

Generating methods

The world's first commercial-scale and grid-connected tidal stream generator – SeaGen – in Strangford Lough. The strong wake shows the power in the tidal current.

Tidal power can be classified into four generating methods:

Tidal stream generator

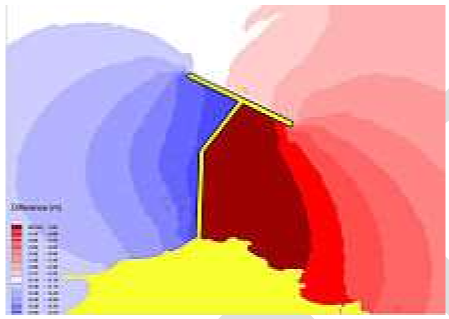
Main article: Tidal stream generator

Tidal stream generators (or TSGs) make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use wind to power turbines. Some tidal generators can be built into the structures of existing bridges or are entirely submersed, thus avoiding concerns over impact on the natural landscape. Land constrictions such as straits or inlets can create high velocities at specific sites, which can be captured with the use of turbines. These turbines can be horizontal, vertical, open, or ducted.

Tidal barrage

Tidal barrages make use of the potential energy in the difference in height (or hydraulic head) between high and low tides. When using tidal barrages to generate power, the potential energy from a tide is seized through strategic placement of specialized dams. When the sea level rises and the tide begins to come in, the temporary increase in tidal power is channeled into a large basin behind the dam, holding a large amount of potential energy. With the receding tide, this energy is then converted into mechanical energy as the water is released through large turbines that create electrical power through the use of generators. Barrages are essentially dams across the full width of a tidal estuary.

Dynamic tidal power



Top-down view of a DTP dam. Blue and dark red colors indicate low and high tides, respectively.

Dynamic tidal power (or DTP) is an untried but promising technology that would exploit an interaction between potential and kinetic energies in tidal flows. It proposes that very long dams (for example: 30–50 km length) be built from coasts straight out into the sea or ocean, without enclosing an area. Tidal phase differences are introduced across the dam, leading to a significant water-level differential in shallow coastal seas – featuring strong coast-parallel oscillating tidal currents such as found in the UK, China, and Korea.

Tidal lagoon

A new tidal energy design option is to construct circular retaining walls embedded with turbines that can capture the potential energy of tides. The created reservoirs are similar to those of tidal barrages, except that the location is artificial and does not contain a preexisting ecosystem. The lagoons can also be in double (or triple) format without pumping or with pumping that will flatten out the power output. The pumping power could be provided by excess to grid demand renewable energy from for example wind turbines or solar photovoltaic arrays. Excess renewable energy rather than being curtailed could be used and stored for a later period of time. Geographically dispersed tidal lagoons with a time delay between peak production would also flatten out peak production providing near base load production though at a higher cost than some other alternatives such as district heating renewable energy storage. The proposed

Tidal Lagoon Swansea Bay in Wales, United Kingdom would be the first tidal power station of this type once built.

6) Osmotic power

Osmotic power, **salinity gradient power** or **blue energy** is the energy available from the difference in the salt concentration between seawater and river water. Two practical methods for this are reverse electro dialysis (RED) and pressure retarded osmosis (PRO). Both processes rely on osmosis with membranes. The key waste product is brackish water. This byproduct is the result of natural forces that are being harnessed: the flow of fresh water into seas that are made up of salt water.

In 1954, Pattle suggested that there was an untapped source of power when a river mixes with the sea, in terms of the lost osmotic pressure, however it was not until the mid '70s where a practical method of exploiting it using selectively permeable membranes by Loeb was outlined.

The method of generating power by pressure retarded osmosis was invented by Prof. Sidney Loeb in 1973 at the Ben-Gurion University of the Negev, Beersheba, Israel. The idea came to Prof. Loeb, in part, as he observed the Jordan River flowing into the Dead Sea. He wanted to harvest the energy of mixing of the two aqueous solutions (the Jordan River being one and the Dead Sea being the other) that was going to waste in this natural mixing process. In 1977 Prof. Loeb invented a method of producing power by a reverse electro dialysis heat engine.

The technologies have been confirmed in laboratory conditions. They are being developed into commercial use in the Netherlands (RED) and Norway (PRO). The cost of the membrane has been an obstacle. A new, lower cost membrane, based on an electrically modified polyethylene plastic, made it fit for potential commercial use.[6] Other methods have been proposed and are currently under development. Among them, a method based on electric double-layer capacitor technology and a method based on vapor pressure difference.

Biomass

Biomass briquettes are an example fuel for production of dendrothermal energy

Biomass is an industry term for getting energy by burning wood, and other organic matter. Burning biomass releases carbon emissions, but has been classed as a renewable energy source in the EU and UN legal frameworks, because plant stocks can be replaced with new growth. Also, since the plants build themselves using carbon dioxide and release oxygen as they grow, the net balance of the carbon dioxide after the matter has burned is zero, meaning no extra carbon dioxide is added to the atmosphere. It has become popular among coal power stations, which switch from coal to biomass in order to convert to renewable energy generation without wasting existing generating plant and infrastructure. Biomass most often refers to plants or plant-based materials that are not used for food or feed, and are specifically called lignocellulosic biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: *thermal*, *chemical*, and *biochemical* methods.

7) Electrical grid:

"Power grid" redirects here. For the board game, see Power Grid.

General layout of electricity networks. Voltages and depictions of electrical lines are typical for Germany and other European systems.

An **electrical grid** is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power, high voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers

Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the electric power transmission network.

The bulk power transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local electric power distribution network).

On arrival at a substation, the power will be stepped down from a transmission level voltage to a distribution level voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

Electrical grids vary in size from covering a single building through *national grids* which cover whole countries, to *transnational grids* which can cross continents.

In telecommunications, **interconnection** is the physical linking of a carrier's network with equipment or facilities not belonging to that network. The term may refer to a connection between a carrier's facilities and the equipment belonging to its customer, or to a connection between two (or more) carriers.

In United States regulatory law, interconnection is specifically defined (47 C.F.R. 51.5) as "the linking of two or more networks for the mutual exchange of traffic."

One of the primary tools used by regulators to introduce competition in telecommunications markets has been to impose interconnection requirements on dominant carriers.

