Magnetic Field Lines and Magnetic Flux :

Let us first discuss the concept of magnetic field lines and magnetic flux. We can represent any magnetic field by magnetic field lines. Unlike the electric lines of force, it is wrong to call them magnetic lines of force, because they do not point in the direction of the force on a charge. The force on a moving charged particle is always perpendicular to the magnetic field (or magnetic field lines) at the particle's position.

The idea of magnetic field lines is the same as for the electric field lines as discussed in the chapter of electrostatics. The magnetic field at any point is tangential to the field line at that point. Where the field lines are close, the magnitude of the field is large, where the field lines are far apart, the field magnitude is small. Also, because the direction of Bat each point is unique, field lines never intersect. Unlike the electric field lines, magnetic lines form a closed loop.

MAGNETIC FLUX:

The flux associated with a magnetic field is defined in a similar manner to that used to define electric flux. Consider an element of area dS on an arbitrary shaped surface as shown in figure. If the magnetic field at this element is B, the magnetic flux through the element is

$d\varphi B = BdS \cos \theta = B.dS$

Here, dSis a vector that is perpendicular to the surface and has a magnitude equal to the area dS and θ is the angle between B and dS at that element. In general, d B f varies from element to element. The total magnetic flux through the surface is the sum of the contributions from the individual area elements.

$\varphi B = d\varphi B = B.dS = BdS \cos \theta$

Note down the following points regarding the magnetic flux :

(i) Magnetic flux is a scalar quantity (dot product of two vector quantities is a scalar quantity)

(ii) The SI unit of magnetic flux is tesla-metre2 (1T-m2 ). This unit is called weber (1Wb).

1 Wb = 1T-m2 = 1 N-m/A

Thus, the unit of magnetic field is also weber/m2 (1Wb/m2).

or 1 T = 1Wb/m2

(iii) In the special case in which Bis uniform over a plane surface with total area S, If B is perpendicular to the surface, then $\cos \theta = 1$ and $\varphi B = B \cdot S$

Gauss's Law for Magnetism

In Gauss's law, the total electric flux through a closed surface is proportional to the total electric charge enclosed by the surface.

For example, if a closed surface encloses an electric dipole, the total electric flux is zero because the total charge is zero.

By analogy, if there were such a thing as a single magnetic charge (magnetic monopole), the total magnetic flux through a closed surface would be proportional to the total magnetic charge enclosed. But as no magnetic monopole has ever been observed, we conclude that the total magnetic flux through a closed surface is zero.

i.e. $B \cdot S = 0$

Unlike electric field lines that begin and end on electric charges, magnetic field lines never have endpoints. Such a point would otherwise indicate the existence of a monopole. For a closed surface, the vector area element dSalways points out of the surface. However, for an open surface we choose one of the possible sides of the surface to be the positive and use that choice consistently.

The magnetic flux passing through a loop of area A is defined as

$\varphi = B \cdot A$ or

$\varphi = BA \cos \theta = B.A$

where B is the component of the magnetic field B perpendicular to the face of the loop. and θ is the angle between the direction of the magnetic field and the vector representing area. Direction of the area vector is outward normal to the face of the loop. If the surface is not plane, we can divide 'any surface into elements of area dA. For each element we determine B the component of normal to the surface at thc position of that element, $B_n = B \cos \theta$ where θ is the angle between the direction of B and a line perpendicular to the surface. In general, this component varies from point to point on the surface.

Magnetic force between two parallel wires

(Current current carrying conductors) :

The above diagram shows two parallel current carrying conductors carrying current I1 and I2 respectively separated by a distance r apart.

From experiment it's observed that parallel current carrying conductors attract each other whereas antiparallel current carrying conductors repel each other.

In the case of two wires carrying parallel current, this force on one wire due to the magnetic field of the other is directed towards another wire. So, wires carrying anti-parallel current repel each other.

In the case of two wires carrying anti-parallel current, this force on one wire due to the magnetic field of the other is directed away from the other wire. So, wires carrying anti-parallel current repel each other.

To find the force of attraction between two parallel current carrying conductors we need the following steps :

Step 1 : To find the magnetic field produced due to current $I_1$ and $I_2$ we have to apply ampere's circuital law. From ampere's circuital law ,

Magnetic Effects of Current and Magnetism

## Magnetic Force for Charged Particle:

We represented electric interactions in two steps:

- A distribution of electric charge at rest creates an electric field E in the surrounding space.

• The electric field exerts a force F = qE on any other charge q that is present in the field .

• We can describe magnetic interactions in a similar way:

I. A moving charge or a current creates a magnetic field in the surrounding space (in addition to its

electric field).

2. The magnetic field exerts a force F on any other moving charge or current that is present in the field.

• Like the electric field, magnetic field is a vector field- that is, a vector quantity associated with each

point in space. We will use the symbol B for the magnetic field. At any position, the direction of B is

defined as that in which the north pole of a compass needle tends to point.

