SYLLABUS

UNIT-I

Law of Motion: Force and Inertia, Law of inertia or Newton's first law of motion, Newton's Second law of motion, Newton's third law of motion and it's applications, Basic forces in nature, Weight of body in lift, Equilibrium of concurrent forces, Lemi's Theorem Friction: Cause of friction, Types of friction, Laws of friction, Angle of friction and repose, Centripetal and centrifugal force, velocity of vehicle on curved leveled and banked road.

[No. of Hrs: 11]

UNIT-II

Work, Energy & Power: Work, Conservative force, Power, Kinetic Energy, Work energy theorem, Potential Energy, Conservation of gravitational P.E. into K.E., P.E. of spring. Collisions: Types of collision, elastic collision in 1D & 2D, Inelastic collision in 1D, Perfectly inelastic collision in 1D. **[No. of Hrs: 11]**

UNIT-III

Electricity & electromagnetism: Electric charge, Electron theory of electrification, Frictional electricity, Properties of electric charge, Coulomb's Law, Superposition Principle, Electric field intensity, Electric Lines of forces. Electrostatics: Line integral of electric field, Electrostatic potential, State & Proof of Gauss's theorem.

Capacitance: Principal of Capacitor, Parallel and spherical capacitors, Grouping of capacitors and their capacitance, Effect of dielectric in capacitors. Current Electricity: Current, Ohm's Law, Resistance, Grouping of resistance, Krichoff's rule, Wheatstone bridge, Slide Wire Bridge. **[No. of Hrs: 11]**

UNIT-IV

Structure of Atom: Thomson's atomic model, Rutherford's alpha scattering experiment and atomic model, Postulates of Bohr's Model. Semiconductors: Energy bands in solids, Difference between metals, insulators and semi conductors, Current carriers in semiconductors, Intrinsic semiconductor, Doping, Extrinsic semiconductors, Formation of p-n junction, Biasing of p-n junction, Light emitting diode. Transistors: Action of n-p-n & p-n-p transistors, Advantages of transistors, Integrated Circuit. **[No. of Hrs: 11]**

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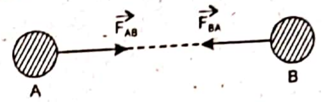
FIRST SEMESTER
PHYSICS
(BCA-207) DECEMBER 2012

Time : 3.00 hrs. **M.M. : 75**

Note: *Attempt any five questions Select one question from each unit including Q no 1 whichis compulsory.*

Q. 1.(*a*) According to Newton third law, "action and reaction are equal and opposite". Then why don't these two forces cancel each other?

Ans. According to Newton third law "action and reaction are equal and opposite". The forces of action and reaction are equal and opposite but they do not act on the same object. Two equal and opposite forces balance each other only if they act on same object.



$\overline{F_{AB}}$ = Force exerted on *A* by *B*.

$\overline{F_{BA}}$ = Force exerted on *B* by *A*.

According to Newton's third law of motion

$$\overline{F_{AB}} = -\overline{F_{BA}}$$

Q. 1.(*b*) A boy is running with constant speed on a circular track. Is it an accelerated motion? If yes, the explain briefly the force that is acting on the boy to keep him in curcular motion.

Ans. If a boy is running with constant speed on a circular track then it is an accelerated motion. The forces acting on boy are contripetal force and centrifugal force. The centrifetal force acting on boy towards the centre of circular track and centrifugal force acting on boy outwards the centre. The both forces acting on boy balance to each other to keep him on circular track.

Q. 1.(*c*) A man of mass 60kg climbs a ladder of height 5m. Calculate the work done by the force of gravity. Take g = 10m/s².

Ans. Given that $m = 60$ kg; $h = 5$ m

Gravitational potential energy or work done by the force of gravity is defined as

$$W = mgh$$
$$= 60 \times 10 \times 5 = 3000 \text{ J}$$

Q. 1.(*d*) "Static friction is a self adjusting force". Is this statement true? Justify your answwar.

Ans. Yes it is true. Static friction is that friction which acts between two surfaces which are at rest relative to each other. It is a balancing force and it acts in direction opposite to the direction of applied force to prevent relative motion between the surface. Its value is equal to the value of applied force. However it has an upper limit. It the applied force exceeds the upper limit, it ceases to act there is a sliding cf the surfaces over each other and then kinetic friction comes into role.

Q. 1.(e) Explain briefly elastic and perfectly inelastic collisions.

Ans. Elastic Collision: An elastic collision is an encounter between two bodies in which the total kinetic energy of two bodies after the encounter is equal to their total kinetic energy before the encounter. Elastic collisions occuer only if there is no net conversion of kinetic energy into other forms. Collisions of atoms is example of elastic collision.

Perfectly inelastic collisions: In this collision kinetic energy is not conserved, but obey the conservation of momentum.

A perfectly inelastic collison (also known as plasitc collision) occurs when the maximum amount of kinetic energy of a system is lost. In a perfectly inelastic collision, i.e. a zero coefficient of restitution, the colliding particles stick together. In such a collision, kinetic energy is lost by bonding the two bodies together. This bonding energy usually results in a maximum kietic energy loss of the system.

Q. 1.(f) Define Ohm's law. Is it a fundamental law or valid only for certain materials and devices Justify your answer.

Ans. Ohm's Law: This law states that the voltage '*V*' across a resistor is directly proportional to the current '*i*' flowing through the resistor.

i.e.,

$$V \propto i$$

Ohm defined the constant of proportionality for a resister to be the resistance, R. Thus,

$$V = iR$$

It is not a fundamental law bacause a nonlinear resistor does not obey ohm's law.

Q. 1.(g) 5 J of work is done in moving a postive charge of 0.5C from one point to another. what is the potential differnence between the two poles?

Ans. Given that $W = 5J, Q = 0.5\,C$

We know that $W = QV$

$$\therefore \quad V = \frac{W}{Q} = \frac{5}{0.5}$$

$$\therefore \quad V = 10\,V$$

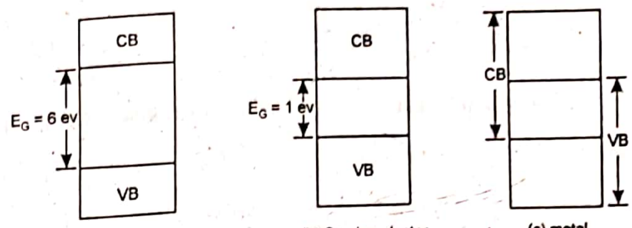
Q. 1.(h) Write the two important conclusions of Rutherford's α-particle scattering experiment.

Ans. The following conclusions from Rutherford's α-particle scattering:

1. Most of the α-Particles passed straigth through the foil without suffering any deflection. This shows that most of the space inside the atom is empty.
2. Some of the α-particles suffered deflection by 90° or even larger angles. For this to happen α-particles must approach a heavy positively charged core inside the atom. This core inside the atom is anmed as nucleus.

Q. 1.(i) Write the difference between metals, insulators and semiconductors on the basis of energy bands in solids.

Ans. A very poor conductor of electricity is called an insulator; an excellent conductor is a metal; and substance whose conductivity lies between these extremes is a semiconductor. A material may be placed in one of these three classes, depending upon its energy-band structure which is shown below:



(a) Insulator (b) Semiconductor (c) metal

Insulator: The energy-band gap between *VB* and *CB* is large. So, the energy which can be supplied to an electron from an applied field is too small to cary the particle from the filled into vacant band. Since electron cannot acquire externally apllied energy, thus conduction is impossible.

Semiconductor: The energy-band gap between *VB* and *CB* is about 1 ev. When an external electric field is applied the VB electron will jumb into CB and conduction takes place. Current is due to both electron and hole.

Metal: There is no energy band gap in metal. The *VB* and *CB* are overlapped to each other. So after applying an external electric field conduction takes place. Current is due to flow of electrons only.

Q. 1.(j) Name the majority and minority carriers in p-type and n-type semicondocurs.

Ans. In p-type semiconductor; hole is majority and electron is minority charge carriers. Since p-type semiconductor forms with addition of acceptor imppurity.

In n-type semicondnctor; electorn is majority and hole is minority change carriers. Since n-type semicondnctor forms with the addition of donar impurity.

UNIT-I

Q. 2.(a) What is wrong with the statement, "Because the car it at rest, there are no forces acting on it ? How would you correct this statement.

Ans. When a car is at rest then different forces acting on it. But net forces acting on it zero. So the given statement can be written as "the car is at rest, there are no net forces acting on it". In other words we can say that "Because the car is at rest, there are all forces acting on it cancel to each other".

Q. 3.(a) State the laws of limiting friction.

Ans. Laws of limiting friction:

(*i*) the direction of friction is always opposite to the direction of motion.

(*ii*) The magnitude of limiting friction depends upon the nature and state of polish of the two surfaces in contact and acts tangentially to the interface between them.

(*iii*) The magnitude of limitng friction '*F*' is directly proportional to narmal reaction '*R*' between the two surfaces in contact.

(*iv*) The magnitudeof limiting friction is independent of area and shape of surfaces in contact as long as the normal reacton remains the same.

Q. 3.(b) The outer rail of a curved railway track is generally raised over the inner why? Explain brieffy.

Ans. The outer rail of a curved railway track is generally raised over the inner bacause when the train is travelling at a certain speed, then there is no frictional force providing sideways thrust and hence reducing wear and tear on the wheels of the train and the rail itself.

This occurs since the upward thrust of the road on the vehicle, acting perpendicularly from an imaginary line between the two rails, provides the required (horizontal) contripetal force to allow the train to round the curve.

UNIT.II

Q. 4.(a) Define work what do you understand by negative work done by force?

Ans. Work: Work is defined as the integral of the force over a distance of displacement.

The SI unit of work is the joule (J), which is defined as the work expended by a force of one newton through a distance of one metre.

The work done by frictional force can be negative. The workdone by force on an object is

$$W = \int F.ds = \int F\cos\theta\, ds$$

where θ is the angle between the force 'F' and an element of displacement 'ds'. If the force is constant and the object moves in a straight line, then this simplifies to

$$W = Fs\cos\theta$$

If $\cos\theta$ gives negative value then work done will be negative.

Q. 4.(b) Does kinetic energy of a body depend upon the direction of motion. Justify your answer.

Ans. Kinetic energy does not depend upon direction of motion because kinetic energy is a scalar quantity and scalar quantity has no any direction. Kinetic energy depends on mass and velocity of the object. It is directly proportional to object mass and square of their velocity. Kinetic energy also depends on surface of the object on which it is placed.

Q. 4.(c) A toy car of mass 0.2 kg is moving with speed 10m/s. Find its kinetic energy. If the car stops due to friction. Find the work done by the force of friction.

Ans. Given that

$$m = 0.2\text{ kg}$$
$$v = 10\text{ m/s}$$

We know that

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}\times 0.2\times(10)^2$$

or,

$$K.E = 10\text{ J } \textbf{Ans.}$$

Q. 5.(a) Define conservative force. Prove that the gravitational force is a conservative force.

Ans. Conservative force: A conservative force is a force with the property that the work done in moving a particle between two points is independent of the path taken. If a particle travels in a closed loop, the net workdone by a conservative force is zero.

A conservative force is dependent only on the position of the object. If a force is conservative, it is possible to assign a numerical value for the potential at any point. we have to prove that the gravitational force is aconservative force.

The work done by gravity is given by mag Δy for any path. It follows that then for any closed path, the work done by gravity is zero, since $\Delta y = 0$ for any closed path.

For the spring force, the work done by the spring force on an object connected to it is given by

$$\int(-kx)\,dx$$

This is equal to $-\frac{1}{2}k\Delta(x^2)$. For any closed path, $\Delta(x^2) = 0$, and so the spring force is a conservative force.

Q. 5.(b) Two indentical ivory balls of mass 1 kg each, moving in opposite directions with speeds 5m/s and 10m/s collide head on. Find the velocities of the balls after the collision. Assume that the collision is perfectly elastic and one dimensional.

Ans. Given that

$$m_1 = m_2 = 1\text{ kg.}$$
$$v_1 = 5\text{m/s and } v_2 = 10\text{ m/s}$$

Let after collisions the velocities of body will be V_1^1 and V_2^1 From conservation of linear momentum

$$m_1v_1 + m_2v_2 = m_1v_1^1 + m_2v_2^1$$

or,

$$1\times 5 + 1\times 10 = 1\times v_1^1 + 1\times v_2^1 \text{ or } v_1^1 + v_2^1 = 15 \quad ...(1)$$

From Conservation of energy.

$$\frac{1}{2}m_1V_1^2 + \frac{1}{2}m_1V_2^2 = \frac{1}{2}m_1V_2^{12} + \frac{1}{2}m_2V_2^{12}$$

or,

$$25 + 100 = V_2^{12} + V_2^{12} \text{ or, } (V_1^{12}) + (V_2^{12}) = 125 \quad ...(2)$$

From equation (1) and (2)

$$2(V_2^{12}) - 30V_2^1 + 100 = 0$$

$$\therefore \quad V_2^1 = \frac{30\pm\sqrt{900-4\times2\times100}}{2\times2} = \frac{30\pm10}{4} = 10\text{m/s}, 5\text{m/s}$$

From (1), $V_1^1 + V_2^1 = 15$

when $V_2^1 = 10\text{m/s};\ V_1^1 = 5\text{m/s}$

when $V_2^1 = 5\text{m/s};\ V_1^1 = 10\text{ m/s}$

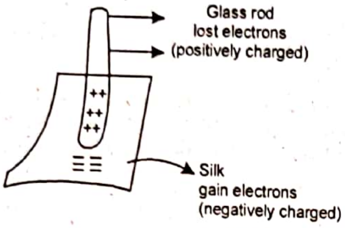
Note: In elastic collision if masses are same then velocities will exchange after collision.

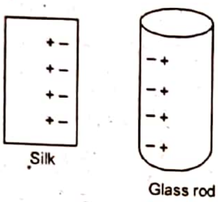
UNIT-III

Q. 6.(a) A glass rod when rubbed with silk cloth acquires positive charge of 1.6×10^{13} Coulombs. Explain it in terms of transfer of electrons. Have the electrons transferred from the glass rod to the silk cloth or from the silk cloth to the glass rod? What is the number of electrons transferred? Charge on an electron $= 1.6\times10^{-19}$C.

Ans. When a glass rod rubbed with silk cloth, some of the electrons are removed from the atoms of the glass rod and deposited on the silk leaving negatively charged and glass positively charge.

From charge conservation property we can say that "Neither charge can be created nor be destroyed". So, when a glass rod rubbed with silk cloth, then equal number of positive charge on rod and negative charge on silk will be create.





Also we have $Q = 1.6 \times 10^{-13}$ coulombs.

and $e = 1.6 \times 10^{-19}$ coulombs.

we know that

$$Q = ne$$

$$\therefore \quad n = \frac{Q}{e} = \frac{1.6\times10^{-13}C}{1.6\times10^{-19}C}$$

$$\therefore \quad n = 10^6$$

So, 10^6 electrons transferred from glass rod.

Q. 6.(b) Define Coulombs's Law.

Ans. Coulombs law states that the electric force between two stationary charged particles is

(i) Inversly proportional to the square of the distance 'r' between the particles and is directed along the line that joins them.

i.e.,
$$F \propto \frac{1}{r^2} \quad ...(1)$$

(ii) Proportional to the product of the charge 'q_1' and 'q_2'

i.e.
$$F \propto q_1 q_2 \quad ...(2)$$

So, coulomb's law can be expressed in the form of equation from (1) and (2)

$$F = k\frac{|q_1||q_2|}{r^2}$$

where k is proportionality Constant, in SI unit the value of k is

$$k = 8.987 \times 10^9\ Nm^2/C^2.$$

Q. 6.(c) Why no two electric field lines can intersect each other? Explain briefly.

Ans. The electric field vector is tangent to the electric field line at each point. The number of lines per unit area through a surface perpendicular to the lines is proportional to the magnitude of the elctric field in that region.

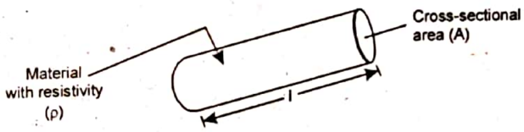
The lines must begin on a positive charge and terminate on a negative charge. No two field lines can cross because the magnitude of charge is different for both positive and negative charge.

Q. 7.(a) What are the factors on which resistance of a conductor depends? Give the corresponding relationship.

Ans. The Resistance of a conductor is defined as

$$R = \rho\frac{l}{A}$$

where
ρ = Resistivity of the material in ohm-m.
l = length of condnctor in meter.
A = cross-sectional area in m^2.

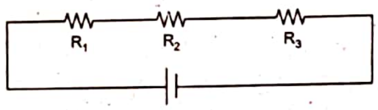


Note: Resistivity depends on temperature so resistance also depends on temperature.

Q. 7.(b) Give three indentical resistors each of resistance 30 Ohms. How can they be connected in a circuit to give a total resistance of 90 Ohms and 10 ohms tespectively?

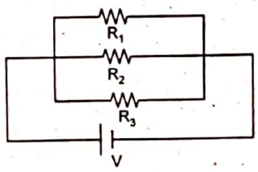
Ans. Given that three indentical resistors each of resistance 30 Ω.

To get total resistance of 90 Ω, connect these three resistance in series.



$$\text{Equivalent Resistance (Req)} = R_1 + R_2 + R_3$$
$$= 30\,\Omega + 30\,\Omega + 30\,\Omega$$
$$\boxed{Req. = 90\Omega}$$

To get total resistance of 10 Ω, connect these three resistance in parallel.



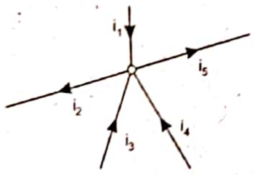
$$\frac{1}{Req.} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{30} + \frac{1}{30} + \frac{1}{30}$$

or
$$\frac{1}{Req.} = \frac{3}{30} \text{ or. } \boxed{Req. = 10\,\Omega}$$

Q. 7.(c) State and explain briefly kirchoff's Rules.

Ans. Kirchoff's Laws: Kirchoff's first law is based on the law of conservation of charge, it states that the algebraic sum of currents entering a node (or a closed boundary) is zero". Mathematically

$$\sum_{n=1}^{N} i_n = 0$$

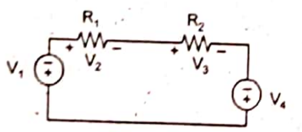


$$i_1 + (-i_2) + i_3 + i_4 + (-i_5) = 0$$

Kirchoff's second law is based on the principle of conservation of energy, it states that "the algebraic sum of all voltages around a closed path (or loop) is zero".

Mathematically,

$$\sum_{m=1}^{M} V_m = 0$$



$$V_1 + (-V_2) + (-V_3) + V_4 = 0$$

UNIT-IV

Q. 8.(a) State the postulates of Bohr's atom model. Explain how these postulates overcome the drawbacks of Rutherford's atom model?

Ans. Bohr's Postulates: Bohr postulated three fundamental laws to overcome the inconsistency in the Rutherford Model.

Postulate I: Electrons connot occupy states at all energy levels as given by classical mechanics; electrons can occupy states at only certain discrete energy levels. When an electron occupies a state at one of these discrete energy levels the electron does not emit radiation and is said to be in stationary or non-rediating state.

Postulate II: When an electron moves one stationary state corresponding to energy W_2 to another stateonary state with lower energy W_1, there results emission of radiation at a frequency f given by

$$F = \frac{(W_2 - W_1)}{h}$$

Where f is the frequency of radiation in Hertz; h, the plant's canstant = 6.626×10^{-34} Joules; and W_1 and W_2 are energies of Joules.

Pstulate III: Any Stationary or non-radiating state is determined by the condition that the angular momentum of the electron in this state is quantized and must be an integral of $h/2\pi$. Thus,

$$mvr = \frac{nh}{2\pi}$$

Where n is an integer. The radii of the various stationary arbit is given by

$$r_n = \frac{\epsilon_0 h^2 n^2}{\pi m q^2}$$
$$= 0.527 \times 10^{-10} n^2 \text{m}$$

The total energy of electron in stationary states in Joules is given by

$$W_1 = \frac{-mq^4}{8\,\epsilon_0^2 h^2 n^2}$$
$$= \frac{-13.6}{n^2} eV$$

If should be noted that the energy is negative and therefore, the energy of an electron in its orbit increases as n increases. The above expressin for the energy of the electron suggets that to remove an electron from the first orbit ($n = 1$) of the hydrogen atom to outside of the atom, that is to ionise the atom the energy required is 13.6 eV. This is known as the ionisation energy or the ionisation potential of the atom.

Q. 8.(b) Explain brefly the formation of energy bands in solid.

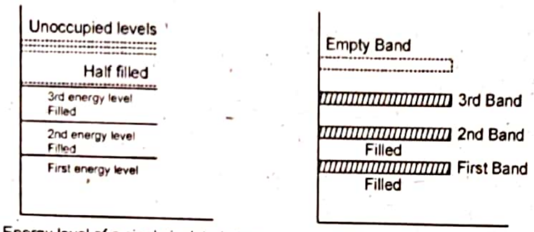
Ans. Energy bands in Solids : In case of a single isolated atom, there are single energy levels (as we have seen in case of nydrogen atom or in case of a gas where the atoms are sufficiently for apart not to exert any influence on one another).

We know that in case of solids, the atoms are arranged in a systematic space lattice and hence the atom is greatly influenced by neighbouring atoms. The closeness of atoms results in intermixing of electrons of neighbouring atoms, of course, for the valence electrons in the outermost shells which are not strongly bounded by necleus. Due to intermixing the number of permissible energy levels increases or there are significant changes in the energy levels. Hence, in case of a solid, instead of single energy levels associated with the single atom, there will be bands of energy levels. A set of such closely packed energy levels is called an energy band. Now, the bands of energy levels are referred to the entire solid as a whole and not to the single individual atom.

Here it should be remembered that individual energies within the band are so close together that for many purposes, the energy bands may be considered to be continuous.

The concept of energy bands can easily be understood with the help of fig. (1.1). Figure [1.1(a)] shows the energy levels of a single isolated atom of silicon. Here an electron can have only single energy corresponding to the orbit in which it exists. Each silicon atom has 14 electrons, two of which occupy K shell, 8 occupy the L shell and 4 occupy the M shell.

Two electrons of M shell are in sub-shell 3s and two are in sub-shell $3p$ *i.e.*, the $3p$ sub-shell is half-filled because it can accommodate a total of 6 electrons. Of course, $3d$ sub-shell is unoccupied.



(a) Energy level of a single isolated atom (b) Energy bands in solid

Fig. 1.1 Energy bands of silicon

Now consider a silicon atom in the solid (say containing 200 stoms). It is obvious that there would be 200 K-shells differing in energy by extremely small amounts. The reason being that no two electrons in this shell see exactly the same charge environment. The 200 K-shells differing in extremely small amounts of energy are so close as to merge into one energy band. This is called first band as shown in fig. [1.1(b)]. Similarly, second orbit electrons form second energy band and so on.

Valence Band: The valence band may be defined as a band which is occupied by the valence electrons or a band having highest occupied band energy.

Conduction Band: The conduction band may be defined as the lowest unfilled energy band. This band may be empty or partially filled.

Forbidden Energy Band Gap: The separation between conduction band and valence band is known as forbidden energy gap. There is not allowed energy state in this gap and hence no electron can stay in the forbidden energy gap.

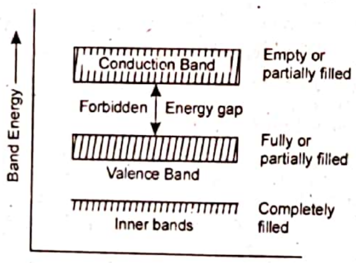


Fig. 1.2

Q. 9.(a) Discuses brifly electrical conduction in semi conductors.

Ans. Electrical conduction in semiconductor is a measures a materials ability to conduct on electric current. In semiconductor material the forbidden energy region is relatively small (~ 1eV) as the temperature is increased, some of valence electrons acquire therm alenergy greater then E_G and hence move into conduction band. These are now free elctrons and they can move about under the influence of a small applied field and concuction takes place. The conduction in semiconductor material is depends on electrons and holes both. The conductivity in semiconductor is defined as

$$\sigma = nq\,\mu_n + pq\,\mu_p \qquad ...(1)$$

where
n = number of electrons
q = charge of electron and holes
μ_n = mobilit of electrons
μ_p = mobility of holes.

The above equation (1) is valid for intrinsic semiconductor material.