UNIT - III

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. What is hydro energy?
2. Write a note on hydropower technology?
3. How the hydrothermal technologies are impact the environment?
4. Write a short note on piezoelectric effect,
5. Explain briefly the piezoelectric generators?
6. Give an importance about hydro energy.

PART - C (6 MARKS)

1. What are the applications of hydropower technology?
2. Write a note on hydropower technology?
3. Explain piezoelectric effect and give some example.
4. Give an importance of piezoelectric effect?

5. What is the role of piezoelectric effect in energy harvesting?
6. Explain the piezoelectric generators?
7. Write a short note on piezoelectric effect, and its applications?

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DEPARTMENT OF PHYSICS

UNIT I :(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

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PROPERTIES OF MATTER AND ACCOUSTICS

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

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PROPERTIES OF MATTER AND ACCOUSTICS

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

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PART-A (Online Examination)

PROPERTIES OF MATTER AND ACCOUSTICS

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

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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

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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

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PROPERTIES OF MATTER AND ACCOUSTICS

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

UNIT- IV

SYLLABUS

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.

Hydro Energy :

Flowing water creates energy that can be captured and turned into electricity. This is called hydroelectric power or hydropower.

The most common type of hydroelectric power plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. But hydroelectric power doesn't necessarily require a large dam. Some hydroelectric power plants just use a small canal to channel the river water through a turbine.

Another type of hydroelectric power plant - called a pumped storage plant - can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir, where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

A small or micro-hydroelectric power system can produce enough electricity for a home, farm, or ranch.

Hydropower types :

- Hydropower is used primarily to generate electricity. Broad categories include:
- Conventional hydroelectric, referring to hydroelectric dams.

- Run-of-the-river hydroelectricity, which captures the kinetic energy in rivers or streams, without a large reservoir and sometimes without the use of dams.
- Small hydro projects are 10 megawatts or less and often have no artificial reservoirs.
- Micro hydro projects provide a few kilowatts to a few hundred kilowatts to isolated homes, villages, or small industries.
- Conduit hydroelectricity projects utilize water which has already been diverted for use elsewhere; in a municipal water system, for example.
- Pumped-storage hydroelectricity stores water pumped uphill into reservoirs during periods of low demand to be released for generation when demand is high or system generation is low.
- Pressure buffering hydropower use natural sources (waves for example) for water pumping to turbines while exceeding water is pumped uphill into reservoirs and releases when incoming water flow isn't enough.

ADVANTAGES:

1. Once a dam is constructed, electricity can be produced at a constant rate.
2. If electricity is not needed, the sluice gates can be shut, stopping electricity generation. The water can be saved for use another time when electricity demand is high.
3. Dams are designed to last many decades and so can contribute to the generation of electricity for many years / decades.
4. The lake that forms behind the dam can be used for water sports and leisure / pleasure activities. Often large dams become tourist attractions in their own right.
5. The lake's water can be used for irrigation purposes.
6. The buildup of water in the lake means that energy can be stored until needed, when the water is released to produce electricity.
7. When in use, electricity produced by dam systems do not produce green house gases. They do not pollute the atmosphere.

DISADVANATGES:

1. Dams are extremely expensive to build and must be built to a very high standard.

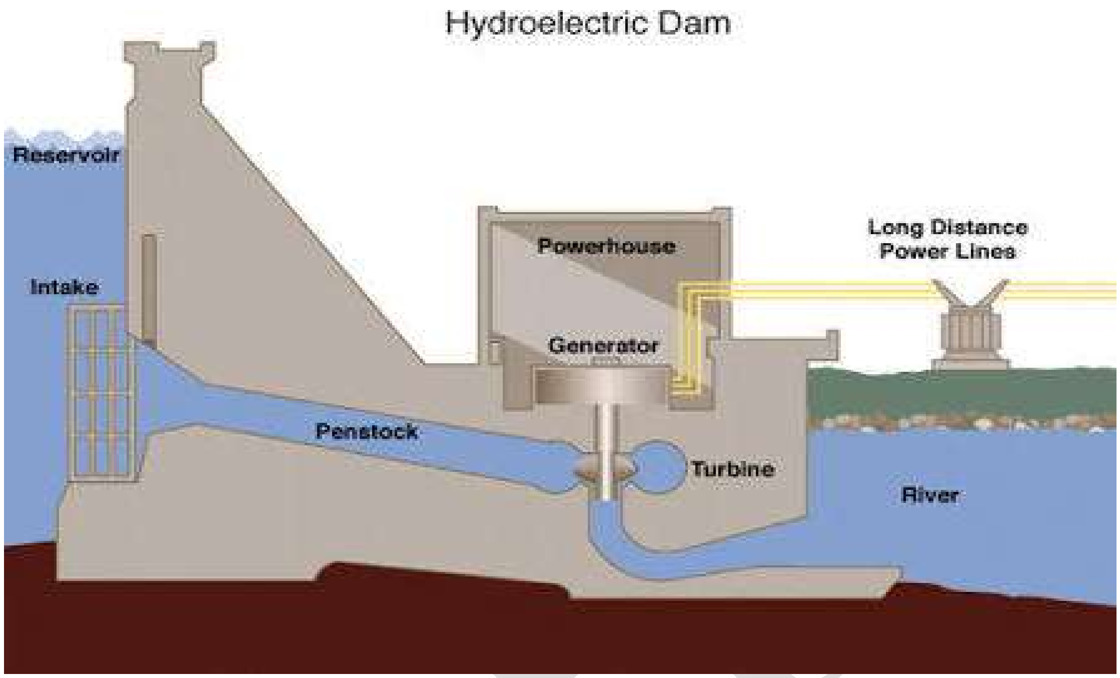
2. The high cost of dam construction means that they must operate for many decades to become profitable.
3. The flooding of large areas of land means that the natural environment is destroyed.
4. People living in villages and towns that are in the valley to be flooded, must move out. This means that they lose their farms and businesses. In some countries, people are forcibly removed so that hydro-power schemes can go ahead.
5. The building of large dams can cause serious geological damage. For example, the building of the Hoover Dam in the USA triggered a number of earth quakes and has depressed the earth's surface at its location.
6. Although modern planning and design of dams is good, in the past old dams have been known to be breached (the dam gives under the weight of water in the lake). This has led to deaths and flooding.
7. Dams built blocking the progress of a river in one country usually means that the water supply from the same river in the following country is out of their control. This can lead to serious problems between neighbouring countries.
8. Building a large dam alters the natural water table level. For example, the building of the Aswan Dam in Egypt has altered the level of the water table. This is slowly leading to damage of many of its ancient monuments as salts and destructive minerals are deposited in the stone work from 'rising damp' caused by the changing water table level.

