UNIT – I

Electrostatics: Coulombs law – electric field – Gauss's law and its applications – potential – potential due to various charge distribution. Parallel plate capacitors – dielectrics- current – galvanometer – voltmeter – ammeter- potentiometric measurements.

Electrostatics:

Coulomb's law

The force between two charged bodies was studied by Coulomb in 1785.Coulomb's law states that the force of attraction or repulsion between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. The direction of forces is alongthe line joining the two point charges.
One Coulomb is defined as the quantity of charge, which when placed at a distance of 1 metre in air or vacuum from an equal and similar charge, experiences a repulsive force of 9×10^9 N. The forces exerted by charges on each other are equal in magnitude and opposite in direction.

Electric Field

Electric field due to a charge is the space around the test charge in which it experiences a force. The presence of an electric field around a charge cannot be detected unless another charge is brought towards it.
When a test charge $q_o$is placed near a charge q, which is the source of electric field, an electrostatic force F will act on the test charge.

Gauss's law

The law relates the flux through any closed surface and the netcharge enclosed within the surface. The law states that the total flux

1

of the electric field E over any closed surface is equal to $\frac{1}{\varepsilon_o}$ times the net charge enclosed by the surface.

q —

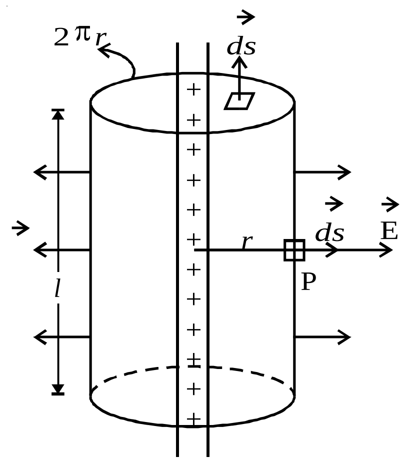
$\varphi = {}_{\varepsilon o}$

This closed imaginary surface is called Gaussian surface. Gauss's law tells us that the flux of E through a closed surface S depends only on the value of net charge inside the surface and not on the location of the charges. Charges outside the surface will not contribute to flux.

Applications of Gauss's Law

i) **Field due to an infinite long straight charged wire**

Consider an uniformly charged wire of infinite length having a constant linear charge density λ (charge per unit E length). Let P be a point at a distance r from the wire (Fig. 1.17) and E be the electric field at the point P. A cylinder of length *l*, radius r, closed at each end by plane caps normal to the axis is chosen as Gaussian surface. Consider a very *Fig 1.17 Infinitely long* small area *ds* on the Gaussian surface. *straight charged wire* By symmetry, the magnitude of the electric field will be the same at all points on the curved surface of the cylinder and directed radially



outward. $_E$ and *ds* are along the same direction.

The electric flux (φ) through curved surface = $\oint$ E ds cos θ

φ = $\oint$ E ds [∵θ= 0;cosθ=1]

= E (2π*rl*)

(∵ The surface area of the curved part is 2π rl)

Since $_E$ and *ds* are right angles to each other, the electric flux through the plane caps = 0

∴ Total flux through the Gaussian surface, φ = E. (2πrl)

The net charge enclosed by Gaussian surface is, q = λl

∴ By Gauss's law,

$E(2\pi rl) = \frac{\lambda l}{\varepsilon_o}$ or $E = \frac{\lambda}{2\pi\varepsilon_o r}$

The direction of electric field E is radially outward, if line charge is positive and inward, if the line charge is negative.

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Electric field due to an infinite charged plane sheet

Consider an infinite plane sheet of charge with surface charge density σ. Let P be a point at a distance *r* from the sheet (Fig. 1.18) and E be the electric field at P. Consider a Gaussian surface in the form of cylinder of cross− sectional area A and length *2r* perpendicular to the sheet of charge. *Fig 1.18 Infinite plane sheet* By symmetry, the electric field is at right angles to the end caps and away from the plane. Its magnitude is the same at P and at the other cap at P′.
Therefore, the total flux through the closed surface is given by

$$\varphi = \int E\, ds_{P} + \int E\, ds_{P1} \quad (\because \theta = 0, \cos\theta = 1)$$

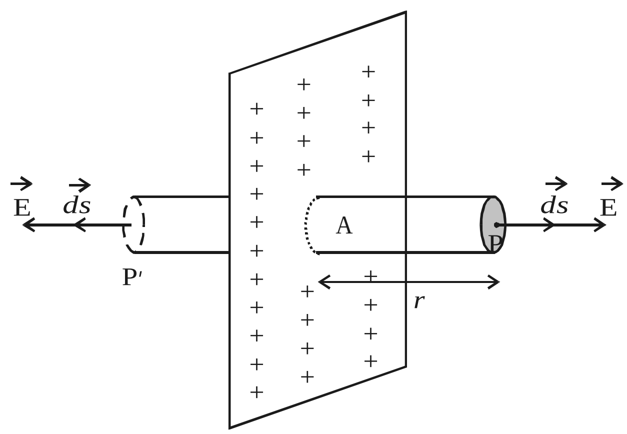
$$= EA + EA = 2EA$$

If σ is the charge per unit area in the plane sheet, then the net positive charge *q* within the Gaussian surface is, $q = \sigma A$

Using Gauss's law,

$$2EA = \frac{\sigma A}{\varepsilon_0}$$

$$\therefore E = \frac{\sigma}{2\varepsilon_0}$$



Capacitance of a conductor

When a charge *q* is given to an isolated conductor, its potential will change. The change in potential depends on the size and shape of the conductor. The potential of a conductor changes by V, due to the charge *q* given to the conductor.

$q \propto V$ or $q = CV$

i.e. $C = q/V$

Here C is called as capacitance of the conductor.

The capacitance of a conductor is defined as the ratio of the charge given to the conductor to the potential developed in the conductor.

The unit of capacitance is farad. A conductor has a capacitance of one farad, if a charge of 1 coulomb given to it, rises its potential by 1 volt.

The practical units of capacitance are μF and pF.

Created by **Dr. E. Siva Senthil**, HOD, Associate Professor, Department of Physics, KAHE.

Principle of a capacitor

Consider an insulated conductor (Plate A) with a positive charge '*q*' having potential V (Fig 1.22a). The capacitance of A is C = q/V. When another insulated metal plate B is brought near A, negative charges are induced on the side of B near A. An equal amount of positive charge is induced on the other side of B (Fig 1.22b). The negative charge in B decreases the potential of A. The positive charge in B increases the potential of A. But the negative charge on B is nearer to A than the positive charge on B. So the net effect is that, the potential of A decreases. Thus the capacitance of A is increased.

If the plate B is earthed, positive charges get neutralized (Fig 1.22c). Then the potential of A decreases further. Thus the capacitance of A is considerably increased. The capacitance depends on the geometry of the conductors and nature of the medium. A capacitor is a device for storing electric charges.

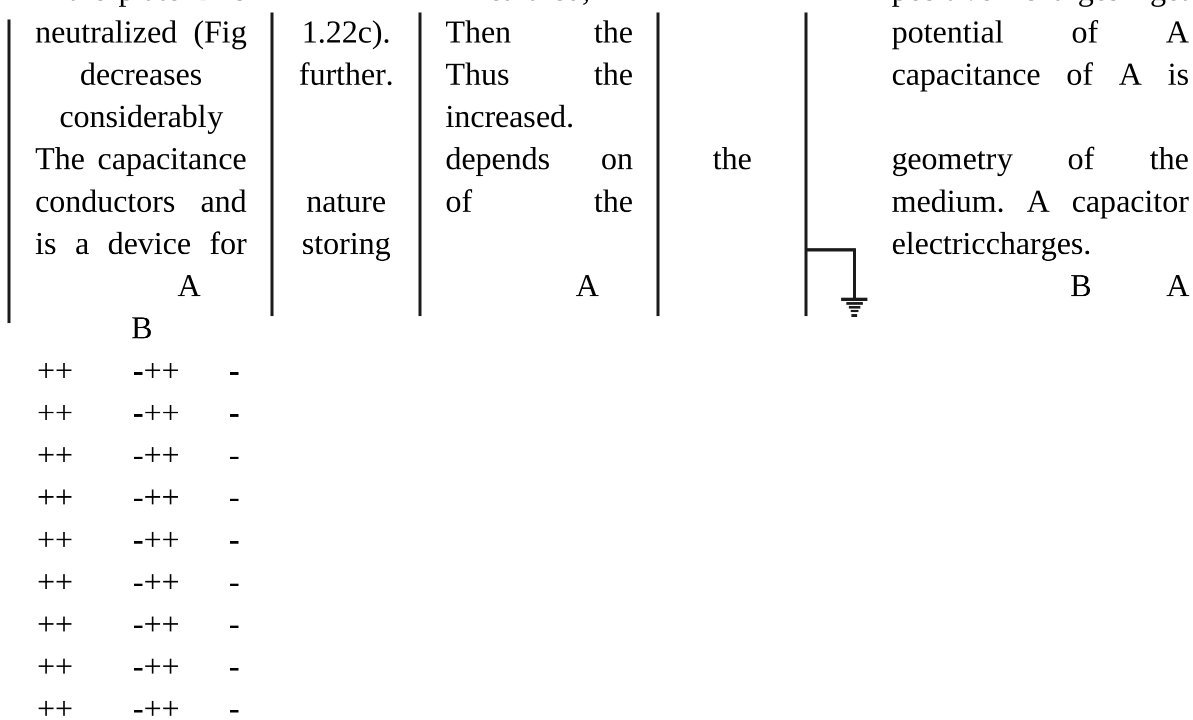


Fig 1.22 Principle of capacitor

Capacitance of a parallel plate capacitor

The parallel plate capacitor consists of two parallel metal plates X and Y each of area A, separated by a distance *d*, having a surface charge

density σ (fig. 1.23). The medium
-q
+*q* is given to the plate X. It induces
a charge –*q* on the upper surface of *Fig 1.23 Parallel plate capacitor* earthed plate Y. When the plates are very close to each other, the field is confined to the region between them. The electric lines of force starting from plate X and ending at the plate Y are parallel to each other and perpendicular to the plates.

By the application of Gauss's law, electric field at a point between the two plates is,

$$E = \frac{\sigma}{\varepsilon_o}$$

Potential difference between the plates X and Y is

$$V = \int_d^0 -E\, dr = -\int_d^0 \frac{\sigma}{\varepsilon_o} dr = \frac{\sigma d}{\varepsilon_o}$$

The capacitance (C) of the parallel plate capacitor

$$C = \frac{q}{V} = \frac{\sigma A}{\sigma d/\varepsilon_o} \quad \left[\text{since}, \sigma = \frac{q}{A}\right]$$

$$\therefore \quad C = \frac{\varepsilon_o A}{d}$$

The capacitance is directly proportional to the area (A) of the plates and inversely proportional to their distance of separation (d).

Dielectrics and polarization

Dielectrics

A dielectric is an insulating material in which all the electrons are tightly bound to the nucleus of the atom. There are no free electrons to carry current. Ebonite, mica and oil are few examples of dielectrics. The electrons are not free to move under the influence of an external field.

UNIT – II

Magnetism: Magnetic field – Biot Savart's law – B due to a solenoid – Amperes law – Faradays law of induction – Lenz's law. Magnetic properties of matter –Dia, para and ferro - Cycle of magnetization – Hysteresis – B-H curve – Applications of B-H curve.

MAGNETISM

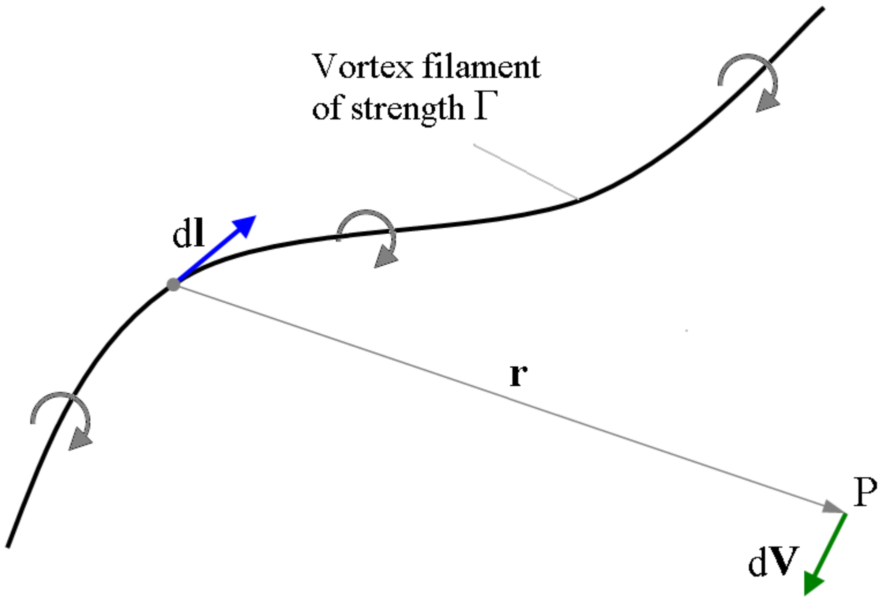
Magnetic field

A vector field in the neighbourhood of a magnet, electric current, or changing electric field, in which magnetic forces are observable. Magnetic fields such as that of Earth cause magnetic compass needles and other permanent magnets to line up in the direction of the field. Magnetic fields force moving electrically charged particles in a circular or helical path. This force—exerted on electric currents in wires in a magnetic field—underlies the operation of electric motors.

The Biot Savart Law states that it is a mathematical expression which illustrates the magnetic field produced by a stable electric current in the particular electromagnetism of physics. It tells the magnetic field toward the magnitude, length, direction, as well as closeness of the electric current. This law is basic to magnetostatics and plays an essential role related to the Coulomb's law in electrostatics. Whenever magneto statics do not apply, then this law must be changed by the equation of Jefimenko's. This law is applicable in the magnetostatic estimate, & is reliable by both Gauss's (magnetism) and Ampere's (circuital) law. The two physicists from French namely "Jean Baptiste Biot" & "Felix Savart" implemented an exact expression intended for magnetic flux density at a position close to a current carrying conductor in the year 1820. Screening a magnetic compass needle deflection, the two scientists completed that every current component estimates a magnetic field in the space (S).

What is Biot Savart Law?

A conductor which carries current (I) with the length (dl), is a basic magnetic field source. The power on one more related conductor can be expressed easily in terms of the magnetic field (dB) due to the primary. The magnetic field dB dependence on the 'I' current, dimension as well as direction of the length dl & on distance 'r' was primarily estimated by Biot & Savart.



Biot Savart Law

Once from end to end observations as well as calculations they derived an expression, that includes the density of magnetic flux (dB), is directly proportional to the element length (dl), the flow of current (I), the sine of the angle θ among the flow of current direction and the vector combining a given position of the field, with the current component is inversely proportional to the square of the distance (r) of the specified point from the current element. This is the Biot Savart law statement.

Magnetic Field Element

Thus, dB is proportional to I dl sinθ/ r^2 or, it can be written as dB = k Idl sinθ / r^2

dH = μ0 μr/4π x Idl Sin θ/ r^2
dH = k x Idl Sin θ/ r^2 (Where k= μ0 μr/4π)
dH is proportional to Idl Sin θ/ r^2
Here, k is a constant, thus the final Biot-Savart law expression is
dB = μ0 μr/4π x Idl Sin θ/ r^2

Solenoids and Magnetic Fields

A solenoid is a long coil of wire wrapped in many turns. When a current passes through it, it creates a nearly uniform magnetic field inside.

Solenoids can convert electric current to mechanical action, and so are very commonly used as switches.

The magnetic field within a solenoid depends upon the current and density of turns.

In order to estimate roughly the force with which a solenoid pulls on ferromagnetic rods placed near it, one can use the change in magnetic field energy as the rod is inserted into the solenoid. The force is roughly

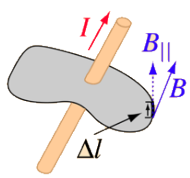
$$\text{force on rod} = \frac{\text{change in magnetic field energy}}{\text{distance rod moves into solenoid}}$$

The energy density of the magnetic field depends on the strength of the field, squared, and also upon the magnetic permeability of the material it fills. Iron has a much, much larger permeability than a vacuum.

Even small solenoids can exert forces of a few newtons.