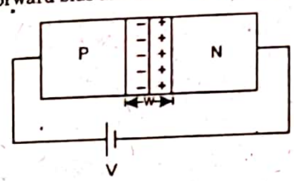
For extrinsic semiconductor material the conductivity is defined as

$\sigma = nq\,\mu_n$ for n-type

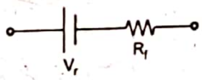
and $\sigma = pq\mu_p$ for p-type

Q. 9.(b) Which biasing makes the p.n junction resistance low? Justify your answer.

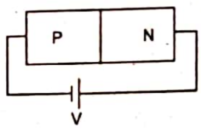
Ans. Forward baised p-n junction diode makes resistance low. An ideal diode should offer zero resistance in forward bias and infinite resistance *PN* diode in reverse Bias:



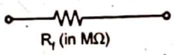
Equivalent circuit:



PN diode in reverse Bias:



Equivalent circuit:

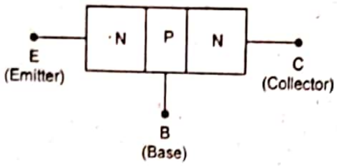


Q. 9.(c) What is a transistor? Write briefly the action of a n-p-n transistor.

Ans. A trausistor is a three terminal semiconductor device in which the operation depends on the interaction of both majority and minority carriers. Transistor is of basic two types:

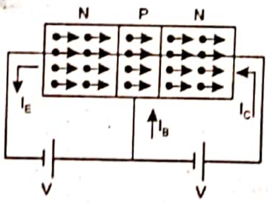
- NPN Transistor and
- PNP Transistor

In NPN transistor, a layer of P-type material is sandwiched between two layers of N-type materials the respresentation is shown below



Operation of N-P-N Transistor: Emitter- base junction is forward bias and collector-bas junction is reverse biased. The forward bias of emitter-base junction Causes a lot of electrons from the emitter region to the base region. As the base is lightly doped with p-type impurity, the number of holes in the base region is very small and hence the number of electrons that combine with hole in the p-type base region is also very small. Hence a few electrons combine with holes to constitute a base current I_B. The remaining electrons (more than 95%) crossover into the collector region to constitute a collector current I_C. Thus the base and collector current summed up given the emitter current

$$I_E = I_B + I_C$$



END TERM EXAMINATION
FIRST SEMESTER [BCA-109]
PHYSICS—DEC. 2013

Time : 3 Hours **M.M. : 75**

Note: *Attempt any five question, including Q.no. 1 which is compulsory. Select one question from each Unit.*

Q.1. (a) If a body is not at rest, then the net force acting on it can not be zero. Is this statement true of false? Justify your answer.

Ans. If a body is not at rest then net force acting on it can be zero. So, the above statement is false.

Newton's second law says that the acceleration of an object is directly propotional to the resultant force acting on it.

If the resultant force on an object is zero (either because no forces are present or the vector sum of the forces present is zero), the object can still move with constant velocity.

Q.1. (b) A man raises a body of mass 10 kg through a height of 2 meters. Find the work done against the force of gravity. Take $g = 10$ m/s².

Ans.
$$m = 10 \text{ kg},$$
$$h = 2 \text{ m}$$
$$\text{Work done } (W) = mgh$$
$$= 10 \text{ kg} \times 10 \text{ m/s}^2 \times 2 \text{ m}$$
$$= 200 \text{ N } \textbf{Ans.}$$

Q.1. (c) Define the SI unit of power. Give its relationship with one horse power.

Ans.
$$\text{Power} = \frac{\text{Workdone}}{\text{Time}} = \frac{\text{Joule (J)}}{\text{Second (S)}} = J/S = \text{watt}$$

since 1 watt = 1 Joule per second.

1 HP = 746 W.

Q.1. (d) Explain how friction helps in walking.

Ans. The firction force provides a reaction force necessary so we can move forwards through the action of our feet. If the ground provides no reaction force in the horizontal direction (hence there being no friction) the force we exert horizontally backwards as we push without toes, would slide along the ground and we would lose the balance.

Q.1. (e) Define Gauss's Law in Electrostatics. Explain briefly.

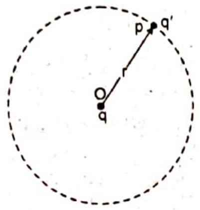
Ans. Gauss' Law states that the flux of the electric field strength vector through any closed surface in the electrostatic field equals the total charge enclosed by the surface, divided by ϵ_0;

$$\oint E.ds = \frac{Q_{\text{total in s}}}{\epsilon_0} \qquad \text{(V.m)}$$

Basically Guass' law is a relationship between the sources inside a closed surface and the field they produce over this entire surface.

Q.1. (f) Define intensity of electric field at a point. Write its SI units.

Ans. Consider a point charge 'q' called source charge placed at a point '0' in space. To find its intensity at a point 'p' at a distance 'r' from the point charge we place a test charge 'q'.



The force experienced by the test charge q' will be

$$F = Eq' \qquad ...(1)$$

According to Coulomb's law the electrostatic force between them is given by:

$$F = \frac{Kqq'}{r^2} \qquad ...(2)$$

We know that

$$E = \frac{F}{q'}$$

or

$$E = \frac{1}{q'} \times F \qquad ...(3)$$

Putting the value of 'F' from equation (2) into equation (3) we get.

$$E = \frac{1}{q'} \times \frac{kqq'}{r^2} = \frac{kq}{r^2}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{kq}{r^2}} \quad \left[\because k = \frac{1}{4\pi\varepsilon_0}\right]$$

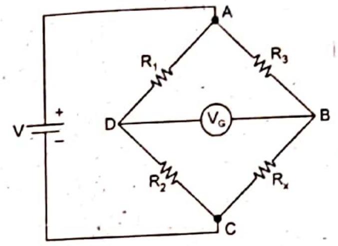
SI unit of Electric field is Coulomb/m^2.

Q.1. (g) Explain briefly the principle of a capacitor.

Ans. The principle of a capacitor is based on the fact that the potential of a conductor is greatly reduced and its capacity is increased without affecting the electric charge in it by placing another earth connected conductor or an oppositely charged conductor in its neighborhood. This arrangement is therefore able to store electric charge. Capacitor are designed to have large capacity of storing electric charge without having large dimensions.

Q.1. (h) What is a Wheatstone bridge? Draw a circuit diagram to briefly explain it.

Ans. A wheat stone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component the unknown component.



In the above figure, R_x is unknown resistance to be measured; R_1, R_2 and R_3 are resistors of known resistance.

If the bridge is balance, then

$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$

$$\Rightarrow \quad \boxed{R_x = \frac{R_2}{R_1} \times R_3}$$

Q.1. (i) What are energy bends in solids? Explain briefly.

Ans. Refer Q.No. 8.(b) of End Term Exam 2012.

Q.1. (j) What are extrinsicsemiconductors? Name the minority carriers in p-type semiconductors. **(2.5 x 10 = 25)**

Ans. An extrinsic semiconductor is a semiconductor that has been doped that is, into which a doping agent has been introduced, giving it different electrical properties than the intrinsic (pure) semiconductor. During doping, impurity atoms act as either donors the electron and hole concentrations of the semiconductor.

Minority carriers in p-type semiconductor will be electrons.

UNIT-I

Q.2. (a) Define Newton's first two laws. Show that the first law can be obtained from the second law.

Ans. Newton's First Law of Motion: Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

Newton's Second Law of Motion: The acceleration of an object is dependent upon two variables–the net force acting upon the object and the mass of the object. Newton's second law also states that "the rate of change of momentum of a body is equal to the resultant force on the body and is in the same direction as the resultant force.

According to 2nd law of motion

$$F = ma$$

Now if no external force, F must be zero.

$$\therefore \quad 0 = ma$$

but mass can't be zero.

$$\therefore \quad a = 0 \text{ or } \frac{dv}{dt} = 0$$

$$\text{or} \quad \int dV = 0$$

$$\text{or} \quad \boxed{V = \text{Constant}}$$

Thus, in absence of external force, a body will remain at rest or uniform motion, which is the Newton's first law of motion.

Q.2. (b) A force of 10 N acts on a body of mass 200 g. Find the acceleration produced in the body.

Ans. Given that

$$F = 10 \text{ N}$$

$$m = 200 \text{ g}$$

$$a = ?$$

According to Newton's second law of motion, we have

$$F = ma$$

$$\text{or} \quad 100 \text{ N} = \frac{200}{1000} kg \times a$$

$$\text{or} \quad a = 50 \text{ m/s}^2 \textbf{ Ans.}$$

Q.2. (c) Define momentum. Write its SI unit. Is it a vector quantity or a scalar quantity? (5 + 4 + 3.5 = 12.5)

Ans. The momentum of a particle is defined as the product of its mass times its velocity. It is a vector quantity. The momentum of a system is the vector sum of the momenta of the objects which make up the system.

If the system is an isolated system, then the momentum of the system is a constant of the motion and subject to the principle of conservation of momentum. It is defined as

$$p = mV$$

SI unit is kg m/s.

Q.3. (a) Differentiate between static and kinetic friction.

Ans. Static friction describes the force needed to initially move a stationary object. There are tables of coefficients of static friction. The force needed to overcome static friction depends on the material making up the object, the surface the object rests on, the mass of the object and the acceleration of gravity. Static friction is generally higher than kinetic or sliding friction.

Kinetic friction (sliding friction) describes the force needed to keep an object moving along a surface. There are tables of coefficients of sliding friction available. It usually takes less force to keep an object moving than it does to initially get it moving from rest. This is because there is a small amount of attraction between the molecules of the object and the surface that must be broken to get it to move. Once moving, the two surfaces are not as tightly connected. You probably have noticed that it is harder to get a heavy object to move initially, but once you get it sliding across the floor it seems easier as long as it keeps moving.

Q.3. (b) Static friction is a self adjusting force. Explain.

Ans. Refer Q. No. 1.(*d*) of End Term Exam 2012.

Q.3. (c) A horizontal force of 490 N is required to slide a sledge weighing 600 kgf over a flat surface. Calculate the coefficient of friction. (12.5)

Ans. Given that $F = 490 \text{ N}, N = 600 \text{ kgf}$

We know that $f = \mu N$ ...(1)

We have, $1 \text{ Kgf} = 9.80 \text{ N}$

$\therefore \quad N = 600 \times 0.80 \text{ N} = 5880 \text{ N}$

From equation (1)

$$\mu = \frac{f}{N} = \frac{490}{5880} = 0.083$$

$\therefore \quad \mu$(cofficient of friction) $= 0.083$ Ans.

UNIT-II

Q.4. (a) Define work and its SI unit. What is the meaning of negative work? Briefly explain.

Ans. When a force acts to move an object, we say that Work was done on the object by the Force. A force is said to do work when acting on a body there is a displacement of the point of application in the direction of the force. For example, when a ball is held above the ground and then dropped, the work done on the ball as it falls is equal to the weight of the ball (a force) multiplied by the distance to the ground (a displacement).

SI unit of work is Joule (J).

Frictional force is always opposing the relative motion of the body. When a body is dragged along a rough surface, the frictional force will be acting in the direction opposite to the displacement. The angle between the frictional force and the displacement of the body will be 180°. Thus, the work done by the frictional force will be negative.

Q.4. (b) Write the expression for the potential energy of a compressed spring Explain the various terms.

Ans. The spring constant, k is a measure of the stiffness of a spring (large $k \rightarrow$ stiff spring, small $k \rightarrow$ soft spring).

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To compress a spring by a distance Δx we must apply a force $F_{ext} = k\Delta x$. By Newton's 3rd law, if we hold a spring in a compressed position, the spring exerts a force $F_s = -k\Delta x$. This is called a linear restoring force because the force is always in the opposite direction from the displacement.

- The sign of F_s shows that the spring resists attempts to compress or stretch it; therefore F_s is a restoring force.

For Example: In Figure (*a*) $\Delta x = x_f - x_i = -5$ which gives $F_s = -k(-5) = 5k$. This force is positive and therefore directed to the right. This means that the spring resists the compression. In Figure (*b*) $\Delta x = x_f - x_i = 3$ which gives $F_s = -3k$. The negative sign indicates that the force is to the left and that the spring resists the restretching.

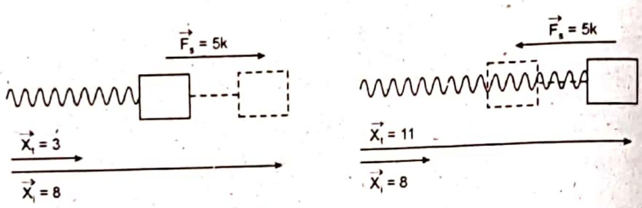


Fig. (*a*) Compressed spring (*b*) Stretched spring.

- The farther we compress or stretch the spring, the greater the restoring force.
- We usually define $x_i = 0$ and $x_f = x$ which gives $F_s = -kx$. This is called Hooke's law.

To find the potential energy stored in a compressed (or stretched) spring, we calculate the work to compress (or stretch) the spring: the force to compress a spring varies from $F_{ext} = F_0 = 0$ (at $x_i = 0$), to $F_{ext} = F_x = kx$ (at $x_f = x$). Since force increases linearly with x, the average force that must be applied is

$$\vec{F}_{ext} = \frac{1}{2}(F_0 + F_x) = \frac{1}{x}kx$$

The work done by $\vec{F}_{ext}$ is $W = \vec{F}_{ext}\ x = \frac{1}{2}kx^2$. This work is stored in the spring as potential energy:

$$PE_s = \frac{1}{2}kx^2$$

Note:

- $PE_s = 0$ when $x = 0$ (at equilibrium).
- PE_s always > 0 when the spring is not in equilibrium.
- PE_s is the same if $x = \pm x_f$ (same PE_s for equal expansion or compression).

Q.4. (*c*) Write the names of different forms of energy. Explain the law of conservation of energy. **(3 + 5 + 4.5 = 12.5)**

Ans. Forms of Energy

Type of Energy	Description
Kinetic	(≥0), that of the motion of a body
Potential	A category comprising many forms in this list
Mechanical	The sum of (usually macroscopic) kinetic and potential energies
Chemical	that contained in molecules
Electric	that from electric fields
Magnetic	that from magnetic field
Radiant	(≥0), that of electromagnetic radiation including light
Nuclear	that of binding nucleons to form the atomic nucleus
Ionization	that of binding an electron to its atom or molecule
Elastic	that of deformation of a material (or its container) exhibiting a restorative force
Gravitational	that from gravitational fields
Intrinsic, the rest energy	(≥0) that equivalent to an object's rest mass
Thermal	A microscopic, disordered equivalent of mechanical energy
Heat	an amount of thermal energy being transferred (in a given process) in the direction of decreasing temperature.
Mechanical work	an amount of energy being transferred in a given process due to displaement in the direction of an applied force.

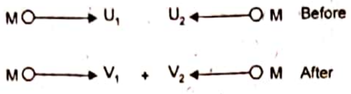
The **law of conservation of energy** states that the total energy of an isolated system cannot change–it is said to be conserved over time. Energy can be neither created nor destroyed, but can change form, for instance chemical energy can be converted to kinetic energy in the explosion of a stick of dynamite.

Q.5. (*a*) Explain elastic and inelastic collisions. Give main differences.

Ans. Refer Q.No. 1(*e*) of End Term Examination 2012.

Q.5. (*b*) Two identical bodies each of mass M moving with speeds U_1 and U_2 along a straight line undergo a head on perfect inelastic collision. Calculate the loss in kinetic energy. **(5 + 7.5 = 12.5)**

Ans. In a totally inclastic collision, the two objects stick together after the collision.



From Conservation of momentum

$$MU_1 + MU_2 = MV_1 + MV_2$$

After Collision $\quad V_1 = V_2 = V$

$$\therefore \quad U_1 + U_2 = 2V$$

$$\therefore \quad V = \frac{U_1 + U_2}{2}$$

We have Initial K.E. $= \frac{1}{2}MU_1^2 + \frac{1}{2}MU_2^2$

Final K.E. $= \frac{1}{2}(M+M)\left(\frac{U_1+U_2}{2}\right)^2$

The fractional loss in K.E.

$$f = \frac{k_i - k_f}{k_i} = \frac{\frac{1}{2}M\left[U_1^2 + U_2^2\right] - \frac{1}{2} \times 2M\left(\frac{U_1+U_2}{2}\right)^2}{\frac{1}{2}M\left[U_1^2 + U_2^2\right]}$$

$$= \frac{\frac{U_1^2+U_2^2}{2} - \frac{(U_1+U_2)^2}{4}}{\frac{U_1^2+U_2^2}{2}} = \frac{2U_1^2 + 2U_2^2 - U_1^2 - U_2^2 - 2U_1U_2}{2(U_1^2+U_2^2)}$$

$$f = \frac{U_1^2 + U_2^2 - 2U_1U_2}{2\left(U_1^2 + U_2^2\right)}$$

$$\boxed{f = \frac{(U_1 - U_2)^2}{2(U_1^2 + U_2^2)}}$$

UNIT-III

Q.6. (*a*) Explain briefly frictional electricity.

Ans. The term "frictional electricity" is not oftenly used. Instead of it Static Electricity is most commonly used term. When we rub the surfaces of two materials against each other the transfer of the electrons takes place from one material to the other. Which material loses electrons or gains, depends on the properties of the materials. Thus the one that gains electrons gets negative charge while other gets positively charged. This transfer of electrons is called frictional electricity.

Q.6. (*b*) Find the force between two stationary charges each 600 micro Coulomb kept 2 meters apart in vacuum. How will the force vary if the charges are kept in a medium of dielectric constant 80?

Ans. Given that $\quad q_1 = q_2 = 600\ \mu C$

$r = 2$ m and $\varepsilon_r = 1$ and $\varepsilon_r = 80$

Case I: When $\quad \varepsilon_r = 1$

$$F = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{r^2}$$

$$= 9 \times 10^9 \times \frac{600 \times 10^{-6} \times 600 \times 10^{-6}}{(2m)^2}$$

$$= \frac{9 \times 10^9 \times 36 \times 10^{-8}}{4} = 810\ N$$

$$\boxed{F = 810\ N \text{ Ans.}}$$

Case II: When $\quad \varepsilon_r = 80$

$$F = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{r^2}$$

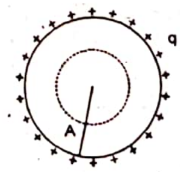
$$F = \frac{1}{4 \times 3.14 \times 8.856 \times 10^{-12} \times 80} \times \frac{36 \times 10^{-8}}{4}$$

$$\boxed{F = 10.11\ N} \text{ Ans.}$$

Q.6. (*c*) Use Gauss's law to show that the electric field inside a charged solid conducting sphere is zero. **(3 +4.5 = 12.5)**

Ans. Gauss theorem states that the total electric flux through a closed surface is 1/ e0 times the net charge enclosed by the enclosed surface.

$$\left[\phi_E = \oint_s E.ds = q/\varepsilon_0\right]$$



Inside a charged spherical conductor, the charge enclosed by the Gaussian surface, $q = 0$.

$$\therefore \quad \phi_E = \frac{q}{E_0} = 0$$

$$\Rightarrow \quad E \times 4\pi r^2 = 0 \Rightarrow \boxed{E = 0}$$

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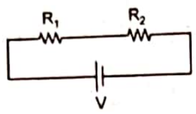
Q.7. (a) The total resistance of two resistors when connected in series is 9Ω and when connected in parallel, their total resistance becomes 2 Ω. Find the value of each resistance.

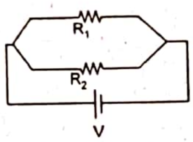
Ans. Let us consider, resistors are connected in series



$$R_{eq} = R_1 + R_2$$

given that $R_{eq} = 9\,\Omega.$

Let us consider, resistors are connected in parallel.



$$\text{Req.} = R_1 \times R_2/R_1 + R_2$$

given that Req. = 2Ω

The both cases possible only when one resistance is 6Ω and another is 3Ω.

Q.7. (b) Define Ohm's law. Is it a fundamental law? Explain briefly.

Ans. Refer Q. No. 1(*f*) of End Term Exam 2012.

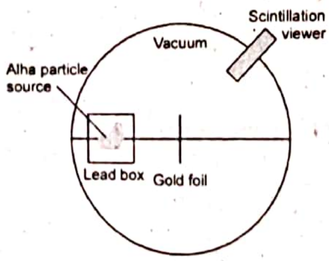
Q.7. (c) State Kirchhoff's rules. Explain with the help of a circuit diagram. (3 + 3.5 + 6 = 12.5)

Ans. Refer Q. No. 7. (*c*) of End Term Exam 2012.

UNIT-IV

Q.8. (a) Explain briefly the basis of Rutherford's atonic model.

Ans. In 1909 Ernest Rutherford conducted what is now a famous experiment where he bombareded gold foil with alpha particles (Helium nuclei). A source which undergoes



alpha decay is placed in a lead box with a small hole in it. Any of the alpha particles which hit the inside of the box are simply stopped by the box. Only those which pass through the opening are allowed to escape, and they follow a straight line to the gold foil. The animation below shows the experiment in action.

Observations

- Most of the alpha particles pass straight through the gold foil.
- Some of the alpha particles get deflected by very small amounts.
- A very few get deflected greatly.
- Even fewer get bounced of the foil and back to the left.

Conclusions

- The atom is 99.99% empty space.
- The nucleus contains a positive charge and most of the mass of the atom.
- The nucleus is approximately 100,000 times smaller than the atom.

Q.8. (b) Why is the density of an atom less than the censity of its nucleus? Explain briefly.

Ans. Because the atom as a whole would have electron clouds and electron clouds have an almost un-measurable density where as the only dense part to the atom is the nucleus. Atomic nuclei are composed of two types of particles, protons and neutrons, which are collectively known as nucleons. A proton is simply the nucleus of an ordinary hydrogen atom, the lightest atom, and has a unit positive charge. A neutron is an uncharged particle of about the same mass as the portion. The number of protons in a given nucleus is the atomic number of that nucleus and determines which chemical element the nucleus will consititute when surrounded by electrons.

The nucleus occupies only a tiny fraction of the volume of an atom (the radius of the nucleus being some 10,000 to 100,000 times smaller than the radius of the atom as a whole), but it contains almost all the mass. An idea of the extreme density of the nucleus is revealed by a simple calculation. The radius of the nucleus of hydrogen is on the order of 10^{-13} cm so that its volume is on the order of 10 – 39 cm3 (cubic centimeter); its mass is about 10 – 24 g (gram). Combining these to estimate the density, we have 10 – 24 g/10 – 39 cm3 = 1015 g/cm3, or about a thousand trillion times the density of matter at ordinary scales (the density of water is 1 g/cm3).

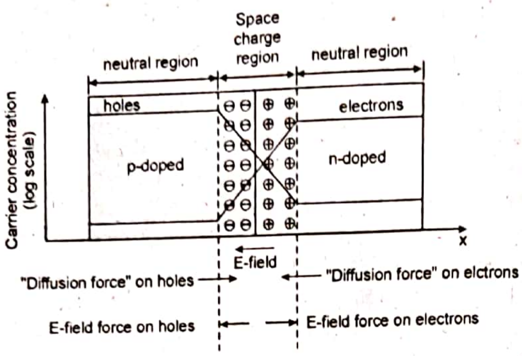
Q.8. (c) State the postulates of Bohr's atomic model. (5 + 3 + 4.5 = 12.5)

Ans. Refer Q.No. 8(*a*) of End Term Exam 2012.

Q.9. (a) What is a p-n junction? Explain briefly how potential barrier is caused in it.

Ans. A **p-n junction** is a boundary or interface between two types of semiconductor material, p-type and n-type, inside a single crystal of semiconductor. It is created by doping, for example by ion implantation, diffusion of dopants, or byepitaxy (growing a layer of crystal doped with one type of dopant on top of a layer of crystal doped with another type of dopant).

In a p-n junction, without an external applied voltage, an equilibrium condition is reached in which a potential difference is formed across the junction. This potential difference is called built-in potential V_{bi}.



After joining p-type and n-type semiconductors, electrons from the n region nea the p-n interface tend to diffuse into the p region. As electrons diffuse, they leave positivel charged ions (donors) in the n region. Likewise, holes from the p-type region near the p n interface begin to diffuse into the n-type region, leaving fixed ions (acceptors) wit negative charge. The regions nearby the p-n interfaces lose their neutrality and becom charged, forming the space charge region or depletion layer.

Q.9. (*b*) In a transistor, base is made thin and lightly doped. Why?

Ans. If the base is heavily doped, a high reverse electric field will be created, whic will lead to decrease in no of electrons reaching the collector.

The width of the base is very thin to increase the majority carrier concentratio gradient in the base region thereby enhancing the diffusion current and also to reduc the number of majority carriers lost due to recombination in the base.

Q.9. (c) List the advantages of integrated circuits over conventional circuits **(5 + 3.5 + 4 = 12.5)**

Ans. ICs take up very little space, allowing products to be made much smaller.

- ICs normally cost much less to make than the individual components needed to do the same function.
- A drastic reduction in size and weight.
- A large increase in reliability.
- possible improvement in circuit performance.

END TERM EXAMINATION [BCA]
FIRST SEMESTER [2014]
PHYSICS [BCA-109]

ime: 3 Hours **Maximum Marks: 75**

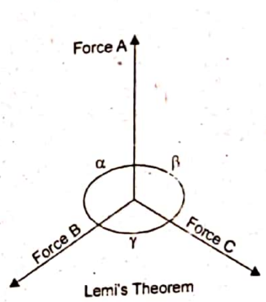
ote: *Attempt any five questions including Q.no.1 which is compulsory. Select one question om each unit.* **(2.5×10 = 25)**

Q.1. (*a*) State Lemi's Theorem.