Hydropower Works :

Hydropower plants capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy.

Hydroplants range in size from "micro-hydros" that power only a few homes to giant dams like Hoover Dam that provide electricity for millions of people.

The photo on the right shows the Alexander Hydroelectric Plant on the Wisconsin River, a medium-sized plant that produces enough electricity to serve about 8,000 people.



Parts of a Hydroelectric Plant :

Most conventional hydroelectric plants include four major components (see graphic below):

Dam: Raises the water level of the river to create falling water. Also controls the flow of water. The reservoir that is formed is, in effect, stored energy.

Turbine: The force of falling water pushing against the turbine's blades causes the turbine to spin. A water turbine is much like a windmill, except the energy is provided by falling water instead of wind. The turbine converts the kinetic energy of falling water into mechanical energy.

Generator: Connected to the turbine by shafts and possibly gears so when the turbine spins it causes the generator to spin also. Converts the mechanical energy from the turbine into electric energy. Generators in hydropower plants work just like the generators in other types of power plants.

Transmission lines: Conduct electricity from the hydropower plant to homes and business.

Environmental impacts of hydro power technology :

Hydropower Is Nonpolluting, but Does Have Environmental Impacts

Hydropower does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area.

Fish Ladder at the Bonneville Dam on the Columbia River Separating Washington and Oregon. Most hydroelectric power plants have a dam and a reservoir. These structures may obstruct fish migration and affect their populations. Operating a hydroelectric power plant may also change the water temperature and the river's flow. These changes may harm native plants and animals in the river and on land.

Reservoirs may cover people's homes, important natural areas, agricultural land, and archeological sites. So building dams can require relocating people. Methane, a strong greenhouse gas, may also form in some reservoirs and be emitted to the atmosphere.

Environmental Impacts of Hydropower Plants :

The impact of hydroelectric power plant on the environment is varied and depends upon the size and type of the project. Although hydropower generation does not burn any fuel to produce power and hence does not emit greenhouse gases, there are definite negative effects that arise from the creation of reservoir and alteration of natural water flow. It is a fact that dams, inter-basin transfers and diversion of water for irrigation purposes have resulted in the fragmentation of 60% of the world's rivers.

ENVIRONMENTAL IMPACT

The physical environment is affected rather significantly by the construction of a hydroelectric power station. Both the river and ecosystem of the surrounding land area will be altered as soon as dam construction begins.

1. Impact of Size and Type of Hydropower Plant :

It is difficult to correlate the damage caused by dams to their size or type, as the impacts depend on local conditions. Generally plants with smaller dams are considered less environmentally damaging than those with larger dams. Also, run-of-river (ROR) hydropower plants are generally less damaging than reservoir power plants, because it is not necessary to flood large areas upstream of the project for storage. Yet in some cases run of river impacts can also be severe due to river diversion over long stretches of the river.

2. Impact of River Diversion :

While both ROR and reservoir types of hydropower dams may divert water, this is always the case with ROR plants, since they seek to increase kinetic energy with an increased head. The length of diversion can range from a few meters or less to kilometers (km). For example, the Teesta-V ROR dam in northeastern India diverts water for a 23 km long stretch of the river. Eventually the diverted water is returned to the river.

Often downstream flows are reduced considerably or even completely stopped during certain periods of time with sudden intervals of high flows. Such drastic variability in water flow impacts the structure of aquatic ecosystems often leading to a loss of biodiversity. Also, under normal conditions, increased sediment transport from low to intermediate flows provides a warning to aquatic organisms that high flows may follow. Abrupt changes from low to high flows obliterate this cue, making it difficult for organisms to respond to impending environmental changes. A decrease in fish populations has been observed in dewatered reaches below diversions. After long periods of little to no flow some species may not be able to recover and go extinct.

3. Impact of the Reservoir :

Dams have major impacts on the physical, chemical and geo-morphological properties of a river. Environmental impacts of dams have largely been negative. Worldwide, at least 400,000 square kilometers have been flooded by reservoirs.

Once the barrier is put in place, the free flow of water stops and water will begin to accumulate behind the dam in the new reservoir. This land may have been used for other things such as agriculture, forestry, and even residences, but it is now unusable. The loss of habitat may not seem severe but if this area was home to a threatened or endangered species, the dam construction could further threaten that species risk of extinction.

3.1 Sedimentation :

Large dams with reservoirs significantly alter the timing, amount and pattern of river flow. This changes erosion patterns and the quantity and type of sediments transported by the river. Sedimentation rate is primarily related to the ratio of the size of the river to the flux of sediments. The reservoir that has been rapidly filling up with water immediately begins filling up with sediment as well. The trapping of sediments behind the dam is a major problem. Every year it is estimated that 0.5 to 1% of reservoir storage capacity is lost due to sedimentation. The engineering problem with sedimentation is that less power is generated as the reservoir's capacity shrinks.

3.2 Downstream Erosion:

Trapping of sediments at the dam also has downstream impacts by reducing the flux of sediments downstream which can lead to the gradual loss of soil fertility in floodplain soils. Clean water stripped of its sediment load is now flowing downstream of the dam. This clean water has more force and velocity then water carrying a high sediment load and thus erosion of the riverbed and banks becomes problematic. Since this is unnatural and a form of "forced erosion" it occurs at a much faster rate than natural river process erosion to which the local ecosystem would be able to adapt.

3.3 Impact on Local Climate :

Another often-ignored environmental effect of the reservoir is the impact on the micro-climate level. Studies indicate that man-made lakes in tropical climates tend to reduce convection and thus limit cloud cover. Temperate regions are also impacted with "steam-fog" in the time period before freezing. Since water cools and warms slower then land, coastal regions tend to be much more moderate then land-locked regions in terms of temperature. Therefore, large dams have a slight moderating effect on the local climate.

3.4 Greenhouse Gas Emission from Dams :

Freshwater reservoirs can emit substantial amounts of the greenhouse gases methane and carbon dioxide as organic matter submerged in a reservoir decays under anaerobic and aerobic conditions, respectively. Studies indicate that GHG emissions from hydropower reservoirs in boreal and temperate region are low relative to the emissions from fossil fuel power plants, but higher relative to life cycle emissions from wind and solar power.