Ampere's Law

The magnetic field in space around an electric current is proportional to the electric current which serves as its source, just as the electric field in space is proportional to the charge which serves as its source. Ampere's Law states that for any closed loop path, the sum of the length elements times the magnetic field in the direction of the length element is equal to the permeability times the electric current enclosed in the loop.



$$\sum B_{||} \Delta l = \mu_0 I$$

Faraday's law of induction

In physics, a quantitative relationship between a changing magnetic field and the electric field created by the change, developed on the basis of experimental observations made in 1831 by the English scientist Michael Faraday.

The phenomenon called electromagnetic induction was first noticed and investigated by Faraday; the law of induction is its quantitative expression. Faraday discovered that, whenever the magnetic field about an electromagnet was made to grow and collapse by closing and opening the electric circuit of which it was a part, an electric current could be detected in a separate conductor nearby. Moving a permanent magnet into and out of a coil of wire also induced a current in the wire while the magnet was in motion. Moving a conductor near a stationary permanent magnet caused a current to flow in the wire, too, as long as it was moving. Faraday visualized a magnetic field as composed of many lines of induction, along which a small magnetic compass would point. The aggregate of the lines intersecting a given area is called the magnetic flux. The electrical effects were thus attributed by Faraday to a changing magnetic flux. Some years later the Scottish physicist James Clerk Maxwell proposed that the fundamental effect of changing magnetic flux was the production of an electric field, not only in a conductor (where it could drive an electric charge) but also in space even in the absence of electric charges. Maxwell formulated the mathematical expression relating the change in magnetic flux to the induced electromotive force (E, or emf). This relationship, known as Faraday's law of induction (to distinguish it from his laws of electrolysis), states that the magnitude of the emf induced in a circuit is proportional to the rate of change of the magnetic flux that cuts across the circuit. If the rate of change of magnetic flux is expressed in units of webers per second, the induced emf has units of volts. Faraday's law is one of the four Maxwell equations that define electromagnetic theory.

Lenz's law states that when an EMF is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced EMF is such, that it produces an induced current whose magnetic field opposes the initial changing magnetic field which produced it
The negative sign used in Faraday's law of electromagnetic induction, indicates that the induced EMF (ε) and the change in magnetic flux ($\delta\Phi_B$) have opposite signs. The formula for Lenz's law is shown below:

$$\epsilon = -N\frac{\partial \Phi_B}{\partial t}$$

Where:
ε = Induced emf
$\delta\Phi_B$ = change in magnetic flux
N = No of turns in coil

Magnetic Properties Of Matter

All matter exhibits magnetic properties when placed in an external magnetic field. Even substances like copper and aluminum that are not normally thought of as having magnetic properties are affected by the presence of a magnetic field such as that produced by either pole of a bar magnet. Depending on whether there is an attraction or repulsion by the pole of a magnet, matter is classified as being **either paramagnetic or diamagnetic**, respectively. A few materials, notably iron, show a very large attraction toward the pole of a permanent bar magnet; materials of this kind are called **ferromagnetic.**

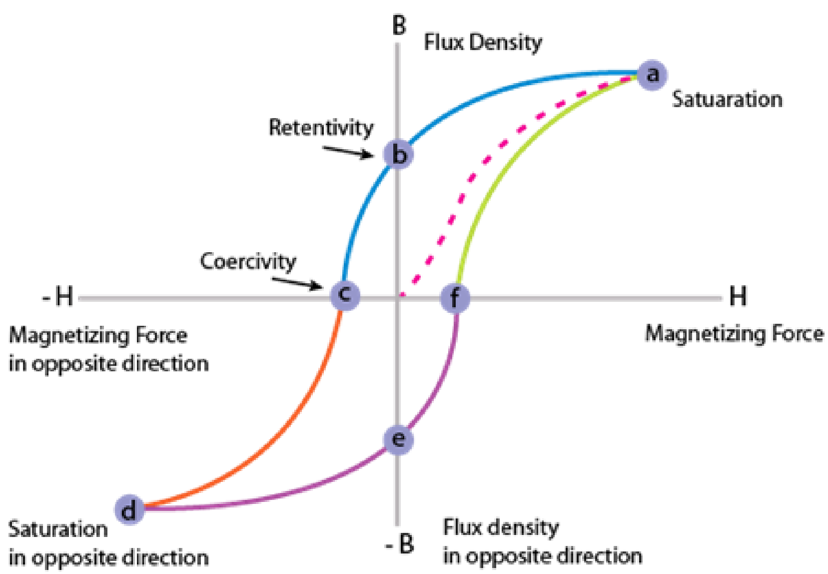
In 1845 Faraday became the first to classify substances as either diamagnetic or paramagnetic. He based this classification on his observation of the force exerted on substances in an inhomogeneous magnetic field. At moderate field strengths, the magnetization $\boldsymbol{M}$ of a substance is linearly proportional to the strength of the applied field $\boldsymbol{H}$. The magnetization is specified by the magnetic susceptibility χ (previously labeled χm), defined by the relation $\boldsymbol{M} = \chi\boldsymbol{H}$. A sample of volume V placed in a field $\boldsymbol{H}$ directed in the x-direction and increasing in that direction at a rate $d\boldsymbol{H}/dx$ will experience a force in the x-direction of $\boldsymbol{F} = \chi\mu_0 VH\,(d\boldsymbol{H}/dx)$. If the magnetic susceptibility χ is positive, the force is in the direction of increasing field strength, whereas if χ is negative, it is in the direction of decreasing field strength. Measurement of the force $\boldsymbol{F}$ in a known field $\boldsymbol{H}$ with a known gradient $d\boldsymbol{H}/dx$ is the basis of a number of accurate methods of determining χ.

Substances for which the magnetic susceptibility is negative (e.g., copper and silver) are classified as diamagnetic. The susceptibility is small, on the order of -10^{-5} for solids and liquids and -10^{-8} for gases. A characteristic feature of diamagnetism is that the magnetic moment per unit mass in a given field is virtually constant for a given substance over a very wide range of temperatures. It changes little between solid, liquid, and gas; the variation in the susceptibility between solid or liquid and gas is almost entirely due to the change in the number of molecules per unit volume. This indicates that the magnetic moment induced in each molecule by a given field is primarily a property characteristic of the molecule.

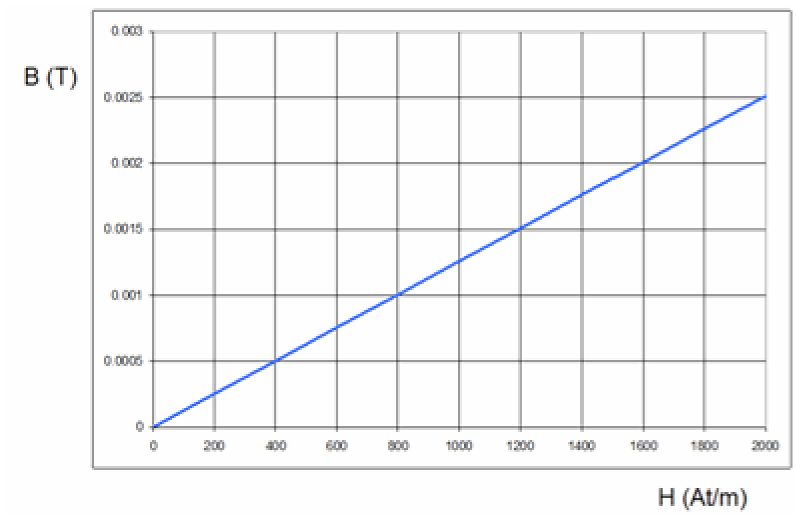
Substances for which the magnetic susceptibility is positive are classed as paramagnetic. In a few cases (including most metals), the susceptibility is independent of temperature, but in most compounds it is strongly temperature dependent, increasing as the temperature is lowered. Measurements by the French physicist Pierre Curie in 1895 showed that for many substances the susceptibility is inversely proportional to the absolute temperature T; that is, $\chi = C/T$. This approximate relationship is known as Curie's law and the constant C as the Curie constant. A more accurate equation is obtained in many cases by modifying the above equation to $\chi = C/(T - \theta)$, where θ is a constant. This equation is called the Curie–Weiss law (after Curie and Pierre-Ernest Weiss, another French physicist). From the form of this last equation, it is clear that at the temperature $T = \theta$, the value of the susceptibility becomes infinite. Below this temperature, the material exhibits spontaneous magnetization—i.e., it becomes ferromagnetic. Its magnetic properties are then very different from those in the paramagnetic or high-temperature phase. In particular, although its magnetic moment can be changed by the application of a magnetic field, the value of the moment attained in a given field is not always the same; it depends on the previous magnetic, thermal, and mechanical treatment of the sample.

Hysteresis

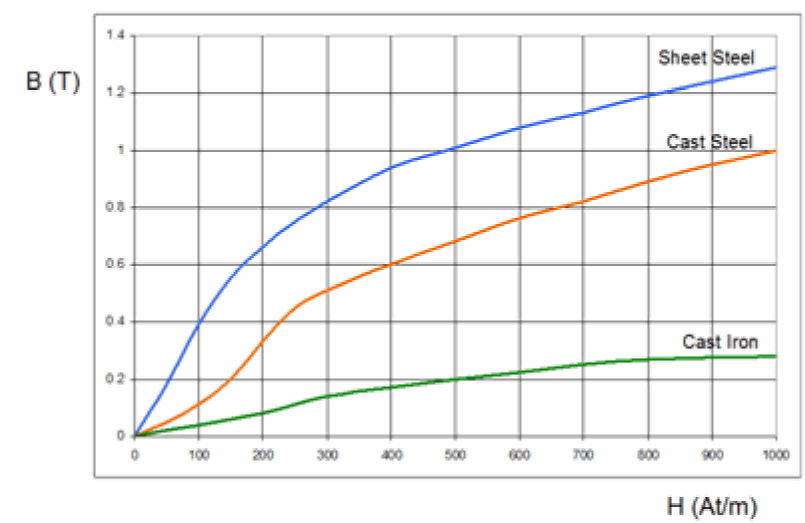
The phenomenon in which the value of a physical property lags behind changes in the effect causing it, as for instance when magnetic induction lags behind the magnetizing force.



The B-H curve is the curve characteristic of the magnetic properties of a material or element or alloy. It tells you how the material responds to an external magnetic field, and is a critical piece of information when designing magnetic circuits. In the plots below, for a vacuum an H of 800 At/m creates a B of 1 mT. With a sheet steel core, an H of 800 At/m creates a B of 1.2 T. A huge increase in B for the same H! The hysteresis comes into play when the material has been magnetized. The B within the material does not go back to what it was before, but is dependent on the history of its magnetization.



B-H for Vacuum

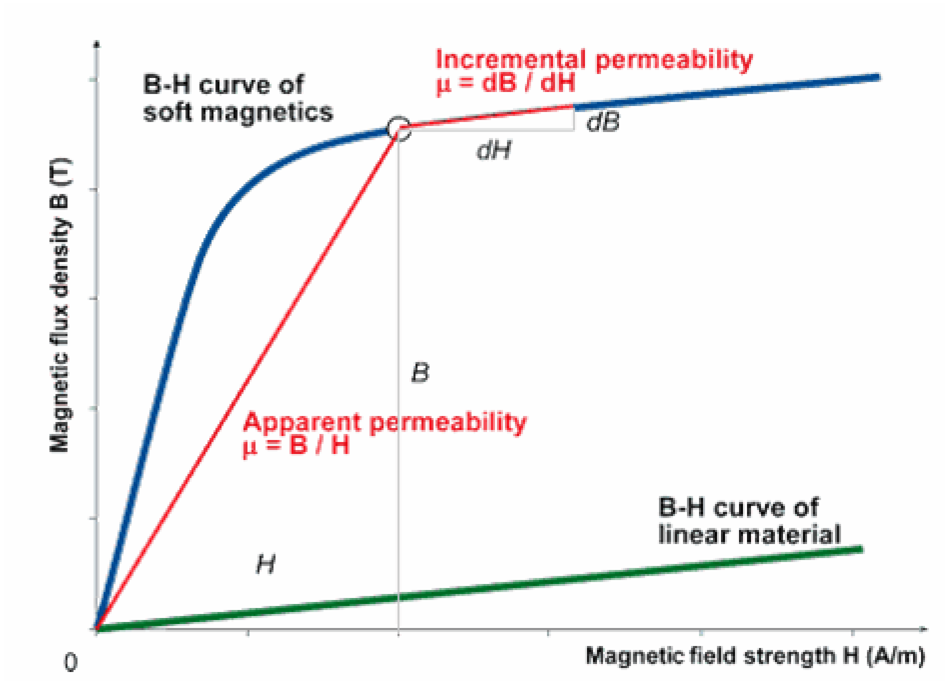


B-H for various materials

Created by **Dr. E. Siva Senthil**, HOD, Associate Professor, Department of Physics, KAHE.

c. The slope of the curve - **Permeability**

The slope of the B-H curve at some location on its curve is its incremental permeability at that location. However, sometimes the permeability is measured from the origin to the location of interest, and that slope is called its apparent permeability, μ.



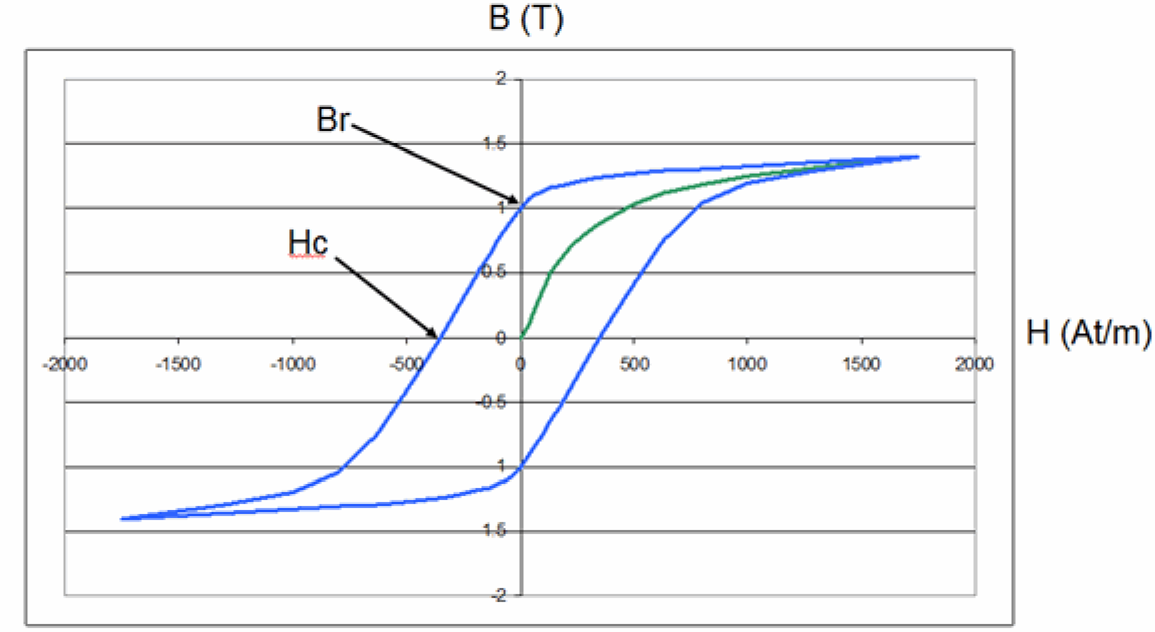
For non-magnetic materials that do not saturate, the curve has a fixed slope approximately equal to μ_0

i. Diamagnetic materials have a slightly smaller slope

ii. Paramagnetic materials have a slightly greater slope

d. Critical points on the curve

For ferromagnetic materials that are non-linear, they have a μ_r that is much greater than 1, but when they saturate their μ_r approaches 1.



i. The residual magnetism, Br, or remanence (or retentivity), is the flux density that is left within the material after it has been magnetized.

ii. A material with a high Br is desired for permanent magnets.
http://en.wikipedia.org/wiki/Remanence

iii. The coercivity, Hc, is the magnetic field intensity that is required to demagnetize the material after it has been magnetized.

iv. A material with a high Hc is desired for permanent magnets to prevent them from being easily demagnetized.

v. Rare earth magnets have a much higher Hc than Alnico magnets.
http://en.wikipedia.org/wiki/Coercivity

vi. The saturation effect of the material occurs when all of the magnetic domains within the material have become aligned with the external magnetic field that surrounds it.

e. Characteristics of soft magnetic material

i. A material with a very low Br and Hc

ii. It does not retain a strong magnetic field (does not make a good permanent magnet), and is easy to demagnetize

iii. The area enclosed by the B-H curve is small, so it has low hysteresis losses or core losses

iv. This material is desired for use in transformers, motors and electromagnets where the magnetic field is always changing.

v. Electrical steels, which contain about 1-2% Si, is a soft magnetic material.

e. Characteristics of hard magnetic material

i. A material with a very high Br and Hc

ii. It retains a strong magnetic field (makes a good permanent magnet), and is difficult to demagnetize

iii. The area enclosed by the B-H curve is large, so it has high hysteresis losses or core losses

iv. This material is desired for use in permanent magnets.

v. Alloys such as AlNiCo and NdFeB are hard magnetic materials.