Ans. Lemi's theorem states that if three coplanar forces are acting on a same point nd keep it stationary, then it obeys the relation

$$\frac{A}{\sin(\gamma)} = \frac{B}{\sin(\beta)} = \frac{C}{\sin(\alpha)}$$

where A, B and C are the magnitude of forces acting at the point (say O), and the values f α, β and γ are the angles directly opposite to the forces C, B and A respectively.



Lemi's Theorem

Q.1. (*b*) Does friction decrease by smoothing the surface in contact? If no, why? Explain briefly.

Ans. No, Friction is dependent on the surface types and the amount of force between them. It can then be decreased or increased by modifying the surface such as: creating a smoother or rougher surface, lubricating or desiccating the surface, or by reducing or increasing the force pressing the surfaces together. Surprisingly the area of contact does not affect frictional force when relative smooth surfaces are in contact since a larger area creates a lower pressure between the surfaces lowering frictional force spread over the larger area. The frictional force per unit area is lower/higher in proportion to the increase/decrease in area.

Q.1. (c) The common sense idea a force is required to sustain motion is incorrect. Justify this statement.

Ans. Yes, this can be understood by the following: Zero total force is always needed to maintain constant velocity. Consider the following made-up numbers:

	Boat moving at a low, constant velocity	Boat moving at a high, constant velocity
Forward force of the wind on the sail...	10,000N	20,000N
Backward force of the water on the hull...	– 10,000N	–20,000N
Total force on the boat	0N	0N

The faster boat still has zero total force on it. The forward force on it is greater, the backward force smaller (more negative), but that's irrelevant because Newton's law has to do with the total force, not the individual forces. This example is q analogous to the one about terminal velocity of falling objects, since there is a frictio force that increases with speed. After casting off from the dock and raising the sail, boat will accelerate briefly, and then reach its terminal velocity, at which the wat frictional force has become as great as the wind's force on the sail.

Q.1. (*d*) State and explain briefly work-energy theorem.

Ans. The energy associated with the work done by the net force does not disapp after the net force is removed (or becomes zero), it is transformed into the Kinetic Ene of the body. We call this the Work-Energy Theorem.

$$W_{net} = \Delta KE = KE_f - KE_0$$

i.e. Work done = final kinetic energy – initial kinetic energy

Q.1. (*e*) Write two important properties of electric charge.

Ans. The two important properties of electric charge are:

• **Conservation of Electric Charge:** Just like energy and mass can be conserv the electric charges can also be conserved.

The law of conservation states that the total charge of an isolated system remai constant that is, Charges can neither be created nor destroyed.

• **Quantisation of Electric Charge:** The principle of quantisation of electric char states that "in nature there is a smallest amount of charge and all other charges a integral multiples of this smallest unit ". That is, if e is the minimum charge then t total charge on the body is equal to ne where n is an integer.

Q.1. (*f*) What fo you understand by electric lines of force? Why two lin cannot intersect?

Ans. Electric field lines of forces: If a charge is isolated then the force experienc by a unit charged placed there is called Electric field , which is due to the electric fie lines. Closer to the charged particle stronger would be electric field lines and vice vers

Two electric field lines do not intersect each other as there could not be two directi of the electric field lines.

Q.1. (*g*) Explain briefly the effect of a dielectric in a capacitor.

Ans. Dielectric are non conducting materials for ex- Glass,mica,wood etc. Wh happened when space between the two plates of the capacitor is filled by a dielectr was first discovered by faraday.

• Faraday discovered that if the space between conductors of the capacitor occupied by the dielectric,the capacitance of capacitor is increased.

• If the dielectric completely fills the space between the conductors of the capacito the capacitance is increased by an factor K which is characteristics of the dielectric an This factor is known as the dielectric constant.

Q.1. (*h*) Explain Kirchoff's first and second rules.

Ans. Refer Q7 (c) from End Term Examination December 2012.

Q.1. (*i*) Explain briefly the concept of stationary orbits.

Ans. According to de-Broglie's concept of stationary orbit, only those orbits are allowed as stationary orbits whose circumfernce or perimeter is an integral multiple of wavelength associated with electron.

That is $$2\pi r = n\lambda$$

where r is the radius of orbit and π the de-Broglie wavelength of electron.

Q.1. (*j*) What are minority and majority carriers in semi-conductors? Give example.

Ans. Refer Q1(j) from End Term Examination December 2012.

UNIT-I

Q.2. (*a*) Name the basic forces in nature. **(3)**

Ans. Basic Forces in Nature:

• It is the force of attraction between any two bodies in the universe.

• The gravitational force is inversely proportional to the square of the distance between the two bodies and directly proportional to the product of the masses of two bodies.

• Gravitational force is small when light bodies are considered and is considerable when massive bodies are taken into account.

$$F = G\frac{m_1m_2}{r^2}$$

Electrostatic force: • It's the force between two charges.

• It's stronger than gravitational force.

• It also follows inverse square law and is proportional to product of the point charges.

$$F = K\frac{q_1q_2}{r^2}$$

Magnetic force: • It can be either attractive or repulsive.

• It can be the force between two magnets or force on a magnet placed in a magnetic field.

Electromagnetic force: •An electric charge moving in a magnetic field experiences a force.

•This is called electromagnetic force. It is a combination of electricity and magnetism.

Nuclear force: • This is a strong force with a short range.

• It is non-central, *i.e.*, it isn't directed along the line joining the centres of the interacting particles.

• This force acts within the nucleus.

Weak force: •This kind of interaction is not well understood as yet.

• Its range is shorter than the nuclear force.

• It is important only for certain nuclear processes like radioactive beta decay.

Q.2. (b) Newton's laws are valid in Inertial frames only. What are the reference frames? Explain briefly.

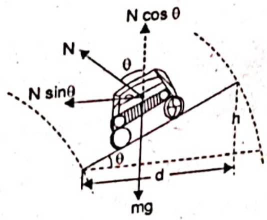
Ans. Valid frames of reference, in which Newton's laws are obeyed, are called inertial frames of reference. Frames of reference that are not inertial are called non-inertial frames. In those frames, objects violate the principle of inertia and Newton's first law. While the truck was moving at constant velocity, both it and the sidewalk were valid inertial frames. The truck became an invalid frame of reference when it began changing its velocity.

You usually assume the ground under your feet is a perfectly inertial frame of reference. It isn't perfectly inertial, however, Its motion through space is quite complicated, being composed of a part due to the earth's daily rotation around its own axis, the monthly wobble of the planet caused by the moon's gravity, and the rotation of the earth around the sun. Since the accelerations involved are numerically small, the earth is approximately a valid inertial frame.

Non-inertial frames are avoided whenever possible, and we will seldom, if ever, have occasion to use them. Sometimes, however, a non-inertial frame can be convenient. Naval gunners, for instance, get all their data from radars, human eyeballs, and other detection systems that are moving along with the earth's surface. Since their guns have ranges of many miles, the small discrepancies between their shells' actual accelerations and the accelerations predicted by Newton's second law can have effects that accumulate and become significant. In order to kill the people they want to kill, they have to add small corrections onto the equation $a=Ftotal/m$. Doing their calculations in an inertial frame would allow them to use the usual form of Newton's second law, but they would have to convert all their data into a different frame of reference, which would require cumbersome calculations.

Q.2. (c) Explain the concept of banking the roads. Calculate the angle of banking so that a vehicle of mass m can go with maximum velocity y on a curved road of radius r without skidding. (6.5)

Ans. Banking of Roads: In hilly areas, circular turns are very frequent and sharp therefore, roads are made in such a way that their outer edge is slightly raised than the inner edge so that sufficient centripetal force could be provided. This is called 'banking of road'.



If θ be the angle of banking, we have,

$$\tan\theta = \frac{h}{d}$$

...edge from the level of inner edge and d is width of the

$$N\cos\theta = mg$$

Also,

$$N\sin\theta = \frac{mv^2}{R}$$

if the vehicle of mass m takes a circular turn of radius R on a banked road with speed v.

$$\tan\theta = \frac{v^2}{Rg}$$

Q.3. (a) Is a body moving with constant speed on a circular path accelerated? If yes—What is the special name of this acceleration? Explain briefly. (5)

Ans. Yes, a body moving at constant speed in circular path experiences acceleration directed towards the centre of the circular path. This acceleration is called a centripetal acceleration and is provided by a centripetal force. The force might be due to gravity, electro-static attraction, the tension is a string etc.

A centripetal force does not change the K.E. of the body because it acts at 90° to the direction of motion. (3)

Q.3. (b) State the laws of friction.

Ans. Laws of Friction:

• **Law 1:** When two bodies are in contact the direction of the forces of Friction on one of them at it's point of contact, is opposite to the the direction in which the point of contact tends to move relative to the other.

• **Law 2:** If the bodies are in equilibrium, the force of Friction is just sufficient to prevent motion and may therefore be determined by applying the conditions of equilibriumof all the forces acting on the body.

The amount of Friction that can be exerted between two surfaces is limited and if the forces acting on the body are made sufficiently great, motion will occur. Hence, we define *limiting friction* as the friction which is exerted when equilibrium is on the point of being broken by one body sliding on another. The magnitude of limiting friction is given by the following three laws.

•**Law 3:** The ratio of the limiting friction to the Normal reaction between two surfaces depends on the substances of which the surfaces are composed, and not on the magnitude of the Normal reaction.

This ratio is usually denoted by μ. Thus if the Normal reaction is R, the limiting friction is μ R.

For given materials polished to the same standard is found to be constant and independent of R.

μ is called *The Coefficient of friction*

• **Law 4:** The amount of limiting friction is independent of the area of contact between the two surfaces and the shape of the surfaces, provided that the Normal reaction is unaltered.

• **Law 5:** When motion takes place, the direction of friction is opposite to the direction of relative motion and is independent of velocity. The magnitude of the force of friction is in a constant ratio to the Normal reaction, but this ratio may be slightly less than when the body is just on the point of moving.

Q.3. (c) Calculate the apparent weight of a body mass m in a life moving upwards with acceleration 'a'. Also, find the apparent weight when the lift is moving downward with acceleration 'a'. (4.5)

Ans. Apparent weight of body of mass m when lift is moving upward with acceleration 'a'

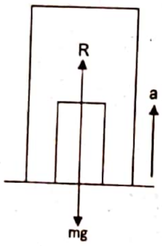
R – mg = ma

R = mg + ma

R > mg

Apparent Weight > true Weight

Body will experience weight gain.



Apparent weight of body of mass m when lift is moving downwards with acceleration 'a'

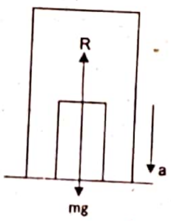
R+ mg = ma

R = mg – ma

R < mg

Apparent Weight < true Weight

Body will experience weight loss.



UNIT-II

Q.4. (a) Define conservative force. What are its important properties? Prove that gravitational force is a conservative force. (5)

Ans. Refer Q5(a) from End Term Examination December 2012.

Q.4. (b) What do you understand by negative work down by a force? Give an example. (2.5)

Ans. As the work done is the dot product of force and displacement, i.e

Workdone = Force .displacement

If the displacement is opposite in direction to the applied force then that work done egative.

Workdone = Force * displacement * cos 180

= Workdone = – Force * displacement

For example: Frictional force is also known as opposing force which is opposite to applied force.

Q.4. (c) A force of 20N moves a body of mass 1kg on a rough surface rizontal) through a distance of 2m. If the coefficient of friction is 0.2, find the rk done by the applied force and the force of friction. (5)

Ans. Work done by applied force = W = F.d

= 20 * 2 = 40 joule

Frictional force = μmg = 0.2 *1 *10 = 2

Work done by frictional force W = μmgd

= 0.2* 1* 10 *2 = 4 joule

Q.5. (a) Derive an expression for the elastic potential energy of a compressed ring. (3.5)]

Ans. Let the length of the spring is 'x' ;

As the extension of the spring upto which it can be extended is proportional to spring nstant (K) and its length (x),

Extension = Kx

When the spring is extended upto double its length then its potential energy creases which is,

Potential energy = integration from 0 to x of Kx ,

= ½Kx^2

Q.5. (b) What are elastic and inelastic collisions? Explain briefly. (3)

Ans. Elastic collision: Elastic collision is that type of collision in which the sum of e kinetic energy before collision and after collision remains constant.

Inelastic collision : Inelastic collision is that type of collision in which the sum of e kinetic energy before collision and after collision does not remain same.

In real life elastic collision is difficult to see while inelastic collision can be seen asily.

Q.5. (c) A body of mass 1kg moves along X-axis with speed 5m/s. It collides ead-on with another body of mass 2kg lying at rest. Find the velocities of the o bodies after the collision. Consider that the collision is perfectly elastic. (6)

Ans.

Mass m1 = 1kg

Mass m2 = 2kg

Speed of m1 = 5 m/s

Then after collision combined speed would be ,

m1u1 + m2u2 = (m1 + m2)v ,

1*5 + 2*0 = (1 +2) v ,

$$5 = 3v,$$

$$5/3 = v,$$

$$1.6666 = v;$$

Therefore, the speed with which the two bodies will move is 1.6666 m/s.

UNIT-III

Q.6. (a) Define Coulamb's law. Using this law, show, how will the forc between two charges change when the distance between the charges is double (3.5)

Ans. Coulamb's Law: Coulamb's Law states "The electric force between tw charged particles is directly proportional to the product of their charges and inverse proportional to the square of the distance between them."

Electric Force F between two charge particles having charges q_1 and q_2 at a distanc

$$F = Kq_1 q_2/r^2$$

When the distance between the charges is doubled, According to the Coulamb Law Force will reduce to ¼h.

$$F = Kq_1 q_2/r^2$$

When the distance between the charges is doubled $F = K q_1 q_2/4 r^2$.

Q.6. (b) Explain briefly line integral of electric field. (3.

Ans. Line Integral of Electric Field: Negative Line Integral of Electric Fiel represents the work done by the electric field on a unit positive charge in moving it fro one point to another in the electric field.

Total work done by the electric field on the test charge in moving it from A to B in th electric field is

$$W_{AB} = -\int_A^B E.dl$$

Q.6. (c) Define electrostatic potential at a point. How much work is require to move a charge of 2C through potential difference of 10V? (5.

Ans. Electrostatic Potential: Electric Potential at a point in the electric field i defined as the work done in moving a unit positive charge from infinity to that point

$$W_{\text{infinite to B}} = -\int_{inf}^B E.dl$$

$$V = \frac{W_{\infty B}}{q_0}$$

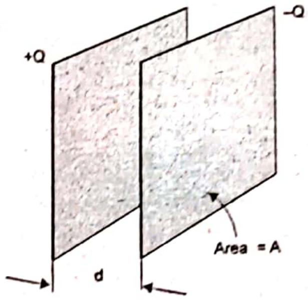
Total work done $W = q V = 2 * 10 = 20$ joule

Q.7. (a) What is the principle of capacitor? Find the capacitance of a paralle plate capacitior having plate area 'A' and the distance between the plates 'd'.(7

Ans. Principle of Capacitor: A combination of two conductors placed close to each other is called a capacitor. One of the conductor is given a positive charge and the othe is given an equal negative charge. The charge on the positive plate is known as charge o the capacitor and the potential difference between the plates is called potential of th capacitor.

A parallel-plate capacitor consists of two large plane plates placed parallel to eac other with a small separation between them.

Capacitance is defined as $C = Q / V$ where V is the potential of the capacitor and Q is change of the capacitor.



Capacitance of a Parallel –Plate Capacitor:

Acc. to Gauss law : $\int_A^B E.ds = Q/\varepsilon_0$

$$E = Q/A.\varepsilon_0$$

Where Q is charge on the capacitor and ε_0 is free space permittivity.

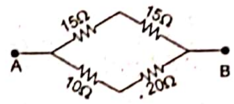
Potential of the capacitor is defined as $V = E d$ where d is distance between two plates.

$$V = Q d / A.\varepsilon_0$$

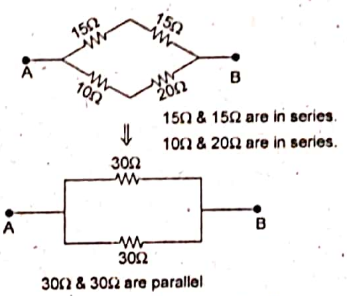
from the definition of capacitance $Q = C V$

Capacitance of parallel plate capacitor is $C = \varepsilon_0 A / d$

Q.7. (b) In the figure find the net resistance between points A and B. **(3)**



Ans.

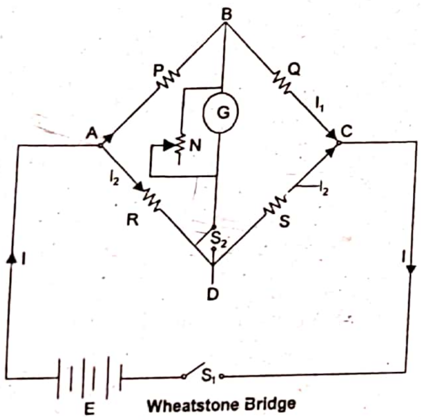


Net Resistance $\frac{1}{R} = \frac{1}{30} + \frac{1}{30} = \frac{2}{30}$

$$R = 15\Omega$$

Q.7. (c) What is a wheatstone bridge? Draw a circuit diagram and explain it. (2.5)

Ans. Wheatstone Bridge: Wheatstone bridge is widely used for measuring any electrical resistance accurately. There are two known resistors, one variable resistor and one unknown resistor connected in bridge form as shown below. By adjusting the variable resistor the current through the Galvanometer is made zero. When the current through the galvanometer becomes zero, the ratio of two known resistors is exactly equal to the ratio of adjusted value of variable resistance and the value of unknown resistance. In this way the value of unknown electrical resistance can easily be measured by using wheatstone.



Wheatstone Bridge

Bridge.

When Glavanometer current is zero.

$$P/Q = R/S$$

Unknown resistance can be determined using:

$$R = P{*}S/Q$$

UNIT-IV

Q.8. (a) State the postulates of Bohr's atomic model. (4.5)

Ans. Postulates of Bohr's Atomic model :

Main postulates of Bohr's atomic theory are:

1. Electrons revolve around the nucleus in circular path, which are known as "Orbits" or "Energy Level".

2. The energy levels are characterized by an integer number known as quantum number of respective orbit. Energy of an electron in one of its allowed orbits is fixed.

3. If an electron jumps from lower energy level to a higher energy level, it absorbs a definite amount of energy. If an electron jumps form higher energy level to a lower energy level, it radiates a definite amount of energy. The energy absorbed or lost is equal to the difference between the energies of the two energy levels.

If an electron jumps from a higher energy level E_2 to a lower energy level E_1. The energy is emitted in the form of light .Amount of energy released is given by:

$$\Delta E = E_2 - E_1$$
$$E_2 - E_1 = h\nu$$

Where

h = Planck's constant (6.6256×10^{-34} j.s)

ν = Frequency of radiant light.

4. Angular momentum of an electron is given by:

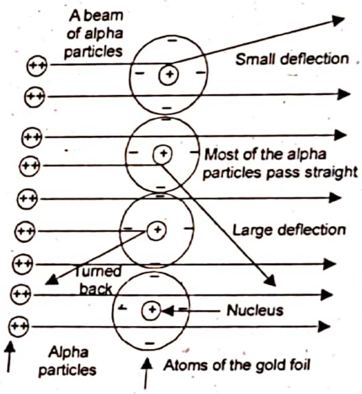
$$m\,v\,r = nh/2\pi$$

Where n =1, 2, 3....(integer), m = mass of electron , V = velocity of electron , r = radius of orbit

Q.8. (b) Explain Rutherford's α-particle scattering experiment. What were the conclusions of the experiment? (5)

Ans. (b):- Rutherford β -particle scattering experiment

In order to know the arrangement of electrons within an atom, Rutherford designed an experiment where fast moving alpha (β)-particles were made to fall on a thin gold foil.



Rutherford concluded from the á-particle scattering experiment that:

(i) Most of the space inside the atom is empty because most of the á-particles passed through the gold foil without getting deflected.

(ii) Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.

(iii) A very small fraction of á-particles were deflected by very large angles, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

On the basis of his experiment, Rutherford put forward the nuclear model of a atom, which had the following features:

(*i*) There is a positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.

(*ii*) The electrons revolve around the nucleus in well-defined orbits.

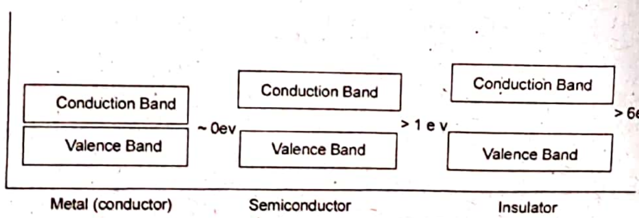
(*iii*) The size of the nucleus is very small as compared to the size of the atom. the radius of the nucleus is about 10^5 times less than the radius of the atom. Nucleus of an atom is very dense and hard.

Q.8. (*c*) Differentiate between conductors, insulators and semiconductors. (3)

Ans. Difference between Conductor, Insulator and Semiconductor:

Conductor	Insulator	Semiconductor
The conductivity of conductor is very high	The conductivity of insulator is very low.	The conductivity of semiconductor is moderate.
It has very low resistivity.	It has very high resistivity	It has moderate resistivity.
It has no forbidden gap. Eg = 0.01 eV	It has large forbidden gap. Eg > 6 eV	It has small forbidden gap. Eg = 1 eV
Conductor has positive temperature coefficient of resistance.	Insulator has negative temperature coefficient of resistance	Semiconddctor has negative temperature cofficient of resistance
There is large number of electrons available for conduction.	There is small number of electrons available for conduction.	There is moderate number of electrons available for conduction.
Example: Metals, aluminium, copper.	Paper, Mica glass.	Silicon, Germanium.

Energy Level Diagram:



Energy Band Diagram of Metal, Semiconductor and Insulator

Q.9. (*a*) What are intrinsic and extrinsic semiconductors? Explain p-type and n-type semiconductors. (3)

Ans. Intrinsic semiconductor: A semiconductor in an extremely pure form is known as intrinsic semiconductor. A semiconductor is intrinsic if its impurity content is less than one part impurity in 100 million parts of semiconductor.

The silicon (Si) and germanium (Ge) are the two most widely used intrinsic semiconductors. In intrinsic semiconductor, the concentration of free electron will always be equal to the concentration of holes.

Extrinsic semiconductor : Intrinsic or pure semiconductor have small conductivity at room temperature. By adding some amount of impurity atoms to a pure or intrinsic semiconductor, conductivity of semiconductor changes (increases appreciably). This process of adding impurity to an intrinsic semiconductor is called doping. The impurity atoms can be of two types:

(*a*) Donor Impurity

(*b*) Acceptor impurity

The material used as impurity in the process of doping is called 'dopant'. If dopant is pentavalent *i.e.* atom containing five electrons in valence shell then it is called donor impurity. The examples of pentavalent impurities are Arsenic (As), Phosphorous (P) and Antimony (Sb).

If dopant is trivalent i.e. atom containing three electrons in valence shell then it is called acceptor impurity. The examples of trivalent impurities are Boron (B), Gallium (Ga), Aluminum (Al) and Indium (In).

A doped semiconductor is called extrinsic semiconductor. Depending upon the types of impurity added, there are two types of extrinsic semiconductors:

(*a*) N - type semiconductor

(*b*) P- type semiconductor

N-type semiconductor: When pentavalent impurity is added to the intrinsic semiconductor, n-type semiconductor is formed. Few pentavalent elements are phosphorous (P), antimony (Sb), arsenic (As) etc. Phosphorous has five electrons in its outermost shell. When phosphorous is added to pure silicon, four electron of phosphorous form covalent bond with the four electrons of silicon. One electron remain loosely attached to the phosphorous atom. A little amount of energy ~ 0.01 evis required to make this electron free. Practically at room temperature all such electrons are free. In this way, each impurity atom donates one free electron to conduction band. Due to this, pentavalent impurity is also called donor type impurity.

In n-type semiconductor, electrons are majority carriers and holes are minority carriers.

P-type semiconductor: When trivalent impurity is added to the intrinsic semiconductor, p-type semiconductor is formed. Few trivalent elements are aluminum (Al), boron (B), arsenic (As) etc. Aluminum has three electrons in its outermost shell. When aluminum is added to pure silicon, three electron of aluminum form covalent bond with the three electrons of silicon. One electron of Si can not make a covalent bond and remain loosely attached. When this electron leave the Si atom , it leaves a vacancy (hole)

Due to this, trivalent impurity is also called acceptor type impurity.