Tropical reservoirs with high levels of organic matter and shallow reservoirs have higher emission levels. A recent compilation of greenhouse gas emissions from reservoirs found a correlation between the age of the reservoir and latitude. Younger reservoirs and those in low latitudes are the highest emitters. For example, of four Brazilian dams in the Amazon, showed that the GHG emissions factor of the electricity produced by those hydropower dams exceed those from a coal-fired power plant.

3.5 Dams Inducing Earthquakes :

Finally, a least studied and most disputed physical impact of reservoirs is the possibility of inducing earthquakes. Many scientists believe that seismic activity can be attributed to the creation of dams and their adjacent storage reservoirs. They postulate that the added forces of the dam along inactive faults seem to free much stronger orogenic tensions. Early research indicates that the depth of the water column may be more important to inducing earthquakes rather than total volume of water in the reservoir. While more research is needed on this subject several disasters such as the Koyna Dam in India seem to provide some truth to this theory. While these impacts can be quite severe often they do not receive the attention of the biological impacts that people tend to associate more with animals like fish.

3.6 Impact on Fisheries :

Dams and river diversion can impact freshwater, as well as marine fisheries. Estuarine and marine fisheries are dependent on estuaries and rivers as spawning grounds and the transport of nutrients from the river to the sea. Migratory fish are especially vulnerable to the impacts of dam construction. Dams can prevent migrating fish such as salmon and eel to reach their spawn grounds.

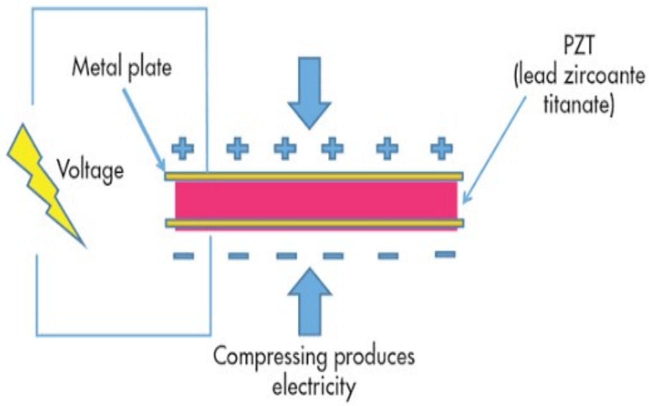
A survey of 125 dams by the World Commission on Dams (WCD) reported that blocking the passage of migratory fish species has been identified as a major reason for freshwater species extinction in North America. Lower catch is a common side effect of dams and has been reported worldwide. There have been cases where fishery production below a dam has increased due to controlled discharge of the sediments.

Piezo electric effect harvesting Principles :

Piezoelectricity is found in crystalline materials that possess non-centrosymmetry. This effect induces an electric polarization proportional to an applied mechanical stress (direct piezoelectric effect) or a mechanical strain proportional to an applied electric field (converse piezoelectric effect). During vibration energy harvesting, piezoelectric materials convert mechanical strain into an electrical charge or voltage via the direct piezoelectric effect. The power output of a particular piezoelectric energy harvester depends upon intrinsic and extrinsic factors. Intrinsic factors include the frequency constant of the piezoelectric element, piezoelectric and mechanical properties of the material, and the temperature and stress dependence of the physical properties. Extrinsic factors comprise of the input vibration frequency, acceleration of the base/host structure, and the amplitude of the excitation. Figure 1 illustrates different configurations of piezoelectric harvesters and their features. The combination of the mechanical architecture and material properties allows for variations in the frequency operating range and the power output.

The efficiency and the power density of a piezoelectric vibration energy harvester are strongly frequency dependent, because, the piezoelectric material generates its maximum power at the electromechanical resonance frequency. The low frequency fundamental mode should be targeted in the design of the energy harvesting device since the potential output power is proportional to $1/f$ (f = the frequency of the fundamental vibration mode). That said, the lower the frequency of the vibration base, the more complex it becomes to design the energy harvesting structure, as the dimension and weight constraints limit the use of the ceramics to achieve the desired fundamental frequency.

What is the Piezoelectric Effect?



Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. The word Piezoelectric is derived from the Greek piezein, which means to squeeze or press, and piezo, which is Greek for “push”.

One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (the generation of electricity when stress is applied) also exhibit the converse piezoelectric effect (the generation of stress when an electric field is applied).

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material.

The piezoelectric effect is very useful within many applications that involve the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, and ultra fine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, such as scanning probe microscopes (STM, AFM, etc). The piezoelectric effect also has its use in more mundane applications as well, such as acting as the ignition source for cigarette lighters.

The History of the Piezoelectric Effect :

The direct piezoelectric effect was first seen in 1880, and was initiated by the brothers Pierre and Jacques Curie. By combining their knowledge of pyroelectricity with their understanding of crystal structures and behavior, the Curie brothers demonstrated the first piezoelectric effect by using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt.

Their initial demonstration showed that quartz and Rochelle salt exhibited the most piezoelectricity ability at the time.

Over the next few decades, piezoelectricity remained in the laboratory, something to be experimented on as more work was undertaken to explore the great potential of the piezoelectric effect. The breakout of World War I marked the introduction of the first practical application for piezoelectric devices, which was the sonar device. This initial use of piezoelectricity in sonar created intense international developmental interest in piezoelectric devices. Over the next few decades, new piezoelectric materials and new applications for those materials were explored and developed.

During World War II, research groups in the US, Russia and Japan discovered a new class of man-made materials, called ferroelectrics, which exhibited piezoelectric constants many times higher than natural piezoelectric materials. Although quartz crystals were the first commercially exploited piezoelectric material and still used in sonar detection applications, scientists kept searching for higher performance materials. This intense research resulted in the development of barium titanate and lead zirconate titanate, two materials that had very specific properties suitable for particular applications.

Piezoelectric Materials :

There are many materials, both natural and man-made, that exhibit a range of piezoelectric effects. Some naturally piezoelectric occurring materials include Berlinite (structurally identical to quartz), cane sugar, quartz, Rochelle salt, topaz, tourmaline, and bone (dry bone exhibits some piezoelectric properties due to the apatite crystals, and the piezoelectric effect is generally thought to act as a biological force sensor). An example of man-made piezoelectric materials includes barium titanate and lead zirconate titanate.