• We can quantify the magnetic field B by using our model of a particle in a field. The existence of

a magnetic field at some point in space can be determined by measuring the magnetic force FB exerted

on an appropriate test particle placed at that point.

•This process is the same one we followed in defining the electric field. Our test particle will be an electrically charged particles such as a proton. If we perform such an experiment, we find the

following results:

- The magnetic' force FB is proportional to the charge q of the particle as well as to the speed v of the

particle.

- When a charged particle moves parallel to the magnetic field vector, the magnetic force FB on the charge

is zero.

- When the velocity vector makes an angle with the magnetic field, the magnetic force acts in a

direction perpendicular to both v and B; that is, the magnetic 'force is perpendicular to the plane formed

by v and B.

- The magnetic force on a negative charge is directed opposite to the force on a positive charge moving in

the same direction.

- If the velocity vector makes an angle with the magnetic field, the magnitude of the magnetic force is

proportional to sin .

These results show that the magnetic force on a particle is more complicated than the electric force.

The magnetic force is distinctive because it depends on the velocity of the particle and because its

direction is perpendicular to both v and B.

Despite this complicated behavior, these observations can be summarized in a compact way by writing the magnetic force in the form FB = q(v x B)

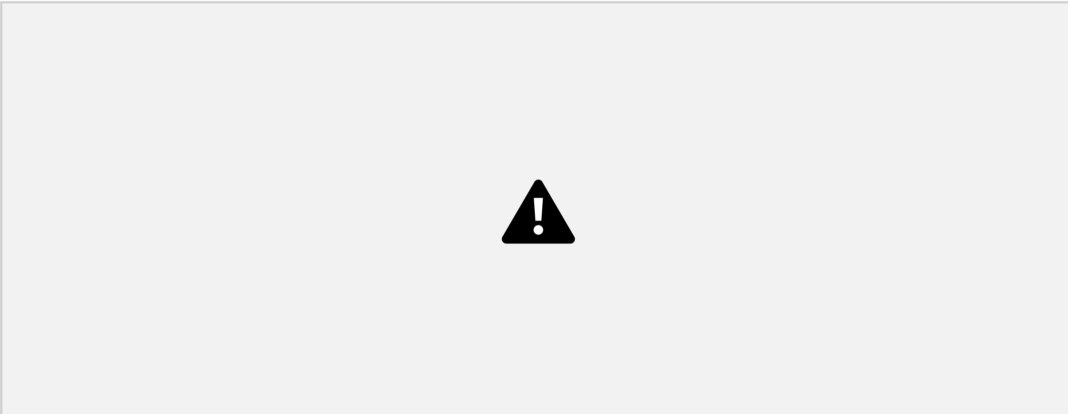
where the direction of the magnetic force is that of (v x B) which, by definition of the cross product, is perpendicular to both v and B. We can regard equation FB = q(v x B) as an operational definition of the magnetic field at a point in space. The S.I. unit of

magnetic field is the tesla (T), where 1T = 1 N s-1 m-1

.

Thus, the magnitude of the magnetic force is FB = Iql vB sinwhere is the angle between v and B. From this expression,we see that FB is zero when B is either parallel or antiparallel to B ( = 0 or 180°).
Furthermore, the force has its maximum value FB = Iql vB when v is perpendicular to B (= 90°).

Right Hand Rules for Determining the Direction of the Magnetic Force Acting on a Moving Charged Particle :



The above figure reviews the right-hand rules for determining the direction of the cross product v x B and determining the direction of FB .
The rule in Fig. depends on our right hand rule for the cross product. Point the four fingers of your_right hand along the direction of ii with the palm facing B and curl them toward B . The extended thumb, which is at a right angle to the fingers, points in the direction of v x B . Because FB = q(v x B), FB is in the direction of your thumb if q is positive and opposite to the direction of your thumb if q is negative.

An alternative rule is shown in Fig. Here the thumb points in the direction of v Ilnd the extended fingers in the direction of B. Now, the force Fs on a positive charge extends outward from your palm.

The advantage of this rule is that the force on the charge is in the direction that you would push on something with your hand-outward from your palm. The force on a negative charge is in the opposite

direction.

There are important differences between electric and magnetic forces on charged particles:

- The electric force is always parallel or antiparallel to the direction of the electric field, whereas the magnetic

force is perpendicular to the magnetic field.

- The electric force acts on a charged particle independent of the particle's velocity, whereas the magnetic force

acts on a charged particle only when the particle is in motion and the force is proportional to the velocity.

- The electric force does work in displacing a charged particle, whereas the magnetic force associated with

a constant magnetic field does not work when a charged particle is displaced.

This last statement is true because when a charge moves in a constant magnetic field, the . magnetic force is always perpendicular to the displacement. Hence, the work done by the magnetic force on the particle is zero.