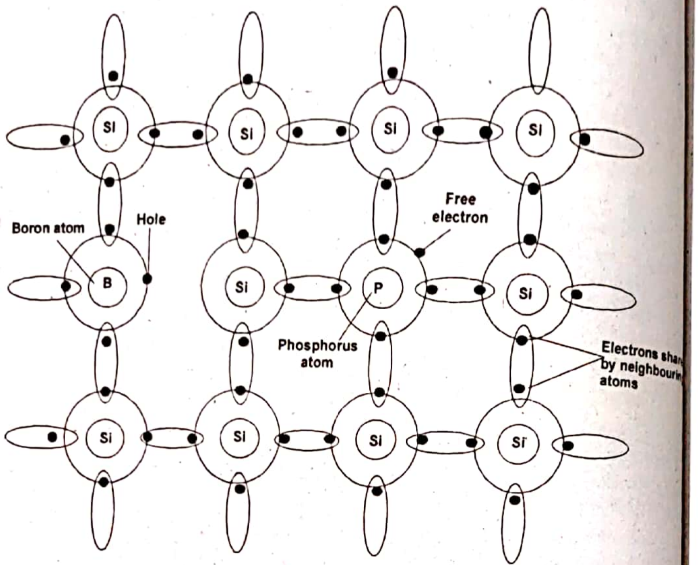


Fig: P type N type Extrinsic Semiconductors

In p-type semiconductor, holes are majority carriers and electrons are minority carriers.

Q.9. (b) Draw circuit diagrams to show forward biased and reversed biased p-n juctions. (3)

Ans. Forward Biased p-n junction diode: In forward biasing condition, p side of a p-n junction diode is connected to positive terminal of external voltage source and n side is connected to negative terminal of external voltage source.Substantial amount of forward current flows when the value of external voltage source is more than the barrier potential. Circuit diagram and V-I characteristics is shown in the figure.

Reverse Biased p-n junction diode: In reverse biasing condition, n side of a p-n junction diode is connected to positive terminal of external voltage source and p side is connected to negative terminal of external voltage source.

Small value of current flows in reverse biased condition and this current is due to the minority carriers. This current is also known as reverse saturation current.

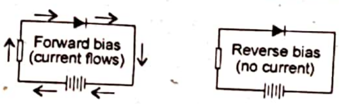


Fig : Circuit Diagrams for forward and reverse bias

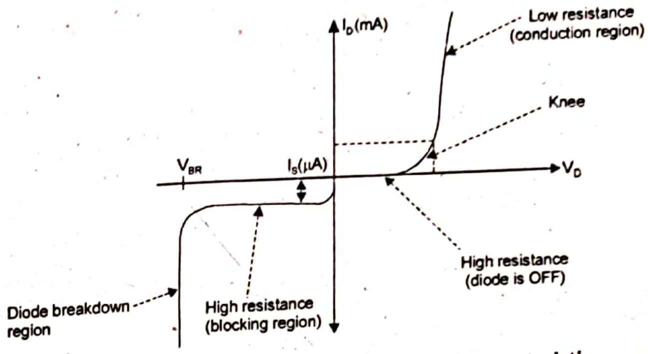
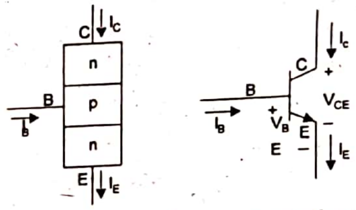


Fig : Figure showing forward and reverse V-I characteristics. Knee voltage and break down voltage is shown here.

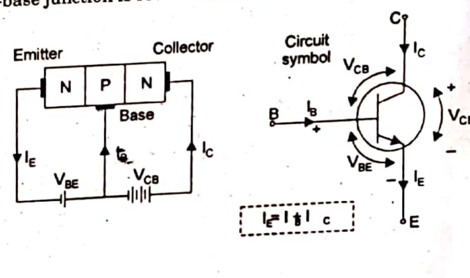
Q.9. (c) Explain the action of a p-n transistor. (6.5)

Ans. Working of a n-p-n transistor: Transistor is a three terminal and two p-n junction device. In this device transfer of resistance takes place hence it is known as Transistor. Transistor are of two types namely p-n-p and n-p-n.



The npn transistor consists of two n-Regions separated by a p-Region. The central portion of transistor which is lightly doped and narrow is called Base B. One of the outer region is heavily doped and moderate in size is known as Emitter E. Emitter emits majority charge carriers. The other outer region is moderately doped and larger in size is known as Collector C. Figure shows the symbol and schematic of n-p-n transistor.

In normal mode of operation of a transistor, Emitter-base junction is forward biased and collector-base junction is reverse biased.



The circuit shows working of npn transistor with base as common terminal for both input and output. Since base- emitter is a forward biased junction, electron being the majority charge carrier in emitter(n region) of n-p-n transistor move towards the base (p region). If V_{EB} overcomes the barrier potential of emitter-base junction, the electron moves to the base junction. This constitutes the emitter current I_E.

In the base region, few electron combines with the holes, which makes base current I_B.

Since the base region is narrow and lightly doped and the base-collector junction is reverse biased, most of the electron cross the base-collector junction and collected in collector. This give rise to collector current I_C.

Thus $$I_E = I_B + I_C$$

By controlling the base current, the collector current can be controlled.

Transistor can be used as amplifier, oscillator and in switching circuit.

END TERM EXAMINATION [DEC. 2015]
FIRST SEMESTER [BCA]
PHYSICS [BCA-109]

Time: 3 Hrs. **MM : 75**

Note: *Attempt any five questions including Q.No.1 which is compulsory.*

Q.1. (a) State ohm's low. Derive the laws of resistances when they are connected in (a) Series (b) parallel.

Ans. Ohm's Law state that :

The potential difference (voltage) across an ideal conductor is proportional to the current through it.

The constant of proportionality is called the "resistance", R.

Ohm's Law is given by:

$$V = IR$$

Where V is the potential difference across **resistance** R and I is the current flowing through R.

When Resistance are connected in series

Fig. 1: Two resistors connected in series

Consider two resistors connected in *series*, as shown in Fig1. It is clear that the same current *I* flows through both resistors. Suppose that the potential drop from point B to point A is *V*. This drop is the sum of the potential drops V_1 and V_2 across the two resistors R_1 and R_2, respectively. Thus,

$$V = V_1 + V_2$$

Accordinged to Ohm's law, the equivalent resistance R_{eq} between B and A is the ratio of the potential drop V across thess points and the current I which flows between them. Thus,

$$R_{eq} = \frac{V}{I} = \frac{V_1 + V_2}{I} = \frac{V_1}{I} + \frac{V_2}{I}$$

Giving

$$R_{eq} = R_1 + R_2$$

Here, we have made use of the fact that current I is common to both resistors. Hence, the rule is "·the equivalent resistance of two resistors connected in series is the individual resistances." For N resistors connected in series, Equation generalize to

$$R_{eq} = \sum_{i=1}^{N} R_i$$

When resistance are connected in parallel

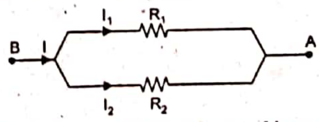


Fig. 2. Two resistors connected in parallel

Consider two resistors connected in parallel, as shown in Fig. 2. It is clear, from the fig. that the potential drop V across the two resistors is the same. In general, however, the currents I_1 and I_2 which flow through resistors R_1 and R_2, respectively, are different. Accroding to Ohm's law, the equivalent resistance R_{eq} between B and A is the ratio of the

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potential drop V across these points and the current I which flows between them. Th current must equal the sum of the currents I_1 and I_2 flowing through the two resistors otherwise charge would build up at one or both of the junctions in the circuit. Thus,

$$I = I_1 + I_2$$

It follows that

$$\frac{1}{R_{eq}} = \frac{I}{V} = \frac{I_1 + I_2}{V} = \frac{I_1}{V} + \frac{I_2}{V},$$

Giving

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}.$$

Here, we have made use of the fact that the potential drop V is common to both resistors. Clearly, the rule is

The reciprocal of the equivalent resistance of two resistances connected in parallel is the sum of the reciprocals of the individual resistances.

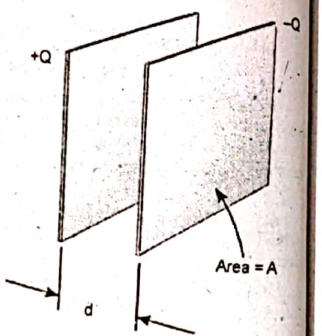
For N resistors connected in parallel, Equation generalizes to

$$1/R_{eq} = \sum_{i=1}^{N}(1/R_i)$$

Q.1.(*b*) What is capacitor? Explain its principle.

Ans. Principle of Capacitor:

A combination of two conductors placed close to each other is called a capacitor. One of the conductor is given a positive charge and the other is given an equal negative charge. The charge on the positive plate is known as charge of the capacitor and the potential difference between the plates is called potential of the capacitor.



A parallel-plate capacitor consists of two large plane plates placed parallel to each other with a small separation between them.

Capacitance is defined as $C = Q/V$ where V is the potential of the capacitor and Q is change of the capacitor.

Q.1. (c) State and explain Newton's second law of motion. Explain some of its consequences.

Ans. Newton's Second law of motion :

Newton's second law states that the forces **F** on an object is equal to the mass m of that object multiplied by the acceleration **a** of the object.

$$\mathbf{F} = m\mathbf{a}.$$

The Second Law is concerned with relating acceleration to mass and net force.

Newton's second law of motion explains how an object will change velocity if it is pushed or pulled upon.

This law states that if you do place a force on an object, it will accelerate (change its velocity), and it will change its velocity in the direction of the force. So, a force aimed in a positive direction will create a positive change in velocity (a positive acceleration). And a force aimed in a negative direction will create a negative change in velocity (a negative acceleration).

Q.1. (*d*) State and explain the laws of limiting friction. How are they verified experimentally?

Ans. Laws of limiting friction: Limiting friction depends on the nature of the surface in contact and their state of polish. It acts tangential to the two surfaces in

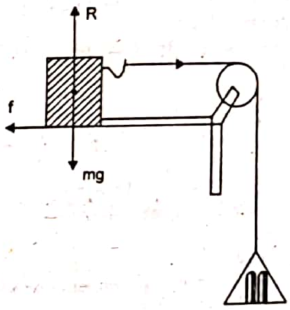
contact and is opposite to the direction of motion of the body. The magnitude of limiting friction is independent of the area of contact.

Laws of limitinf friction

1. The direction of limiting frictional force is always opposite the direction of motion.
2. Limiting friction acts tangential to the two surfaces in contact.
3. The magnitude of limitíng friction is directly proportional to the normal reaction between the two surfaces.
4. The limiting friction depends upon the material, the nature of the surfaces in contact and their smoothness.
5. For any two given surfaces, the magnitude of limiting friction is independent of the shape or the area of the surfaces in contact so long as the normal reaction remains the same.

Verification of law of limiting friction

Take a block of wood of specific mass, a thread, pulley, a pan and a few weights and arrange them as shown in the figure.



Now add a few weights in the empty pan. The block does not move. This shows that even though the string pulls the block to the right, the frictional force pulls it to the left. Hence, 1st law is verified.

Since the frictional force facts horizontal to the surface, it is tangential to the surface of contact. Hence, 2nd law is verified.

Keep adding weights in the pan and on the block so that the block just begins to move. Now add some additional weight on the block and adjust the weight on the pan so that the block just begins to move again. Note the weight of the block + the weight on it and the weight on the pan. You will notice that they increase or decrease proportionally. Hence, law three is verified.

Replace the wooden block with a glass block, stone block and note the weight of the pan. This observation will verify the law of static friction i.e. the fourth law. Now consider any one of the blocks. Change the face of the surface of contact and position of the block. You will notice that the weight in the pan will be the same for all cases (when the block just begins to move). This verifies the law of limiting friction. This verifies the fifth law.

Q.1. (*e*) What is meant by weight? Discuss the apparent weight of a man in a lift/elevator.

Ans. The **weight** of an object is the force of gravity on the object and may be defined as the mass times the acceleration of gravity, w = mg. Since the **weight** is a force, its SI unit is the newton. Density is mass/volume.

Mass is a measurement of how much matter is in an object; **weight** is a measurement of how hard gravity is pulling on that object. **Mass** is the same everywhere whether one is on Earth, on the moon or floating in space where as weight keeps chaging depending upon the gravity.

Apparent Weight: An object's weight, called "actual weight", is the downward force exerted upon it by the earth's gravity. By contrast, an object's apparent weight is the upward force (the normal force, or reaction force), typically transmitted through the ground, that opposes gravity and prevents a supported object from falling.

It is apparent weight, rather than actual weight, that a spring weighing scale measures. An object's apparent weight is equal to its actual weight, except if:

The object has an acceleration with a vertical component (relative to the earth), as in a lift.

Some force other than the earth's gravity and the normal force is acting on the object. This may be buoyancy, magnetic force, centrifugal force, or the gravitational force of another body.

The equation for measuring apparent weight is **F** = mg + ma.

F represents apparent weight in newtons, m is the mass of the object, g is the **acceleration** due to **gravity**(9.8 meters per second squared on Earth's surface) and a is the **acceleration** of the object.

Q.2. (a) Discuss the inelastic collision of two bodies in one dimension. Calculate the velocities of bodies after the collision. Discuss different cases. (7)

Ans. Inelastic Collision: The collision in which only the momentum remains conserved but kinetic energy does not remain conserved are called inelastic collisions.

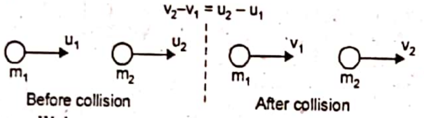
In an inelastic collision some or all the involved forces are non-conservative forces. Total energy of the system remains conserved.

If after the collision two bodies stick to each other then the collision is said to be perfectly inelastic.

One Dimensional or Head-on Collision: If the initial and final velocities of colliding bodies lie along the same line, then the collision is called one dimensional or head-on collision.

Inelastic One Dimensional Collision: Applying Newton's experimental law we have

$$v_2 - v_1 = u_2 - u_1$$



Velocities after collision

$$v_1 = (m_1 - m_2)u_1 + 2m_2u_2/(m_1 + m_2)$$

and

$$v_2 = (m_2 - m_1)u_2 + 2m_1u_1/(m_1 + m_2)$$

When masses of two colliding bodies are equal, then after the collision, the bodies exchange their velocities.

$$v_1 = u_2 \text{ and } v_2 = u_1$$

If second body of same mass ($m_1 = m_2$) is at rest, then after collision first body comes to rest and second body starts moving with the initial velocity of first body.

$$v_1 = 0 \text{ and } v_2 = u_1$$

If a light body of mass m_1 collides with a very heavy body of mass m_2 at rest then after collision

$$v_1 = -u_1 \text{ and } v_2 = 0$$

It means light body will rebound with its own velocity and heavy body will continue to be at rest. If a very heavy body of mass m_1 collides with a light body of mass m_1 collides with a light body of mass $m_2(m_1 >> m_{21})$ at rest, then after collision

$$v_1 = u_1 \text{ and } v_2 = 2u_1$$

In Inelastic One Dimensional Collision

Loss of kinetic energy

$$\Delta E = m_1m_2/2(m_1 + m_2)(u_1 - u_2)^2(1 - e^2)$$

Q.2. (b) A cyclist speeding at 18 km/h on level road takes a sharp circular turn of radius 3 m without reducing the speed. The coefficient of static friction is 0.1 will the cyclist slip while taking the turn. (5.5)

Ans. Given $\mu = 0.1, r = 3\,m$.

Now, the maximum safe speed of the cyclist on unbanked road having frictional coefficient μ is given by

$$v_{max} = \sqrt{\mu r g} = \sqrt{0.1 \times 3 \times 9.8} = 1.71 \text{ ms}^{-1}$$

But, the given speed of the cyclist,

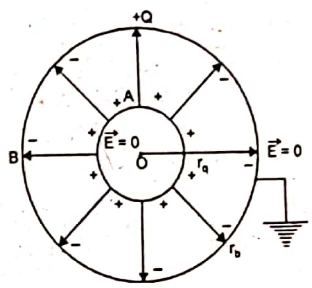
$$v = 18 \text{ km/h} = 18 \times \frac{5}{18} \text{ m/s} = 5 \text{ ms}^{-1}$$

On comparing both the speeds, it is found that the given speed is more than the maximum safe speed; therefore the cyclist will slip.

Q.3. (a) What is a spherical capacitor? Derive an expression for its capacitance. (7)

Ans. Spherical capacitor: Basically the spherical conductors consist of hollow spherical conductor plates having some radius, surrounded by any another sphere.

In this case we have chosen two spheres to clarify its structure *i.e.* Sphere A and sphere B. Sphere A is having a radius r_a and sphere B having radius r_b. Positive charge is given to the inner and outer surface of the conductor A. So B will get induced negative charge on its inner surface and positive charge on its outer surface. We have done earthing of the outer surface of conductor B, so it will be discharged means all the positive charge will go into earth.



Electric field inside the conductor A is Zero according to the phenomenon of Electrostatic shielding.

So E = 0, for $r < r_a$. So electric field outside the plate B will be also Zero.

If E = 0 and $r > r_b$ then the electric field present between the two plates will be directed outwards as shown in the figure below:

The above diagram is of the spherical plate present inside a conductor. The electric potential of the above sphere A is shown below:-

$$V_A = \frac{Q}{4\pi\varepsilon_0 r_a} - \frac{Q}{4\pi\varepsilon_0 r_b}$$

$$V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_a} - \frac{1}{r_b}\right] = \frac{Q}{4\pi\varepsilon_0}\frac{(r_b - r_a)}{r_a r_b}$$

But the sphere B which is the outer one is grounded so its potential becomes zero. If we find the potential difference between both the spheres A and B, then

$$V_A - V_B = \frac{Q}{4\pi\varepsilon_0}\frac{(r_b - r_a)}{r_a r_b}$$

$$C = \frac{Q}{V} = \frac{Q}{V_A - V_B} = \frac{Q4\pi\varepsilon_0 r_a}{Q(r_b - r_a)}$$

$$C = \frac{4\pi\varepsilon_0 r_a r_b}{(r_b - r_a)}$$

Q.3. (b) Three capacitors of capacitance 5,4 and 3μF are connected so that first and second are in series and the third are in parallel with them. Calculate the capacitance of the combination.

Ans. When the capacitors are connected in series.

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C} = \frac{1}{5}+\frac{1}{4} \quad C = 2.2\ \mu F$$

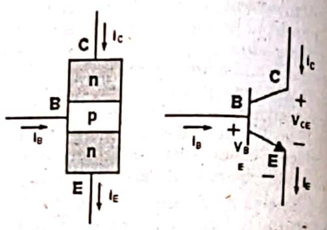
When capacitors are connected in parallel

$$C = C_1 + C_2$$
$$C = 2.2 + 3 = 5.2\ \mu F$$

Q.4. (a) With the help of circuit diagram explain the action of a N-P-N transistors. What are the advantages of transistors? (7)

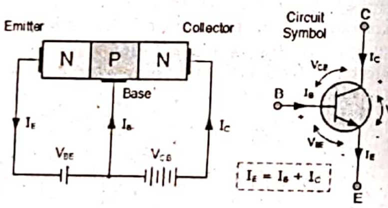
Ans. Working of a *n-p-n* transistor: Transistor is a three terminal and two p-n junction device. In this device transfer of resistance takes place hence it is known as Transistor. Transistor are of two types namely p-n-p and n-p-n.

The npn transistor consists of two n-Regions separated by a p-Region. The central portion of transistor which is lightly doped and narrow is called Base B. One of the outer region is heavily doped and moderate in size is known as Emitter E. Emitter emits majority charge carriers. The other outer region is moderately doped and larger in size is known as Collector *C*. Figure shows the symbol and schematic of *n-p-n* transistor.



In normal mode of operation of a transistor, Emitter-base junction is forward biased and collector-base junction is reverse biased.

The circuit shows working of npn transistor with base as common terminal for both input and output. Since base- emitter is a forward biased junction, electron being the majority charge carrier in emitter (*n*-region) of *n-p-n* transistor move towards the base (*p*-region). If V_{EB} overcomes the barrier potential of emitter-base junction, the electron moves to the base junction. This constitutes the emitter current I_E.



In the base region, few electron combines with the holes, which makes base current I_B.

Since the base region is narrow and lightly doped and the base-collector junction is reverse biased, most of the electron cross the base-collector junction and collected in collector. This give rise to collector current I_C.

Thus
$$I_E = I_B + I_C$$

By controlling the base current, the collector current can be controlled.

Transistor can be used as amplifier, oscillator and in switching circuit.

Q.4. (b) Desribe Rutherford's alpha scattering experiment. (5.5)

Ans. Rutherford α-particle scattering experiment:

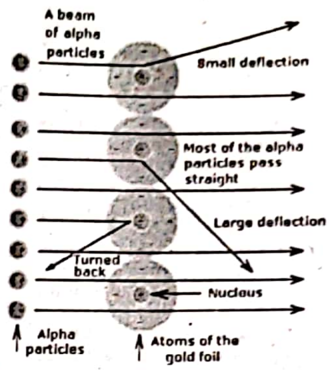
In order to know the arrangement of electrons within an atom, Rutherford designed an experiment where fast moving alpha (α)-particles were made to fall on a thin gold foil.

Rutherford concluded from the α-particle scattering experiment that :

(*i*) Most of the space inside the atom is empty because most of the α-particles passed through the gold foil without getting deflected.

(*ii*) Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.

(*iii*) A very small fraction of α-particles were deflected by very large angles, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.



On the basis of his experiment, Rutherford put forward the nuclear model of an atom, which had the following features:

(*i*) There is a positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.

(*ii*) The electrons revolve around the nucleus in well-defined orbits.

(*iii*) The size of the nucleus is very small as compared to the size of the atom.the radius of the nucleus is about 10^5 times less than the radius of the atom. Nucleus of an atom is very dense and hard.

Q.5. (a) Obtain the condition for balancing of a wheatstone bridge using kirchhoff's laws. (7)

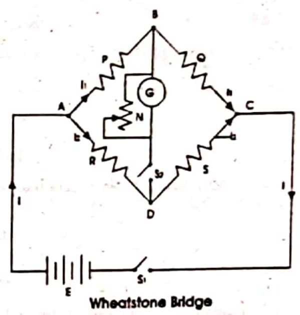
Ans. Wheatstone Bridge: Wheatstone bridge is widely used for measuring any electrical resistance accurately. There are two known resistors, one variable resistor and one unknown resistor connected in bridge form as shown below. By adjusting the variable resistor the current through the Galvanometer is made zero. When the current through the galvanometer becomes zero, the ratio of two known resistors is exactly equal to the ratio of adjusted value of variable resistance and the value of unknown resistance. In this way the value of unknown electrical resistance can easily be measured by using WHEATSTONE BRIDGE.

When Galvanometer current is zero.

$$P/Q = R/S$$

Unknown resistance can be determined using :

$$R = P*S/Q$$



Wheatstone Bridge

Q.5. (b) A body of mass 5kg initially at arrest is subjects a force of 20N. What is the kinetic energy ecquired by the body at the end of 10 sec.? (5.5)

Ans.
$$M = 5\text{ Kg},\quad F = 20\text{ N}$$
$$u = 0,\ t = 10\text{ sec}$$

From Newton's law of motion: $v = u + a*t$

and $a = F/m = 20/5 = 4\text{ m/s}^2$

$v = 0 + 4*10 = 40\text{ m/s}$

Kinetic energy $K = mv^2/2 = 5*40*40/2$

$= 4000$ Joule

Q.6. (a) What is meant by banking of roads? Obtain an expression for the maximum speed which a vehicle can safely negotiate a curved road banked at an angle θ. (7)

Ans. The phenomenon of raising outer edge of the curved road above the inner edge is to provide necessary centripetal force to the vehicles to take a safer turn and the curved road is called Banking of Roads.

Consider a vehicle of weight 'Mg' moving round a curved path of radius 'r' with speed 'V' on a road banked through angle θ. If OA is banked road and OX is horizontal line, then ∠AOX = θ is called angle of banking of road. Refer Fig. (1)

Following forces are involved:

1. The weight 'Mg' acting vertically downwards.
2. The reaction 'R' of the ground to the vehicle acting along normal to the banked road OA in upward direcion.
3. The vertical component R. cos θ of R will balance the weight of the vehicle.
4. The horizontal component R.sin θ of R will provide necessary centripetal force to the vehicle.