In recent years, due to the growing environmental concern regarding toxicity in lead-containing devices and the RoHS directive followed within the European Union, there has been a push to develop lead free piezoelectric materials. To date, this initiative to develop new lead-free piezoelectric materials has resulted in a variety of new piezoelectric materials which are more environmentally safe.

Applications Best Suited for the Piezoelectric Effect :

Due to the intrinsic characteristics of piezoelectric materials, there are numerous applications that benefit from their use:

1. High Voltage and Power Sources :

An example of applications in this area is the electric cigarette lighter, where pressing a button causes a spring-loaded hammer to hit a piezoelectric crystal, thereby producing a sufficiently high voltage that electric current flows across a small spark gap, heating and igniting the gas. Most types of gas burners and ranges have a built-in piezo based injection systems.

2.Sensors :

The principle of operation of a piezoelectric sensor is that a physical dimension, transformed into a force, acts on two opposing faces of the sensing element. The detection of pressure variations in the form of sound is the most common sensor application, which is seen in piezoelectric microphones and piezoelectric pickups for electrically amplified guitars. Piezoelectric sensors in particular are used with high frequency sound in ultrasonic transducers for medical imaging and industrial nondestructive testing.

3. Piezoelectric Motors :

Because very high voltages correspond to only tiny changes in the width of the crystal, this crystal width can be manipulated with better-than-micrometer precision, making piezo crystals an important tool for positioning objects with extreme accuracy, making them perfect for use in motors, such as the various motor series offered by Nanomotion. Regarding piezoelectric motors, the piezoelectric element receives an electrical pulse, and then applies directional force to an opposing ceramic plate, causing it to move in the desired direction. Motion is generated when the piezoelectric element moves against a static platform (such as ceramic strips).

The characteristics of piezoelectric materials provided the perfect technology upon which Nanomotion developed our various lines of unique piezoelectric motors. Using patented piezoelectric technology, Nanomotion has designed various series of motors ranging in size from a single element (providing 0.4Kg of force) to an eight element motor (providing 3.2 Kg of force). Nanomotion motors are capable of driving both linear and rotary stages, and have a wide dynamic range of speed, from several microns per second to 250 mm/sec and can easily mount to traditional low friction stages or other devices. The operating characteristics of Nanomotion's motors provide inherent braking and the ability to eliminate servo dither when in a static position.

Human Power :

Human power is an often overlooked form of renewable energy with quite a bit of potential. As energy prices rise with no relief in sight, more companies are developing devices designed to harness human power and make use of our most natural resource: our own bodies. There are a number of ways to generate human power, and in fact most of them are based on principles we use every day that many people don't realize actually produce energy. Perhaps the most common example of human power in modern devices is the Faraday flashlight. Retail department stores and television sales offer these "eternal" flashlights that need no batteries. Rather, they are run by human power-simply shake the flashlight vigorously for about thirty seconds, and the flashlight will produce a strong, steady source of light for several minutes. Faraday flashlights operate using magnets and copper coils.

Human power can also be used for crank generators, which are devices that generate electricity by manually turning a crank. Crank generators often incorporate built-in flashlights, and are available with a range of energy output. Small human power crank generators can produce enough energy from three minutes of cranking to power a dead cell phone for two to eight minutes. Larger capacity crank generators are capable of much more energy output.

The most popular and effective method of human power generation, however, is cycling. There are several devices that can convert human power from cycling to energy. Most are either free-standing equipment with pedals attached to a generator, or a portable device that actually attaches to a bicycle and generates power while you ride. Human power is an exciting form of alternative, renewable energy that offers the added benefit of exercise while you pump out power.

Linear alternator :

A linear alternator is essentially a linear motor used as an electrical generator.
An alternator is a type of alternating current (AC) electrical generator. The devices are often physically equivalent. The principal difference is in how they are used and which direction the

energy flows. An alternator converts mechanical energy to electrical energy, whereas a motor converts electrical energy to mechanical energy. Like most electric motors and electric generators, the linear alternator works by the principle of electromagnetic induction. However, most alternators work with rotary motion, whereas "linear" alternators work with "linear" motion (i.e. motion in a straight line).

Theory :

When a magnet moves in relation to an electromagnetic coil, this changes the magnetic flux passing through the coil, and thus induces the flow of an electric current, which can be used to do work. A linear alternator is most commonly used to convert back-and-forth motion directly into electrical energy. This short-cut eliminates the need for a crank or linkage that would otherwise be required to convert a reciprocating motion to a rotary motion in order to be compatible with a rotary generator.

Applications :

The simplest type of linear alternator is the Faraday Flashlight. This is a torch (UK) or flashlight (USA) which contains a coil and a permanent magnet. When the appliance is shaken back and forth, the magnet oscillates through the coil and induces an electric current. This current is used to charge a capacitor, thus storing energy for later use. The appliance can then produce light, usually from a light-emitting diode, until the capacitor is discharged. It can then be re-charged by further shaking.

Other devices which use linear alternators to generate electricity include the free-piston linear generator, an internal combustion engine, and the free-piston Stirling engine, an external combustion engine.

UNIT - IV

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Write a note on cell.
2. Write a note on batteries.
3. What are the applications of electromagnetic energy?
4. Give a short note on any two renewable energies.
5. State briefly about geothermal energy.
6. Give a note on electromagnetic energy.

PART - C (6 MARKS)

1. How the energy is harvesting from electromagnetic effect?
2. Describe about geothermal energy?
3. Write a short note on renewable energy sources?
4. Give the importance about renewable sources of energy?
5. Write the different type of renewable energy sources and give the examples.
6. Explain why we need the renewable energy?

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(For the candidates admitted from 2018 onwards)
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UNIT I :(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

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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	dimensionl ess 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

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DEPARTMENT OF PHYSICS

UNIT I :(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

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UNIT I :(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

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

PROPERTIES OF MATTER AND ACCOUSTICS

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	Terotechnolog y	nanotribolo gy	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

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UNIT I :(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

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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

UNIT- V

SYLLABUS

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications, Geothermal Energy: Geothermal Resources, Geothermal Technologies. Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.

Energy Harvesting from Electromagnetic Energy

Many schemes have been proposed recently focusing in the development of systems capable of harnessing useful electrical energy from existing environmental sources, especially in the wireless sensor networking community. Photo-Voltaic conversion of visible part of the electromagnetic spectrum to electrical power is well established and Photo-Voltaic cells provide relatively high efficiency over a broad range of wavelengths. These devices are typically low cost and provide voltage and current levels that are close to those required for micro-electronics. Conversion of ambient RF signals to useful electrical energy is far more challenging due to the broadband, low intensity nature of the signals typically present. An example of a system drawing energy from RF signals are crystal radio kits that draw their power directly from AM radio stations, which play audibly through high-impedance headphones without needing a local energy source.