From the work- energy theorem, we conclude that the kinetic energy of a charged particle call1lot be altered by a constant magnetic field alone. In other words, when a charge moves with a velocity v, all applied magnetic field can alter the direction of the velocity vector, but it can not  change the speed of the particle.

## Elasticity

Elasticity, the 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 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 per cent of its original length, while for strips of certain rubberlike materials, elastic extensions of up to 1,000 per cent 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 engineering mechanics 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), $\sigma$, and the extension ratio (the difference between extended and initial lengths divided by the initial length), $e$. In other words, $\sigma$ 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 per cent. This theory is commonly applied in the analysis of engineering structures and of seismic disturbances.

**Current Electricity**

Many inventions and discoveries have been made in order to facilitate human life smoothly. The discovery of current electricity is one such discovery that we are highly dependent on to make our life easier. Benjamin Franklin is credited with the discovery of electricity.

What is Current Electricity?

Current electricity is defined as the flow of electrons from one section of the circuit to another.

Electromotive Force (EMF) and Voltage:

When two bodies at different potentials are linked with a wire, free electrons stream from Point 1 to Point 2, until both the objects reach the same potential, after which the current stops flowing. Until a potential difference is present throughout a conductor, current runs.

From the above analogy, we can define electromotive force and voltage as follows:

Electromotive Force Definition: Electromotive force is defined as the electric potential produced by either an electrochemical cell or by changing the magnetic field.

**Voltage Definition: Voltage is defined as the electric potential difference between two points.**

**Types of Current Electricity**

There are two types of current electricity as follows:

Direct Current (DC)

Alternating Current (AC)

### Direct Current

The current electricity whose direction remains the same is known as direct current. Direct current is defined by the constant flow of electrons from a region of high electron density to a region of low electron density. DC is used in many household appliances and applications that involve a battery.

### Alternating Current

The current electricity that is bidirectional and keeps changing the direction of the charge flow is known as alternating current. The bidirectionality is caused by a sinusoidally varying current and voltage that reverses directions, creating a periodic back and forth motion for the current. The electrical outlets at our home and industries are supplied with alternating current.

### Generation of Current Electricity

Current electricity can be generated by the following methods:

By moving a metal wire through a magnetic field (Both alternating current and direct current can be generated by the following method)

By a battery through chemical reactions (Direct current can be generated through this method)

### Relative Motion Between Magnetic Field and Coil

Note that this setup must be a part of an electric circuit, otherwise the electrons have nowhere to go and current electricity won't be generated.

## Capacitor

Capacitors are the simple passive device that can store an electrical charge on their plates when connected to a voltage source.

The capacitor is a component that has the ability or "capacity" to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery.

There are many different kinds of capacitors available from very small capacitor beads used in resonance circuits to large power factor correction capacitors, but they all do the same thing, they store charge.

In its basic form, a capacitor consists of two or more parallel conductive (metal) plates that are not connected or touching each other but are electrically separated either by air or by some form of a good insulating material such as waxed paper, mica, ceramic, plastic or some form of a liquid gel as used in electrolytic capacitors. The insulating layer between the plates of a capacitor is commonly called the Dielectric.

Due to this insulating layer, DC current can not flow through the capacitor as it blocks it allowing instead a voltage to be present across the plates in the form of an electrical charge.

The conductive metal plates of a capacitor can be either square, circular or rectangular, or they can be of a cylindrical or spherical shape with the general shape, size, and construction of a parallel plate capacitor depending on its application and voltage rating.

When used in a direct current or DC circuit, a capacitor charges up to its supply voltage but blocks the flow of current through it because the dielectric of a capacitor is non-conductive and basically an insulator. However, when a capacitor is connected to an alternating current or AC circuit, the flow of the current appears to pass straight through the capacitor with little or no resistance.

There are two types of electrical charge, a positive charge in the form of Protons and a negative charge in the form of Electrons. When a DC voltage is placed across a capacitor, the positive (+ve) charge quickly accumulates on one plate while a corresponding and opposite negative (-ve) charge accumulate on the other plate. For every particle of +ve charge that arrives at one plate a charge of the same sign will depart from the -ve plate. Then the plates remain charge neutral and a potential difference due to this charge is established between the two plates. Once the capacitor reaches its steady-state condition an electrical current is unable to flow through the capacitor itself and around the circuit due to the insulating properties of the dielectric used to separate the plates.

The flow of electrons onto the plates is known as the capacitors Charging Current which continues to flow until the voltage across both plates (and hence the capacitor) is equal to the applied voltage Vc. At this point, the capacitor is said to be “fully charged” with electrons.

The strength or rate of this charging current is at its maximum value when the plates are fully discharged (initial condition) and slowly reduces in value to zero as the plates charge up to a potential difference across the plates of the capacitor equal to the source voltage.

**Surface Chemistry**

Surface chemistry is referred to as the study of the phenomenon occurring on the surfaces of substances. This is very applicable in industries and day to day lives. In other words, surface chemistry deals with all types of surface phenomena.