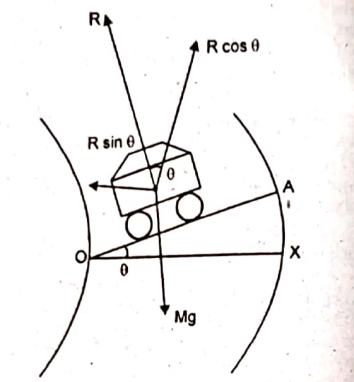


Fig. (1) Vehicle moving on Banked Road

Thus,

$$R.\cos\theta = Mg \quad ...(1)$$

And

$$R\sin\theta = \frac{Mv^2}{r} \quad ...(2)$$

On dividing equation (1) and equation (2), we get

$$\frac{R\sin\theta}{R\cos\theta} = \frac{Mv^2/r}{Mg}$$

$$\tan\theta = \frac{v^2}{rg} \quad ...(3)$$

Knowing 'v' and 'r1', we can calculate θ. If 'h' is the height AX of outer edge of the road then from fig (2).

$$OX = \sqrt{OA^2 - AX^2} = \sqrt{b^2 - h^2}$$

$$\tan\theta = \frac{AX}{OX} = \frac{h}{\sqrt{b^2-h^2}} \quad ...(4)$$

From equations (3) and (4) we get

$$\tan\theta = \frac{v^2}{rg} = \frac{h}{\sqrt{b^2-h^2}}$$

From above eqn. we can calculate h, usually $h << b$. Therefore, h^2 is negligible, hence.

$$\tan\theta = \frac{v^2}{rg} = \frac{h}{b}$$

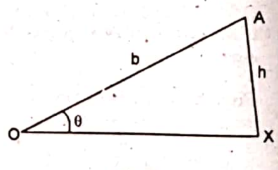


Fig. 2.

Roads are generally banked for the average speed of vehicles passing over them. However, if the speed of a vehicle is somewhat less or more than this, the self adjusting state friction will operate between tyre and road and vehicle will not skid.

Q.6. (b) How does the weight of man standing in a lift changes when the lift accelerates. **(5.5)**

(i) upwards (ii) downwards with an acceleration a.

Ans. Refer Q.3(c) from End Term Examination 2014.

END TERM EXAMINATION [DEC. 2016]
FIRST SEMESTER [BCA]
PHYSICS (BCA–109)

Time : 3 hrs. **M.M. : 75**

Note: Attempt any five questions including Q. no. 1 which is compulsory. Select one question from each unit.

Q.1. (a) Explain Newton's first law from Newton's second law. **(2.5)**

Ans. Newton's second law states that rate of change of momentum is equal to applied force or

$$F \propto \frac{dP}{dt} \text{ or } F = km\frac{dv}{dt}$$

When $F = 0$, $\frac{dv}{dt} = 0$ since $m \neq 0$ and units are so chosen that $k = 1$.

$\Rightarrow v$ is constant or 0

This proves that a body will be at rest or in uniform rectilinear motion when there is no external force acting on it, which is Newton's first law.

Q.1. (b) A 10 gram bullet is shot from a 5 kg gun with a velocity of 400 m/s. What is the speed of recoil of the gun? **(2.5)**

Ans. Mass of the bullet $m_1 = 10\ g = \frac{10}{1000}\ kg$

Initial velocity of the bullet $u_1 = 0$

Final velocity of the bullet $v_1 = 400$ m/s

Mass of the gun $m_2 = 5$ kg

Initial velocity of the gun $u_2 = 0$

Final velocity of the gun $v_2 = ?$

From Law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

or

$$0 = m_1v_1 + m_2v_2$$

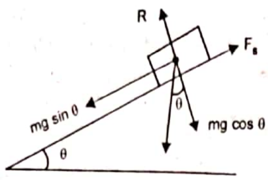
$$\Rightarrow \quad v_2 = -\frac{m_1v_1}{m_2} = -\frac{10}{1000} \times \frac{400}{5}$$

$$\Rightarrow \quad v_2 = -0.8 \text{ m/s}$$

The gun recoils with a speed of 0.8 m/s in a direction opposite to the direction of motion of the bullet (indicated by the negative sign)

Q.1. (c) Define angle of repose and find expression for it. **(2.5)**

Ans. The minimum angle that an inclined plane makes with the horizontal direction such that a body placed on it just begins to slide, is called angle of repose.



Let θ be the angle of repose of a plane on which a body of mass 'm' is placed. Then

$$R = mg\cos\theta \quad ...(1)$$

where R is the normal reaction,

and $$F_s = mg\sin\theta \quad ...(2)$$

Dividing equation (2) by (1)

$$\frac{F_s}{R} = \frac{mg\sin\theta}{mg\cos\theta} = \tan\theta \quad ...(3)$$

Since $$\frac{F_s}{R} = \mu s = \tan\alpha, \quad ...(4)$$

where μ_s is coefficient of friction and α is the angle of friction

From 3 and 4 we have

$$\boxed{\theta = \alpha}$$

The angle of friction is numerically equal to angle of repose.

Q.1. (d) A ball of mass 0.5 kg moving with a velocity of 30 ms^{-1} undergoes a head-on collision with another ball of unknown mass at rest. After collision, it rebounds with velocity of 10 ms^{-1}. Find the mass of other ball. (2.5)

Ans. Here $m_1 = 0.5$ kg, $u_1 = 30$ m/s, $u_2 = 0$

and $v_1 = -10$ m/s

Also,

$$v_1 = \frac{(m_1 - m_2)}{m_1 + m_2}u_1$$

$$\therefore \quad -10 = \frac{(0.5 - m_2)30}{(0.5 + m_2)}$$

$$\Rightarrow \quad -5 - 10m_2 = 15 - 30m_2$$

$$\Rightarrow \quad 20m_2 = 20$$

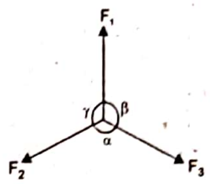
or $$m_2 = 1 \text{ kg}.$$

Hence, the mass of the other ball is 1 kg.

Q.1. (e) What are concurrent forces? Obtain a condition for the equilibirum of three concurrent forces. (2.5)

Ans. A number of forces acting at a common point on a body are called concurrent forces.

Let three concurrent forces F_1, F_2 and F_3 be acting at a point o as shown in the figure.

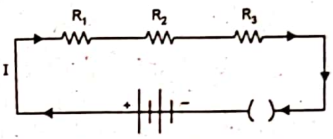


Let the angle between F_2 & F_3 be α, F_3 & F_1 be β and F_1 & F_2 be γ then for equilibrium the following condition is satisfied

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

Q.1. (f) Derive an expression for the resistances connected in series. (2.5)

Ans. Let three resistances R_1, R_2 and R_3 be connected in series to a battery of potential difference V. as shown in the figure.



Let I be the current in the circuit, then

$$V_1 = IR_1 \quad ...(1)$$

$$V_2 = IR_2 \quad ...(2)$$

and $$V_3 = IR_3 \quad ...(3)$$

where V_1, V_2 and V_3 are potential differences a across R_1, R_2 and R_3 respectvely,

Adding (1), (2) of (3) we get

$$V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3 \quad ...(4)$$

$$\Rightarrow \quad V = I(R_1 + R_2 + R_3) \quad ...(5)$$

Here V is total potential difference, then comparing with

$$V = IR \quad ...(6)$$

we get

$$R = R_1 + R_2 + R_3 \quad ...(7)$$

where R is equivalent resistance in series. For n resistors in series, eqn. (7) can be written as

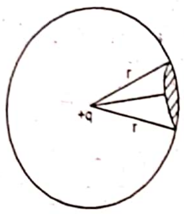
$$R = R_1 + R_2 + ... + R_n$$

Q.1. (g) State and prove Gauss's theorem. (2.5)

Ans. Gauss Theorem: Total electric flux through a closed surface is $1/\varepsilon_0$ times the electric charge enclosed by the surface.

$$\phi_E = \oint\!\!\oint_S \vec{E}.d\vec{s} = \frac{1}{\varepsilon_0} q_{enc}$$

Proof: Let a charge of magnitude +q placed at the origin. Consider a spherical Gaussian surface of radius r and center at the origin, enclosing the charge as shown in the figure



The electric flux through $d\vec{s}$ is

$$\phi_E = \vec{E}.d\vec{s} = |\vec{E}||d\vec{s}|\cos 0° \quad ...(1)$$

$$\Rightarrow \quad \phi_E = Eds \quad ...(2)$$

Total flux is given by

$$\phi_E = \oint\!\!\oint_S Eds = E\oint\!\!\oint_S ds = E\,4\pi r^2 \quad ...(3)$$

The magnitude of electric field due to a charge q at r is given by

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \quad ...(4)$$

From (3) and (4)

$$\phi_E = \frac{q}{4\pi\varepsilon_0 r^2}.4\pi r^2$$

$$\Rightarrow \quad \boxed{\phi_E = \frac{q}{\varepsilon_0}}$$

Hence Gauss theorem is proved.

Q.1. (h) State and explain the postulates of Bohr's atomic model. (2.5)

Ans. Postulates of Bohr's atomic model:

1. Stationary state: Electrons revolve around the nucleus in special orbits in which no radiant energy is emitted. These orbits are called stationary states

2. Angular momentum quantisation: The orbits allowed for electrons are the ones for which angular momentum is an integral multiple of $\frac{h}{2\pi}$ where h is planck's constant ($h = 6.626 \times 10^{-34}$ JS)

or
$$L = \frac{nh}{2\pi}$$

3. Transitions: When an electron makes a transition from state of higher energy to one of lower, a photon of energy equal to energy difference of the two states is emitted.

$$h\nu = E_f - Ei$$

here ν is the frequency of photon emitted, E_f and Ei are final and initial energy states, respectively.

Q.1. (i) Distinguish between intrinsic and extrinsic semiconductors. (2.5)

Ans.

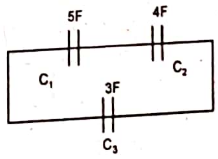
S.No.	Intrinsic semiconductors	Extrinsic semiconductors
1.	These semiconductors are pure group IV elements	1. These semiconductors are obtained by adding pentavalent or trivalent impurities to group IV elements
2.	Electrical conductivity is temperature dependent. It increases with increase in temperature	2. Electrical conductivity is dependent on amount of impurity added
3.	Concentration of electrons and holes is equal i.e. $n_e = n_h$	3. Concentration of electrons is higher in n-type semiconductor and of holes is higher in p-type, semiconductor.
4.	Intrinsic carrier concentration ration is given by $n_i = n_e = n_h$	4. For n type semiconductor semiconductor. $n_e >> n_h$ and for p-type $n_h >> n_e$
5.	**Examples:** Silicon (Si) Germanium (Ge)	**Example** Gallium Arsenide (GaAs) Indium Phosphide (InP)

Q.1. (j) Three capacitors of capacitances 5,4 and 3 farad respectively are connected with the first and second in series and the third in parallel with them. Find the capacitance of the combination. (2.5)

Ans.

Let $C_1 = 5F \quad C_2 = 4F$ and $C_3 = 3F$

Since C_1 and C_2 are in series



$\therefore$ Equivalent capacitance of C_1 and C_2 is

$$C_{12} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{5\times 4}{5+4}F = \frac{20}{9}F$$

Since C_3 is in parallel with C_{12}

Equivalent capacitance

$$C = C_{12} + C_3 = \frac{20}{9} + 3$$

$$C = \frac{47}{9}F$$

Capacitance of the combination is $\frac{47}{9}F$

UNIT-I

Q.2. (a) What is meant by limiting friction? State the laws of friction. (5)

Ans. Limiting friction is the maximum value of static friction between two surfaces in contact with each other. When applied force exceeds limiting friction, the surfaces begin to slide over each other.

Laws of friction:

(1) Force of friction acts tangential to the surface and is directly proportional to the normal reaction.

$F = \mu_s N$, where μ_s is called the coefficient of static friction.

(2) Force of friction is independent of the area of contact.

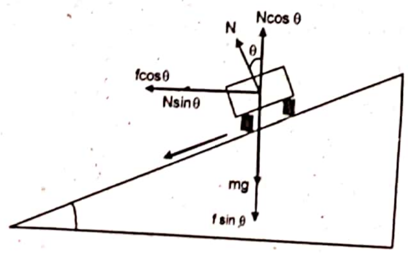
(3) Force of friction depends upon the nature of the surfaces in contact.

(4) Coefficient of static friction is slightly higher than coefficient of kinetic friction.

(5) Within reasonable limits, kinetic friction is independent of the velocity.

Q.2. (b) Obtain an expression for the maximum speed of a vehicle on the banked road. (7.5)

Ans. Maximum speed of a vehicle on a banked road:



The following forces act on a vehicle on a banked road:

1. Weight of the vehicle vertically downwards.
2. Normal reaction (N) normal to the surface of the road, upwards.
3. Friction (f) tangential to the surface, downwards.

Since there is no acceleration in the vertical direction,

$$N\cos\theta = mg + f\sin\theta \quad \text{...(1)}$$

The centripetal force is provided by the horizontal components of f and N therefore,

$$F_{centripetal} = N\sin\theta + f\cos\theta = mv^2/R \quad \text{...(2)}$$

Substituting $f = \mu_s N$ in (1) we get,

$$N\cos\theta - \mu_s N\sin\theta = mg \quad \text{...(3)}$$

$$\Rightarrow N(\cos\theta - \mu_s\sin\theta) = mg \quad \text{...(4)}$$

$$\Rightarrow \quad N = mg/(\cos\theta - \mu_s\sin\theta) \quad \text{...(5)}$$

from(2)

$$N\sin\theta + \mu_s N\cos\theta = mv^2/R$$

$$N(\sin\theta + \mu_s\cos\theta) = mv^2/R \quad \text{...(6)}$$

=>

Substituting value of N from (5) in (6), we get

$$\frac{mg(\sin\theta + \mu_s\cos\theta)}{\cos\theta - \mu_s\sin\theta} = \frac{mv^2_{max}}{R} \text{ or}$$

$$v_{max} = \left\{rg\frac{\mu_s + \tan\theta}{1-\mu_s\tan\theta}\right\}^{\frac{1}{2}}$$

Q.3. (a) How does the weight of man standing on a lift change when the lift accelerates upwards and downwards with an acceleration "a"? Also discuss the variation of weight when the lift moves with uniform velocity and fall freely. (8.5)

Ans. Let the weight of the man be mg and R be the normal reaction.

(i) When the lift is moving up with an acceleration 'a' the following condition holds true:

$$ma = R - mg$$

$$\Rightarrow \quad R = mg + ma = m(g+a)$$

Hence for a lift accelerating upwards, apparent weight is greater than true weight.

(ii) When the lift is moving down with an acceleration 'a'

$$ma = mg - R$$

$$R = mg - ma = m(g - a)$$

$\Rightarrow$

Hence for a lift accelerating downwards, apparent weight is lesser than true weight.

(iii) When the lift of moving upwards or downwards with uniform velocity

$$a = 0$$

$$R = mg$$

$\Rightarrow$

Therefore for a lift moving with uniform velocity, true weight and apparent weight are equal.

(iv) When lift is in free fall, a = g and

$$R = m(g - a) = 0,$$

Hence for free fall the person feels weightless.

Q.3. (*b*) A car of mass 1200 kg can take a turn on a circuular level road of radius of 150 m with a maximum speed of 15m/s without skidding. Find the force of friction and the coefficient of friction.
(4)

Ans. Given that m = 1200 kg, R = 150 m and v_{max} = 15 m/s. Since

$$v^2_{max} = \mu_s Rg$$

or

$$\mu_s = \frac{v^2_{max}}{Rg}$$

$\Rightarrow$

$$\mu_s = \frac{15^2}{150 \times 9.8} = 0.15$$

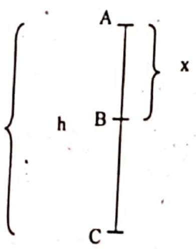
Also, force of friction

$$F = \mu_s N = \mu_s mg = 0.15 \times 1200 \times 9.8 = 1764 \text{ N}$$

UNIT-II

Q.4. (*a*) Show that the total mechanical energy of a body falling freely under gravity is conserved. **(8)**

Ans. Let a body of mass m at rest, fall from point A at a height h as shown in the figure. Further, the body passes through point B at a distance x from the top and makes contact at point C on the ground vertically below A.



Total Energy at A = Potential Energy at A+ Kinetic Energy at A

$$\text{Total Energy at A} = \frac{1}{2}mv^2 + mgh = 0 + mgh = mgh$$

$$\text{Total Energy at B} = \frac{1}{2}m(u^2 + 2gx) + mgh \quad [v^2 - u^2 = 2gx]$$

$$= mgx + mg(h - x) = mgh$$

$$\text{Total Energy at C} = \frac{1}{2}mv^2 + 0$$

$$= \frac{1}{2}m(u^2 + 2gh) = mgh$$

The total mechanical energy at all points is mgh and hence remains conserved.

Q.4. (*b*) Explain work energy theorem. **(4.5)**

Ans. Work Energy Theorem: The work done by net force on a body is equal to change in kinetic energy of the body.

Consider a net force F working on a body of mass m which moves through a small distance dx in the direction of force, then the small amount of work done is given by:

$$\Delta W = F.dx$$

Total work done is then:

$$W = \int F.dx$$

$\Rightarrow$

$$W = \int madx = \int m\frac{dv}{dt}dx = \int mvdv$$

$\Rightarrow$

$$W = \int_u^v mvdv = m\left[\frac{v^2}{2}\right]_u^v = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$\Rightarrow$

$$W = KE_{Final} - K.E._{Initial} = \Delta KE$$

Q.5. (*a*) Define coefficient of restitution and discuss it for three types of collisions. **(4)**

Ans. Coefficient of restitution is defined as the ratio of velocity of approach before collision to velocity of separation after the collision.

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

(i) In case of an elastic collision, the coefficient of restitution is 1 as there is no loss of kinetic energy

(ii) Inelastic collision is a general case where some kinetic energy is lost. The value of coefficient of restitution lies between 0 and 1 for this type of collision.

(iii) For a perfectly inelastic collision maximum kinetic energy is lost. The value coefficient of restitution for such a collision is 0

Q.5. (b) Prove that, when two bodies of equal masses undergo elastic collision in one dimension, their velocities are just interchanged. (8.

Ans. Elastic collision in one dimension: Consider the elastic one dimension collision of a body A having mass m_1 and initial velocity u_1 with another body B of mass m_2 and initial velocity u_2. The final velocities of A and B are v_1 and v_2 respectively. Then, from law of conservation of momentum:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow \quad m_1(u_1 - v_1) = m_2(v_2 - u_2) \quad ...(1)$$

Also, from law of conservation of energy: ...(2)

$$\Rightarrow \quad \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$\Rightarrow \quad m_1u_1^2 - m_1v_1^2 = m_2v_2^2 - m_2u_2^2$$

$$\Rightarrow \quad m_1(u_1 + v_1)(u_1 - v_1) = m_2(v_2 + u_2)(v_2 - u_2) \quad ...(3)$$

Dividing (3) by (2);

$$u_1 + v_1 = u_2 + v_2 \quad ...(4)$$

Substituting of v_2 from (4) in (1)

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2(u_1 - u_2 + v1)$$

$$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2u_1 - m_2u_2 + m_2v_1$$

$$\Rightarrow (m_1 - m_2)u_1 + 2m_2u_2 = (m_1 + m_2)v_1$$

$$\Rightarrow v_1 = \frac{(m_1 - m_2)}{(m_1 + m_2)}u_1 + \frac{2m_2}{(m_1 + m_2)}u_2 \quad ...(5)$$

similarly

$$v_2 = \frac{(m_2 - m_1)}{(m_1 + m_2)}u_2 + \frac{2m_1}{(m_1 + m_2)}u_1 \quad ...(6)$$

For $m_1 = m_2$

Equation (5) becomes

$v_1 = u_2$

and 6 becomes

$v_2 = u_1$

Hence, for bodies of equal mass colliding elastically in one dimension, the velocities interchange.

UNIT-III

Q.6. State Kirchhoff's first and second law and explain how they are applied to derive the principle of Wheatstone bridge. (12.5)

Ans. Kirchoff's Rules

(i) Junction rule: At any junction, the algebraic sum of the currents meeting at a junction is zero.

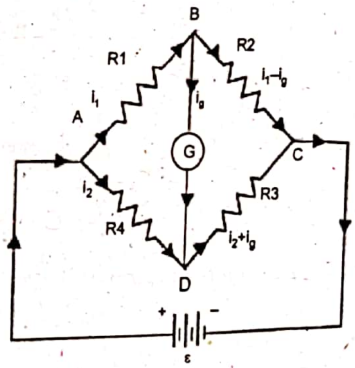
$$\Sigma i = 0$$

(ii) Loop rule: The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero.

$$\Sigma v = 0$$

Wheatstone bridge

Wheatstone bridge is a network of four resistors R1, R2,R3 and R4 connected as shown in the figure.



Applying loop rule to ABDA in the circuit,

$$i_1R_1 + i_gG - i_2R_4 = 0 \quad ...(1)$$

Applying loop rule to BCDB in the circuit,

$$(i_1 - i_g)R_2 - (i_2 + i_g)R_3 - i_gG_g = 0 \quad ...(2)$$

Under balanced condition $i_g = 0$

$\therefore$ (1) and (2) become

$$i_1R_1 = i_2R_4 \quad \text{and} \quad ...(3)$$

and

$$i_1R_2 = i_2R_3 \quad ...(4)$$

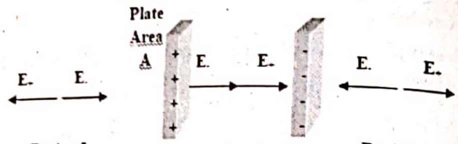
Dividing (3) by (4)

$$\frac{R_1}{R_2} = \frac{R_4}{R_3}$$

The above condition is the underlying principle of the wheatstone bridge.

Q.7. Obtain Expression capacitance of the parallel plate capacitor with and without dielectric. (12.5)

Ans. Capacitance of a Parallel Plate Capacitor (without dielectric) Consider a parallel plate capacitor with plate are 'A' and plate separation 'd' with magnitude of charge on the plates as Q. The space around the capacitor can be divided in three regions as shown in the figure.



The electric fields due to positively and negatively charged plates in Region I are directed opposite to each other and have a magnitude $\frac{\sigma}{2\varepsilon_0}$, therefore net field in region I is:

$$E_1 = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

Similarly, electric field in region III is also zero.

$$E_2 = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

The electric fields due to positive and negative plates in region II are the same direction, therefore field in region II is given by:

$$E = E_1 + E_2$$

$$\Rightarrow \quad E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} \quad ...(1)$$

The electric potential between the plates is

$$V = Ed = \frac{\sigma}{\varepsilon_0} d = \frac{Q}{A\varepsilon_0} d \quad ...(2)$$

The capacitance is given by:

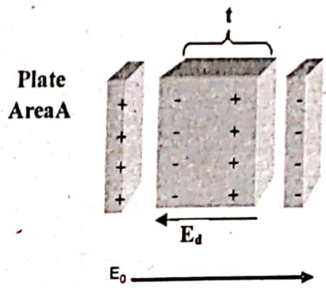
$$C = \frac{Q}{V} \quad ...(3)$$

From (2) and (3)

$$C = \frac{\varepsilon_0 A}{d}$$

Capacitance of a Parallel plate capacitor(with dielectric)

Now a dielectric slab of thickness 't' is inserted between the plates of the capacitor.



The net field within the capacitor in this case would be

$$V = E_0 d - E_d t$$

$$\Rightarrow \quad V = E_0 d - \frac{E_0 t}{k} \quad ...(1)$$

Also, the electric field without dielectric is given by

$$E_0 = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0} \quad ...(2)$$

And the capacitance is

$$C = \frac{Q}{V} \quad ...(3)$$

From (1), (2) and (3)

$$C = \frac{A\varepsilon_0}{\left[d - t + \frac{t}{K}\right]} \quad ...(4)$$

When the dielectric completely fills the capacitor then d = t and (4) becomes

$$C = \frac{A\varepsilon_0}{\left[\frac{d}{k}\right]} = \frac{A\varepsilon_0}{d} K = KC_0$$

$C = KC_0$ where C_0 is the capacitance without the dielectric and K is the dielectric constant of the material which fills up the capacitor

UNIT-IV

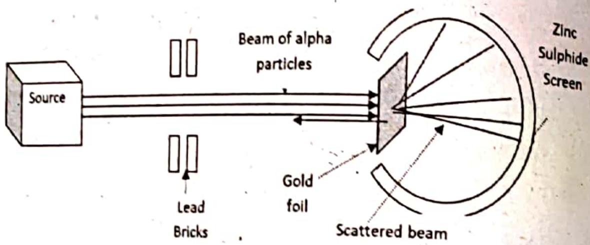
Q.8. What are the drawbacks of Thomson's atom model? Explain Rutherford's experiment on scattering of alpha particles and state the significance of results. (12.5)

Ans. Drawbacks of Thomson model of atom:

- The model could not explain the distribution of charge within the atom.
- The spectrum of various elements could not be explained on the basis of this model.
- It could not explain the stability of the atom.
- It says nothing about the existence of nucleus within the atom.

Rutherford's Alpha Scattering experiment

The experimental setup consist of a radioactive source which emits alpha particles of energy 5MeV. This beam of particles is collimated using lead bricks. The beam is scattered by a thin gold foil having a thickness of the order of a micrometer. A zinc sulphide screen acts as a detector as it produces scintillations(bright spots) when alpha particles are incident on it.