One of the examples of similar harvesting scheme is the aftermarket modules that flash LED’s using energy from electromagnetic waves when a cell phone uses its radio. Rather than relying on the limited energy scavenged from ambient radiation, other approaches actively beam power from a transmitter to remote devices. The dream of wirelessly broadcasting power to an urban area dates back to the turn of the 20’th century and Nicola Tesla, who experimented with grandiose concepts of global resonance and gigantic step-up coils that radiated strong, 150 kHz electromagnetic fields able to illuminate gas-filled light bulbs attached to a local antenna and ground at large distances. Recently researchers have experimented with microwave transmission

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of power in domestic environments. At much lower power levels, short-range wireless power transmission is now commonplace in passive Radio Frequency Identification (RFID) systems, which derive their energy inductively, capacitively or radiatively from the tag reader.

Researchers have explored the possibility of extracting power from the magnetic fields from high-voltage power lines. Many of these techniques use a current transformer to convert the magnetic fields to usable current. A recent work describes energy harvesting from power lines attached to electric motors. Solutions based on current transformers require that the single current carrying wire be passed through it. There are some commercial products which can be snapped on a high-voltage single wire. All similar techniques are quite limited in applications because of their placement constraints. Recently, Anthony Rowe et al. designed an LC tank based receiver circuit tuned to the AC 60Hz and used the received signal for clock synchronization.

In this paper, we investigate the feasibility of harvesting energy from the magnetic fields emanating from the AC power lines in addition to synchronization. Average available power from this harvesting scheme is lower than the requirements of a typical sensor node, so the node should only be turned on when enough energy has been accumulated for the useful work. The mismatch in duty-cycles and wake-up times of different nodes in a network will severely constrain the coordination among nodes. Therefore, by powering a wireless sensor device through the magnetic fields we can also exploit the dual advantage of maintaining the clock synchronization using the same signal. It was established in that nodes may remain synchronized for long periods of time without exchanging messages because of the global clock from the EM fields. However, other energy harvesting schemes with limited available power may not be practical if frequent communication is required just to maintain the clock synchronization.

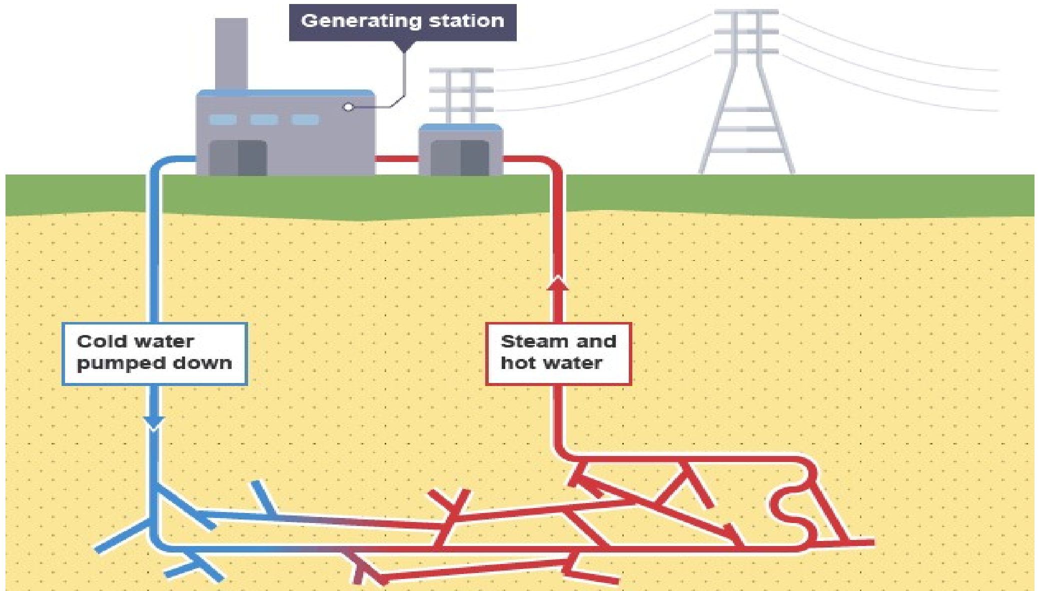
We need to measure the average power that can be extracted from the magnetic fields emanating from AC power lines, in order to understand the feasibility of proposed energy harvesting system. We conducted controlled experiments where we observed the power available from various arrangements of current carrying conductors and configuration of inductors in the magnetic field associated with the conductors.

We laid two parallel conductors on a graduated flat board, and these conductors were used to power a load consisting of ten light bulbs of 100 Watts each in parallel. When the complete load is applied, a current of 8.4 Amps flows through the conductors. We explored many inductors for conducting our experiments. The results presented in the paper are using two inductors with inductance values of L = 15H and L = 4.50H. The experiments for each of the inductors were conducted separately in order to avoid any magnetic coupling effects. We present the results for the following experiments: Measured induced voltage on the inductors for varying distances from a pair of conductors, where the distance between the conductors is very high (> 15 inches). Change the supplied load and measure the induced voltage. Keep the conductors at a distance of one inch apart with the inductors between the conductors and measure the variation of the induced voltage along with the height of the inductors from the plane of the conductors. Measure the voltage induced on the inductor when placed over a bunch of wires passing in a metal conduit typically seen in buildings.

Limitations

Not unlike many other energy harvesting schemes, there are some limitations of using magnetic fields of the AC power lines. Firstly, magnetic field strength from the power lines is significant only in their close proximity, which limits the freedom of placement of harvesting system close to the AC wires. However, we can extract power even if the wires are laid inside the wall and the device is placed on the wall at a distance of few(2-3) inches. If the power cables are deployed in metal conduits then most of the magnetic field is constrained inside it, which nullifies any possibility of harvesting energy. Second limitation of the system is that a highly efficient power transfer circuit is required to store charge in a super-capacitor with minimum losses.

Geo thermal energy :



The Earth's heat-called geothermal energy-escapes as steam at a hot springs in Nevada. Credit: Sierra Pacific

Geothermal energy is the heat from the Earth. It's clean and sustainable. Resources of geothermal energy range from the shallow ground to hot water and hot rock found a few miles beneath the Earth's surface, and down even deeper to the extremely high temperatures of molten rock called magma.