## What is Surface Chemistry?

It is the study of the chemical phenomena that occur at the interface of two surfaces which can be solid-liquid, solid-gas, solid-vacuum, liquid-gas, etc. Some applications of surface chemistry are known as surface engineering. There are various phenomena taking place on the surface of a substance and out of them some are:

Adsorption

Heterogeneous Catalysis

Corrosion

Crystallization

## Applications of Surface Chemistry

In a wider perspective, surface chemistry deals with the interaction of surfaces of one system with that of the other system. Some phenomena work on this principle such as:

Catalysis

Colloid Formation

Electrode Reactions

Chromatography

Surface Chemistry has a major role in various chemical processes such as:

Enzymatic reactions at the biological interfaces found in the cell walls and membranes

In the electronics industry, the use in the surface and interface of microchips used in computers.

In automobile exhausts, the heterogeneous catalysts found in the catalytic converter for cleaning emissions.

### Role of Adsorption in Surface Chemistry

Accumulation of species on higher concentrations on the surface of a substance due to intermolecular force is known as adsorption. For Example, gases such as H2, O2, N2 adsorbs on the surface of activated charcoal.

Difference between Adsorption and Absorption

Enthalpy of Adsorption: The amount of heat energy liberated when one mole of gas is adsorbed on the unit surface area of adsorbent is known as enthalpy of adsorption.

### Types of Adsorption

Due to the force of interaction between adsorbate and adsorbent, adsorption in surface chemistry is classified into two types.

### Physical Adsorption or Physisorption

There exists a weak van der Waals force between adsorbate and adsorbent.

**Characteristics:**

Nature of forces: weak van der Waals forces

Specificity: It is not specific in nature

Reversibility: The process is reversible

Layer: It is a multi-layered process

Enthalpy of adsorption: Low enthalpy of adsorption [ 20 – 40 KJ/mole ]

The energy of activation: Very low

Desorption: Very easy

Factors affecting: Surface area of adsorbent nature of adsorbate, pressure, temperature.

**Chemical Adsorption or Chemisorption**

It is due to strong chemical forces between adsorbate and adsorbent.

**Characteristics:**

Nature of forces: Strong chemical forces

Specificity: Highly specific nature

Reversibility: It is irreversible

Layer: It is a single-layered process

Enthalpy of adsorption: High enthalpy of adsorption [40 – 400 KJ/mole]

The energy of activation: Very high

Desorption: Very difficult

Factors affecting: Surface area of adsorbent, nature of adsorbate Temperature

**Solution**

**What is a Solution?**

**A solution is a homogeneous mixture of two or more components in which the particle size is smaller than 1nm.**

Common examples of solutions are sugar in water and salt in water solutions, soda water, etc. In a solution, all the components appear as a single phase. There is particle homogeneity i.e. particles are evenly distributed. This is why a whole bottle of soft drink has the same taste throughout.

Characteristics of Solution

Solutions have two components, one is solvent and the other is solute.

**What is a Solvent?**

The component that dissolves the other component is called the solvent.

**What is Solute?**

The component(s) that is/are dissolved in the solvent is/are called solute(s).

Generally solvent is present in major proportion compared to the solute. The amount of solute is lesser than the solvent. The solute and solvent can be in any state of matter i.e. solid, liquid, and gas.

Solutions that are in the liquid state consist of a solid, liquid, or gas dissolved in a liquid solvent. Alloys and air are examples of solid and gaseous solutions respectively.

**Solution Examples**

The following examples illustrate solvent and solute in some solutions.

- Air is a homogeneous mixture of gases. Here both the solvent and the solute are gases.
- Sugar syrup is a solution where sugar is dissolved in water using heat. Here, water is the solvent and sugar is the solute.
- Tincture of iodine, a mixture of iodine in alcohol. Iodine is the solute whereas alcohol is the solvent.

Types of Solution

Liquid solutions, such as sugar in water, are the most common kind, but there are also solutions that are gases or solids. Any state of matter (solid, liquid, or gas) can act both as a solute or as a solvent during the formation of a solution. Therefore, depending upon the physical states of solute and solvent, we can classify them into nine different types of solutions.

| S.No | Types of Solution | Solute | Solvent | Examples |
| --- | --- | --- | --- | --- |
| 1 | Solid-solid | solid | solid | Alloys like brass, bronze, etc. |
| 2 | Solid-liquid | solid | liquid | The solution of sugar, salt, etc in water. |
| 3 | Solid-gas | solid | gas | Sublimation of substances like iodine, camphor, etc into the air. |
| 4 | Liquid-solid | liquid | solid | Hydrated salts, mercury in amalgamated zinc, etc. |

| | | | | |
|---|---|---|---|---|
| 5 | Liquid-liquid | liquid | liquid | Alcohol in water, benzene in toluene |
| 6 | Liquid-gas | liquid | gas | Aerosol, water vapor in the air. |
| 7 | Gas-solid | gas | solid | Hydrogen absorbed in palladium |
| 8 | Gas-liquid | gas | liquid | Aerated drinks |
| 9 | Gas-gas | gas | gas | A mixture of gases etc |

Mutual Inductance

The magnetic interaction between two wires carrying steady currents. The current in one wire causes a magnetic field, which exerts a force on the current in the second wire. An additional interaction arises between two circuits when there is a changing current in one of the circuits.