Significance of the result

1.A very large number of alpha particles pass through the foil and do not scatter. This implies that atom consists largely of hollow space.

2.A few alpha particles(0.14%) are deflected by large angles which indicates presence of strong positively charged core.

3.1 in 8000 alpha particles were scattered by 180° which implies that most of the mass and charge is concentrated in a very small space. Rutherford called this area the nucleus of the atom.

Q.9. Write notes on:

Q.9. (a) Distance of closest approach (4.5)

Ans. Distance of closest approach: The alpha particle, before rebounding back, stops at a minimum distance from the nucleus. This distance is called distance of closest approach. It is used to estimate the size of the nucleus.

The potential energy of the alpha particle at distance of closest approach is given by

$$P.E. = \frac{1}{4\pi\varepsilon_0}\frac{2ze^2}{d_{min}} = K.E.$$

$$\Rightarrow d_{min} = \frac{1}{4\pi\varepsilon_0}\frac{2ze^2}{K.E}$$

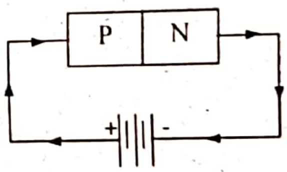
Substituting the known values the nuclear size is estimated as 10^{-15} m

Q.9. (b) Impact parameter (4)

Ans. Impact Parameter: The alpha particle scattering trajectory depends on how close it passes by the nucleus. The impact parameter is the perpendicular distance of the initial velocity vector of the alpha particle from the centre of the nucleus. Alpha particles having small impact parameters are scattered by large angles. For back scattering, impact parameter is minimum.

Q.9. (c) Forward biasing and reverse biasing in p-n junction (4)

Ans. Forward biasing of a p-n junction: A diode is forward biased when external voltage is applied in such a way the the p side of the diode is connected to the positive and n to the negative terminal of the battery.



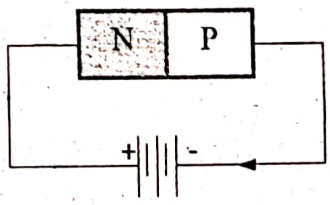
In this condition, following happens:

1.The holes move towards the n side and electrons towards the p side.

2.Most of the voltage is dropped across the depletion region.

3.The barrier voltage decreases and when the applied voltage exceeds the barrier voltage, current starts to flow in the circuit.

Reverse biasing of a p-n junction: A diode is reverse biased when external voltage is applied in such a way the n side of the diode is connected to the positive and p to the negative terminal of the battery.



In this condition, following happens:

1. The majority carriers move away from the junction.
2. Width of the depletion region increases and resistance becomes very large.
3. The minority carriers, i.e., holes on the n side and electrons on the p side move towards the junction. This causes a small current of the order of micro ampere, called reverse current.
4. If excess reverse voltage is applied, diode may breakdown causing large current. This limit of voltage is called breakdown voltage.

END TERM EXAMINATION [DEC. 2017]
FIRST SEMESTER [BCA]
PHYSICS [BCA-109]

Time : 3 hrs. **M.M. : 75**

Note: *Attempt any five questions including Q.no.1 which is compulsory, Select one question from each unit.*

Q.1. Attempt all the parts:

Q.1.(a) State Newton's laws of motion and mention their implications. **(2.5)**

Ans. Newton's first law states that, if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by a force. This postulate is known as the law of inertia.

Newton's second law is a quantitative description of the changes that a force can produce on the motion of a body. It states that the time rate of change of the momentum of a body is equal in both magnitude and direction to the force imposed on it. The momentum of a body is equal to the product of its mass and its velocity. Momentum, like velocity, is a vector quantity, having both magnitude and direction. A force applied to a body can change the magnitude of the momentum, or its direction, or both. Newton's second law is one of the most important in all of physics. For a body whose mass m is constant, it can be written in the form $F = ma$, where F (force) and a (acceleration) are both vector quantities. If a body has a net force acting on it, it is accelerated in accordance with the equation. Conversely, if a body is not accelerated, there is no net force acting on it.

Newton's third law states that when two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction. The third law is also known as the law of action and reaction. This law is important in analyzing problems of static equilibrium, where all forces are balanced, but it also applies to bodies in uniform or accelerated motion. The forces it describes are real ones, not mere bookkeeping devices. For example, a book resting on a table applies a downward force equal to its weight on the table. According to the third law, the table applies an equal and opposite force to the book. This force occurs because the weight of the book causes the table to deform slightly so that it pushes back on the book like a coiled spring.

Q.1.(b) Mention laws of limiting friction and explain how they can be verified experimentally. **(2.5)**

Ans. Refer Q1(d) from End Term Examination December 2015.

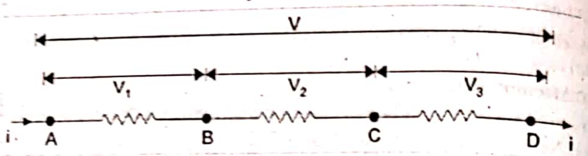
Q.1.(c) Write down the laws of resistances connected in series and parallel. **(2.5)**

Ans. Resistances in Series

Suppose you have, three resistors, R_1, R_2 and R_3 and you connect them end to end as shown in the figure below, then it would be referred as **resistances in series**. In case of series connection, the equivalent resistance of the combination, is sum of these three electrical resistances. That means, resistance between point A and D in the figure below, is equal to the sum of three individual resistances. The current enters in to the point A of the combination, will also leave from point D as there is no other parallel path provided in the circuit.

Now say this current is I. So this current I will pass through the resistance R_1, R_2 and R_3. Applying Ohm's law, it can be found that voltage drops across the resistances will be $V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$. Now, if total voltage applied across the combination of resistances in series, is V. Then obviously

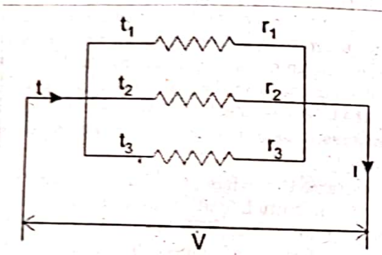
$$V = IR_1 + IR_2 + IR_3$$



Since, sum of voltage drops across the individual resistance is nothing but the equal to applied voltage across the combination.

Resistances in Parallel

Let's three resistors of resistance value R_1, R_2 and R_3 are connected in such a manner, that right side terminal of each resistor are connected together as shown in the figure below, and also left side terminal of each resistor are also connected together.



Parallel Resistor

This combination is called **resistances in parallel**. If electric potential difference is applied across this combination, then it will draw a current I (say). As this current will get three parallel paths through these three electrical resistances, the current will be divided into three parts. Say currents I_1, I_1 and I_1 pass through resistor R_1, R_2 and R_3 respectively. Where total source current $I = I_1 + I_2 + I_3$. Now, as from the figure it is clear that, each of the **resistances in parallel**, is connected across the same voltage source, the voltage drops across each resistor is same, and it is same as supply voltage V (say). Hence, according to Ohm's law, $V = I_1R_1 + I_2R_2 + I_3R_3$.

Q.1.(d) What is a Gaussian surface? Mention the one widely used Gaussian surfaces and how it is produced. **(2.5)**

Sol. A **Gaussian surface** (sometimes abbreviated as G.S.) is a closed surface in three-dimensional space through which the flux of a vector field is calculated; usually the gravitational field, the electric field, or magnetic field.

Spherical surface: A spherical Gaussian surface is used when finding the electric field or the flux produced by any of the following:

- a point charge
- a uniformly distributed spherical shell of charge
- any other charge distribution with spherical symmetry

The spherical Gaussian surface is chosen so that it is concentric with the charge distribution.

Cylindrical surface: A cylindrical Gaussian surface is used when finding the electric field or the flux produced by any of the following:

- an infinitely long line of uniform charge
- an infinite plane of uniform charge
- an infinitely long cylinder of uniform charge

Q.1. (e) Explain how a light emitting diode works. **(2.5)**

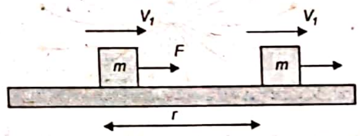
Ans. The light emitting diode emits light when it is forward biased. When a voltage is applied across the junction to make it forward biased, current flows as in the case of any PN junction. Holes from the p-type region and electrons from the n-type region enter the junction and recombine like a normal diode to enable the current to flow. When this occurs energy is released, some of which is in the form of light photons.

It is found that the majority of the light is produced from the area of the junction nearer to the P-type region. As a result the design of the diodes is made such that this area is kept as close to the surface of the device as possible to ensure that the minimum amount of light is absorbed in the structure.

To produce light which can be seen the junction must be optimised and the correct materials must be chosen. Pure gallium arsenide releases energy in the infra read portion of the spectrum. To bring the light emission into the visible red end of the spectrum aluminium is added to the semiconductor to give aluminium gallium arsenide (AlGaAs). Phosphorus can also be added to give red light. For other colours other materials are used. For example gallium phoshide gives green light and aluminium indium gallium phosphide is used for yellow and orange light. Most LEDs are based on gallium semiconductors.

Q.1 (f) State work-energy theorem. **(2.5)**

Ans. The principle of work and kinetic energy (also known as the work-energy theorem) states that the work done by the sum of all forces acting on a particle equals the change in the kinetic energy of the particle. This definition can be extended to rigid bodies by defining the work of the torque and rotational kinetic energy.



Kinetic Energy: A force does work on the block. The kinetic energy of the block increases as a result by the amount of work. This relationship is generalized in the work-energy theorem.

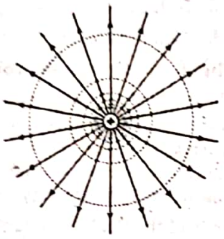
Q.1. (g) Define *equipotential surface* and *equipotential lines*. Schematically show equipotential lines for a point charge and an electric dipole. **(2.5)**

Ans. Equipotential lines are like contour lines on a map which trace lines of equal altitude. In this case the "altitude" is electric potential or voltage. Equipotential lines are always perpendicular to the electric field. In three dimensions, the lines form equipotential surfaces. Movement along an equipotential surface requires no work because such movement is always perpendicular to the electric field.

Equipotential lines: point charge

The electric potential of a point charge is given by

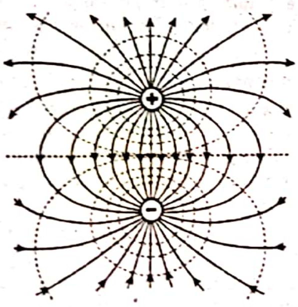
$$V = \frac{kQ}{r} = \frac{Q}{4\pi\varepsilon_0 r}$$



so that the radius r determines the potential. The equipotential lines are therefore circles and a sphere centered on the charge is an equipotential surface. The dashed lines illustrate the scaling of voltage at equal increments - the equipotential lines get further apart with increasing r.

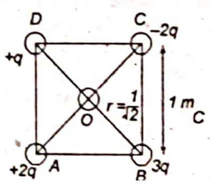
Equipotential lines: Electric dipole

The electric potential of a dipole show mirror symmetry about the center point of the dipole. They are everywhere perpendicular to the electric field lines.



Q.1.(h) Four charges of q, –2q, 3q and 2q are placed at the corners of a square of side 1 m. Calculate the electric potential at the centre of the square (Given: q = 2×10^{-8} C). **(2.5)**

Ans.



As side of square = 1m

Then AC = $\sqrt{2}$

Distance of each and every charge from centre i.e. AO = OC = OB = 0D

$$= \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}} = r$$

Net potential $= k\left(\frac{q}{r} + \frac{3q}{r}\right)$

[Here net potential for points B and C like zero.]

$$V = \frac{K}{r}(4q)$$

$$= \frac{4\pi\varepsilon_0\sqrt{2}}{1}(4q)$$

$$= 16\pi\varepsilon_0\sqrt{2}\,q$$

Q.1. (i) Write down the postulates of Bohr's atomic model. **(2.5)**

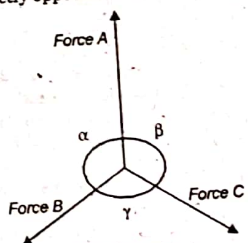
Ans. Refer Q.1(h) from EndTerm Examination December 2016.

Q.1. (j) State Lemi's theorem. Give one application of the theorem. **(2.5)**

Ans. Lami's theorem states that if three coplanar forces are acting on a same point and keep it stationary, then it obeys the relation

$$\frac{A}{\sin(\gamma)} = \frac{B}{\sin(\beta)} = \frac{C}{\sin(\alpha)}$$

where A, B and C are the magnitude of forces acting at the point (say O), and the values of α, β *and* γ are the angles directly opposite to the forces C, B and A respectively.



Lami's Theorem

UNIT–I

Q.2.(a) Explain the concept of banking of roads. Obtain an expression for the maximum speed a car can safely move on a curved road banked at an angle θ. What is the ideal, or critical speed (the speed for which no friction is required between the car's tires and the surface) for a car moving on a curved road of radius 50 m at a banking angle of 15°? **(9)**

Ans. Refer Q.6.(a) from EndTerm Examination December 2015.

Here, radius of curve, r = 50 m

banking angle, θ = 15°

Free-fall acceleration, $g = 9.8\ m/s^2$

We have to find out the ideal speed v (the speed for which no friction is requir[ed] between the car's tires and the surface)

By Using

$$v^2 = rg \tan\theta$$

$$v = \sqrt{rg\tan\theta}$$

$$= \sqrt{(50\ m)(9.8\ m/s^2)(\tan 15^0)} = 11\ m/s$$

If the car has a speed of about 11 m/s, it can negotiate the curve without any frictio[n].

Q.2. (b) A car of mass 2000 kg travels around a flat circular race track of radius r = 85 m. The car starts at rest and its speed increases at the constant rat[e] of 0.6 m/s. What is the speed of the car at the point when its centripetal and tangential acceleration are equal? (3.5)

Ans. The tangential acceleration of the car is

$$a_\theta = 0.6\ m/s$$

When the car travels with tangential velocity υ its centripetal acceleration is

$$a_r = \upsilon^2/r$$

Hence, $a_r = a_\theta$ when $\quad \dfrac{\upsilon^2}{r} = a_\theta$

or $\quad v = \sqrt{r\,a_\theta} = \sqrt{85 \times 0.6} = 7.14\ m/s$

Q.3. (a) Out of three basic Newton's law of motion, which one is the most fundamental one and why? Discuss with the help of suitable example. (8)

Ans. Newton's second law is a quantitative description of the changes that a force can produce on the motion of a body. It states that the time rate of change of the momentum of a body is equal in both magnitude and direction to the force imposed on it. The momentum of a body is equal to the product of its mass and its velocity. Momentum, like velocity, is a vector quantity, having both magnitude and direction. A force applied to a body can change the magnitude of the momentum, or its direction, or both. Newton's second law is one of the most important in all of physics. For a body whose mass m is constant, it can be written in the form $F = ma$, where F (force) and a (acceleration) are both vector quantities. If a body has a net force acting on it, it is accelerated in accordance with the equation. Conversely, if a body is not accelerated, there is no net force acting on it.

This is the most powerful of Newton's three Laws, because it allows quantitative calculations of dynamics: how do velocities change when forces are applied. fundamental difference between Newton's 2nd Law and the dynamics of Aristotle: according to Newton, a force causes only a *change in velocity* (an acceleration); it does not maintain the velocity as Aristotle held.

This is sometimes summarized by saying that under Newton, $F = ma$, but under Aristotle $F = mv$, where v is the velocity. Thus, according to Aristotle there is only a velocity if there is a force, but according to Newton an object with a certain velocity maintains that velocity unless a force acts on it to cause acceleration (that is, a change in the velocity).

Q.3. (b) Discuss various types of friction & their possible causes. Mention some of the advantages of friction. (4.5)

Ans. Types of Friction: Kinetic Friction: When two bodies that are in contact with each other and move rubbing the surfaces that are in contact, the friction existing between them is called kinetic friction. The direction of the force is such that the relative slipping is opposed by the retarding force (friction).

Magnitude of kinetic frictional force $f_k = \mu_k N$

Where,

F_k = magnitude of kinetic friction

N = Normal reaction

μ_k = coefficient of kinetic friction

Static Friction: The opposing force which comes into play when an object does not move over another object, even when the force is applied to make it move is called Static Friction. Hence it can also be defined as a force which comes into play when two bodies are not moving relative to each other.

Static friction prevents objects from sliding or rolling over each other.

For example, when we push a heavy object, because of the friction the object is unable to move through the surface. Then we apply some force on the object. Once it moves through the surface, it is very easy to move further. When we were unable to move the object, it was static friction. When it was moving we were overcoming the kinetic friction, which is found to be less than static friction.

The magnitude of static friction depends upon is (coefficient of static friction) and N (net normal reaction of the body).

Rolling Friction: Rolling frictional force is a force that slows down the motion of a rolling object. Basically it is a combination of various types of frictional forces at point of contact of wheel and ground or surface. When a hard object moves along a hard surface then static and molecular friction force retards its motion. When soft object moves over a hard surface then its distortion makes it slow down.

Fluid Friction: When a body moves in a fluid or in air then there exists a resistive force which slows down the motion of the body, known as fluid frictional force. A freely falling skydiver feels a drag force due to air which acts in the upward direction or in a direction opposite to skydiver's motion. The magnitude of this drag force increases with increment in the downward velocity of skydiver. At a particular point of time the value of this drag force becomes equal to the driving force and skydiver falls with a constant velocity.

Causes of Friction: Let us understand its origin and main cause for it. Take two pieces of sandpaper facing each other. Now bring them in contact and try to rub them against each other, you will find it difficult to move. Why do you think so? The answer is that the irregularities of both the surfaces get locked with each other and prevent slipping.

The same is the case between two sheets of paper, sheets of glass, even two different materials like a wooden plank on a concrete floor, being rubbed against each other. In the case of two well polished surfaces, interlocking occurs but at a microscopic level.

Friction is the retarding force which comes into play when a body actually moves or tends to move over the surface of another body. To move a body we need force. When we move or try to move a body over another body by the aid of a force, the interlocking causes a retarding frictional force which acts in the opposite direction of the applied force.

Friction can also be caused due to molecular adhesion, sticky materials can lead to friction. It can also be caused by deformation. When the material is soft, it deforms under pressure and hence causes more resistance to motion.

ADVANTAGES OF FRICTION: Friction plays a vital role in our daily life. Without friction we are handicap.

1. It becomes difficult to walk on a slippery road due to low friction. When we move on ice, it becomes difficult to walk due to low friction of ice.
2. We cannot fix nail in the wood or wall if there is no friction. It is friction which holds the nail.
3. A horse cannot pull a cart unless friction furnishes him a secure Foothold.
4. It helps in stopping the vehicles when breaks are applied.
5. Fluid Friction Makes Parachutes Float and Planes Fly

UNIT-II

Q.4. (a) Differentiate between elastic and inelastic collisions and obtain an expression for the velocities after collision and the energy lost in inelastic collision between two bodies. (9)

Ans. An elastic collision is a collision where the colliding objects bounce back without undergoing any deformation or heat generation. An inelastic collision is a collision where the colliding objects are distorted and heat is generated.

In an elastic collision, the momentum and total kinetic energy before and after the collision is the same. In other words, it can be said that the total kinetic energy and momentum are conserved during the elastic collision. So there is no wasting of energy in an elastic collision. An example of an elastic collision is the movement of the swinging balls.

In an inelastic collision, the energy changes into other energies such as sound energy or thermal energy. In an inelastic collision, the energy is not conserved. An example of an inelastic collision is an automobile collision.

Some of the characteristics of elastic collisions are as follows: kinetic energy is conserved, linear momentum is conserved, and total energy is conserved. The forces during an elastic collision are conservative, and the mechanical energy is not transformed into some other form of energy such as sound energy or thermal energy.

Some of the characteristics of inelastic collisions are as follows: kinetic energy is not conserved, linear momentum is conserved, and total energy is conserved. The forces during inelastic collisions are non-conservative, and the mechanical energy is transformed into some other form of energy such as sound energy or thermal energy.

Consider two particles of mass m_1 and m_2 moving at velocities $\vec{v}_1$ and $\vec{v}_2$ respectively.

Before they collide, they have a combined energy of $E_{init} = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_1v_2^2$ and combined momentum or $\vec{P}_{init} = m_1\vec{v}_1 + m_2\vec{v}_2$.

Since the collision is perfectly inelastic, after the collision there is a single combined object of mass $m_1 + m_2$. Since momentum is conserved, this object has momentum equal to the total initial momentum $\vec{p} = (m_1 + m_2)\vec{v}_f$. The velocity of the combined object $\vec{v}_f$ is then given by

$$(m_1 + m_2)\vec{v}_f = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$\vec{v}_f = \frac{m_1}{m_1+m_2}\vec{v}_1 + \frac{m_2}{m_1+m_2}\vec{v}_2$$

The energy depends on the squared magnitude of $\vec{v}_f$. which is the dot product of $\vec{v}_f$ with it self. If the angle between $\vec{v}_1$ and $\vec{v}_2$ is θ, then this equals

$$\|\vec{v}_f\|^2 = \frac{m_1^2}{(m_1+m_2)^2}v_1^2 + \frac{m_2^2}{(m_1+m_2)^2}v_2^2 + \frac{m_1m_2}{(m_1+m_2)^2}v_1v_2\cos\theta$$

The final energy E_f is

$$E_f = \frac{1}{2}(m_1+m_2)\|\vec{v}_f\|^2$$

$$= \frac{1}{2}\left[\frac{m_1^2}{(m_1+m_2)}v_1^2 + \frac{m_2^2}{(m_1+m_2)}v_2^2 + \frac{m_1m_2}{(m_1+m_2)}v_1v_2\cos\theta\right]$$

Q.4.(b) A body of mass 50 g moving with speed of 10 m/s undergoes an elastic collision with another body of mass 150 g at rest. Find the kinetic energies of the two bodies after head-on elastic collision. (3.5)

Ans. Collision is elestic in nature

Here $m_1 = 50$ g.

$u_1 = 10$ m/s

$m_2 = 150$ g

$u_2 = 0$ **(body at rest)**

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1$$

$$v_2 = \left(\frac{2m}{m_1 + m_2}\right)u_1$$

$$v_1 = \left(\frac{-100}{200}\right)10 = -5\ m/s$$

$$v_2 = \frac{2\times 50}{200}\times 10 = +5\ m/s$$

Q.5. (a) Define conservative force and prove that gravitational force is a conservative force. Give one example of non-conservative force. (8)

Ans. Refer Q4(a) from End Term Examination December 2014.

Q.5. (b) Discuss conservation of energy in an inelastic collision. (4.5)

Ans. Conservation of energy in Inelastic Collision

In the special case where two objects stick together when they collide, the fraction of the kinetic energy which is lost in the collision is determined by the combination of conservation of energy and conservation of momentum.

From conservation of momentum:

$$m_1v_1 = (m_1 + m_2)v_2 \Rightarrow v_2 = \frac{m_1}{m_1 + m_2}v_1$$

The ratio of kinetic energies before and after is:

$$\frac{KE_f}{KE_i} = \frac{\frac{1}{2}(m_1+m_2)\left[\frac{m_1}{m_1+m_2}v_1\right]^2}{\frac{1}{2}m_1v_1^2} = \frac{m_1}{m_1+m_2}$$

The fraction of kinetic energy lost is:

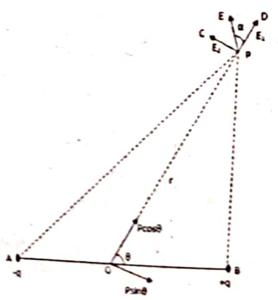
$$\frac{KE_i - KE_f}{KE_i} = \frac{\left[1-\frac{m_1}{m_1+m_2}\right]KE_i}{KE_i} = \frac{m_1}{m_1+m_2}$$

One of the practical results of this expression is that a large object striking a very small object at rest will lose very little of its kinetic energy. If your car strikes an insect, it is unfortunate for the insect but will not appreciably slow your car. On the other hand, if a small object collides inelastically with a large one, it will lose most of its kinetic energy.

UNIT-III

Q.6. (a) Derive an expression for electric field strength at a point due to an electric dipole. (8)

Ans. The below derivation can be used to determine the electric field at any point due to an electric dipole. Thus this is a generalized expression and can be used to determine the electric field due to dipole at equatorial and axial point too.



Consider a short electric dipole AB having dipole moment **p**. Let the point of interest is at a distance r from the centre O of the dipole. Let the line OP makes an angle θ with the direction of dipole moment **p**.