UNIT – III

Modern Physics: Einstein's Photoelectric effect-characteristics of photoelectron –laws of photoelectric emission-Einstein's photo electric equations- Compton effect-matter waves-De-Broglie Hypothesis. Heisenberg's uncertainty principle-Schrödinger's equation- particle in a box.

Modern Physics

Einstein's Photoelectric effect

The photoelectric effect is a phenomenon where electrons are emitted from the metal surface when the light of sufficient frequency is incident upon. The concept of photoelectric effect was first documented in 1887 by Heinrich Hertz and later by Lenard in 1902. But both the observations of the photoelectric effect could not be explained by Maxwell's electromagnetic wave theory of light. Hertz (who had proved the wave theory) himself did not pursue the matter as he felt sure that it could be explained by the wave theory. It, however, failed on the following accounts:

According to the wave theory, energy is uniformly distributed across the wavefront and is dependent only on the intensity of the beam. This implies that the kinetic energy of electrons increases with light intensity. However, the kinetic energy was independent of light intensity.

Wave theory says that light of any frequency should be capable of ejecting electrons. But electron emission occurred only for frequencies larger than a threshold frequency (ν0).

Since energy is dependent on intensity according to wave theory, the low-intensity light should emit electrons after some time so that the electrons can acquire sufficient energy to get emitted. However, electron emission was spontaneous no matter how small the intensity of light.

Following is the table with link of other experiment related to photoelectric effect:

Einstein's explanation of Photoelectric effect

Einstein resolved this problem using Planck's revolutionary idea that light was a particle. The energy carried by each particle of light (called quanta or photon) is dependent on the light's frequency (ν) as shown:

E = hν

Where *h = Planck's constant = 6.6261 × 10-34 Js.*

Since light is bundled up into photons, Einstein theorized that when a photon falls on the surface of a metal, the entire photon's energy is transferred to the electron.

A part of this energy is used to remove the electron from the metal atom's grasp and the rest is given to the ejected electron as kinetic energy. Electrons emitted from underneath the metal surface lose some of the kinetic energy during the collision. But the surface electrons carry all the kinetic energy imparted by the photon and have the maximum kinetic energy.
We can write this mathematically as:

Energy of photon
= energy required to eject electron (work function) + Maximum kinetic energy of the electron
E = W + KE
hν = W + KE
KE = hν – w

At the threshold frequency ν0 electrons are just ejected and do not have any kinetic energy. Below this frequency there is no electron emission. Thus, the energy of a photon with this frequency must be the work function of the metal.

w = $h\nu_0$
Thus, Maximum kinetic energy equation becomes:
KE = 12mv2max=hν–$h\nu_0$
12mv2max=h($\nu - \nu_0$)

Vmax is the maximum kinetic energy of the electron. It is calculated experimentally using the stopping potential. Please read our article on Lenard's observations to understand this part.

Stopping potential = $e\nu_0$ = 12mv2max
Thus, Einstein explained the Photoelectric effect by using the particle nature of light.
Stay tuned with BYJU'S to learn more about the photoelectric effect along with engaging video lectures.

Compton effect, increase in wavelength of X-rays and other energetic electromagnetic radiations that have been elastically scattered by electrons; it is a principal way in which radiant energy is absorbed in matter. The effect has proved to be one of the cornerstones of quantum mechanics, which accounts for both wave and particle properties of radiation as well as of matter.

Matter waves

It is **the wave** formed by **matter**, or in another word, particles. Precisely speaking, every **matter** formed by particles, or just particles like electrons, have **wave**-like **property**, which means they can behave both like particles and **waves**. It is only when particles move that they have **wave**-like **property**

De Broglie's Thesis

In his 1923 (or 1924, depending on the source) doctoral dissertation, the French physicist Louis de Broglie made a bold assertion. Considering Einstein's relationship of wavelength *lambda* to momentum *p*, de Broglie proposed that this relationship would determine the wavelength of any matter, in the relationship:

lambda = *h* / *p*

recall that *h* is Planck's constant

This wavelength is called the *de Broglie wavelength*. The reason he chose the momentum equation over the energy equation is that it was unclear, with matter, whether *E* should be total energy, kinetic energy, or total relativistic energy. For photons, they are all the same, but not so for matter.

Assuming the momentum relationship, however, allowed the derivation of a similar de Broglie relationship for frequency *f* using the kinetic energy E_k:

$f = E_k / h$

Alternate Formulations

De Broglie's relationships are sometimes expressed in terms of Dirac's constant, *h-bar* = *h* / (2*pi*), and the angular frequency *w* and wavenumber *k*:

$p = h\text{-}bar * kE_k$

$= h\text{-}bar * w$

Experimental Confirmation

In 1927, physicists Clinton Davisson and Lester Germer, of Bell Labs, performed an experiment where they fired electrons at a crystalline nickel target. The resulting diffraction pattern matched the predictions of the de Broglie wavelength. De Broglie received the 1929 Nobel Prize for his theory (the first time it was ever awarded for a Ph.D. thesis) and Davisson/Germer jointly won it in 1937 for the experimental discovery of electron diffraction (and thus the proving of de Broglie's hypothesis).

Further experiments have held de Broglie's hypothesis to be true, including the quantum variants of the double slit experiment. Diffraction experiments in 1999 confirmed the de Broglie wavelength for the behavior of molecules as large as buckyballs, which are complex molecules made up of 60 or more carbon atoms.

Significance of the de Broglie Hypothesis

The de Broglie hypothesis showed that wave-particle duality was not merely an aberrant behavior of light, but rather was a fundamental principle exhibited by both radiation and matter. As such, it becomes possible to use wave equations to describe material behavior, so long as one properly applies the de Broglie wavelength. This would prove crucial to the development of quantum mechanics. It is now an integral part of the theory of atomic structure and particle physics.

Macroscopic Objects and Wavelength

Though de Broglie's hypothesis predicts wavelengths for matter of any size, there are realistic limits on when it's useful. A baseball thrown at a pitcher has a de Broglie wavelength that is smaller than the diameter of a proton by about 20 orders of magnitude.

The Heisenberg uncertainty principle states that it is impossible to know simultaneously the exact position and momentum of a particle. That is, the more exactly the position is determined, the less known the momentum, and vice versa. This principle is not a statement about the limits of technology, but a fundamental limit on what can be known about a particle at any given moment. This uncertainty arises because the act of measuring affects the object being measured. The only way to measure the position of something is using light, but, on the sub-atomic scale, the interaction of the light with the object inevitably changes the object's position and its direction of travel.

The Schrödinger Equation and a Particle in a Box

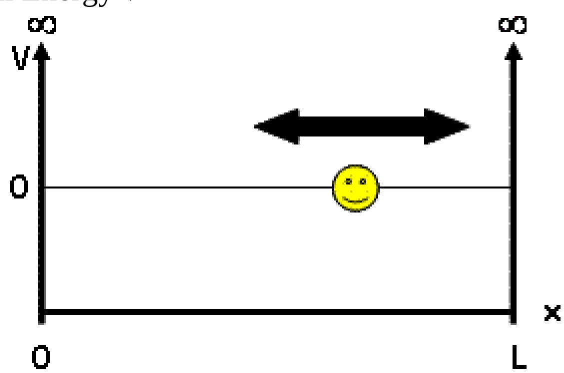
The particle in a box model (also known as the infinite potential well or the infinite square well) describes a particle free to move in a small space surrounded by impenetrable barriers. The model is mainly used as a hypothetical example to illustrate the differences between classical and quantum systems. In classical systems, for example a ball trapped inside a large box, the particle can move at any speed within the box and it is no more likely to be found at one position than another. However, when the well becomes very narrow (on the scale of a few nanometers), quantum effects become important. The particle may only occupy certain positive energy levels. The particle in a box model provides one of the very few problems in quantum mechanics which can be solved analytically, without approximations. This means that the observable properties of the particle (such as its energy and position) are related to the mass of the particle and the width of the well by simple mathematical expressions. Due to its simplicity, the model allows insight into quantum effects without the need for complicated mathematics. It is one of the first quantum mechanics problems taught in undergraduate physics courses, and it is commonly used as an approximation for more complicated quantum systems.

A particle in a 1-dimensional box is a fundamental quantum mechanical approximation describing the translational motion of a single particle confined inside an infinitely deep well from which it *cannot* escape.

The particle in a box problem is a common application of a quantum mechanical model to a simplified system consisting of a particle moving horizontally within an infinitely deep well from which it cannot escape. The solutions to the problem give possible values of E and ψψ that the particle can possess. E represents allowed energy values and ψ(x)ψ(x) is a wavefunction, which when squared gives us the probability of locating the particle at a certain position within the box at a given energy level.

To solve the problem for a particle in a 1-dimensional box, we must follow our **Big, Big recipe for Quantum Mechanics:**

Define the Potential Energy, *V*
Solve the Schrödinger Equation
Define the wavefunction
Define the allowed energies
Step 1: Define the Potential Energy *V*



***A particle in a 1D infinite potential well of dimension* LL.**

The potential energy is *0 inside the box* (V=0 for 0<x<L) and *goes to infinity at the walls of the box* (V=∞ for x<0 or x>L). We assume the walls have infinite potential energy to ensure that the particle has zero probability of being at the walls or outside the box. Doing so significantly simplifies our later mathematical calculations as we employ these **boundary conditions** when solving the Schrödinger Equation.

Step 2: Solve the Schrödinger Equation
The time-independent Schrödinger equation for a particle of mass *m* moving in one direction with energy *E* is

−ℏ22md2ψ(x)dx2+V(x)ψ(x)=Eψ(x)(1)(1)−ℏ22md2ψ(x)dx2+V(x)ψ(x)=Eψ(x)

with
ℏℏ is the reduced Planck Constant where ℏ=h2πℏ=h2π
m is the mass of the particle
ψ(x)ψ(x) is the stationary time-independent wavefunction
V(x) is the potential energy as a function of position
EE is the energy, a real number

This equation can be modified for a particle of mass *m* free to move parallel to the x-axis with zero potential energy (V = 0 everywhere) resulting in the quantum mechanical description of free motion in one dimension:

−ℏ22md2ψ(x)dx2=Eψ(x)(2)(2)−ℏ22md2ψ(x)dx2=Eψ(x)

This equation has been well studied and gives a general solution of:

ψ(x)=Asin(kx)+Bcos(kx)(3)(3)ψ(x)=Asin(kx)+Bcos(kx)

where A, B, and k are constants.

Step 3: Define the wavefunction

The solution to the Schrödinger equation we found above is the general solution for a 1-dimensional system. We now need to apply our **boundary conditions** to find the solution to our particular system. According to our boundary conditions, the probability of finding the particle at x=0 or x=L is zero. When x=0x=0, sin(0)=0sin(0)=0, and cos(0)=1cos(0)=1; therefore, *B must equal 0* to fulfill this boundary condition giving:
ψ(x)=Asin(kx)(4)(4)ψ(x)=Asin(kx)

We can now solve for our constants (A and k) systematically to define the wavefunction.

Solving for k

Differentiate the wavefunction with respect to x:

dψdx=kAcos(kx)(5)(5)dψdx=kAcos(kx)
d2ψdx2=−k2Asin(kx)(6)(6)d2ψdx2=−k2Asin(kx)
Since ψ(x)=Asin(kx)ψ(x)=Asin(kx), then

d2ψdx2=−k2ψ(7)(7)d2ψdx2=−k2ψ

If we then solve for k by comparing with the Schrödinger equation above, we find:

k=(8π2mEh2)1/2(8)(8)k=(8π2mEh2)1/2

Now we plug k into our wavefunction:

ψ=Asin(8π2mEh2)1/2x(9)(9)ψ=Asin(8π2mEh2)1/2x

Solving for A

To determine A, we have to apply the boundary conditions again. Recall that the *probability of finding a particle at x = 0 or x = L is zero.*

When x=Lx=L:

0=Asin(8π2mEh2)1/2L(10)(10)0=Asin(8π2mEh2)1/2L
This is only true when
(8π2mEh2)1/2L=nπ(11)(11)(8π2mEh2)1/2L=nπ
where n = 1,2,3…

Plugging this back in gives us:

ψ=AsinnπLx(12)(12)ψ=AsinnπLx
To determine AA, recall that the total probability of finding the particle inside the box is 1, meaning there is no probability of it being outside the box. When we find the probability and set it equal to 1, we are *normalizing* the wavefunction.
∫L0ψ2dx=1(13)(13)∫0Lψ2dx=1

For our system, the normalization looks like:

A2∫L0sin2(nπxL)dx=1(14)(14)A2∫0Lsin2(nπxL)dx=1
Using the solution for this integral from an integral table, we find our normalization constant, AA:
A=2L−−√(15)(15)A=2L

Which results in the normalized wavefunction for a particle in a 1-dimensional box:

ψ=2L−−√sinnπLx(16)(16)ψ=2LsinnπLx
Step 4: Determine the Allowed Energies

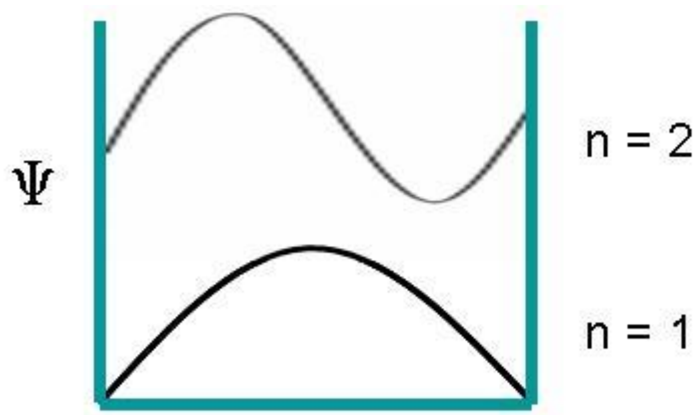
Solving for E results in the allowed energies for a particle in a box:

En=n2h28mL2(17)(17)En=n2h28mL2
This is an important result that tells us:

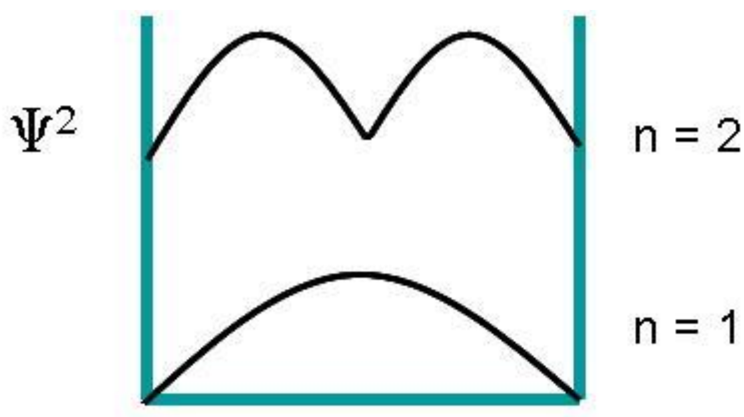
The energy of a particle is quantized and
The lowest possible energy of a particle is **NOT** zero. This is called the **zero-point energy** and means the particle can **never be at rest** because it always has some kinetic energy.

This is also consistent with the Heisenberg Uncertainty Principle: if the particle had zero energy, we would know where it was in both space and time.

The wavefunction for a particle in a box at the n=1n=1 and n=2n=2 energy levels look like this:



The probability of finding a particle a certain spot in the box is determined by squaring ψψ. The probability distribution for a particle in a box at the n=1n=1 and n=2n=2 energy levels looks like this:



Notice that the number of **nodes** (places where the particle has zero probability of being located) increases with increasing energy n. Also note that as the energy of the particle becomes greater, the quantum mechanical model breaks down as the energy levels get closer together and overlap, forming a continuum. This continuum means the particle is free and can have any energy value. At such high energies, the classical mechanical model is applied as the particle behaves more like a continuous wave. Therefore, the particle in a box problem is an example of Wave-Particle Duality.