Consider two neighbouring coils of wire as shown in Fig. Current flowing in coil 1 produces magnetic field and hence, a magnetic flux through coil 2. If the current in coil 1 changes, the flux through coil 2 changes as well. According to Faraday’s law this induces an emf in coil 2. In this way, a change in the current in one circuit can induce a current in a second circuit. This phenomenon is known as mutual induction. Like the self-inductance ( L ) , two circuits have mutual inductance ( M ) . It also have two definitions as under:

## First Definition

Suppose the circuit 1 has a current i1 flowing in it. Then, total flux $N_2\ \varphi_{B2}$ linked with circuit 2 is proportional to the current in 1. Thus,

$N_2\ \varphi_{B2} \propto i_1$ or $N_2\ \varphi_{B2} = Mi_1$

Here, the proportionality constant M is known as the mutual inductance M of the two circuits.

Thus, $M = N_2\ \varphi_{B2}/\ i_1$

From this expression, M can be defined as the total flux $N_2\ \varphi_{B2}$ linked with circuit 2 per unit current in circuit 1.

## Second Definition

If we change the current in circuit 1 at a rate $di_1/dt$ , an induced emf e2 is developed in circuit 1, which is proportional to the rate $di_1/dt$ . Thus,

$e_2 \propto di_1/dt$

$e_2 = -M\ (di_1/dt)$

Here, the proportionality constant is again M. Minus sign indicates that e2 is in such a direction that it opposes any change in the current in circuit 1. From the above equation,

$M = |-e/\ (di_1/dt)\ |$

This equation states that, the mutual inductance of two circuits is the magnitude of induced emf $e_2$ per unit rate of change of current $di_1/dt$ .

Note down the following points regarding the mutual inductance:

1. The SI unit of mutual inductance is henry (1H).

2. M depends upon closeness of the two circuits, their orientations and sizes and the number of turns etc.

4. A good approach for calculating the mutual inductance of two circuits consists of the following steps:

(a) Assume any one of the circuits as primary (first) and the other as secondary (second).

(b) Pass a current i1 through the primary circuit.

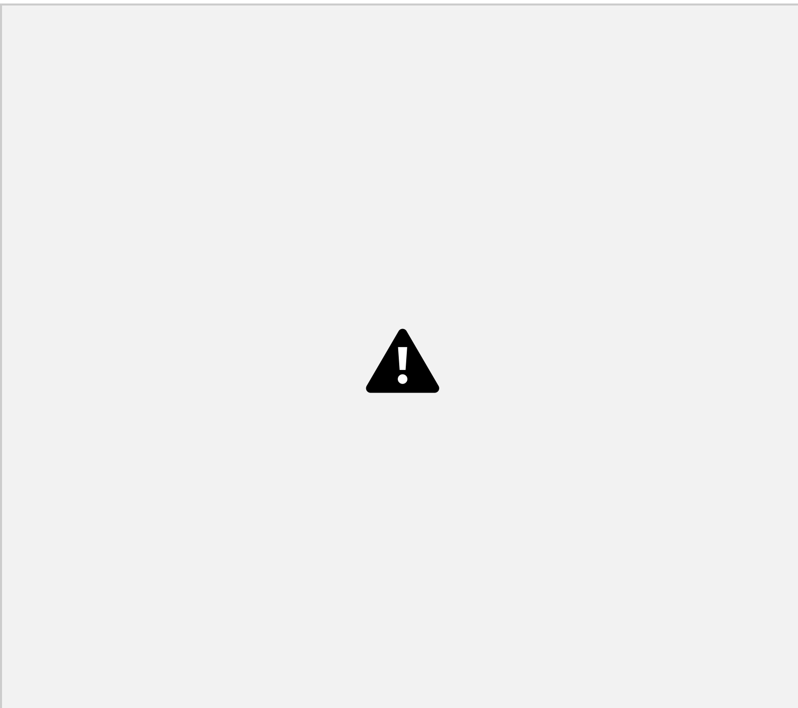
(c) Determine the magnetic field B produced by the current $i_1$ .

(d) Obtain the magnetic flux $\varphi_{B2}$ .

(e) With this flux, the mutual inductance can be found from, $M = N_2\ \varphi_{B2} / i_1$

Mutual Inductance of a Solenoid Surrounded by a Coil

Figure shows a coil of N2 turns and radius R2 surrounding a long solenoid of length l1 , radius R1 and number of turns N1 .