Almost everywhere, the shallow ground or upper 10 feet of the Earth's surface maintains a nearly constant temperature between 50 °F and 60 °F (10 °C and 16 °C). Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger-a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

In the United States, most geothermal reservoirs of hot water are located in the western states, Alaska, and Hawaii. Wells can be drilled into underground reservoirs for the generation of electricity. Some geothermal power plants use the steam from a reservoir to power a turbine/generator, while others use the hot water to boil a working fluid that vaporizes and then turns a turbine. Hot water near the surface of Earth can be used directly for heat. Direct-use applications include heating buildings, growing plants in greenhouses, drying crops, heating water at fish farms, and several industrial processes such as pasteurizing milk.

Hot dry rock resources occur at depths of 3 to 5 miles everywhere beneath the Earth's surface and at lesser depths in certain areas. Access to these resources involves injecting cold water down one well, circulating it through hot fractured rock, and drawing off the heated water from another well. Currently, there are no commercial applications of this technology. Existing technology also does not yet allow recovery of heat directly from magma, the very deep and most powerful resource of geothermal energy.

Advantages :

1) It is a renewable source of energy.
2) By far, it is non-polluting and environment friendly.
3) There is no wastage or generation of by-products.
4) Geothermal energy can be used directly. In ancient times, people used this source of energy for heating homes, cooking, etc.
5) Maintenance cost of geothermal power plants is very less.
6) Geothermal power plants don't occupy too much space and thus help in protecting natural environment.
7) Unlike solar energy, it is not dependent on the weather conditions.

Disadvantages :

1) Only few sites have the potential of Geothermal Energy.
2) Most of the sites, where geothermal energy is produced, are far from markets or cities, where it needs to be consumed.
3) Total generation potential of this source is too small.
4) There is always a danger of eruption of volcano.
5) Installation cost of steam power plant is very high.
6) There is no guarantee that the amount of energy which is produced will justify the capital expenditure and operations costs.
7) It may release some harmful, poisonous gases that can escape through the holes drilled during construction.

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Carbon capture technology :

CCS, or Carbon Capture and Storage, is a working low carbon technology which captures carbon dioxide (CO2) from the burning of coal and gas for power generation, and from the manufacturing of steel, cement and other industrial facilities, and transports it by either pipeline or ship, for safe and permanent underground storage, preventing it from entering the atmosphere and contributing to anthropogenic climate change.

There are three stages to CCS: capture, transport, and safe underground storage.

Capture – First, the carbon dioxide is removed, or separated, from coal and gas power plants, and from the manufacturing of steel and cement. There are three types of capture; post-combustion, pre-combustion and oxyfuel combustion. This is called carbon dioxide capture and can captures 90% of carbon dioxide emissions.

Transport – The carbon dioxide is then compressed and transported to a suitable storage site. The transport is generally carried out in pipelines. Ship transport is also an option for offshore carbon dioxide transport.

Storage – The carbon dioxide is the injected into a suitable storage site deep below the ground. The storage site must be a geological formation that ensures safe and permanent storage. Storage can either take place in depleted oil & gas fields, or deep saline formations.

Carbon capture is divided into two main areas:

Carbon Capture and Storage (CSS)

Bio Carbon Capture and Storage (Bio CSS)

Carbon Capture and Storage (CSS)

CSS is the process of capturing and storing CO_2 emissions from power plants and industrial manufacturing plants. There are three methods for CSS, which are:

Post-combustion

Precombustion

Oxy-fuel combustion

Post-combustion involves capturing waste gases by adding a filter to the smoke stack of power and manufacturing plants. The captured gases (called flue gases) are processed to extract CO_2, which then gets shipped to a storage area. This process recovers 80 to 90 percent of the waste CO_2. The advantages include being able to retrofit older styled plants with this system. The disadvantages include that the final CO_2 extraction and preparation for storage process is energy intensive.

Pre-combustion, as the name implies, involves capturing CO_2 before a fossil fuel is burned. This process involves extracting CO_2 by partially oxidizing the fuel in a gasifier, which results in the separation of CO_2 from CO (carbon monoxide) and H_2 (Hydrogen). The hydrogen can then be used as fuel. Approximately 80 to 90 percent of CO_2 is captured this way. The advantages include that the process is relatively inexpensive. The disadvantages include that the process cannot be retrofitted to older plants.

Oxy-fuel combustion involves burning fossil fuels in pure oxygen instead of air, which creates CO_2 and water vapor. The water vapor is condensed leaving almost pure CO_2, which can then be transported to a storage area. This process captures about 90 percent of the CO_2. The advantages include an effective method of carbon capture. The disadvantages include the cost of supplying pure oxygen.

Carbon storage

All three of the above carbon capture processes require that the captured CO_2 be stored. Carbon storage is an area that is still under development and full of questions. There are two main areas for CO_2 storage: underground and under water.

Underground storage includes injecting CO_2 into:

- Oil fields
- Gas fields
- Saline formations
- Basalt formations
- Sandstone reservoirs

Although the technology exists to accomplish CO_2 storage in these types of geological formations there remain many unknowns, e.g., the long term effects of stored CO_2 on these areas and the potential for leakage. In most cases storing CO_2 involves unrecoverable costs.

On the other hand, there is plenty of space for storage. It has been estimated that in the U.S. alone there is enough underground CO_2 storage area to last 500 years.

Under water CO_2 storage techniques include:

Dissolution:

Injecting CO_2 to depths greater than 1000 m, where the CO_2 dissolves

Lake:

Injecting CO_2 to depths below 3000 m where a CO_2 "lake" forms due to the CO_2 being heavier than water

Storing CO_2 as clathrate hydrates:

Under high pressure and low temperature, e.g., the deep ocean floor, CO_2 becomes a negatively buoyant icy compound called clathrate hydrate

Techniques for storing CO_2 under water are less well understood than those for underground storage and pose many questions including:

Electrical Cell:

Electrical Cell is a power generating device which converts the stored chemical energy into electrical energy. Is it the combination of electrodes and electrolytes, where a difference of certain electric potential is established between the electrodes as a result of the chemical reaction between the electrodes and electrolytes.

The difference in the electric potential between electrodes in an electrical cell depends upon the types of electrolytes and electrodes used.