IMPORTANT FACTS TO LEARN FROM THE PARTICLE IN THE BOX

- The energy of a particle is quantized. This means it can only take on discrete energy values.
- The lowest possible energy for a particle is **NOT** zero (even at 0 K). This means the particle *always* has some kinetic energy.
- The square of the wavefunction is related to the probability of finding the particle in a specific position for a given energy level.
- The probability changes with increasing energy of the particle and depends on the position in the box you are attempting to define the energy for.
- In classical physics, the probability of finding the particle is independent of the energy and the same at all points in the box.

UNIT – V

Digital Electronics

Digital Electronics: Decimal – binary – octal and hexadecimal numbers– their representation, inter-conversion, addition and subtraction, negative numbers. Sum of products – product of sums – their conversion – Simplification of Boolean expressions - K-Map – min terms – max terms - (2, 3 and 4 variables). Basic logic gates – AND, OR, NOT, NAND, NOR and EXOR gates – NAND and NOR as universal building gates – Boolean Algebra – Laws of Boolean Algebra – De Morgan's Theorems – Their verifications using truth tables.

Number Systems

There are infinite ways to represent a number. The four commonly associated with modern computers and digital electronics are: decimal, binary, octal, and hexadecimal.

Decimal (base 10) is the way most human beings represent numbers. Decimal is sometimes abbreviated as dec.

Decimal counting goes:
0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, and so on.

Binary (base 2) is the natural way most digital circuits represent and manipulate numbers. (Common misspellings are "bianary", "bienary", or "binery".) Binary numbers are sometimes represented by preceding the value with '0b', as in 0b1011. Binary is sometimes abbreviated as bin.

Binary counting goes:

0, 1, 10, 11, 100, 101, 110, 111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111, 10000, 10001, and so on.

Octal (base 8) was previously a popular choice for representing digital circuit numbers in a form that is more compact than binary. Octal is sometimes abbreviated as oct.

Octal counting goes:

0, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, and so on.

Hexadecimal (base 16) is currently the most popular choice for representing digital circuit numbers in a form that is more compact than binary. (Common misspellings are “hexdecimal”, “hexidecimal”, “hexedecimal”, or “hexodecimal”.) Hexadecimal numbers are sometimes represented by preceding the value with '0x', as in 0x1B84. Hexadecimal is sometimes abbreviated as hex.

Hexadecimal counting goes:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, 10, 11, and so on.

All four number systems are equally capable of representing any number. Furthermore, a number can be perfectly converted between the various number systems without any loss of numeric value.

At first blush, it seems like using any number system other than human-centric decimal is complicated and unnecessary. However, since the job of electrical and software engineers is to work with digital circuits, engineers require number systems that can best transfer information between the human world and the digital circuit world.

It turns out that the way in which a number is represented can make it easier for the engineer to perceive the meaning of the number as it applies to a digital circuit. In other words, the appropriate number system can actually make things less complicated.

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Fundamental Information Element of Digital Circuits

Almost all modern digital circuits are based on two-state switches. The switches are either on or off. It doesn't matter if the switches are actually physical switches, vacuum tubes, relays, or transistors. And, it doesn't matter if the 'on' state is represented by 1.8 V on a cutting-edge CPU core, -12 V on a RS-232 interface chip, or 5 V on a classic TTL logic chip.

Because the fundamental information element of digital circuits has two states, it is most naturally represented by a number system where each individual digit has two states: binary.
For example, switches that are 'on' are represented by '1' and switches that are 'off' are represented by '0'. It is easy to instantly comprehend the values of 8 switches represented in binary as 10001101. It is also easy to build a circuit to display each switch state in binary, by having an LED (lit or unlit) for each binary digit.

Conversion of Numbers

Conversion of numbers from one system to another becomes necessary to understand the process and the logic of the operations of a computer system. It is not very difficult to convert numbers from one base to another. We will first discuss about the conversion of binary numbers to their decimal equivalents.

(i) Expansion Method:

In expansion method the conversion of binary numbers to their decimal equivalents are shown with the help of the examples.

1. Convert the decimal numbers to their binary equivalents:

(a) 256

Solution:

256

256	128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0	0

Since the given number 256 appears in the first row, we put 1 in the slot below 256 and fill all the other slots to the right of this slot with zeros.

Thus, $256_{10} = 100000000_2$

Addition and subtraction of octal numbers are explained using different examples.

Addition of octal numbers:

Addition of octal numbers is carried out by the same principle as that of decimal or binary numbers.

Evaluate:

(i) $(162)_8 + (537)_8$

Solution:

```
 1 1      <---- carry
 1 6 2
 5 3 7
------
 7 2 1
```

Therefore, sum = 721_8

(ii) $(136)_8 + (636)_8$

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Solution:

```
  1      <---- carry
 1 3 6
 6 3 6
 -----
 7 7 4
```

Therefore, sum = 774_8

(iii) $(25.27)_8 + (13.2)_8$

Solution:

```
 1          <---- carry
 2 5 . 2 7
 1 3 . 2
 ---------
 4 0 . 4 7
```

Therefore, sum = $(40.47)_8$

(iv) $(67.5)_8 + (45.6)_8$

Solution:

```
  1 1          <---- carry

  6 7 . 5

  4 5 . 6
 ---------
1 3 5 . 3
```

Therefore, sum = $(135.3)_8$

(b) 77

Solution:

77

(b) 77

Solution:

77

The given number is less than 128 but greater than 64. We therefore put 1 in the slot corresponding to 64 in the first row. Next, we subtract 64 from 77 and get 13 as remainder.

This remainder is less than 16 and greater than 8. So we put 1 in the slot corresponding to 8 and subtract 8 from 13. This gives 13 - 8 = 5. This remainder is greater than 4 and less than 8.

Hence we put 1 in the slot corresponding to 4 and subtracting 4 from 5 we get 1. Now, 1 is present in the right hand most slot of the first row. We, therefore, put 1 in the corresponding slot and fill all other slots with zeros.

Thus, 7710 = 10011012.

Conversion of decimal fractions to binary fractions may also be accomplished by using similar method. Let us observe the procedure with the help of the following example:

2. Convert 0.67510 to its binary equivalent.

Solution:

Convert Decial Number to Binary Number

Subtract .5 from the given number to get .675 - .5 = .175 and place 1 in the slot corresponding to .5 of the first row.

Now the number .175 is less than .25 and greater than .125. So, we put 1 in the slot corresponding to the number .125 of the first row and subtract .125 from .175 to get .175 - .125 = .05. The remainder .05 is less than .0625 but greater than .03125.

Hence we put 1 in the slot corresponding to 0.3125 and the subtraction given .05 - .03125 = .01875 and continue the process. The other slots are then filled with zeros.

64	32	16	8	4	2	1
1	0	0	1	1	0	1

Thus, .67510 = (.10101…)2

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Thus, .67510 = $(.10101\ldots)_2$

Subtraction of octal numbers:

Similarly, subtraction of octal numbers can be performed by following the rules of subtraction of decimal numbers.

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Thus, for performing addition and subtraction of octal numbers we can follow the rules of addition and subtraction of decimal numbers.

Boolean functions may be practically implemented by using electronic gates. The following points are important to understand.

Electronic gates require a power supply.

Gate **INPUTS** are driven by voltages having two nominal values, e.g. 0V and 5V representing logic 0 and logic 1 respectively.

The **OUTPUT** of a gate provides two nominal values of voltage only, e.g. 0V and 5V representing logic 0 and logic 1 respectively. In general, there is only one output to a logic gate except in some special cases.

There is always a time delay between an input being applied and the output responding.

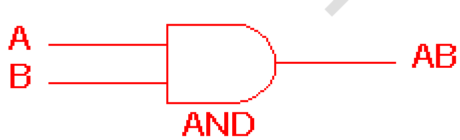
Truth Tables

Truth tables are used to help show the function of a logic gate. If you are unsure about truth tables and need guidence on how go about drawningthem for individual gates or logic circuits then use the truth table section link.

Logic gates

Digital systems are said to be constructed by using logic gates. These gates are the AND, OR, NOT, NAND, NOR, EXOR and EXNOR gates. The basic operations are described below with the aid of truth tables.

AND gate



2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

The AND gate is an electronic circuit that gives a **high** output (1) only if **all** its inputs are high. A dot (.) is used to show the AND operation i.e. A.B. Bear in mind that this dot is sometimes omitted i.e. AB

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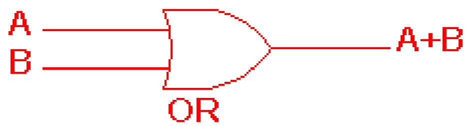
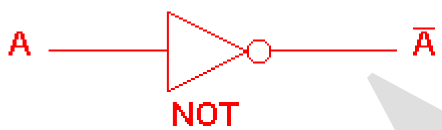
OR gate



2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

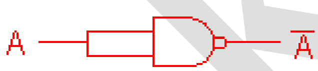
The OR gate is an electronic circuit that gives a high output (1) if **one or more** of its inputs are high. A plus (+) is used to show the OR operation.

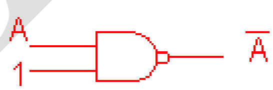
NOT gate



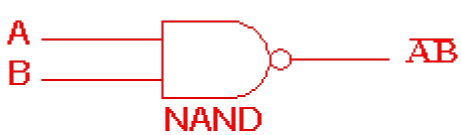
NOT gate	
A	$\overline{A}$
0	1
1	0

The NOT gate is an electronic circuit that produces an inverted version of the input at its output. It is also known as an *inverter*. If the input variable is A, the inverted output is known as NOT A. This is also shown as A', or A with a bar over the top, as shown at the outputs. The diagrams below show two ways that the NAND logic gate can be configured to produce a NOT gate. It can also be done using NOR logic gates in the same way.





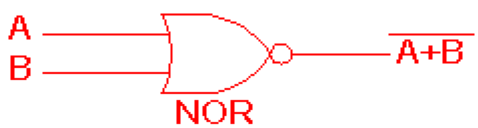
NAND gate



2 Input NAND gate		
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

This is a NOT-AND gate which is equal to an AND gate followed by a NOT gate. The outputs of all NAND gates are high if **any** of the inputs are low. The symbol is an AND gate with a small circle on the output. The small circle represents inversion.

NOR gate

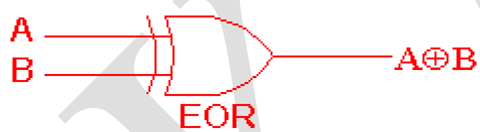


2 Input NOR gate		
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

This is a NOT-OR gate which is equal to an OR gate followed by a NOT gate. The outputs of all NOR gates are low if **any** of the inputs are high.

The symbol is an OR gate with a small circle on the output. The small circle represents inversion.

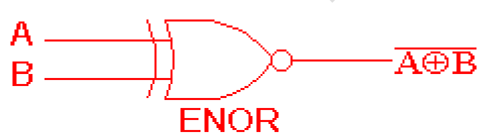
EXOR gate



2 Input EXOR gate		
A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

The '**Exclusive-OR**' gate is a circuit which will give a high output if **either, but not both**, of its two inputs are high. An encircled plus sign ($\oplus$) is used to show the EOR operation.

EXNOR gate



2 Input EXNOR gate		
A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

The '**Exclusive-NOR'** gate circuit does the opposite to the EOR gate. It will give a low output if **either, but not both**, of its two inputs are high. The symbol is an EXOR gate with a small circle on the output. The small circle represents inversion.

The NAND and NOR gates are called *universal functions* since with either one the AND and OR functions and NOT can be generated.

Note:

A function in *sum of products* form can be implemented using NAND gates by replacing all AND and OR gates by NAND gates.

A function in *product of sums* form can be implemented using NOR gates by replacing all AND and OR gates by NOR gates.

Table 1: Logic gate symbols

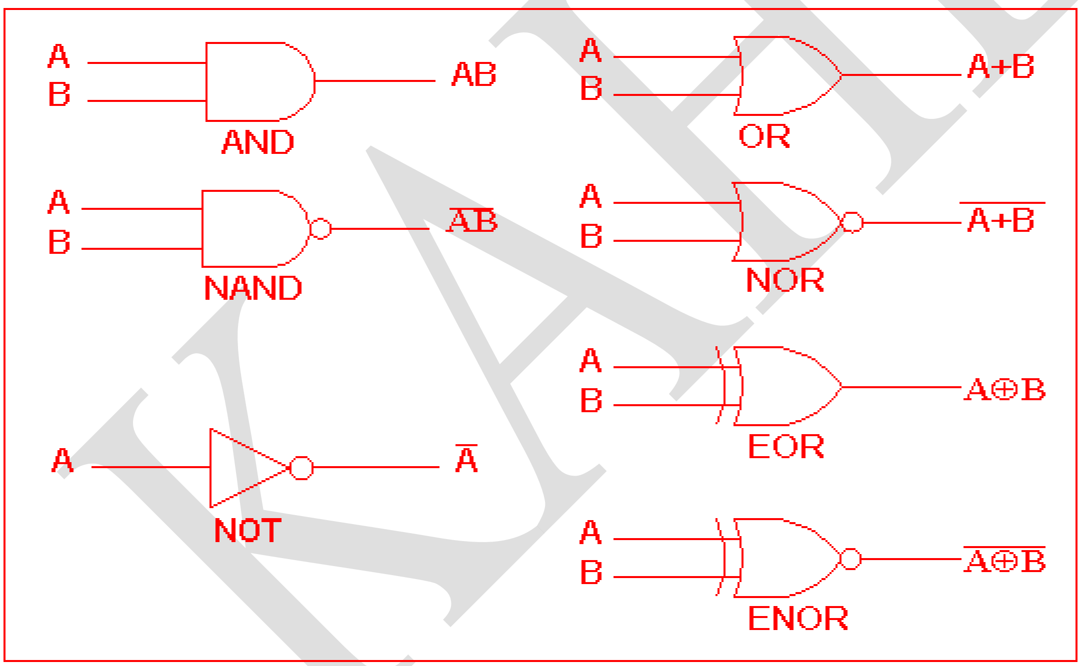


Table 2 is a summary truth table of the input/output combinations for the NOT gate together with all possible input/output combinations for the other gate functions. Also note that a truth table with 'n' inputs has 2^n rows. You can compare the outputs of different gates.

Table 2: Logic gates representation using the Truth table

NOT gate	
A	$\overline{A}$
0	1
1	0

INPUTS		OUTPUTS					
A	B	AND	NAND	OR	NOR	EXOR	EXNOR
0	0	0	1	0	1	0	1
0	1	0	1	1	0	1	0
1	0	0	1	1	0	1	0
1	1	1	0	1	0	0	1

Universal Gate | NAND and NOR Gate as Universal Gates

We have discussed different types of logic gates in previous articles. Now coming to the topic of this article we are going to discuss the **Universal Gate**. AND, NOT and OR gates are the basic gates; we can create any logic gate or any Boolean expression by combining a mixture of these gates.

But NOR gates and NAND gates have the particular property that any **one of them** can create any logical Boolean expression if appropriately designed. Meaning that you can create any logical Boolean expression using ONLY NOR gates or ONLY NAND gates. Other logical gates do not have this property. If you which to play around with these universal gates as part of an electronics project, many of the best Arduino starter kits contain these universal NOR and

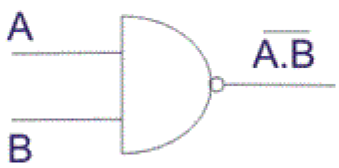
NAND gates.

Now we will look at the operation of NOR gates and NAND gates as **universal gates**.

NAND gate as Universal Gate

The below diagram is of a two input NAND gate. The first part is an AND gate and second part is a dot after it represents a NOT gate. So it is clear that during the operation of NAND gate, the inputs are first going through AND gate and after that, the output gets reversed, and we get the final output. Now we will look at the truth table of NAND gate.

We will consider the truth table of the above NAND gate i.e. a two-input gate. The two inputs are A and B.

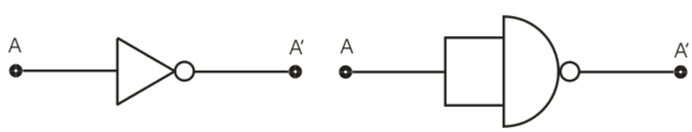


NAND gate

truth table of a nand gate

Inputs		Output
A	B	$X = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

Now we will see how this gate can be used to make other gates.



This is the circuit diagram of a NAND gate used to make work like a NOT gate, the original logic gate diagram of NOT gate is given besides.