To calculate M between them, let us assume a current i1 in solenoid. There is no magnetic field outside the solenoid and the field inside has magnitude,

$B = {}_0 (N_1/l_1)i_1$

and is directed parallel to the solenoid's axis. The magnetic flux $\varphi B2$ through the surrounding coil is, therefore, $\varphi_{B2} = B(\pi R_{21}) = {}_0 N_1\ i_1/ l_1\ (\pi R_{21})$

Now $M = N_2\ \varphi_{B2}/ i_1 = {}_0 N_1 N_2 \pi R_{21}/ l_1$

Note that M is independent of the radius $R_2$ of the surrounding coil. This is because solenoid's magnetic field is confined to its interior. In principle, we can also calculate M by finding the magnetic flux through the solenoid produced by the current in the surrounding coil. This approach is much more difficult, because $\varphi_{B1}$ is so complicated. However, since $M_{21} = M_{12}$ , we do know the result of this calculation.

## Radiation.

Radiation is defined as a process involving the transfer of heat from one place to another place without heating the intervening medium. The term radiation used here is another word for electromagnetic waves. These waves are formed due to the superposition of electric and magnetic fields perpendicular to each other and carry energy.

In general, the word radiation has been adopted after the phenomenon of waves that usually tend to radiate from a source.

### Important Types Of Radiation

In Physics, we study different forms of Radiation. The commons ones include;

Electromagnetic radiation: These include radiations such as microwaves, infrared, ultraviolet, radio waves, x-rays, and gamma radiation (γ), visible light.
Particle radiation: These include alpha radiation (α), beta radiation (β), and neutron radiation.

Acoustic radiation: Some of the popular ones are sound, ultrasound, and seismic waves.
Gravitational radiation: This is a type of radiation that often takes the form of gravitational waves or ripples in the curvature of spacetime.

Additionally, radiation is mainly described or divided as ionizing or non-ionizing radiation. This is done depending on the energy of the radiated particles.

## Properties of Radiation

(a) All objects emit radiation simply because their temperature is above absolute zero, and all objects absorb some of the radiation that falls on them from other objects.

(b) Maxwell on the basis of his electromagnetic theory proved that all radiations are electromagnetic waves and their sources are vibrations of charged particles in atoms and molecules.

(c) More radiations are emitted at a higher temperature of a body and lesser at a lower temperature.

(d) The wavelength corresponding to the maximum emission of radiations shifts from a longer wavelength to a shorter wavelength as the temperature increases. Due to this, the color of a body appears to be changing. Radiations from a body at NTP has predominantly infrared waves.

(e) Thermal radiations travel with the speed of light and in a straight line.

(f) Radiations are electromagnetic waves and can also travel through a vacuum.

(g) Similar to light, thermal radiations can be reflected, refracted, diffracted, and polarized.

(h) Radiation from a point source obeys an inverse square law (intensity a $1/r^2$ ).

## Chemical kinetics

Chemical kinetics is an important topic in Physical Chemistry and basically deals with helping students understand the different aspects of a chemical reaction. More specifically, the term 'kinetics' deals with the rate of change of some quantity. For example, the rate of change of displacement is given as velocity. Likewise, acceleration is the rate of change of velocity.

Usually, based on this rate, chemical reactions can be classified as fast (eg: Na + $H_2O$), Moderate (Mg + $H_2O$) and slow (esterification) reactions. In this article, we will learn more about chemical kinetics and see ways to quantify the rate of a reaction and look into various factors which affect the rate of reaction.

### What is Chemical Kinetics?

Chemical kinetics also called reaction kinetics helps us understand the rates of reactions and how it is influenced by certain conditions. It further helps to gather and analyze the information about the mechanism of the reaction and define the characteristics of a chemical reaction.

### Rate of Formations and Disappearances

In any chemical reaction, as the reaction proceeds, the amount of reactants decreases, whereas the amount of products increases. One has to understand that the rate of the overall reaction depends on the rate at which reactants are consumed or the rate at which the products are formed.

If a graph is plotted between the concentration of reactants and products and time, rate of formation of products and rate of disappearance of reactants can be easily calculated from the slope of curves for products and reactants. The overall rate of the reaction may or may not be equal to the rate of formations and disappearances.

(a) Product concentration is zero at time t = 0

(a) Product concentration is zero at time t = 0

(b) at time t = 0, both reactants and products are present.

From the graph, it is understood that the slope of the reactants curve is negative and that for product curve is positive, indicating the concentration of reactants and products, decreases and increases respectively. We will take a simple reaction as an example to illustrate how the rate of overall reactions, rate of disappearances of reactants and rate of formation of products are related.

## What is “Modern Physics”?

“Modern” physics means physics based on the two major breakthroughs of the early twentieth century: relativity and quantum mechanics.

Physics-based on what was known before then (Newton’s laws, Maxwell’s equations, thermodynamics) is called “classical” physics.