Resolve **p** into two components:

- pcosθ along OP

- psinθ perpendicular to OP

Point P is on the axial line with respect to pcosθ. So, electric field intensity at P due to short dipole is given by:

$$E_1 = 2p\cos\theta/4\pi\xi_0 r^3 \text{ along PD}$$

Point P is on the equatorial line with respect to psinθ. So, electric field intensity at P due to short dipole is given by:

$$E_2 = P\sin\theta/4\pi\xi_0 r^3 \text{ along PC}$$

Since, E1 and E2 are perpendicular to each other the resultant electric field intensity is given by:

$$E = \sqrt{E_1^2 + E_2^2}$$

$$= \sqrt{\left(\frac{2p\cos\theta}{4\pi\xi_0 r^3}\right)^2 + \left(\frac{p\sin\theta}{4\pi\xi_0 r^3}\right)^2}$$

$$= \frac{p}{4\pi\xi_0 r^3}\sqrt{4\cos^2\theta + \sin^2\theta}$$

$$= \frac{p}{4\pi\xi_0 r^3}\sqrt{3\cos^2\theta + 1}$$

This is the expression for electric field due to electric dipole at any point.

Q.6.(b) A parallel plate capacitor has a capacitance of 112 pF, a plate area of 96.5 cm² and a mica dielectric (k_e = 5.4). At a 55 V potential difference, calculate: **(4.5)**

(i) the electric field strength in the mica.
(ii) the magnitude of the free charge on the plates.
(iii) the magnitude of the induced surface charge.

Ans.

$$C_0 = 112 \times 10^{-12}\,F$$
$$A = 96.5 \times 10^{-4}\,m^2$$
$$K = 5.4$$
$$V = 55\,V$$

(i) $$C = kC_0 = k\varepsilon_0\frac{A}{L}$$

$$\Rightarrow \quad 112\,pF = \frac{5.4 \times 8.85 \times 10^{-12} \times 96.5 \times 10^{-4}}{L}$$

$$\Rightarrow \quad L = \frac{5.4 \times 8.85 \times \cancel{10^{-12}} \times 96.5 \times 10^{-4}}{112 \times \cancel{10^{-12}}}$$

$$\Rightarrow \quad 41.18 \times 10^{-4}\,m$$

Now, $$E = V/L$$

$$= \frac{55}{41.18 \times 10^{-4}}$$

$$= 13.4\ KV/m$$

(ii) 112 pf = Q/55V

$Q = 6.16 \times 10$^-9 coulombs = 6.16 nC.

(iii) The magnitude of the induced surface charge on the mica = (4.4/5.4) (6.16 × 10^-9) = 5.019 × 10^-9 coulombs = 5.02 nC

Q.7. (a) What is Wheatstone bridge? Explain it using a schematic diagram. Why are Wheatstone Bridge circuits very important in measuring resistance accurately? **(6)**

Ans. Refer Q.7.(c) from EndTerm Examination December 2014.

A Wheatstone bridge, also called a null comparator, is used for measuring accurate resistance. The major challenge of accurate resistance measurement is to alleviate the loading effect of the circuit by the meter.

Such an inaccuracy is caused by the drawing of power by the meter, although the amount of power drawn is negligibly small, from the circuit, even if it has a very high impedance (e.g 10 MΩ).

For accurate measurement of Rx, the Wheatstone bridge plays a great role, as the galvanometer, in balanced condition, does not draw any power from the circuit. This increases accuracy by alleviating the "loading" effect of the circuit by the meter.

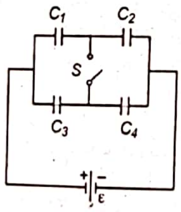
The Wheatstone bridge is called a null comparator because it makes a measurement by comparing two quantities, one of known value, the other unknown.

The unknown value is adjusted until it equals the known value and the detector placed across them gives a zero or null reading.

The following condition holds for the balanced Wheatstone bridge:

$$\frac{R_1}{R_2} = \frac{R_3}{R_X}$$

Q.7. (b) A 12 V battery charges four capacitors are shown in Figure below. **(6.5)**



If $C_1 = 1\ \mu F$, $C_2 = 2\ \mu F$, $C_3 = 3\mu F$, and $C_4 = 4\ \mu f$.

(i) What is the equivalent capacitance of the group C_1 and C_2 if switch S is open?

(ii) What is the charge on each of the four capacitors if switch S is open?

(iii) What is the charge on each of the four capacitors if switch S is closed?

Ans. 1. If switch is S is open the net capacitance of C_1 and C_2

$$\frac{1}{C_1} + \frac{1}{C_2} = 1 + \frac{1}{2} = \frac{3}{2}\mu F$$

2. If switch S is open then charge on each capacitor.

$$q_1 = C_1V = 1 \times 12 = 12\ C$$
$$q_2 = C_2V = 2 \times 12 = 24\ C$$
$$q_3 = C_3V = 3 \times 12 = 36\ C$$
$$q_4 = C_4V = 4 \times 12 = 48\ C$$

3. If S is closed then charge becomes

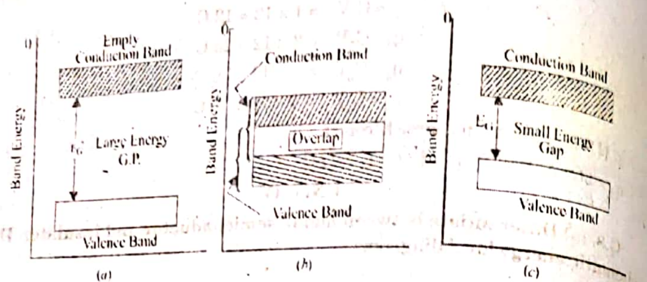
$q_1 = 6C;\ q_2 = 12\ C;\ q_3 = 18\ C;\ q_4 = 24\ C$

UNIT-IV

Q.8. (a) Differentiate between metal, semiconductor and insulator. Draw schematic energy level diagrams. **(6)**

Ans.

Basis for Comparison	Metal	Insulator	Semiconductor
Definition.	The elements which allow the flow of electric current through it by the application of voltage.	The elements which do not allow any flow of electric charge	The elements whose conductivity lies between insulators and conductors.
Electric Conductivity	Good conductor.	Bad conductor.	At 0K works, it works as an insulator while by applying thermal agitation or by adding impurity becomes good conductor.
Examples.	Copper, Mercury, Silver, Al, Water, Acids, Human Body, Metallic Salt, Charcoal.	Wood, Rubber, Glass, Ebonite, Mica, Sulphur, Dry air.	Germanium, Silicon, Cotton, Wool, Marble, Sand, Paper, Ivory, Moist air.
Energy Band.	Conduction band and valence band overlap each other.	Conduction band and valence band are separated by 6eV.	Conduction band and valence band separated by 1eV.
Temperature Coefficient.	Positive temperature Coefficient of resistance.	Negative Temperature Coefficient of resistance.	Negative Temperature Coefficient of resistance.
Charge carriers.	Electrons.	They do not contain any charge carriers.	Intrinsic charge carriers are holes and electrons.
Current Flow.	Current flow due to electrons.	Current does not flow.	Current flow due to holes and electrons.
Number of Charge Carriers.	Very High.	Negligible.	Low.
Effect of temperature on conductivity.	Conductivity decreases.	Conductivity Increases.	Conductivity Increases.
On Increasing Temperature.	The number of current carriers decreases.	The number of current carriers increases.	The number of current carriers increases.

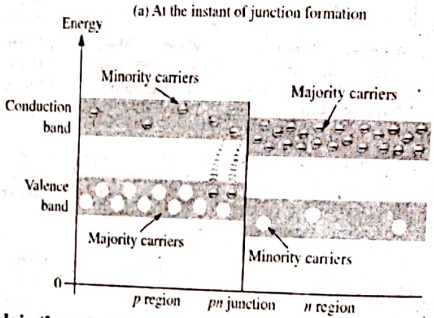


Q.8.(b) Explain the principle of operation of p-n junction diode using energy level diagrams. Draw the current-voltage characteristics of junction diode. **(6.5)**

Ans. The valence and conduction bands in an n-type material are at slightly lower energy levels than the valence and conduction bands in a p-type material. Recall that p-type material has trivalent impurities and n-type material has pentavalent impurities. The trivalent impurities exert lower forces on the outer-shell electrons than the pentavalent impurities. The lower forces in p-type materials mean that the electron orbits are slightly larger and hence have greater energy than the electron orbits in the n-type materials.

An energy diagram for a p-n junction at the instant of formation is shown in Figure. As you can see, the valence and conduction bands in the n region are at lower energy levels than those in the p region, but there is a significant amount of overlapping.

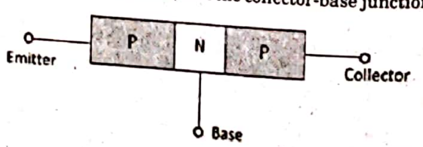
(a) At the instant of junction formation



Q.9. (a) Explain the principles of operation of p-n-p transistor using schematic diagrams. **(6)**

Ans. The transistor in which one n-type material is doped with two p-type materials such type of transistor is known as PNP transistor. It is a current controlled device. The small amount of base current controlled both the emitter and collector current.

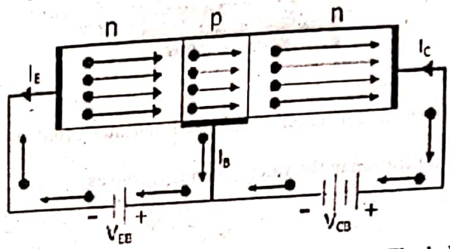
The construction of PNP transistor is shown in the figure below. The emitter-base junction is connected in forward biased, and the collector-base junction is connected in reverse biased. The emitter which is connected in the forward biased attracts the electrons towards the battery and hence constitutes the current to flow from emitter to collector.



The base of the transistor is always kept positive with respect to the collector so that the hole from the collector junction cannot enter into the base. And the base-emitter is kept in forward due to which the holes from the emitter region enter into the base and then into the collector region by crossing the depletion region.

Working of PNP Transistor

The emitter-base junction is connected in forward biased due to which the emitter pushes the holes in the base region. These holes constitute the emitter current. When these electrons move into the N-type semiconductor material or base, they combined with the electrons. The base of the transistor is thin and very lightly doped. Hence only a few holes combined with the electrons and the remaining are moved towards the collector space charge layer. Hence develops the base current.



The collector base region is connected in reverse biased. The holes which collect around the depletion region when coming under the impact of negative polarity collected or attracted by the collector. This develops the collector current. The complete emitter current flows through the collector current I_C.

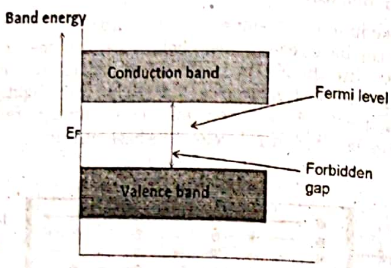
Q.9. (b) Distinguish between intrinsic and extrinsic semiconductors. Schematically show the positions of Fermi levels in an intrinsic semiconductor, an n-type and a p-type semiconductor. **(6.5)**

Ans.

Intrinsic Semiconductors	Extrinsic Semiconductors
Intrinsic semiconductors, also called an undoped semiconductors or i-type semiconductor, are pure semiconductor without any significant dopant species present. The number of charge carriers is therefore determined by the properties of the material itself instead of the amount of impurities.	These are impure semiconductors. When a small quantity of impurity is mixed in a pure or intrinsic conductor, conductivity of semiconductor increases. Such an impure semiconductor is called extrinsic semiconductor.
Conductivity of intrinsic semiconductors is poor.	Conductivity of extrinsic semiconductors is large.
Number of electrons in conduction band and holes in valence band are approximately equal.	If it is an n-type electrons are in majority and if it is a p-type holes are in majority.
Fermi energy level lies at the centre of forbidden energy gap.	In n-type Fermi-level lies near the bottom of conduction band and in p-type near the top of valence base.

Fermi level in intrinsic semiconductor

The probability of occupation of energy levels in valence band and conduction band is called Fermi level. At absolute zero temperature intrinsic semiconductor acts as perfect insulator. However as the temperature increases free electrons and holes gets generated. In intrinsic or pure semiconductor, the number of holes in valence band is equal to the number of electrons in the conduction band. Hence, the probability of occupation of energy levels in conduction band and valence band are equal. Therefore, the Fermi level for the intrinsic semiconductor lies in the middle of forbidden band.



Fermi level in the middle of forbidden band indicates equal concentration of free electrons and holes.

The hole-concentration in the valence band is given as

$$p = N_v.e^{\frac{-(E_F-E_V)}{K_BT}}$$

The electron-concentration in the conduction band is given as

$$n = N_c e^{\frac{-(E_C-E_F)}{K_BT}}$$

Where K_B is the Boltzmann constant

T is the absolute temperature of the intrinsic semiconductor

Nc is the effective density of states in the conduction band.

Nv the effective density of states in the valence band.

The number of electrons in the conduction band is depends on effective density of states in the conduction band and the distance of Fermi level from the conduction band.

The number of holes in the valence band is depends on effective density of states in the valence band and the distance of Fermi level from the valence band.

For an intrinsic semiconductor, the electron-carrier concentration is equal to the hole-carrier concentration.

It can be written as

$$p = n = n_i$$

Where P = hole-carrier concentration; n = electron-carrier concentration

and n_i = intrinsic carrier concentration

The fermi level for intrinsic semiconductor is given as,

$$E_F = \frac{E_C + E_V}{2}$$

Where E_F is the fermi level; E_C the conduction band; E_V is the valence band

Therefore, the Fermi level in an intrinsic semiconductor lies in the middle of the forbidden gap.

END TERM EXAMINATION [NOV. DEC. 2018]
FIRST SEMESTER [BCA]
PHYSICS [BCA–109]

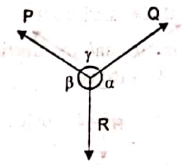
Time : 3 hrs. **M.M. : 75**

Note: *Attempt any five questions in all including Q. no. 1 which is compulsory. Select one question from each unit.*

Q.1. Attempt all parts of following.

Q. 1. (a) State Lemi's theorem and elaborate it with one example. (2.5)

Ans. Lemi's Theorem states that if three concurrent forces are in equilibrium then magnitude of each force is proportional to sine of the angle between other two forces.



$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

where P,Q,R are magnitude of forces acting at a common point (concurrent forces) and α, β, γ are the angles directly opposite to the forces respectively.

Q.1. (b) What is the inertial reference frame? Explain with example. (2.5)

Ans. Inertial Frames are those in which Newton's laws of motion are valid. In this frame of reference a body does not accelerate if zero net force is acting on it: such a body is at rest or moving at a constant speed in a straight line. Earth is considered to be an almost inertial frame because rotation of earth is very slow. So a person waiting for a bus at the bus stop will always be in inertial frame because he is standing still. For a person who is travelling in a bus fellow passengers are at rest. The passenger in a moving bus will be in inertial frame of reference if it is moving with constant velocity.

Q. 1. (c) Write the properties of friction. Why is coefficient of kinetic friction always less than coefficient of static friction? (2.5)

Ans. Whenever the surface of a body slides over another, each body experiences a contact force which always opposes the relative motion between the surfaces. This contact force is called frictional force. Intermolecular interaction arising due to elastic properties of matter is the cause of frictional force.

Types of frictions

(i) Static friction: It is the friction force that acts between surfaces at rest. It is almost independent of the area of contact (Although it is dependent on micro area of contact). It is proportional to normal force. This static friction force can vary from zero to a certain maximum value. It is self adjusting force.Maximum static friction force: or limiting friction is the opposing force which comes into play when a body is just on the verge of moving over surface of another body.

(ii) Kinetic Friction: When the applied force increases beyond limiting friction the body actually starts moving. The opposing force which comes into play when a body starts moving over another surface is called kinetic friction. It opposes relative motion.

Coefficient of kinetic friction is always less than coefficient of static friction. More force is required to move a body at rest because of inertia and more inter molecular interaction between the surfaces as compared to when the object is in motion. Therefore coefficient of static friction is always greater than coefficient of kinetic friction.

Q. 1. (d) Suppose a particle moveds along x-axis, decide whether the K.E. of particle increase, decrease or remain same if velocity changes.

(i) From -3m/sec to -2 m/sec (ii) From -2m/sec to 2m/sec. **(2.5)**

Ans. (i) Velocity changes from -3m/s to -2m/s.

Kinetic energy $K = \frac{1}{2} m v^2$

Initial Kinetic Energy = $\frac{1}{2}$ m $(-3)^2$ = 4.5m joule ;

Final Kinetic Energy = $\frac{1}{2}$ m $(-2)^2$ = 2m joule

if velocity changes from -3m/s to -2m/s the kinetic energy of the particle decreases.

(ii) Velocity changes from -2m/s to 2m/s.

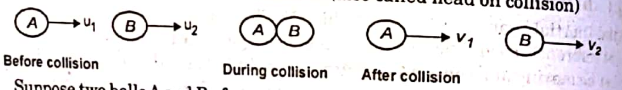
Initial Kinetic Energy = $\frac{1}{2}$ m $(-2)^2$ = 2m joule ;

Final Kinetic Energy = $\frac{1}{2}$ m $(2)^2$ = 2m joule

∴ if velocity changes from –2m/s to 2m/s the kinetic energy of the particle remains same.

Q. 1.(e) Show that in 1-D elastic collision, the relative velocity of the particle is unchanged in magnitude but is reversed in direction. **(2.5)**

Ans. Elastic Collision in one Dimension (also called head on collision)



Suppose two balls A and B of masses m_1 and m_2 are moving initially along the same straight line with velocities u_1 and u_2 respectively,

When $u_1 > u_2$ relative velocity of approach before collision = $u_1 - u_2$

Hence the two balls collide. Let the collision be perfectly elastic. After collision, suppose v_1 is velocity of A and v_2 is velocity of B along the same straight line. When $v_2 > v_1$ the bodies separate after collision.

Relative velocity of separation after collision = $v_2 - v_1$

Linear momentum of the two balls before collision = $m_1 u_1 + m_2 u_2$

Linear momentum of the two balls after collision = $m_1 v_1 + m_2 v_2$

As linear momentum is conserved in an elastic collision, therefore

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2 \quad ...(1)$$

or

$$m_1 (u_1 - v_1) = m_2 (v_2 - u_2) \quad ...(2)$$

Total K.E. of the two balls before collision = $\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$

Total K.E. of the two balls after collision = $\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

As K.E. is also conserved in an elastic collision,

$$\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 \quad ...(3)$$

Or

$$\frac{1}{2} m_1 (u_1^2 - v_1^2) = \frac{1}{2} m_2 (v_2^2 - u_2^2)$$

Or

$$m_1 (u_1^2 - v_1^2) = m_2 (v_2^2 - u_2^2) \quad ...(4)$$

Divide equation (4) by equation (2)

$$\frac{m_1 \left(u_1^2 - v_1^2\right)}{m_1 (u_1 - v_1)} = \frac{m_2 (v_2^2 - u_2^2)}{m_2 (v_2 - u_2)}$$

Or

$$\frac{(u_1 + v_1)(u_1 - v_1)}{u_1 - v_1} = \frac{(v_2 + u_2)(v_2 - u_2)}{(v_2 - u_2)} \quad ...(5)$$

Or

$$u_1 + v_1 = v_2 + u_2$$

Or

$$v_2 - v_1 = u_1 - u_2$$

Hence in one dimensional elastic collision relative velocity of separation after collision is equal to relative velocity of approach before collision.

Q.1. (f) State Gauss's law in electrostatics and show that $\Delta \vec{E} = \rho/\epsilon_0$, where ρ is charge density. **(2.5)**

Ans. Gauss' law in electrostatics states that the total electric flux out of a closed surface is equal to the charge enclosed divided by the permittivity.

$$\Delta \phi = \frac{q}{\epsilon_0} \Rightarrow \Delta E . \Delta S = \frac{q}{\epsilon_0}$$

$$\Rightarrow \Delta E = \frac{q}{\Delta S . \epsilon_0} = \frac{\rho}{\epsilon_0}. \text{ Hence proved}$$

Q.1. (g) State Kirchhoff's rule and explain it. **(2.5)**

Ans. Kirchhoff's Rules

Ist Law or Current Law or Junction Rule:

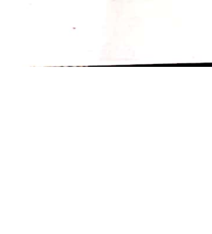
The algebraic sum of electric currents at a junction in any electrical network is always zero, i.e ΣI=0 at any point in a circuit. This law is based on conservation of charge.

2nd Law or The Loop Rule or Voltage Law

The rule states that " the algebraic sum of potential difference across all the circuit elements along a closed loop in a circuit is zero.

ΣV=0 in a closed loop. Kirchoff's **loop rule is based on the law of conservation of energy.**

1st Law



2nd Law.

First consider loop ACDA, $-I_3R_3 + E - I_1R_1 - I_2R_2 = 0$

For loop ABCA, $-I_4R_4 - I_5R_5 + I_2R_2 = 0$

Q. 1.(h) Give the postulates of Bohr's Model.

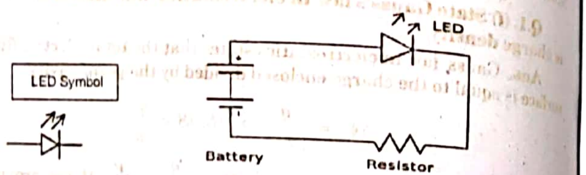
Ans. Refer Q.1.(h) of End Term Examination 2016. **(2.5)**

Q. 1. (i) Write the name of current carriers in semiconductor materials. What is the effect of temperature in intrinsic semiconductors? (2.5)

Ans. Current carriers in semiconductors are electrons and holes. Number density of electrons and holes is same in intrinsic semiconductors. As temperature increases more covalent bonds are broken due to thermal energy gained by electrons, thus electrons leave the bond and jump to conduction band leaving holes behind in valence band. Therefore as temperature increases resistance of a semiconductor decreases.

Q. 1. (j) Give the working and applictions of LED. (2.5)

Ans. Light emitting diode (LED): Light emitting diode is a photo electronic device which converts electrical energy into light energy. It is a heavily doped p-n junction diode which under forward bias emits spontaneous radiation. The diode is covered with a transparent cover so that the emitted light may come out.



When p-n junction is forward biased, the movement of majority charge carriers takes place across the junction. The electrons move from n-side to p-side through the junction and holes from p-side to n-side through the junction, then due to recombination of holes and electrons energy is released at the junction which is emitted as light. Since it lies in visible region so it can be observed.

Applications: LEDs are used in various electronic devices such as digital watches, traffic lights, calculators, digital displays, LED televisions.

UNIT-I

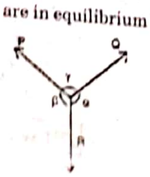
Q. 2. (a) Discuss the equilibrium of concurrent forces with examples. A resultant force of 20 N gives a body of mass m an acceleration of 8.0 m/sec², and a body of mass M an acceleration of 24 m/sec². What acceleration will this force cause two masses to acquire if fastened together? (8)

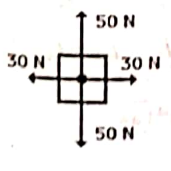
Ans. Concurrent forces are those forces which act at a common point.

A body is said to be in equilibrium if the net force acting on the body is zero. A body in equilibrium may be at rest or in uniform motion because in uniform motion velocity is constant hence acceleration is zero.

If two forces are acting on a body; for the body to be in equilibrium $\vec{F1} + \vec{F2} = 0$.

If three forces are in equilibrium then they can be represented as: $\vec{P} + \vec{Q} + \vec{R} = 0$



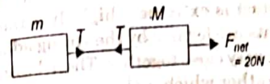


If four forces are in equilibrium then $\vec{F1} + \vec{F2} + \vec{F3} + \vec{F4} = 0$.

(i) $F_{net} = 20N$, $a = 8\ m/s^2$, mass = m $F = ma \Rightarrow m = \frac{F}{a} = \frac{20}{8} = 2.5\ kg$

(ii) $F_{net} = 20N$, $a' = 24 m/s^2$, mass = M

$$\Rightarrow \quad M = \frac{F_{net}}{a'} = \frac{20}{24} = \frac{5}{6} kg$$



$F_{net} = 20N$ $F_{net} - T = Ma$ ...(1)

and $T = ma$ ...(2)

Using (1) and (2)

$F_{net} - ma = Ma \Rightarrow F_{net} = (M + m)\, a$

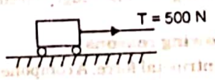
$$\Rightarrow a = \frac{F_{net}}{M + m} = \frac{20}{\frac{5}{6} + 2.5} = 6\ m/s^2$$

Q. 2. (b) Explain the need for automobile seat belts in terms of Newton's first law. A horizontal cable pulls a 200 kg cart along a horizontal track. The tension in the cable is 500 N. Starting from rest (a) how long will it take the cart to reach a speed of 8 m/sec? (b) How far will it have gone? (4.5)

Ans. According to Newton's first law 'Every body continues to remain in its state of rest or of uniform motion in a straight line unless compelled by some external force to act otherwise'.

It is a common experience to have a jerk when a vehicle starts moving from its position of rest. Our body which is at rest inside the vehicle starts moving along with the vehicle, when it starts all of a sudden. Only the lower part of the body starts moving whereas the upper part of the body continues to be at rest because of tendency of a body to continue in its state of rest unless it is acted upon by an external force according to Newton's first law. Therefore there is a need for seatbelts in automobiles for safety of the person sitting inside, in case automobile starts or stops suddenly the person is not hurt.