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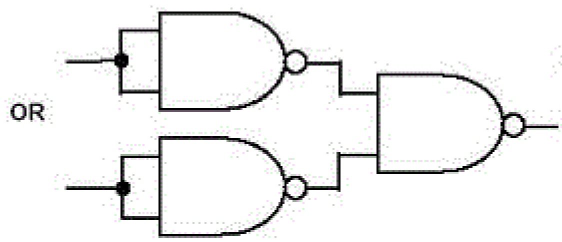
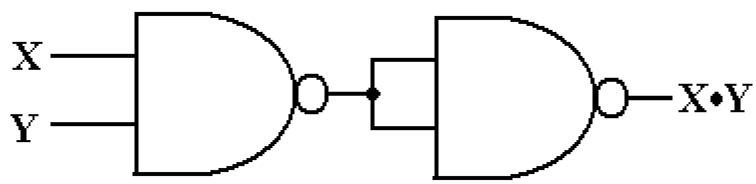


A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

The above diagram is of an OR gate made from combinations of NAND gates, arranged in a proper manner. The truth table of an OR gate is also given beside the diagram.

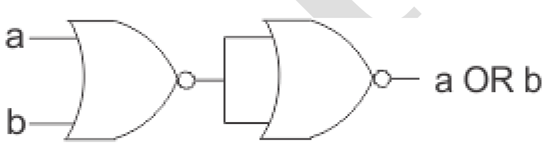
Now we will see the design of an AND gate from NAND gates.



The above diagram is of an AND gate made from NAND gate. So we can see that all the three basic gates can be made by only using NAND gates, that's why this gate is called **Universal Gate**, and it is appropriate.

NOR gate as universal gate

We have seen how NAND gate can be used to make all the three basic gates by using that alone. Now we will discuss the same in case of NOR gate.



The above diagram is of an OR gate made by only using NOR gates. The output of this gate is exactly similar to that of a single OR gate. We can see the circuit arrangement of OR gate using, NOR gate is similar to that of AND gate using NAND gates.

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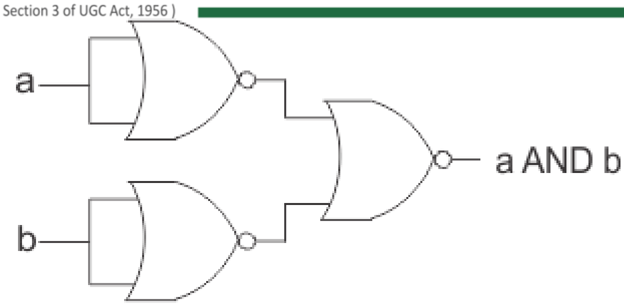
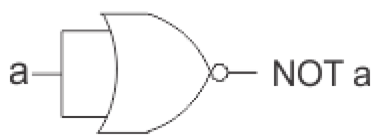


The above diagram as the name suggests is of AND gate using only NOR gate, again we can see that the circuit diagram of AND gate using only NOR gate is exactly similar to that of OR gate using only NAND gates. Now we will finally see how we can make a NOT gate by using only NOR gates.



The above diagram is of a NOT gate made by using a NOR gate. The circuit diagram is similar to that of NOT gate made by using only NAND gate.
So, from the above discussion, it is clear that all the three basic gates (AND, OR, NOT) can be made by only using NOR gate. And thus, it can be aptly termed as **Universal Gate**.

Laws of Boolean Algebra

As well as the logic symbols "0" and "1" being used to represent a digital input or output, we can also use them as constants for a permanently "Open" or "Closed" circuit or contact respectively.

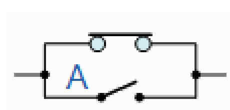
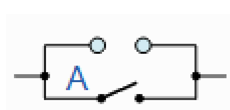
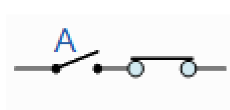
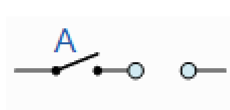
A set of rules or Laws of Boolean Algebra expressions have been invented to help reduce the number of logic gates needed to perform a particular logic operation resulting in a list of functions or theorems known commonly as the **Laws of Boolean Algebra**.

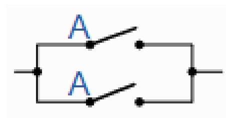
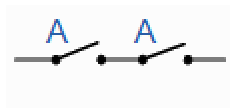
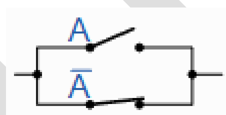
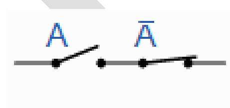
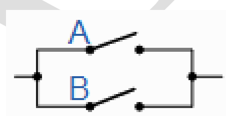
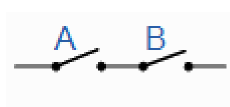
Boolean Algebra is the mathematics we use to analyse digital gates and circuits. We can use these "Laws of Boolean" to both reduce and simplify a complex Boolean expression in an attempt to reduce the number of logic gates required. *Boolean Algebra* is therefore a system of mathematics based on logic that has its own set of rules or laws which are used to define and reduce Boolean expressions.

The variables used in **Boolean Algebra** only have one of two possible values, a logic “0” and a logic “1” but an expression can have an infinite number of variables all labelled individually to represent inputs to the expression, For example, variables A, B, C etc, giving us a logical expression of A + B = C, but each variable can ONLY be a 0 or a 1.

Examples of these individual laws of Boolean, rules and theorems for Boolean Algebra are given in the following table.

Truth Tables for the Laws of Boolean

Boolean Expression	Description	Equivalent Switching Circuit	Boolean Algebra Law or Rule
A + 1 = 1	A in parallel with closed = "CLOSED"		Annulment
A + 0 = A	A in parallel with open = "A"		Identity
A . 1 = A	A in series with closed = "A"		Identity
A . 0 = 0	A in series with open = "OPEN"		Annulment

A + A = A	A in parallel with A = "A"		Idempotent
A . A = A	A in series with A = "A"		Idempotent
NOT A = A	NOT NOT A (double negative) = "A"		Double Negation
A + A = 1	A in parallel with NOT A = "CLOSED"		Complement
A . A = 0	A in series with NOT A = "OPEN"		Complement
A+B = B+A	A in parallel with B = B in parallel with A		Commutative
A.B = B.A	A in series with B = B in series with A		Commutative
A+B = A.B	invert and replace OR with AND		de Morgan's Theorem
A.B = A+B	invert and replace AND with OR		de Morgan's Theorem

Laws of Boolean Algebra

The basic **Laws of Boolean Algebra** that relate to the *Commutative Law* allowing a change in position for addition and multiplication, the *Associative Law* allowing the removal of brackets for addition and multiplication, as well as the *Distributive Law* allowing the factoring of an expression, are the same as in ordinary algebra.

Each of the *Boolean Laws* above are given with just a single or two variables, but the number of variables defined by a single law is not limited to this as there can be an infinite number of variables as inputs too the expression. These Boolean laws detailed above can be used to prove any given Boolean expression as well as for simplifying complicated digital circuits.

A brief description of the various **Laws of Boolean** are given below with A representing a variable input.

Description of the Laws of Boolean Algebra

A + (B + C) = (A + B) + C = A + B + C (OR Associate Law)

A(B.C) = (A.B)C = A . B . C (AND Associate Law)

(1) Two separate terms NOR´ed together is the same as the two terms inverted (Complement) and AND´ed for example: A+B = A . B

(2) Two separate terms NAND´ed together is the same as the two terms inverted (Complement) and OR´ed for example: A.B = A + B

Other algebraic Laws of Boolean not detailed above include:

Distributive Law – This law permits the multiplying or factoring out of an expression.

A(B + C) = A.B + A.C (OR Distributive Law)

A + (B.C) = (A + B).(A + C) (AND Distributive Law)

Absorptive Law – This law enables a reduction in a complicated expression to a simpler one by absorbing like terms.

A + (A.B) = A (OR Absorption Law)

A(A + B) = A (AND Absorption Law)

Associative Law – This law allows the removal of brackets from an expression and regrouping of the variables.

A + (B + C) = (A + B) + C = A + B + C (OR Associate Law)

A(B.C) = (A.B)C = A . B . C (AND Associate Law)

Boolean Algebra Functions

Using the information above, simple 2-input AND, OR and NOT Gates can be represented by 16 possible functions as shown in the following table.

Function	Description	Expression
1.	NULL	0
2.	IDENTITY	1
3.	Input A	A
4.	Input B	B
5.	NOT A	A
6.	NOT B	B
7.	A AND B (AND)	A . B
8.	A AND NOT B	A . B

9.	NOT A AND B	A . B
10.	NOT AND (NAND)	A . B
11.	A OR B (OR)	A + B
12.	A OR NOT B	A + B
13.	NOT A OR B	A + B
14.	NOT OR (NOR)	A + B
15.	Exclusive-OR	A . B + A . B
16.	Exclusive-NOR	A . B + A . B

Laws of Boolean Algebra Example No1

Using the above laws, simplify the following expression: (A + B)(A + C)

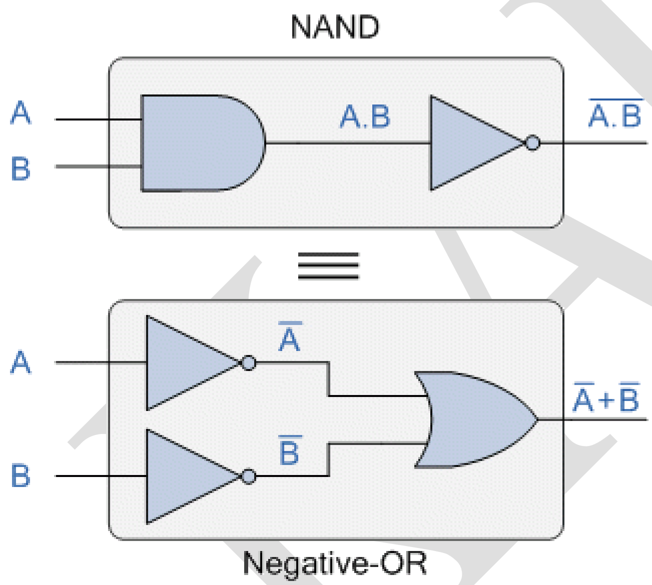
	Q =	(A + B).(A + C)
	A.A + A.C + A.B + B.C	– Distributive law
	A + A.C + A.B + B.C	– Idempotent AND law (A.A = A)
	A(1 + C) + A.B + B.C	– Distributive law
	A.1 + A.B + B.C	– Identity OR law (1 + C = 1)
	A(1 + B) + B.C	– Distributive law

	A.1 + B.C	– Identity OR law (1 + B = 1)
	A + (B.C)	– Identity AND law (A.1 = A)

Then the expression: (A + B)(A + C) can be simplified to A + (B.C) as in the Distributive law.

DeMorgan's Theorem

DeMorgan´s Theorem and Laws can be used to to find the equivalency of the NAND and NOR gates



As we have seen previously, Boolean Algebra uses a set of laws and rules to define the operation of a digital logic circuit with "0's" and "1's" being used to represent a digital input or output condition. Boolean Algebra uses these zeros and ones to create truth tables and mathematical expressions to define the digital operation of a logic AND, OR and NOT (or inversion) operations as well as ways of expressing other logical operations such as the XOR (Exclusive-OR) function.

While George Boole's set of laws and rules allows us to analyise and simplify a digital circuit, there are two laws within his set that are attributed to **Augustus DeMorgan** (a nineteenth century English mathematician) which views the logical NAND and NOR operations as separate NOT AND and NOT OR functions respectively.

But before we look at **DeMorgan's Theory** in more detail, let's remind ourselves of the basic logical operations where A and B are logic (or Boolean) input binary variables, and whose values can only be either "0" or "1" producing four possible input combinations, 00, 01, 10, and 11.

Truth Table for Each Logical Operation

Input Variable		Output Conditions			
A	B	AND	NAND	OR	NOR
0	0	0	1	0	1
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	0	1	0

The following table gives a list of the common logic functions and their equivalent Boolean notation where a "." (a dot) means an AND operation, a "+" (plus sign) means an OR operation, and the complement or inverse of a variable is indicated by a bar over the variable.

Logic Function	Boolean Notation

AND	A.B
OR	A+B
NOT	A
NAND	A .B
NOR	A+B

DeMorgan's Theory

DeMorgan's Theorems are basically two sets of rules or laws developed from the Boolean expressions for AND, OR and NOT using two input variables, A and B. These two rules or theorems allow the input variables to be negated and converted from one form of a Boolean function into an opposite form.

DeMorgan's first theorem states that two (or more) variables NOR´ed together is the same as the two variables inverted (Complement) and AND´ed, while the second theorem states that two (or more) variables NAND´ed together is the same as the two terms inverted (Complement) and OR´ed. That is replace all the OR operators with AND operators, or all the AND operators with an OR operators.

DeMorgan's First Theorem

DeMorgan's First theorem proves that when two (or more) input variables are AND'ed and negated, they are equivalent to the OR of the complements of the individual variables. Thus the equivalent of the NAND function and is a negative-OR function proving that A.B = A+B and we can show this using the following table.

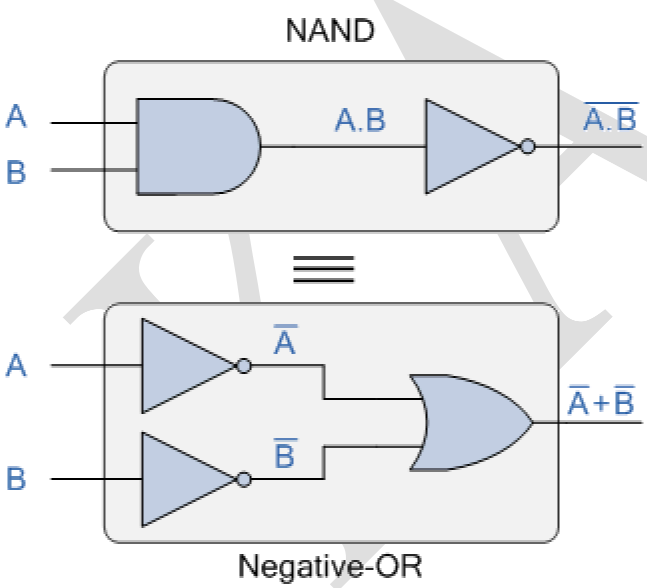
Verifying DeMorgan's First Theorem using Truth Table

Inputs	Truth Table Outputs For Each Term

B	A	A.B	A.B	A	B	A + B
0	0	0	**1**	1	1	**1**
0	1	0	**1**	0	1	**1**
1	0	0	**1**	1	0	**1**
1	1	1	**0**	0	0	**0**

We can also show that A.B = A+B using logic gates as shown.

DeMorgan's First Law Implementation using Logic Gates



The top logic gate arrangement of: A.B can be implemented using a NAND gate with inputs A and B. The lower logic gate arrangement first inverts the two inputs producing A and B which become the inputs to the OR gate. Therefore the output from the OR gate becomes: A+B

Thus an OR gate with inverters (NOT gates) on each of its inputs is equivalent to a NAND gate function, and an individual NAND gate can be represented in this way as the equivalency of a NAND gate is a negative-OR.

DeMorgan's Second Theorem

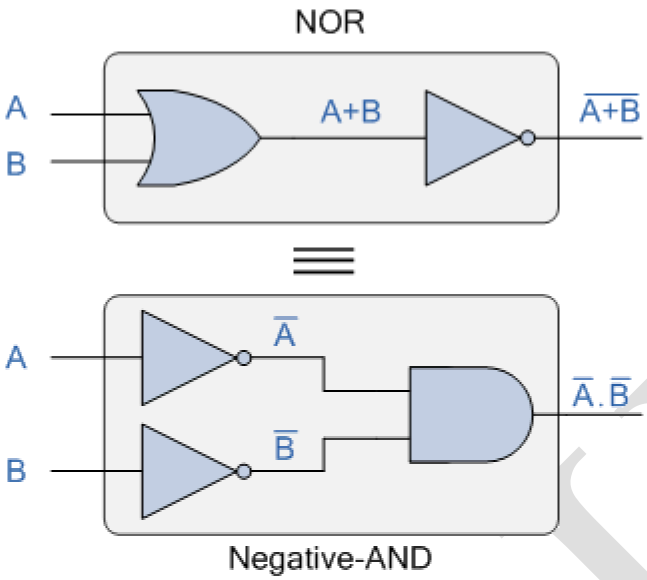
DeMorgan's Second theorem proves that when two (or more) input variables are OR'ed and negated, they are equivalent to the AND of the complements of the individual variables. Thus the equivalent of the NOR function and is a negative-AND function proving that A+B = A.B and again we can show this using the following truth table.