This course traces in some detail just how the new ideas developed. We examine the experimental and theoretical paradoxes that forced thinking out of the traditional path.  This is a valuable exercise—the classical ideas are in much better accord with common sense (defined by Einstein as the layer of prejudices in place by age eighteen), so seeing how the new physics came about is helpful in overcoming that “common sense” and getting a better understanding of nature.

But this is not just a course on concepts: the lectures and homework are sufficient to give the student a basic technical grasp of special relativity, and of Schrödinger’s quantum mechanics.

## Energy Fundamentals

### Thermodynamic Aspects of Energy

The concept of “energy” evolved gradually through the ages, and reached the concept today as defined in physics. Modern physics is developed on identifying and observing phenomena. When the observed things happen in the same way an innumerable number of times, then we observe and identify a “phenomenon.” In short, a phenomenon represents a “law of physics,” and there are many laws of physics as there are many phenomena. The “law of energy conservation” is one of them, and this law is one of the two main pillars of “classical thermodynamics.” Thermodynamics is built on two main laws, known as the laws of thermodynamics, of which “the law of energy conservation” is known as the first law. The second law of thermodynamics involves the process of conversion of heat into work, stating that heat flows spontaneously “one-way,” i.e., from higher to lower temperature. The laws of thermodynamics cannot be derived from any other principles; so, they are “first principles” of physics. Essentially, thermodynamics is considered the subject of “energy” as a physical quantity in the most comprehensive manner. The science of thermodynamics appeared and developed due to humankind’s need to technologically master energy. It is a fact that the occurrence of the energy concept as well as the formation and development of thermodynamics science have been stimulated by the practical needs of designing, developing, evaluating heat engines, assessing their effectiveness, and measuring their efficiency.

Thermodynamics and the concept of “energy” shaped and developed together since the industrial revolution; however, the theory behind are incomplete and thermodynamics certainly evolves. For instance, recognizing systems at thermodynamic nonequilibrium became important. Expansion of thermodynamics in this respect is brought by “constructal law,” which also brings up the idea of the live state in thermodynamics, as opposed to the dead state. This new extension makes thermodynamics more complete and will be more prominent in the near future. Exergy will continue to play a major role as an important tool required for achieving better performance by reducing irreversibility. Multigeneration as well is an intriguing concept, which integrates itself into the new trend in thermodynamics, energy, and technology.

**What are the Fundamental Forces in Nature?**

There are four universal or fundamental forces in nature. Without these forces, all matter in the world will fall apart. Force as such is any pull or push that causes an object to alter its physical state (in terms of motion or deformity). Newton defined a force as anything that causes an object of mass ‘m’ to move with an acceleration ‘a’. Following are the four fundamental forces in nature:

- Gravitational force
- Electromagnetic force
- Strong nuclear force
- Weak nuclear force

A brief overview of the four fundamental forces.

## Gravitational Force

Why is the universe not filled with floating human beings and cows and cars and other such things? Obviously, because the gravitational force of the earth holds us to the planet. Gravitational force is the force responsible for holding planets in their orbits and this is possible only because of their infinitely long-range.

### What is Gravitational Force?

Gravitational force is one of the four fundamental forces of nature. It is the weakest of the four. It is also the attractive force that arises from the gravitational interaction.

According to Newton’s law of gravity, it states that the gravitational force between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them.

When considered for massive objects, like the sun, or giant planets, the gravitational force is considered to be strong as the masses of these objects are also large. On an atomic level, this force is considered weak.

### Gravitational Force of Earth

The gravitational force of the earth is 9.807 $m/s^2$.

### Gravitational Force Examples

- The revolving of the moon around the earth is due to gravitational attraction between them.
- The formation of tides in the ocean is due to the gravitational force acting between the earth and the moon.

## Electromagnetic Force

Did you know that you have never truly ever touched anything in the world? You are matter, and we know that all matter is made up of atoms. Atoms in turn have a dense nucleus, protons, neutron, and electrons. And where are these electrons? They occupy the outermost layer of an atom. Now, what is the charge on electrons? They have negative charges.

By their nature, all particles are only attracted to particles that have an opposite charge and repel those with like charges.

Say you feel like holding a pen. The pen is a matter made of atoms filled with nuclei, neutrons, protons, and electrons spinning around the nucleus as well. By nature, the electrons that you are made of and the electrons that make up your pen will repel each other. So technically, you never truly touch anything!

These are electromagnetic forces.  Why does a comb get charged when you continuously brush your hair? Why are the subatomic particles held together? Because… Electromagnetic forces!

These have a long-range and the effect of their forces diminishes over distance due to the shielding effect. However, sub-atomically, they have short-range and are considered strong forces but still weaker than strong nuclear forces.

### Strong Nuclear Forces

Out of the four fundamental forces, nuclear forces are the strongest attractive forces. Electromagnetism holds matter together, but there was no explanation on how the nucleus is held together in the atom. If we consider only electromagnetism and gravity, then the nucleus should actually fly off in different directions. But it doesn't, implying that there exists another force within the nucleus that is stronger than the gravitational force and electromagnetic force. This is where nuclear forces come into play. Strong nuclear forces are responsible for holding the nuclei of atoms together.