1. Primary Cell:

An Electrical cell which is powered by the irreversible chemical reaction is called Primary Cell. Since the primary cell is powered by irreversible chemical reaction , It cannot be recharged after being used so it can be used only once and need to be disposed off after single use. Most of the primary cell contains their electrolytes in solid form absorbed within some absorbent material so these kind of cells are also called Dry Cell.

2. Secondary Cell:

The Electrical Cell which can be electrically recharged after being used is called secondary cell. These kinds of cells are powered by reversible chemical reaction and the state of Electrodes and Electrolyte can be reversed to its original form by applying external power source after being used. Secondary Cells usually have high discharge rate performance compared to Primary cell, and can be used with high loads that requires good discharge rate performance.

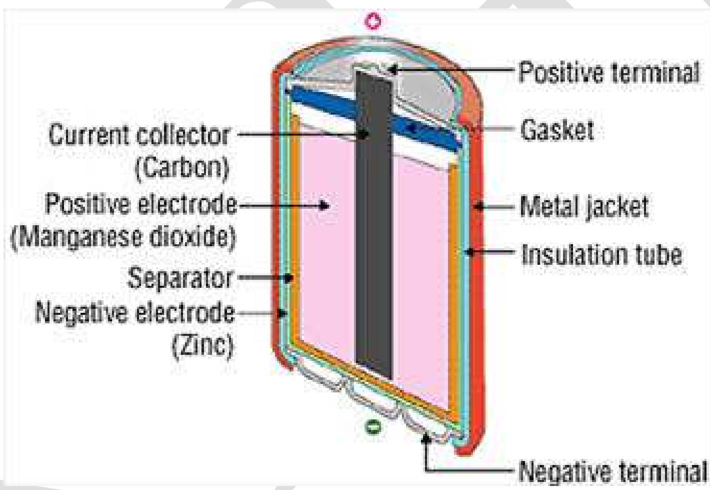
3. Reserve Cell:

The types of cells where one of the key components of the cell is separated from the rest of the components until activated manually or by some automatic means is called reserve cell. These kinds of cell remain deactivated and nonfunctional until it is activated manually or by some means like heat, water or other means. One example is thermal cell where the electrolyte remains inactive in its solid form until the heat applied melts the electrolyte to activate the cell.

4. Fuel Cell:

A Fuel Cell is the kind of cell where the chemical energy from a fuel fed into the cell is converted into electrical energy through a chemical reaction with oxidizing agent. The fuel that is fed into a fuel cell can be Hydrogen , Hydrocarbons, Natural gas etc. A fuel cell can produce electricity as long as the fuel and the oxidizing agent is fed into the fuel cell.

Battery:



A single unit of electro-chemical generator is known as Electrical Cell, while the combination of several such units connected electrically is known as a Battery. Several cells are combined and connected electrically in series or parallel to form a battery which has two main terminal electrodes one Positive and one Negative. The electrical potential difference between the two main electrodes depends upon the numbers of cells , types of cells and the types of combination used to form the battery.

Types of Battery:

Based on the electric properties batteries can be classified into two main groups:

Primary Battery:

Primary battery is the type of battery which is made up of primary cells. The energy is inherently present in the cells of Primary Battery. These kinds of batteries are non-rechargeable and are for single time use. Examples of primary battery are: Leclanche battery, zinc-chlorine battery, alkaline-manganese battery, metal air battery etc.

Secondary Battery:

Secondary battery is the type of battery which is made up of secondary cells. The energy is induced in the chemicals of the cells of the secondary battery by applying external energy or sources prior to using it. Examples of secondary battery are: lead-acid battery , nickel cadmium battery, nickel-iron battery etc.

Secondary cells are used in a variety of places due to it's chemical and physical properties. The secondary batteries can also be classified into following types based on their use:

1. Automotive / SLI / Portable Batteries.

These kinds of batteries are used in automobiles and portable systems. The battery is used for Starting, Lighting & Ignition (SLI) in automobiles. Examples of Automotive or SLI or Portable batteries are: lead-acid batteries, nickel-cadmium batteries etc.

2. Vehicle Traction / Motive Power / Industries Batteries.

These kinds of batteries are used to power battery powered vehicles or to power various high power devices in industries. These kinds of batteries have high energy density in the range of 100-120 Watt Hour / Kilo Gram. Batteries like Lead-acid batteries, nickel-iron batteries silver-zinc batteries etc falls in this kind and also various high-temperature batteries are under development which also falls under this kind of batteries.

3. Stationary Batteries.

These kinds of batteries are used in stationary systems, Such as standby power systems and load-leveling systems. These kinds of batteries are used to store power when load is low or extra power is available and provide extra power to the system when load is very high or no power is available.

Environmental Sustainability :

Environmental sustainability icon to define environmental sustainability we must first define sustainability. Sustainability is the ability to continue a defined behavior indefinitely. To define what environmental sustainability is we turn to the experts.

Herman Daly, one of the early pioneers of ecological sustainability, looked at the problem from maintenance of natural capital viewpoint. In 1990 he proposed that:

1. For renewable resources, the rate of harvest should not exceed the rate of regeneration (sustainable yield);
2. The rates of waste generation from projects should not exceed the assimilative capacity of the environment (sustainable waste disposal); and
3. For nonrenewable resources the depletion of the nonrenewable resources should require comparable development of renewable substitutes for that resource.

This list has been widely accepted. It's an elegant abstraction, one that made me pause and read it three times when I first encountered it.

The list can be shortened into a tight definition. Environmental sustainability is the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely. If they cannot be continued indefinitely then they are not sustainable.

UNIT - V

PART - A (20 MARKS)

(Q.NO 1 TO 20 Online Examination)

PART - B (2 MARKS)

1. Write a note on batteries and applications.
2. Give a short note on any two renewable energies.
3. State electromagnetic effect.
4. Write the needs of the renewable energy?
5. Write the examples of different type of renewable energy sources.
6. Give the applications of renewable energy.

PART - C (6 MARKS)

1. What are the applications of electromagnetic energy?
2. Give the importance about renewable sources of energy?
3. Describe about renewable energy?
4. Write a short note on renewable energy sources?
5. Give the examples of renewable and non renewable sources.
6. Explain the energy is harvesting from electromagnetic effect?

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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

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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

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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

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

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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

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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	$v = f\lambda$	$f = v\lambda$	lambda = fv	v = f + lambda	$v = f\lambda$
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

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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

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