Verifying DeMorgan's Second Theorem using Truth Table

Inputs		Truth Table Outputs For Each Term				
B	A	A+B	A+B	A	B	A . B
0	0	0	**1**	1	1	**1**
0	1	1	**0**	0	1	**0**
1	0	1	**0**	1	0	**0**
1	1	1	**0**	0	0	**0**

We can also show that A+B = A.B using logic gates as shown.

DeMorgan's Second Law Implementation using Logic Gates



The top logic gate arrangement of: A+B can be implemented using a NOR gate with inputs A and B. The lower logic gate arrangement first inverts the two inputs producing A and B which become the inputs to the AND gate. Therefore the output from the AND gate becomes: A.B

Thus an AND gate with inverters (NOT gates) on each of its inputs is equivalent to a NOR gate function, and an individual NOR gate can be represented in this way as the equivalency of a NOR gate is a negative-AND.

Although we have used DeMorgan's theorems with only two input variables A and B, they are equally valid for use with three, four or more input variable expressions, for example:

For a 3-variable input

A.B.C = A+B+C

and also

A+B+C = A.B.C

For a 4-variable input

A.B.C.D = A+B+C+D

and also

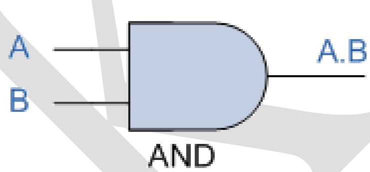
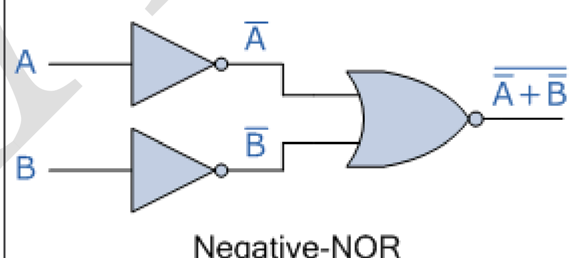
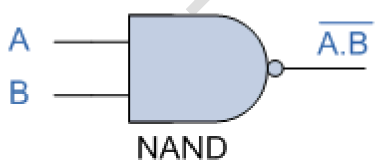
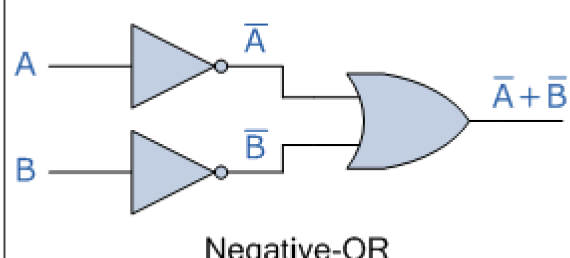
A+B+C+D = A.B.C.D

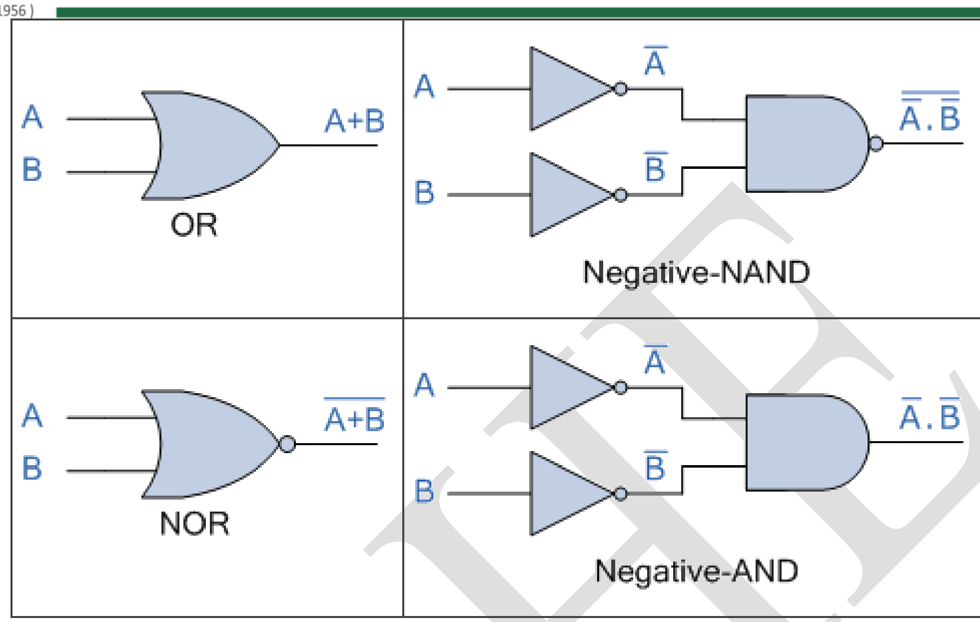
and so on.

DeMorgan's Equivalent Gates

We have seen here that DeMorgan's Theorems replace all of the AND (.) operators with OR (+) and vice versa and then complements each of the terms or variables in the expression by inverting it, that is 0's to 1's and 1's to 0's before inverting the entire function. Thus to obtain the DeMorgan equivalent for an AND, NAND, OR or NOR gate, we simply add inverters (NOT-gates) to all inputs and outputs and change an AND symbol to an OR symbol or change an OR symbol to an AND symbol as shown in the following table.

DeMorgan's Equivalent Gates

Standard Logic Gate	DeMorgan's Equivalent Gate
	
	



Then we have seen that the complement of two (or more) AND'ed input variables is equivalent to the OR of the complements of these variables, and that the complement of two(or more) OR'ed variables is equivalent to the AND of the complements of the variables as defined by *DeMorgan*.

[19MMU203]
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B. Sc., DEGREE EXAMINATIONS, APRIL
Second Semester
DEPARTMENT OF MATHEMATIC
PHYSICS - II

QUESTIONS	**OPTION 1**
UNIT-I	
If the distance between two charge is doubled the electrostatic force between the charge will be______	fourtime more
The field due to a wire of uniform charge density at a perpendicular distance y from it	increases with increase in y
Field due to a uniformly charged ring at an axial point at distance very large as compared to the radius of the ring	independent of x
Electric charge enclosed by Gaussian surface is	0
For gauss's law point charges in closed surface must be distributed	arbitrarily
Electric field intensity outside two charged parallel plate is	$\sigma/2\varepsilon_0$

The total electric flux over any closed surface is	ε_0
Electric flux lines due to an infinite sheet of charge is	converging
One electron volt is ___________.	1.6 x 10^{-19}joule
_________ law establishes a relationship between the electric flux and the electrostatic charge.	Lenz's
The ratio ϵ/ϵ0 is a dimensionless quantity known as ________	relative permeability
The electric field lines begin at the ___________ charge and terminate at the _________ charge.	positive, negative
Total electric flux emanating from a charge q coulomb placed in air is _____________.	q/ϵ_0
Gauss's law due to different charge distribution is used to calculate	electric field
The total flux across a closed surface enclosing charge is independent of	shape of the closed surface
The unit of Electric flux is ___________.	Gauss's
.Mechanical pressure on the surface of a charged conductor having surface charge density σ is ___________.	$\epsilon_0\, \sigma^2$
If the separation between two charges is increased the electric potential energy	always decreases

Electric intensity due to an infinitely long plane sheet of a conductor at appoint close to its surface is	independent of r
The total electric flux through a closed surface depends on	location of the charge only
Electric field intensity due to an infinite plane sheet of charge is	σ/ε_0
Law stated as flux is $^1/_{Eo}$ times total charge is	ohms law
A Gaussian sphere closes an electric dipole within it. Then the total flux through the sphere is	half due to a single charge
The Flux of electric field is____	scalar
Flux density is measured in	Tesla
Which of the following quantities are scalar?	dipole moment
A dipole is placed in a uniform electric field with its axis parallel to the field. It experiences	only a net force
Electric potential energy U of two point charges is	$q_1q_2/4\varepsilon_0\pi r^2$
If a point lies at a distance x from the midpoint of the dipole, the electric potential at the point is proportional to	$1/x^2$
The law that governs the force between electric charge is called	Amperes

The minimum value of the charge in any object cannot be less than	1.6 x $10^{-19 coulomb}$
An electric field can deflect	X rays
Inside the hollow spherical conductor, the potential	is constant
The intensity at a point due to a charge is inversely proportional to	amount of the charge
The distance between two charge is douled then the force between them would become	half
A surface enclosed an electric dipole, the flux through the surface is	infinite
Electric potential is a	vector quantity
The potential at any point inside a charged sphere is	zero
Two smallspheres eaach carrying a charge q are placed r metre apart, one of the spheres is taken around the other one in a circular path, the work done will be equal to	force between them x r
State which of the following is correct?	J=Coulomb x volt
A positively charged glass rod attracts an object. The object must be	negatively charged
A charge q islocated at the centre of a hypothetical cube. The electric flux through any face of the cube is	q/ϵ0

The force between two electrons seperated by a distance r varies as	r^2
The energy stored per unit volume of the medium of relative permittivity is ______________.	$\epsilon_r \epsilon_0 E^2/2$
All magnetic moments within a domain will point in the ___________ direction.	Different
The electrical energy consumed by a coil is stored in the form of:	magnetic field
Electricity may be generated by a wire:	carrying current
A magnetic field has:	lines of reluctance
The polarity of induced voltage while a field is collapsing is	opposite to the force creating it
What is magnetic flux?	the number of lines of force in webers
The energy stored in the charged capacitor is __________.	$1/2\ CV^2$
The arrangement in which one conductor is charged and other is earthed is named as _____________.	capacitor
___________ device is useful to reduce voltage fluctuations in electric power supplies.	capacitor
The capacitance of a capacitor C is____________	q/v

_______capacitors can bewidely used in the tuning circuits of radio receivers.	mica
_______capacitors are used widely in a radia-set as a smoothing capacitors	electrolytic
________capacitor is used in a.c bridges	electrolytic
___________ device is used to measure electrostatic potentials	electrometers
A dielectric slab is introduced between the plates of an isolated charged parallel plate air capacitor.Which of the following quantities will remain unchanged?	charge on the capacitor
The p.d across a capacitor is kept constant.If a dielectric slab of dielectric constant K is introduced between the plates,the stored energy will be __________.	decreases by a factor K
Capacitance has the dimension ____________.	$M^{-1}L^{-2}T^{4}I^{2}$
In gauss's law the electric flux E through a closed surface (s) depends on the value of net charge __________.	Inside the surface
The unit of capacitance is ____________.	Farad
_________ device is used to generate and detect electromagnetic oscillation of high frequency.	capacitor
The normal component of D are ________________ across the boundary by the surface charge density	continuous
The tangential component of the electric field is __________ across the boundary.	continuous

The potential difference between the conductors is proportional to the ________________ on the capacitor.	charge
The coaxial cable used in communication system is a common example for which type of capacitor ___________.	spherical
Variable air capacitor is used in ______________.	A.c bridges
__________ capacitors can be used only in unidirectional power supplies.	mica
An electron- volt (eV) is a unit of	Energy
Farad is the unit of	capacitance
In a charged capacitor the energy is stored in	the field between the plates
No current flows between two charged bodies connected together when they have the same	charge
Dielectric materials are	insulating materials
Dielectric constant of vacuum is	infinity
For making a capacitor it is better to select a dielectic having	low permittivity
A dielectric material must be a	resistor

Which of the following material has highest value of dielectric constant	glass
When a dielectric slab is introduced in a parallel plate capacitor, the potential difference between the plates will	remain unchanged
A capacitor consists of	two insulators seperated by a condenser

Unit-II

Which of the following material requires least magnetizing field to magnetize it?	Gold
Basic source of magnetism _______________	Charged particles alone
Units for magnetic flux density	Wb / m^2
Magnetic permeability has units as	Wb / m^2
Magnetic field strength's units are	Wb / m^2
Example for dia-magnetic materials	super conductors
Example for ferro-magnetic materials	super conductors

Example for anti-ferro-magnetic materials	salts of transition elements
Example for ferri-magnetic materials	salts of transition elements
Magnetic susceptibility para-magnetic materials is	0.00001
Magnetic susceptibility dia--magnetic materials is	0.00001
Magnetic susceptibility ferro-magnetic materials is	0.00001
Typical size of magnetic domains ______ (mm)	1 to 10
Example for magnetic material used in data storage devices	45 Permalloy
Susceptibility of a magnetic material is defined as the ratio of _________ induced in material to magnetic field intensity (H)	Intensity of magnetization
Those substances which are weakly magnetized in the direction opposite to that of the external magnetic field are called as ___________	ferromagnetic substances
The magnetic field that exists in vacuum and induces magnetism is called _____________	magnetic intensity
The temperature at which the domain structure gets destroyed and ferromagnetic substance is converted into paramagnetic substance is called as ___________	zeropoint temp.
The ability of magnetizing field to magnetize a material medium is called ____________	magnetic intensity

Relative Magnetic Permeability (μr) = _____________	1+χ
Those substances which are strongly magnetized in the direction of the external magnetic field are called as _________	paramagnet
Magnetic fields do no interact with _____________.	Moving permanent magnets
The magnetic permeability of a material is defined as ratio of magnetic induction (B) to ______	susceptibility
Above Curie temperature, Ferromagnetic substances become __________	magnet
_________ is defined as pole strength per unit area of cross section of material	susceptibility
The Curie Temperature (°K) for Nickel is __________ °K	136
The degree or extent to which magnetic field can penetrate or permeate a material is called ____________	magnetic permeability
Total number of magnetic lines of force crossing per unit area normally through a material is called _________	magnetic permeability
The magnetic energy stored in an inductor is ______ current	Directly proportional to
The ratio of the permeability of material to the permiabiity of air or vacuum.	Relative permeability
The property of magnetic materials of retaining magnetism after withdrawal of the magnetizing force is known as	Retentivity

The force between two magnetic poles varies with the distance between them. The variation is ______ to the square of that distance.	Equal
Permeability means	The conductivity of the material for magnetic lines of force
The magnetic field inside a solenoid	is constant
Paramagnetic substance has a relative permeability of	Slightly less than one
For which of the following substance, the magnetic susceptibility is independent of temperature____	Dia
Electromagnets are made of soft iron because soft iron has___	high susceptibility and low retentivity
Magnetic field is always _____________.	solenoidal
Magnetic flux has the dimension ___________.	$ML^{2}T^{-2}I^{-1}$
The permeability of free space is __________ WbA-1m-1.	$\mu_0=4\pi$
The intrinsic magnetic moment of the atoms of a material is not zero.The material _______________.	must be paramagnetic
The relative permeability of a material is 0.98.The material must be ________________.	paramagnetic
Hysteresis refers to the ______ between flux density of the material and the magnetizing force applied.	Leading effect

Hydrogen is an example of a _____ material.	Paramagnetic
Cobalt is an example of a ______ material	Paramagnetic
Magnetic intensity is a	Phasor quantity
The core of a magnetic equipment uses a magnetic material with	Least permeability
Which of the following is a paramagnetic material?	Carbon
.________ crystals are frequently used in computers memory cells.	Ferroelectric
Platinum exhibits the property of ___________.	diamagnet
Diamagnetic substance are attracted by magnetic field.The attraction is __________.	very strong
A moving charge produces ___________.	electric field only
Differential form of Ampere's law for a steady current is __________.	$\Delta x H = J + \partial D/\partial t$
The phenomenon by which a magnetic substance becomes a magnet when it is place near a magnet	Magnetic effect
Which of the following materials has permeability slightly less than that of free space?	Paramagnetic

The property of a material which opposes the creation of magnetic flux in it	Resistance
The susceptibility of a paramagnetic gas varies ________ as the absolute temperature.	directly
If the relative permeability is less than 1,then the material will be________________.	dia
If the relative permeability is greater than 1,then the material will be________________.	dia
If the relative permeability is very much greater than 1,then the material will be________________.	dia
Lenz's law is a consequence of the law of conservation of	energy
Lenz's law does not violate the principle of	conservation of charge
The direction of the induced emf during electromagnetic induction is determined by	Lenz's law
Alternative current generator is basically based upon	amperes law
Moving a coil in and out of magnetic field induces	force
Which two values are plotted on a B-H curve graph?	reluctance and flux density
Faraday’s law states that the:	irection of the induced voltage produces an opposition