$m = 200\ kg$, $T = 500\ N$



$u = 0\ m/s$, $v = 8\ m/s$

$T = ma \quad \Rightarrow a = \frac{T}{m} = \frac{500}{200} = 2.5\ m/s^2$ $\boxed{a = 2.5\ m/s^2}$

Now $v = u + at \Rightarrow 8 = 0 + 2.5 \times t \Rightarrow \boxed{t = 3.2 s}$

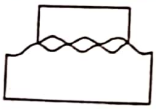
Also $v^2 - u^2 = 2as \Rightarrow 64 - 0 = 2 \times 2.5 \times s$

$\Rightarrow \boxed{s = 12.8\ m}$

Q. 3. (a) Explain microscopic basis of friction. Consider an automobile moving along a straight horizontal road with a speed v_0. The driver applies the brakes and brings the car to a halt without skidding. If the coefficient of static friction between tires and road is μs, what is the shortest distance in which the automobile can be stopped? (6)

Ans. Whenever the surface of a body slides over another, each body experiences a contact force which always opposes the relative motion between the surfaces. This contact force is called frictional force.

Earlier it was thought that roughness of the two surfaces causes friction (in the figure) because it can be easily seen that smoother the surfaces, lesser is the friction. Interlocking of irregularities of the two surfaces causes hindrance to sliding. The current view is a slight deviation from the old view. Due to irregularities, the common surface area which is in actual contact of the two surfaces, is much less than the total overall area in contact. The pressure at the points of contact is extremely high. It is thought that at the points of contact, small, cold-welded joints are formed by the strong adhesive forces between molecules of two surfaces which are very close together. These have to be broken away before one surface can move over the other which is the cause of friction.



$u = v_0$; $v = 0$, $f_{sm} = \mu_s R$

$$a = \frac{F}{m} = \frac{f_{sm}}{m}$$

$$= \frac{\mu_s \cancel{m} g}{\cancel{m}}$$

$$\Rightarrow \boxed{a = \mu_s g}$$

$v^2 - u^2 = 2as$

$\Rightarrow 0 - v_0^2 = 2as$

$\Rightarrow -v_0^2 = 2\mu_s gs$

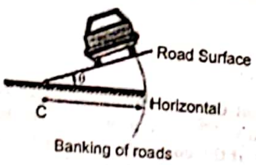
$$\Rightarrow \boxed{s = \frac{v_0^2}{2\mu_s g}}$$

Q. 3. (b) Why is roadbed is banked for transportation? Show that angle of banking is tan(θ) = v²/Rg, where R is curvature of radius and v is velocity of object. A conical pendulum is formed by attaching a 53 gm pebble to a 1.4 m string. The pebble swings around in a circle of radius 25 cm. What is the speed of pebble? (6.5)

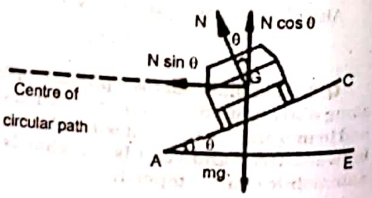
Ans. The phenomena of raising the outer edge of a curved road above the inner edge is called banking.

Banking is done for following reasons

1. To provide necessary centripetal force. A component of normal reaction provides the necessary centripetal force even if friction is not adequate.
2. To reduce frictional wear and tear of tyres.
3. To avoid skidding
4. To avoid overturning of vehicles.



Banking of roads

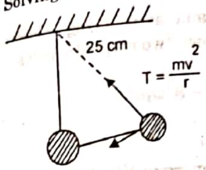


If friction is absent we can write following equations from the diagram

$N \cos\theta = mg$ ...(1)

$N \sin\theta = mv^2/r$ ...(2) where mv^2/r is the centripetal force,

Solving (1) and (2) angle of banking is $\tan\theta = v^2 / rg$



$m = 53$ g

$r = 25$ cm $= 0.25$ m

$$\frac{mv^2}{r} = mg$$

$\Rightarrow v^2 = rg$

$v^2 = 250 \times 10^{-2}$

$v^2 = 2.5$

$$\boxed{v = \sqrt{2.5}\ \text{m/s}}$$

UNIT-II

Q. 4. (a) State and prove work energy theorem. What is the conservative force? The potential energy of a particle undergoing one dimensional motion along the *x*-axis is $U(x) = \frac{1}{4}cx^4$, c is 8N/m³. Its total energy at $x = 0$ is 2 Joule, and it is not subject to any non-conservative force. Find (a) the positions where its kinetic energy is zero. (b) the force at this position. (5)

Ans. Work- Energy theorem states that work done by a force in displacing a body is equal to the change in kinetic energy of the body.

To prove the work energy theorem for a constant force, suppose

m = mass of the body,

u = initial velocity of the body,

F = force applied on the body in the direction of motion,

v= final velocity of the body

according to equation of motion $v^2 - u^2 = 2as$

multiply both sides by ½ m

$\frac{1}{2}m(v^2 - u^2) = mas = Fs$ (because F= m a)

$\frac{1}{2}m(v^2 - u^2) = W$ ($W = Fs\cos 0°$ force and displacement in same direction)

∴ change in kinetic energy = work done (**Hence proved.**)

Conservative Forces: A force is said to be conservative if work done by or against the force in moving a body depends only on the initial and final positions of the body, and not on the nature of path followed between the initial and the final positions.

Properties of conservative forces:

1. Work done by or against a conservative force, in moving a body from one position to the other depends only on the initial and final positions of the body.

2. Work done by or against a conservative force does not depend upon the nature of the path followed by the body in going from initial position to the final position.

3. Work done by or against a conservative force in moving a body through any round trip (i.e. closed path(also called cyclic path), where final position coincides with the initial position of the body is always zero.

For example, Gravitational force is a conservative force.

Other example of conservative forces are: force in an elastic spring ; electrostatic force between two electric charges, magnetic force between two magnetic poles.

$$U(x) = \frac{1}{2}Cx^4, \quad C = 8\,N/m^3$$

$$\text{Total energy} = 2\,J \text{ at } x = 0$$

$$\text{Total energy} = \text{Potential energy + Kinetic energy}$$

$$= \frac{1}{4}Cx^4 + \frac{1}{2}mv^2$$

(i) When K.E. = 0

$$T.E = \frac{1}{4}Cx^4 = 2$$

$$\Rightarrow x^4 = 1$$

$$\Rightarrow x = \pm 1$$

(ii)

$$F = -\frac{\Delta U}{\Delta x} = -\frac{1}{4}C.4.x^3$$

$$= -\frac{1}{4}C_4\Big]_{x=\pm 1} = -8x^3, \quad F = -8N$$

or

$$F = 8\,N.$$

Q. 4. (b) Derive the expression of gravitational potential energy to bring an object from infinity. How much electrical energy would be used by an elevator lifting a 75 Kg person through a height of 50 m if the elevator system has overall efficiency of 25%. Assume the mass of the empty elevator car is properly balanced by a counterweight. (7.5)

Ans. Gravitational potential energy to bring from infinity **derivation: out of** syllabus derivation.

$$m = 75\,kg, \quad h = 50m, \quad \eta = 25\%, \quad \eta = \frac{W_0}{W_i}$$

$$\text{Input energy} = W = mgh$$

$$= 75 \times 10 \times 50$$

$$= 37500\,J.$$

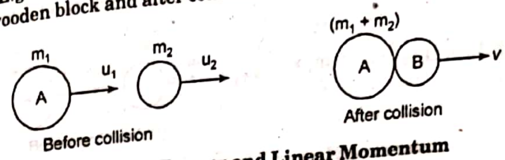
$$\eta = \frac{W_0}{W_i} \Rightarrow \frac{25}{100} = \frac{W_0}{37500}$$

$$\Rightarrow W_0 = 375 \times 25$$

$$\boxed{W_0 = 9{,}375\,J}$$

Q. 5. (a) What is completely inelastic collision? Express the kinetic energy of a particle in terms of its mass m and the magnitude of linear momentum PA block of mass m_1 = 4 Kg and initial velocity u_1 = 41 m/sec makes a 1-D elastic collision with a block of mass m_2 = 3 Kg at u_2 = 21 m/sec. Find their final mommentum. (5.5)

Ans. Perfectly inelastic collision is the collision in which two bodies stick together after collision. E.g. when mud is thrown on the wall it sticks to the wall, or when bullet is fired into a wooden block and after collision both move together.



Relation between Kinetic Energy and Linear Momentum

Let m = mass of a body

V = velocity of the body

∴ Linear momentum of the body, P = m v

And K.E. of the body $= \frac{1}{2}mv^2 = \frac{1}{2}\frac{(m^2v^2)}{m}$

$$\therefore K.E. = \frac{p^2}{2m}$$

$$m_1 = 4\,kg, \quad m_2 = 3\,kg, \quad u_1 = 41\,m/s, \quad u_2 = 21\,m/s$$

$$v_1 = \frac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2} = \frac{167}{7}$$

$$v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2} = \frac{307}{7}$$

$$\text{Final momentum} = m_1v_1 + m_2v_2$$

$$= 227\,kg\,m/s.$$

Q. 5. (b) Derive the expression of the centre of mass of two colliding bodies if the target is initially stationary. An electron collides elastically with Hydrogen atom intially at rest. What percentage of electron's initial kinetic energy is transformed to Hydrogen atom? The mass of the Hydrogen atom is 1840 times the mass of electron) (7)

Ans. Centre of mass expression out of syllabus

$$m_H = 1840\,m_e \qquad \underset{u_1}{e} \longrightarrow \underset{u_2=0}{(H)}$$

$$\text{Initial kinetic energy of } e^- = \frac{1}{2}m_eu_1^2$$

$$\text{Final kinetic energy of H} = \frac{1}{2}m_Hv_2^2$$

$$v_2 = \frac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2} = \frac{2m_1u_1}{m_1 + m_2}$$

$$= \frac{2m_1u_1}{1841m_1}$$

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$$\Rightarrow v_2 = \frac{2u_1}{1841}$$

Initial K.E. of $H^- = 0$

$$\text{Final K.E. of H} = \frac{1}{2}\,1840\,m_1 \times \left(\frac{u_1}{1841}\right)^2$$

$$= \frac{2\times 1840}{(1841)^2} m_1 u_1^2$$

$$\frac{x}{100}\times\frac{1}{2}m_1u_1^2 = \frac{2\times 1840}{(1841)^2}m_1u_1^2$$

$$\Rightarrow \boxed{x = 0.2\%}$$

UNIT-III

Q.6. (a) What is the source of frictional electricity? Give the properties of electric lines of force. A proton orbits with a speed 294 km/sec just outside a charged sphere of radius 1.13 cm. Find the charge on the sphere. (m_p –1.27 × 10^{-27} kg $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m) (8)

Ans. Frictional electricity is the electricity produced by rubbing two suitable bodies and transfer of electrons from one body to other. If we pass a comb through hair, comb becomes electrically charged and can attract small pieces of paper.

Properties of Electric Lines of Force or Field Lines:

1. The electric lines of force are imaginary lines.

2. A unit positive charge placed in the electric field tends to follow a path along the field line if it is free to do so.

3. The electric lines of force originate from a positive charge and terminate on a negative charge.

4. The tangent to an electric field line at any point gives the direction of the electric field at that point.

5. Two electric lines of force can never cross each other. If they do, then at the point of intersection, there will be two tangents. It means there are two values of the electric field at that point, which is not possible.Further, electric field being a vector quantity,there can be only one resultant field at the given point, represented by one tangent at the given point for the given line of force.

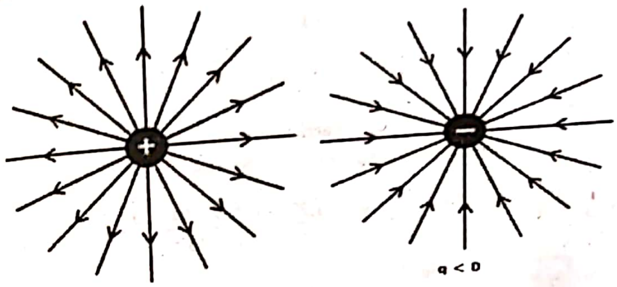
6. Electric lines of force are perpendicular to the surface of a positively or negatively charged body.

7. Electric lines of force contract lengthwise to represent attraction between two unlike charges.

8. Electric lines of force exert lateral (sideways) pressure to represent repulsion between two like charges.

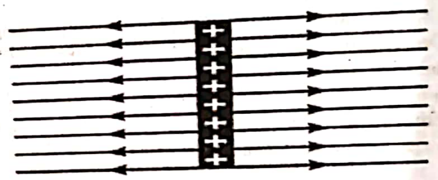
9. Electric lines of force do not pass through a conductor. Hence, the interior of the conductor is free from the influence of the electric field.

- The magnitude of the field is indicated by the density of the field lines.
- Magnitude is strong near the center where the field lines are close together, and weak farther out, where they are relatively apart.
- Field lines of a single positive charge points radially outwards while that of a negative charge are radially inwards as shown below in the figure.

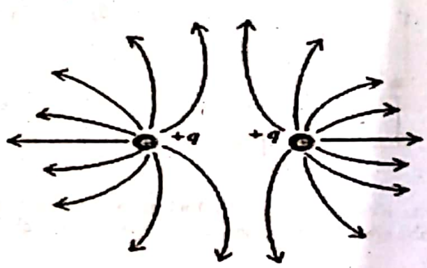


q > 0 q < 0

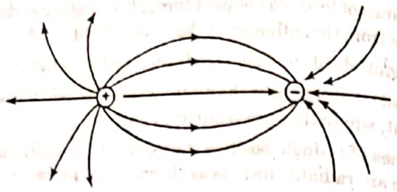
- The figure below shows the lines of force due to an infinitely large sheet of positive charge.



- Field lines around the system of two positive charges gives a different picture and describe the mutual repulsion between them.



- Field lines around a system of a positive and negative charge clearly shows the mutual attraction between them as shown below in the figure.



Speed of proton v = 294 km/s, r = 1.13 cm

$= 1.13 \times 10^{-2}$ m

$$\frac{1}{4\pi \epsilon_0}\frac{q_1 q_2}{r^2} = \frac{mv^2}{r}$$

$$\because \begin{bmatrix} \text{Electrostatic force of attraction} & = \text{Centripetel force} \\ \text{between proton and sphere} & \text{between} \end{bmatrix}$$

$$\Rightarrow \frac{9\times 10^{9} \times 1.6\times 10^{-19} \times q_2}{(1.13\times 10^{-2})^2} = \frac{1.27\times 10^{-27} \times (294\times 10^{3})^2}{1.13\times 10^{-2}}$$

$$\Rightarrow \boxed{q_2 = 7.62 \times 10^{-10} C}$$

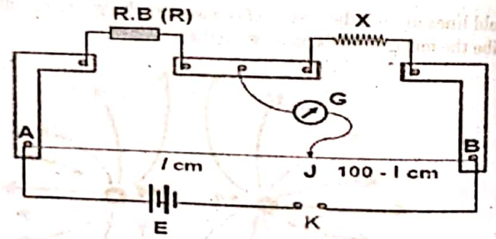
Q. 6. (b) Derive an expression for electric potential at the axis of ring due to a ring of uniform line charge. **(4.5)**

Ans. Out of syllabus**

Q. 7.(a) What is slide wire bridge? Explain working principle with a schematic diagram. Compare the slide wire bridge with wheat stone bridge. **(5)**

Ans. Meterbridge or slide wire bridge

- Meter bridge is based on the principle of wheatstone bridge and it is used to find the resistance of an unknown conductor or to compare two unknown resistance
- Figure below shows a schematic diagram of a meter bridge ·



It consists of copper strips and a 1m long wire made of manganin or constantan having uniform area of cross-section. This wire is stretched along a meter scale on a wooden base.

- A resistance box R and an unknown resistance X are connected as shown in figure.
- One terminal of galvanometer is connected to point D and another terminal is joined to a jockey that can be slide on bridge wire.

- When we adjust the suitable resistance of value R in the resistance box and slide this jockey along the wire then a balance point is obtained called null point i.e. when no current is flowing through the galvanometer.
- Since the circuit now is the same as that of wheatstone bridge ,so from the condition of balanced wheatstone bridge we have

$$P/Q = R/S$$

Here resistance P equals

$$P = lr$$

And

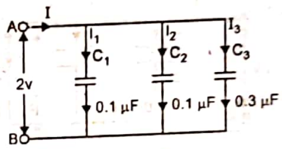
$$Q = (100 - l)$$

Where r is resistance per unit length of the wire

$$lr/(100 - l)r = R/X \quad \text{or}$$

$$X = (100 - l)R/l$$

Q. 7. (b) What is the effect of dielectric having inserted in parallel plate capacitor? Consider the following give circuit diagrm. Answer the following questions. **(7.5)**



(a) Calculate the equivalent capacitance.

(b) Calculate total charges.

(c) Determine charges on individual capacitors

Ans. The capacitance of a parallel plate capacitor increases when a dielectric is introduced between the plates of the capacitor.

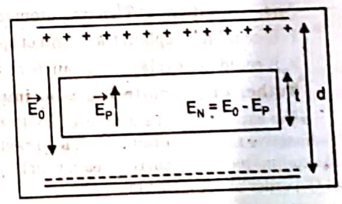
Capacitance of Parallel Plate Capacitor with Dielectric Slab:

$$V = E_0(d - t) + E_N t$$

$$K = \frac{E_0}{E_N} \quad \text{or} \quad E_N = \frac{E_0}{K}$$

$$\therefore \quad V = E_0(d - t) + \frac{E_0 t}{K}$$

$$V = E_0\left[(d - t) + \frac{t}{K}\right]$$



$$\text{But} \quad E_0 = \frac{\sigma}{\varepsilon_0} = \frac{qA}{\varepsilon_0}$$

and $C = \frac{q}{V}$ or $C = \frac{A\varepsilon_0}{d\left[1-\frac{t}{d}\left(1-\frac{1}{K}\right)\right]}$

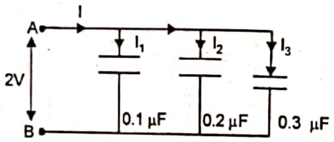
$\therefore$ $C = \frac{A\varepsilon_0}{\left[(d-t)+\frac{t}{K}\right]}$ or $\boxed{C = \frac{C_0}{\left[1-\frac{t}{d}\left(1-\frac{1}{K}\right)\right]}}$

$C > C_0$ i.e. capacitance increases with introduction of dielectric slab.

If the dielectric slab occupies the whole space between the plates, i.e. $t = d$, then

$$C = KC_0$$

Dielectric Constant $\boxed{K = \frac{C}{C_0}}$



$$C_{eq} = 0.1 + 0.2 + 0.3$$
$$= 0.6\ \mu F.$$
$$Q = C_{eq}V$$
$$= 0.6 \times 10^{-6} \times 2$$
$$= 1.2\ \mu C.$$

$Q_1 = C_1V$
$= 0.1 \times 10^{-6} \times 2$
$= 0.2\ \mu C$

$Q_2 = C_2V = 0.2 \times 10^{-6} \times 2 = 0.4\ \mu C$

$Q_3 = C_3V = 0.3 \times 10^{-6} \times 2 = 0.6\ \mu C$

UNIT-IV

Q. 8. (a) What are the key failures of Thomson's atomic model? Write the conclusions of Rutherford's alpha scattering experiment. (7.5)

Ans. Limitations of Thomson atom model were the following –

1. It could not explain the origin of spectral series of hydrogen and other atoms.
2. It could not explain large angle of scattering of particles from thin metal foil.

Rutherford's scattering experiment:

The experimental set up used by Rutherford and his collaborators consisted of a radioactive source contained in a lead cavity. The alpha particles emitted by the source are collimated into a narrow beam which is allowed to fall on a thin gold foil of thickness of the order of 2.1×10^{-7} m.

The alpha particles produce bright flashes or scintillations on the ZnS screen. These are observed in the microscope and counted at different angle from the direction of incidence of the beam.

Observations.

(i) Most of the alpha particles pass straight through the gold foil it means they do not suffer any collision with gold atoms.

(ii) Only about 0.14% of incident α-particles scatter by more than 1°.

(iii) Rarely one α particle in every 8000 α particles deflect by more than 90°.

(iv) Very rarely an α particle retraces its path i.e. gets deflected at 180°.

The conclusions were given on the basis of the observations of alpha scattering experiment and a nuclear model was given by Rutherford.

The essential features of Rutherford's nuclear model of the atom or planetary model of the atom are as follows :

1. Every atom consists of a tiny central core, called the atomic nucleus, in which the entire positive charge and almost entire mass of the atom are concentrated.

2. The size of nucleus is of the order of 10^{-15} m, which is very small as compared to the size of the atom which is of the order of 10^{-10} m.

3. The atomic nucleus is surrounded by certain number of electrons. As atom the whole is electrically neutral, the total negative charge of electrons surrounding nucleus is equal to total positive charge on the nucleus.

4. These electrons revolve around the nucleus in various circular orbits as do the planets around the sun. The centripetal force required by electron for revolution is provided by the electrostatic force of attraction between the electrons the nucleus.

Q. 8. (b) Though silicon an aluminium have the same atomic density and mass density, the difference in their electrical resistivity is very high. Why? What is meant by potential barrier across a p-n junction? (5)

Ans. Silicon and Aluminium have same atomic density and mass density but difference in their electrical resistivity is very high. Silicon is a semiconductor (atomic number 14) whereas Aluminium is a metal(atomic number 13).In case of Silicon crystal structure there are four valence electrons which form four covalent bonds with other silicon atoms and in case of aluminium the crystal structure is *fcc* where three free electrons are available. Since there are free electrons available for conduction, conductivity of aluminium is high thus it has low resistivity as compared to Silicon.

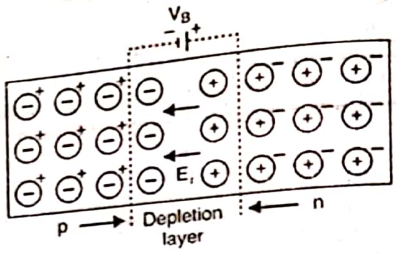
Potential barrier across a p-n junction. When a p-type semiconductor crystal is brought into close contact with an n-type semiconductor crystal under suitable conditions the resulting arrangement is called a p-n junction or junction diode.

When p-n junction is formed, due to difference in concentration of charge carriers in the two regions the electrons from n-region diffuse through the junction into p-region and holes from p-region diffuse into n-region. When an electron diffuses from n- region, it leaves behind an ionized donor atom in n-region, having positive charge which is immobile. As diffusion of electrons continues from n-region to p-region junction, more positively charged donor atoms are created in n-region resulting in layer of positive charge near the junction in n-region

Similarly, when a hole diffuses from p-region to n- region of p-n junction, it leaves behind an ionized acceptor atom in p-region having negative charge resulting in a layer of negative charge near the junction in p-region.

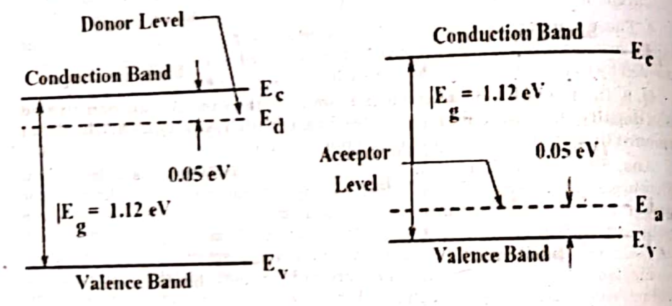
As the diffusion continues a layer of positive charge is formed in the n region and layer of negative charge is formed in p region.This region which is devoid of any free charge carriers(i.e. holes and electrons) is called depletion layer.

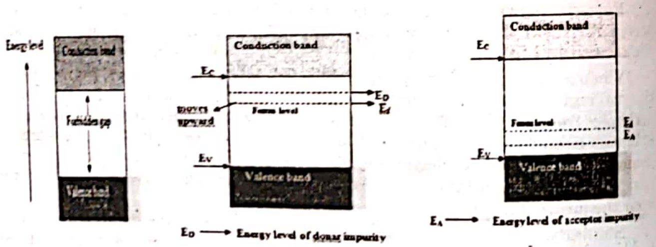
A point comes when accumulation of immobile charges on both sides of junction restricts further movement of electrons and holes. Thus it acts as a barrier called potential barrier (V_B). Value of V_B at room temperature: For Si 0.7 V, for Ge 0.3V.



Q. 9. (a) Indicate on an energy level diagram the conduction band and valence bands, donor and acceptor states. What are positions of Fermi levels for (a) an intrinsic semiconductor (b) a n-type semiconductor (c) a p-type semiconductor. (6)

Ans.





Q. 9. (b) Discuss the working of a PNP transistor as an amplifier in common base configuration. Define the current gain in common base configuration. Derive the expressions for voltage gain and power gain. (6.5)

Ans. Out of syllabus