### General Organic Chemistry

General Organic Chemistry (GOC) covers the fundamental concepts in the vast field of organic chemistry. A strong understanding of the concepts that come under GOC plays a vital role in the study of relatively advanced topics (such as the mechanisms of named reactions). Keeping this in mind, all general organic chemistry concepts have been explained in a concise, informative manner in this article.

### GOC Basics

### General Components of an Organic Reaction

A typical reaction mechanism proceeds in the following manner:

Reactants + Catalyst or Energy → Intermediate (Transition State) → Product

Adequate reaction conditions facilitate the formation of an intermediate from the chemical reaction between the reactants. These intermediates are generally unstable and quickly react further to yield a product.

The reactants of an organic reaction can be classified as:

Reagents – reactive chemical species that trigger the reaction by attacking another species.

Substrate – the species that is attacked by a reagent in an organic reaction.

The site of reagent attack can vary based on the nature of the reagent (electrophilic or nucleophilic):

Electrophiles – They are electron-deficient species that attack the substrate at a region where the electron density is high.

Nucleophiles – They are electron-rich species that tend to donate their electrons. Nucleophiles generally attack the reagent at a region where the electron density is low.

**Cleavage of Bonds & Reaction Intermediates**

Chemical reactions generally involve the breakage of existing chemical bonds and the formation of new ones. A covalent bond can break in two different ways:

Homolytic Fission – the covalent bond is cleaved in such a manner that each participating atom leaves with one unpaired electron. The chemical species that are created as a result of homolytic fission are called free radicals. They are highly reactive (due to their unstable electron configurations).

Heterolytic Fission – the covalent bond is cleaved in such a manner that one atom retains both the electrons and the other retains none. Heterolytic fissions feature the formation of an ion pair – a positively charged cation and a negatively charged anion.

**Inductive Effect**

(Main Article: Inductive Effect)

The introduction of an electron-rich or electron-deficient species to a carbon chain results in the formation of a permanent dipole. This effect is called the inductive effect (since the dipole is induced by the difference in the electronegativities of the atoms in the molecule).

**Salient Features of the Inductive Effect**

It is a permanent effect.

It is dependent on distance (its magnitude decreases as the distance between the atoms increases).

It is relayed through sigma bonds.

**Types of Inductive Effects**

+I effect: The positive inductive effect (abbreviated to +I effect) involves the transmission of a negative charge through the chain. It occurs when an electron-donating group is introduced to a chain of atoms. Example of +I species: Alkyl group.

-I effect: The -I effect, also known as the negative inductive effect, occurs when an electron-withdrawing group is introduced to a chain of atoms. This results in the transmission of a positive charge through the chain. Example of -I species: Halogens (such as fluorine and chlorine).

**Wave Optics**

**Wave optics also called Physic optics deals with the study of various phenomena such as polarization, diffraction, interference, and other occurrences where ray approximation of geometric optics cannot be done. Thus, the section of optics that deals with the behavior of light and its wave characteristics is said to be wave optics.**

**In wave optics, the approximation is carried out by using ray optics for the estimation of the field on a surface. Further, it involves integrating a ray-estimated field over a mirror, lens, or aperture for the calculation of the scattered or transmitted field.**

**Wave Optics Theories**

Wave optics stands as a witness for a famous standoff between two great scientific communities who dedicated their lives to understanding the nature of light. One supports the particle nature of light; the other supports the wave nature.

Sir Isaac Newton stands as a prominent figure that supported the voice of particle nature of light, who proposed a corpuscular theory which states that “light consists of extremely light and tiny particles known as corpuscles which travel with very high speeds from the source of light to create a sensation of vision by reflecting on the retina of the eye".

Young's Double Slit Experiment

Using this theory Newton was able to explain reflection and refraction but failed to explain the cause of interference, diffraction, and polarization. The major failure of Newton's corpuscular theory was that it could not explain why the velocity of light was lesser in the denser medium compared to vacuum.

### Huygens Wave Theory

No one dared to challenge Newton's corpuscular theory until Christopher Huygens proposed his wave theory of light in the early 18th century. According to Huygens's theory, light consists of waves that travel through a very dilute and highly elastic material medium present everywhere in space". This medium is called ether.

As the medium is supposed to be very dilute and highly elastic, its density would be very low and the modulus of elasticity would be very high so that the speed of the light would be very large.

Huygens's wave theory was able to explain phenomena like reflection, refraction, interference, and diffraction of light. But failed to explain:

- Polarization as Huygens assumed light waves to be mechanical disturbances that are longitudinal in nature.
- Black body radiation, photoelectric effect, and Compton Effect.
- Hypothetical medium ether was never discovered and now we know light can propagate in a vacuum.