What does Faraday’s law concern?	a magnetic field in a coil
What is hysteresis?	lead between voltage and current
What type of device consists of a coil with a moveable iron core?	solenoid

UNIT - III

Einstein's theory of photoelectric effect is based on	Newtons corpuscular theory of light
The equation E= hν was deduced by:	Heisenberg
De Broglie wavelength (λ) associated with moving particles, mass, m, and velocity v is	h/mv
Based on quantum theory of light, the bundles of energy =	hν
De Broglie wavelength (λ) associated with moving particles of K.E is	h/mv
Wave nature is not observed in daily life because we are using ____________.	Microscopic particles
_______ year de Broglie proposed that the idea of dual nature.	1921
de Broglie wavelength (λ) associated with charge q and potential difference of V volts is	h/mv
The photoelectric effect was explained by Albert Einstein by assuming that:	light is a wave.
The Compton Effect supports which of the following theories?	Special Theory of Relativity.
Which one of the following objects, moving at the same speed, has the greatest de Broglie wavelength?	Neutron
Which of the following formulas can be used to determine the de Broglie wavelength?	λ = hmv
The idea of dual nature of light was proposed by	Plank

According to the de Broglie's hypothesis of matter waves, the concepts of energy, momentum and wavelength are applicable to	moving particles but not to radiation (photon)
Experimental verification of de Broglie's matter waves was obtained in	Einstein‟s Photoelectric experiment
The first experimental evidence for matter waves was given by _______	Einstein
The de Broglie wavelength wave length of a moving electron subjected to a potential V is	1.26/V1/2
Compute the de Broglie wavelength of an electron that has been accelerated through a potential difference of 9.0 kV. Ignore relativists effects.	1.3 x 10-11 m
Heisenberg's uncertainty principle states for the energy and time is	$\Delta E \Delta t = h$
In which of the following is the radius of the first orbit minimum?	hydrogen atom
The Kinetic energy of electron of mass (m) is given by (T)	p/2m
Heisenberg's uncertainty principle states for the angular momentum and angle is	$\Delta J \Delta \theta = h$
The radius of the nucleus of any atom is of the order of ____ m	10-8 m
Heisenberg's uncertainty principle states for the position and momentum is	$\Delta p \Delta q = h$
The uncertainty in the total energy (ΔE) is	$\Delta T + \Delta V$
Based on the uncertainty principle, the minimum momentum (Pmin) =	h/I
Who proposed the uncertainty principle?	Bohr
The kinetic energy of electron in the atoms is	4 Mev
According to Heisenberg‟s Uncertainty principle, Indeterminism in the measurement of canonically conjugate variables is due to	imperfection in measuring instruments
The value of ħ is	6.625×10^{-34} nm
The mass of an electron is	9×10^{-34} nm

If we measure the position of a particle accurately then the uncertainty in measurement of momentum at the same instant becomes	0
If we measure the energy of a particle accurately then the uncertainty in measurement of the time becomes	0
Uncertainty principle is applicable to	macroscopic particles
Uncertainty principle can be easily understandable with help of	Dalton's effect
Heisenberg gave his concept in	1923
Heisenberg uncertainty principle is used for	data processing
The Heisenberg uncertainty principle is concerned with what two properties?	mass and velocity
Energy of photon is directly related to the	wavelength
____ forms of Schroedinger's equation describe the motion of non-relativistic material particle.	$H\psi = E\psi$
If ψ_1 and ψ_2 are two different wave functions, both being satisfactory solution of wave equation for a given system, then these functions will be normalized, if	$\psi_j{}^*\psi_j d\tau = 1$
Schrodinger suggested seeking solutions of the waves equation which represents ___ waves.	non-progressive
Momentum operator in Schroedinger equation (Pop) is	$\hbar/i$
The minimum energy of a particle in a box (E) is	$\hbar^2/ml^2$
The Schroedinger time-dependent wave equation is	$H\psi = E\psi$
The time-dependent Schroedinger equation is partial differential equation having ___ variables.	1
The Schroedinger equation for a free particle is	$\Delta^2\psi + (2m/\hbar^2)(E)\psi = 0$
The time independent form of Eop is	H
Wave function Ψ of a particle is	real quantity
Wave function is represented by ________	ψ
Schroedinger attempt the physical interpretation of ψ in terms of _______	volume density
In wave function, energy per unit volume is equal to ___	A^2
Photon density is ____	hν
Photon density is proportional to ______	hν

Particle density is proportional to ______	hν
Schrodinger's equation described the	wave function
Solutions to Schrodinger's equation are labeled with	psi
The hypothesis that nuclear forces possess an exchange character was put forward by	Pauli
Heisenberg force is due to	exchange of space

UNIT - IV

The potential involved outside the nucleus is ____	gravitational
The atomic mass is almost equal to _____	the mass of the electron
The nuclear radius is proportional to	A^2/3
The nucleon density at the centre of any nucleus is	proportional to A
The force which holds the nucleons together in a nucleus is	elelctromagnetic force
The non-central part of the nuclear force is called	elelctromagnetic force
Nuclear exchange forces arise due to	exchange of mesons
Nucleus is	positively charged
Proton has the charge	1637 times of an electron
Neutrons has the charge	1639 times of an electron
The difference between the total mass of the individual nucleons and the mass of the nucleus is known as	mass defect
The mass of the nucleus is normally -------- the total mass of the nucleons	greater than

Instrument used to measure nuclear masses and their other properties is called	Mass spectrograph
The constant nucleon density inside the nucleus supports	liquid drop model of the nucleus
The constant binding energy per nucleon supports	shell model
In the liquid drop model, the restoring force after deformation is supplied by	internal force
The surface energy is proportional to ---- where A is the mass number	A
The liquid drop model could not explain satisfactorily ----	surface vibration of the nuclei
According to alpha particle model, a nucleus can be considered as	a sphere of individual nucleons
Alpha particle model could not describe the ground and excited states of	nuclei other than even-even nuclides
It is seen that nuclei with ----- nucleons are most stable, where n=1,2,3,….	2n-1
The nuclei with Z = ----- and ------ are found to be more than usually stable	50, 20
The resemblance of the nucleus with a drop of liquid led to the suggestion of ----- model.	Fermi gas model
The nuclear fission can be best explained using	shell model
As per liquid drop model, if the energy of the incident neutron is less than the critical energy, ----- takes place.	radiative capture
Which model is the combination of liquid drop and shell model	Collective model

Nuclei with N or Z near the end of a shell are found in …………. Distinct groups, known as islands of isomerism	three
Alpha particle is emitted from	outside the nucleus
The spin of an alpha particle is	1
Alpha particle is of ----- parity	no parity
The penetrating power of alpha particle is	large
There are ---- types of beta emission	2
The spin of the beta particle is	01-Feb
What is the most penetrating radiation?	gamma
Which types of radiation is the most dangerous?	gamma
A particle striking on the target nucleus, is absorbed by it and a new particl	photo disintegration
Emission of alpha and beta rays is an example of	photo disintegration
The strong nuclear force is	charge dependent

UNIT-V

Which number system is not a positional notation system?	ROMAN
The 10’s complement of the octal number 715 is	63
The 9’s complement of 381 is	372
The 1’s complement of the binary number 1101101 is	10
The 2’s complement of the binary number 010111.1100 is	101001.11
Which system has a base or radix of 10:	Binary digit
In which counting, single digit are used for none and one:	Decimal counting
In which numeral every position has a value 2 times the value f the positio	Decimal
In which digit the value increases in power of two starting with 0 to left of t	Hexadecimal
Which system is used in digital computers because all electrical and electro	Hexadecimal number
Which number is formed from a binary number by grouping bits in groups (	Binary
Which number system has a base of 16 :	Binary number system
. Counting in hex, each digit can be increment from__________:	0 to F
Which number can be converted into binary numbers by converted each he:	Binary number
. How many system of arithmetic, which are often used in digital syster	5
Which are the system of arithmetic, which are often used in digital system:	Binary digit
A number system that uses only two digits, 0 and 1 is called the_________	Octal number system
Which of the following gates is known as coincidence detector?	AND
An inverter is also called as	NOT
Which gate has two or more input signals in which all input must be high to	OR
A NOR gate has a high output only when the input bits are	low
A NOR gate is logically equivalent to an OR gate followed by an	AND
Boolean expression for NOR gate with two inputs x and y can be written as	(x+y)’
Boolean expression for NAND gate with two inputs x and y can be written	xy
NAND gates can be used as which type gates?	NOT
An OR gate can be imagined as	switches connected in s
Which gate is known as Universal gate?	NOT

Any Boolean expression can be implemented using	only NOR gates
Which digits are used to represent high & low level in digital circuits?	1 0
Complement of a Variable is represented by _________ over the Letter.	slash
What is the value for 1+1 in Boolean Addition?	2
Multiplication in Boolean algebra is the same as the __________ function	AND
The operation of an inverter is________	Complement Input vari
___________is same as Inversion.	complementation
The output of an AND gate is 1(High) only when both inputs are ________	1 0
The output of an OR gate is 1(High) only when any one or more of the inpu	high
NAND is a complement of __________	NOT
NOR is a complement of __________	NOT
Commutative Law of Addition of 2 variables is written as	A+B=B+A
Commutative Law of Multiplication of 2 variables is written as	AB=BA
Associative law of addition is stated as	A + (B + C) = (A+B)+(
Associative law of multiplication is stated as	A (BC)=(AB) C
Distributive Law is stated as	A (B+C) = AB + AC
In Boolean algebra A + 0 =?	A
In Boolean algebra A + 1 =?	A
In Boolean algebra A .0 =?	A
In Boolean algebra A .1 =?	A
In Boolean algebra A +A =?	A
In Boolean algebra $A + \bar{A}$ =?	A
In Boolean algebra A .A =?	A
In Boolean algebra $A. \bar{A}$ =?	A
In Boolean algebra A + AB =?	A
In Boolean algebra $A + \bar{A}B$ =?	A
In Boolean algebra (A +B)(A + C) =?	A
The Complement of a Sum =	Sum of the Complemen
Sum of Product expression is	two or more AND func
Product of Sum expression is	AND of two or more (
Boolean expression can be simplified using	Associative law
Sum of products expression is implemented with ________	AND-OR logic
The output of an exclusive – OR gate is HIGH when inputs have	Same state
The output of an exclusive – NOR gate is HIGH when inputs have	Same state
Any Logic Expression can be implemented using	NAND / NOR
What are the common internal gate failures?	open input or output &
The interconnecting paths represent a common electrical point is known as	Cell
The coincidence circuit is otherwise called as	Exclusive-NOR
NAND & NOR gates are called as	Universal Gates
Sum of products can be done using	demorgan's theorem
Two variables will be represented by	eight minterms
The output of AND gates in SOP is connected to	NOT gates
The minterms in a karnaugh map are marked with a	y
Small circle in a NAND circuit represents	input

Tabulation method is adopted for giving simplified function in	subtraction of sum
Each square in a karnaugh map represents a	points
Sum of products can be done using	demorgan's theorem

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OPTION 2	OPTION 3	OPTION 4
four time less	will increase into two times	will decrease into two times
decrease with increaase in y	remains constant	depends upon the length of the wire
directly proportional to x	directly proportional to x^2	inversely proportional to x^2
1	min	max
sequentially	rational	in line
σ / ε_0	infinity	0

σ / ε_0	ε_0 / σ	q / ε_0
radial	uniform and perpendicular to the sheet	uniform and parallel to the sheet
1.6 x 10-19volt	1.6 x 10-19joule	1.6 x 10 -21joule
Keplers	Faraday	Gauss’s
relative permittivity	absolute permittivity	permeability
negative, positive	both positive	both negative
ϵ_0 q	q	$4\pi q$
electric charge	electric intensity	electric field lines.
	volume of the enclosure	actual spatial argument of charges within the surface all
Weber	$Nm^{-2}c^{-1}$	Nc^{-1}
σ^2 / ϵ_0	$\sigma^2 / 2\epsilon_0$	$\sigma / 2\epsilon_0$
always increases	remains the same	may increase or decrease

proportional to $1/r^2$	proportional to r	inversely proportional to 1/r
the shape of the closed surface only	the value of the net charge only	both charge and shape
$q/2\varepsilon_0$	$\sigma/2\varepsilon_0$	q/ε_0
newton's law	gauss's law	coulombs law.
double due to a single charge	zero	dependent on the position of the dipole
vector	zero	infinity
Weber	Ampere- turn	Maxwell
electric force	electric field	electric potential
only a torque	both a net force and torque	neither a net force nor a torque
$q_1q_2/4\varepsilon_0\pi r$	$pE\sin\theta$	$pE\cos\theta$
$1/x^3$	$1/x^4$	$1/x^{3/2}$
Coulomb law	Faraday	Ohms

3.2 x 10^{-19} Coulomb	4.8 x 10^{-19}Coulomb	1 coulomb
neutrons	alpha particle	gamma rays
varies directly as the distance from the centre	varies inversely as the distance from the centre	varies inversely as the square of the distance from the centre
size of the charge	distance of the point	square of the distance from the charge
one-fourth	doubled	four times
positive	negative	zero
scalar quantity	neither vector nor scalar	fictitious quantity
same as potential on the surface	smaller than the potential on the surface	greater than the potential on the surface
force between them x 2r	force between them / 2nr	zero
J=Coulomb / volt	J= volt/ ampere	J= volt x ampere
either negative charged or neutral	neutral	positively charged
q/2ϵ0	q/4ϵ0	q/4ϵ0

relative permittivity	r^-1	r^-2
$\epsilon_0 E^2/2$	$\epsilon_r \epsilon_0 E/2$	$\epsilon_0 E/2$
Same	Positive	Negative
force field	electrostatic field	electrical field
wrapped as a coil	passing through a flux field	that has neutral domains
polar fields	lines of force	magnetomotive force
independent of the force creating it	identical to the force creating the field	present only if the force is stationary
the number of lines of force in maxwells	the number of lines of force in flux density	the number of lines of force in teslas
1/2qV	v/q	qV
condenser	capacitor/ condneser	comparator
condenser	converter	comparator
qv	v/q	v/q

electrolytic	paper	variable air
mica	both mica and electrolytic	variable
variable air capacitor	both mica and electrolytic	mica
magnetometers	potentiometer	galvanometer
p.d across the capacitor	energy of the capacitor	electric field inside the capacitor
increases by a factor K	remains constant	increases or decreases depending on the nature of the dielectric
$ML^2 T^{-4} I^{-2}$	$ML T^{-3} I^{-1}$	$M^{-1}L^{-1}T^3I$
outside the surface	on the surface	in the surface
coulomb/volt	Farad and Coulomb/Volt	ohm
voltmeter	Resistor	galvanometer
Discontinuous	Random	Discrete
Discontinuous	Random	Discrete

voltage	current	time
cylindrical	Air capacitor	Parallel plate capacitor
D.c bridges	both a and b	tuning circuits
Electrolytic	paper	variable
Potential difference	Charge	Momentum
self inductance	mutual inductance	conductance of an electrolyte
positive chaarge	negative charge	neutral
potential	capacitance	resistance
semiconducting materials	magnetic materials	ferroelectric materials
100	one	zero
high permitivitty	permitivity same as that of air	permitivity slightly more thanair
insulator	good conductor	semi conductor

vacuum	ceramics	oil
decrease	increases	becomes zero
two conductors seperated by an insulator	2 insulator	2 conductor
Silver	Tungsten	Cobalt
Movement of charged particles	Magnetic dipoles	Magnetic domains
Wb / A.m	A / m	Tesla / m
Wb / A.m	A / m	Tesla / m
Wb / A.m	A / m	Tesla / m
alkali metals	transition metals	Ferrites
alkali metals	transition metals	Ferrites

rare earth elements	transition metals	Ferrites	
rare earth elements	transition metals	Ferrites	
-10^-5	10^5	10^-5 to 10^-2	
-10^-5	10^5	10^-5 to 10^-2	
-10^-5	10^5	10^-5 to 10^-2	
0.1-1		0.05	0.001
CrO2	Cunife	Alnico	
magnetizing field	magntic induction	Conductivity	
diamagnetic	paramagnet	anti ferro	
magnetizing field	magnetic field intensity	magnetization	
high temperature	curie temperature	domain thoery	
magnetic field	magnetic field intensity	magnetization	

1/χ	1+χ	1+H
anti ferro	diamagnetic	ferromagnetic substances
Stationary permanent magnets	Moving electric charges	Stationary electric charges
magnetic intensity	magnetic field intensity	magnetic field
anti ferro	diamagnetic	paramgnetic
magnetizing field	magnetic field intensity	intensity of magnetization
316	613	631
susceptibility	magntic induction	intensity
susceptibility	magntic induction	intensity
Inversely proportional to	Directly proportional to the square of	Inversely proportional to the square of
Relative permittivity	Relative conductivity	Relative reluctivity
Reluctivity	Resistivity	Conductivity

Greater than	Directly proportional	Inversely proportional
The magnetization test in the material after exciting field has beenremoved	the strength of an electromagnet	The strength of the permanent magnet
is uniform	increases with distance from the axis	decreases with distance from the axis
Equal to one	Slightly greater than one	Very much greater than one
Para	Ferro	ferri
high susceptibility and high retentivity	low susceptibility and low retentivity	low susceptibility and high retentivity
Irrotational	harmonic in character	rotational
$MLT^{-2}I^{-1}$	$ML^{2}T^{-}I^{-1}$	$ML^{2}T^{-2}I$
μ_0=4πx107	μ_0=4πx10 $^{-7}$	μ_0=4πx10 -8
must be diamagnetic	must be ferromagnetic	may be paramagnetic or ferromagnetic
diamagnetic	ferromagnetic	ferrimagnetic
Ratio	Equality	Lagging effect

Diamagnetic	Ferromagnetic	Non- magnetic
Diamagnetic	Ferromagnetic	Non- magnetic
Physical quantity	Scalar quantity	Vector quantity
Low permeability	Moderate permeability	High permeability
Copper	Bismuth	Oxygen
Diamagnetic	Paramagnetic	Ferrielectric
ferromagnet	paramagnet	none
weak	zero	negative
magnetic field only	both electric and magnetic fields	neither electric nor magnetic
$\Delta x B=\mu_0 J$	$\Delta . B=0$	$\int B.dl= \mu 0I$
Magnetic phenomenon	Magnetic induction	Electromagnetic induction
Non- magnetic	Ferromagnetic	Diamagnetic

Reluctance	Permeance	Conductance
inversely	Similarily	opposite
para	ferro	ferri
para	ferro	ferri
para	ferro	ferri
momentum	mass	charge
conservation of energy	conservation of mass conservation of momentum	
Amperes law	Maxwell law	Faaradays law
Lenz's law	faradays law	coulombs law
potential difference	emf	voltage
permeability and reluctance	magnetizing force and permeability	flux density and magnetizing force
emf is related to the direction of the current	emf depends on the rate of cutting flux	direction of an induced current produces an aiding effect

a magnetic field cutting a conductor	a magnetic field in a conductor	a magnetic field hystersis
lag between cause and effect	lag between voltage and current	lead between cause and effect
armature	read switch	relay

Huygen's wave theory of light	Maxwell's electromagnetic theory of light	Planck's quantum theory of light
de Broglie	Einstein	Planck
h/√2mEk	h/√2mqV	h/√2mkT
hλ	h/ν	h/λ
h/√2mEk	h/√2mqV	h/√2mkT
macroscopic particles	molecules	atoms
1922	1923	1925
h/√2mEk	h/√2mqV	h/√2mkT
light is a particle.	an electron behaves as a wave.	an electron behaves as a particle.
Light is a wave.	Thomson model of the atom.	Light is a particle.
Electron	Tennis ball	Bowling ball
$\lambda = h/mv$	$\lambda = mv/h$	$\lambda = hm/c$
De Broglie	Einstein	Maxwell

moving particles as well as to radiation (photon)	radiation (photon) but not to moving particles	neither to moving particles nor to radiation (photon).
Davisson and Germer Experiment	Compton‟s Experiment	Plank
de Broglie	Plancks	Davisson and Germer
12.26/V1/2	12.26/V	2.26/V1/2
1.7×10^{-22} m	1.2×10^{-26} m	1.7 x 10 3 m
$\Delta E \Delta t = h/2\pi$	$\Delta E \Delta t = 2\pi h$	$\Delta E \Delta t = 2 \pi /h$
A tritium atom	Triply ionized beryllium	Doubly ionized helium
$p^2/2m$	2mp	$2mp^2$
$\Delta J \Delta \theta = h/2\pi$	$\Delta J \Delta \theta = 2\pi h$	$\Delta J \Delta \theta = 2 \pi /h$
10 -14 cm	10-14m	10-10 m
$\Delta p \Delta q = h/2\pi$	$\Delta p \Delta q = 2\pi h$	$\Delta p \Delta q = 2 \pi /h$
$\Delta T - \Delta V$	ΔT	ΔV
$\hbar$	$\hbar l$	$l/ \hbar$
De Broglie	Heisenberg	Schroedinger
6 Mev	8 MeV	97 Mev
imperfection in measurement methods	the interminisim inherent in the auantum world itself	
5×10^{-34} nm	1.055×10^{34}nm	1.0555×10^{-34} nm
9×10^{-31} m	6×10^{-34} nm	6.625×10^{-30} nm

Infinity	1	constant
Infinity	1	constant
microscopic particles	gases	liquids
Compton's effect	electron effect	photoelectric effect
1927	1957	1933
information processing	data processinerosion	dilation
momentum and position	position and velocity	momentum and mass
wave number	frequency	amplitude
$H\psi \neq E\psi$	$H\psi < E\psi$	$H\psi > E\psi$
$\psi_j{}^*\psi_j d\tau \neq 1$	$\psi_j{}^*\psi_j d\tau > 1$	$\psi_j{}^*\psi_j d\tau < 1$
progressive	non-standing	standing
$\hbar i$	$i/\hbar$	Ħ
$\hbar^2/2ml^2$	$ml^2/\hbar^2$	$2ml^2/\hbar^2$
$H\psi \neq E\psi$	$H\psi < E\psi$	$H\psi > E\psi$
2	3	4
$\Delta^2\psi + (2m/\hbar^2)(E)\psi \neq 0$	$\Delta^2\psi + (2m/\hbar^2)(E)\psi < 0$	$\Delta^2\psi + (2m/\hbar^2)(E)\psi > 0$
V	U	T
a complex quantity	an imaginary quantity	any one of these
E	H	W
current density	density	charge density
E^2	H2	ψ^2
A^2/h	A^2/ν	$A^2/h\nu$
A^2	h	ν

ψ^2	h	ν
complement of the wave function	behavior of "matter" waves	motion of light
phi	mu	pi
Rutherford	Heisenberg	Max Plank
exchange of spin	exchange of space and spin	exchange of moments
electromagnetic	nuclear	Coulombic
the mass of the nucleus	the mass of the protons	the mass of the neutrons
A	A^1/3	A^2
proportional A^2	proportional Z	almost the same
gravitational force	strong nuclear force	weak interaction
tensor force	magnetic force	static force
exchange of charge	exchange moments	exxchange of strangeness
negatively charged	neutral	charge keeps on changing
1737 times of an electron	1837 times of an electron	1937 times of an electron
1739 times of an electron	1839 times of an electron	1939 times of an electron
binding energy	packing fraction	mass excess
equal to	less than	can be anything

nuclear spectrometer	NMR spectrometer	magnetic spectrometer
shell model	collective model	unified model
collective model	liquid drop model	unified model
gravitational attraction	surface tension	repulsion
A^1/3	A^2/3	A^2
surface energy of the nuclei	all the above	low lying discrete energy levels of nuclei
poly-atomic molecule of alpha particles	alpha and beta particles	poly-atomic molecule of beta particles
even-even nuclides	even-odd nuclides	odd-even nuclides
4n-2	4n	2n
50,40	20, 40	30, 40
collective model	liquid drop model	Shell model
liquid drop model	Fermi gas model	collective model
fusion	gamma ray emission	fission
Unified model	optical model	Super-conductivity model

two	seven	four
inside the nucleus	from the external orbits	inside a proton
01-Feb	03-Feb	0
odd	even	odd or even
small	medium	zero
1	3	4
03-Feb	1	0
alpha	beta	positron
alpha	beta	they are equally dangerous
radiative capture	elastic scattering	disintegration
radiative capture	spontaneous decay	spallation reaction
both charge and size dep	charge indendent	size dependent

Binary	decimal	Hexadecimal
539	285	395
508	618	390
100010	10011	1101110
101000.01	10111.0011	101000.0011
Hexadecimal digit	Decimal digit	Octal digit
Octal counting	Hexadecimal counting	Binary counting
Octal	Hexadecimal	Binary
Decimal	Binary	Octal
Binary number	Octal number	Decimal number
Octal	Decimal	Hexadecimal
Octal number system	Decimal number system	Hexadecimal number system
0 to G	0 to H	0 to J
Decimal number	Octal number	Hexadecimal number
6	3	4
Decimal digit	Hexadecimal digit	All of these
Binary number system	Decimal number system	Hexadecimal number system
OR	NOT	NAND
OR	AND	NAND
NAND	AND	NOR
high	some low some high	None of the above
NAND	XOR	INVERTER
x . y	x+y	xy’ + x’y
x+y	x’+y’	None of the above
OR	AND	All of the above
switches connected in p	MOS transistors connected in serie	None of the above
AND	NAND	OR

only NAND gates	only AND gates	only XOR gates
0 1	0 0	1 1
bar	dot	hyphen
10	1	0
OR	NOT	NOR
add +1 to input variable	add –1 to input variable	minus input variable
exclusive	AND	OR
0 0	1 1	0 1
low	medium	high
AND	OR	NOR
AND	OR	NAND
B+A=B+A	A+B=A + B	AB=AB
BA=BA	AB=AB	AB=A+B
(A + B)+ C = (A+B)+C	(A+B) C = A (B+C)	AB+C = A+BC
ABC=ACB	AB = BA	ABC=CAB
AB + AC = ABC	AB + C= AC + B	(AB) + C = AB + AC
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	–A	1
0	B	A + B
0	B	A +BC
Product of the Complem	Complement of the sum	Sum
two or more OR functio	two or more AND functions NOR	two or more OR functions NOR to
OR of two or more ANI	AND of two or more NAND funct	OR of two or more NAND functio
rules and laws of Boolea	Distributive law	None of the above
OR-AND logic	NAND logic	NOR logic
Opposite State	Complement State	Alternate State
Opposite State	Complement State	Alternate State
AND / OR	X-OR / OR	NAND / AND
open input or output & I	open input or output & driving inp	open input or output & bad input o
Node	Point	Junction
Exclusive – OR	Exclusive – AND	Exclusive – NAND
Functional gates	Logical Gates	Combinational gates
algebric theorem	demorgan's postulate	algebric postulate
six minterms	five minterms	four minterms
OR gates	AND gates	XOR gates
x	0	1
bits	output	complement

sum of products	product of sums	subtraction of product
values	minterm	maxterm
algebric theorem	demorgan's postulate	algebric postulate

ANSWER

four time less

decrease with increaase in y

inversely proportional to x^2

0

arbitrarily

0

q/ε_0

uniform and perpendicular
to the sheet

1.6 x 10^{-19}joule

Gauss's

relative permittivity

positive, negative

q/ϵ_0

electric intensity

all

$Nm^{-2}c^{-1}$

$\sigma^2 / 2\epsilon_0$

may increase or decrease

independent of r

the value of the net charge only

$\sigma/2\varepsilon_0$

gauss's law

zero

scalar

Tesla

electric potential

neither a net force nor a torque

$q_1q_2/4\varepsilon_0\pi r$

$1/x^2$

Coulomb law

1.6×10^{-19}coulomb

alpha particle

is constant

square of the distance from the charge

one-fourth

zero

scalar quantity

same as potential on the surface

zero

J=Coulomb x volt

either negative charged or neutral

$q/4\epsilon 0$

r^-2

$\epsilon_r \epsilon_0 E^2/2$

Same

magnetic field

passing through a flux field

lines of force

opposite to the force creating
it

the number of lines of force
in webers

$1/2\ CV^2$

capacitor/ condneser

capacitor

q/v

variable air

both mica and electrolytic

variable air capacitor

electrometers

charge on the capacitor

increases by a factor K

$M^{-1}L^{-2}T^{4}I^{2}$

Inside the surface

Farad and Coulomb/Volt

capacitor

Discontinuous

continuous

charge

Parallel plate capacitor

A.c bridges

Electrolytic

Energy

capacitance

the field between the plates

potential

insulating materials

one

high permitivitty

insulator

ceramics

decrease

two conductors seperated by
an insulator

Cobalt

Movement of charged
particles

Wb / m^2

Wb / A.m

A / m

super conductors

alkali metals

rare earth elements

transition metals

0.00001

10^-5 to 10^-2

10^-5 to 10^-2

0.001

CrO_2

Intensity of magnetization

diamagnetic

magnetizing field

curie temperature

magnetic field intensity

$1+\chi$

ferromagnetic substances

Stationary electric charges

magnetic intensity

paramgnetic

intensity of magnetization

631

magnetic permeability

magntic induction

Directly proportional to the square of

Relative permeability

Retentivity

Inversely proportional

The conductivity of the material for magnetic lines of force

is uniform

Slightly greater than one

Dia

high susceptibility and low retentivity

solenoidal

$ML^{2}T^{-2}I^{-1}$

$\mu_0=4\pi x10^{-7}$

may be paramagnetic or ferromagnetic

diamagnetic

Lagging effect

Paramagnetic

Ferromagnetic

Vector quantity

High permeability

Oxygen

Ferroelectric

paramagnet

weak

both electric and magnetic fields

$\Delta x B = \mu_0 J$

Electromagnetic induction

Diamagnetic

Reluctance

inversely

dia

para

ferro

energy

conservation of energy

Lenz's law

faradays law

emf

flux density and magnetizing force

emf depends on the rate of cutting flux

a magnetic field cutting a conductor

lag between cause and effect

solenoid

Planck's quantum theory of light

Einstein

h/mv

hν

h/mv

macroscopic particles

1923

h/mv

light is a particle

Light is a particle.

electron

$\lambda = h/mv$

De Broglie

moving particles as well as to
radiation (photon)

Davisson and Germer
Experiment

Davisson and Germer

12.26/V1/2

1.7×10^{-22} m

$\Delta E \Delta t = h/2\pi$

hydrogen atom

$p^2/2m$

$\Delta J \Delta \theta = h/2\pi$

10-14m

$\Delta p \Delta q = h/2\pi$

$\Delta T + \Delta V$

ħ

Heisenberg

97 Mev

imperfection in measuring
instruments

1.055×10^{34}nm

9×10^{-31} m

Infinity

Infinity

microscopic particles

Compton's effect
1927

information processing

momentum and position

frequency

$H\psi = E\psi$

$\psi_j{}^*\psi_j d\tau = 1$

standing
$\hbar/i$
$\hbar^2/2ml^2$
$H\psi = E\psi$

3

$\Delta^2\psi + (2m/\hbar^2)(E)\psi = 0$
H

real quantity
ψ

charge density
A^2
$A^2/h\nu$
A^2

ψ^2

behavior of "matter" waves
psi

Heisenberg
exchange of space and spin

Coulombic

the mass of the nucleus
A^1/3

almost the same

strong nuclear force

tensor force

exchange of mesons

positively charged

1837 times of an electron

1839 times of an electron

mass defect

less than

Mass spectrograph

liquid drop model of the nucleus

liquid drop model

surface tension
A^2/3

low lying discrete energy levels of nuclei

poly-atomic molecule of alpha particles

nuclei other than even-even nuclides

4n

50, 20

liquid drop model

liquid drop model

radiative capture

Collective model

four

inside the nucleus
0
even
small
3
01-Feb
gamma
gamma
disintegration
spontaneous decay
charge indendent

ROMAN
539
618
100010
101000.01
Decimal digit
Binary counting
Binary
Binary
Binary number
Hexadecimal
Hexadecimal number system
0 to F
Hexadecimal number
4
All of these
Decimal number system
AND
NOT
AND
low
INVERTER
(x+y)’
x+y
All of the above
switches connected in parallel
NAND

only NAND gates
1 0
bar
1
AND
Complement Input variable
complementation
1 1
high
AND
OR
A+B=B+A
AB=BA
A + (B + C) = (A+B)+C
A (BC)=(AB) C
A (B+C) = AB + AC
A
1
0
A
A
1
A
0
A
A + B
A +BC
Sum of the Complements
two or more AND functions OR together
AND of two or more OR functions
rules and laws of Boolean algebra
AND-OR logic
Opposite State
Same state
NAND / NOR
open input or output & shorted input or output
Junction
Exclusive – OR
Universal Gates
demorgan's theorem
four minterms
OR gates
1
complement

product of sums
minterm
demorgan's theorem