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+2 PHYSICS MINIMUM LEVEL MATERIAL FOR LATE BLOOMERS

VOLUME – II THREE MARKS AND FIVE MARKS

SAIVEERA ACADEMY TEST SERIES

1.One Marks Test (Lesson wise , Half portion , Full portion) [EM]

2.Revision Test (4 tests) [EM]

3.Half Portion Test (2 tests) [EM]

4.Full Portion Test (10 tests) [EM]

5.Chapterwise (20 tests) [EM]

Contact

SAIVEERA ACADEMY

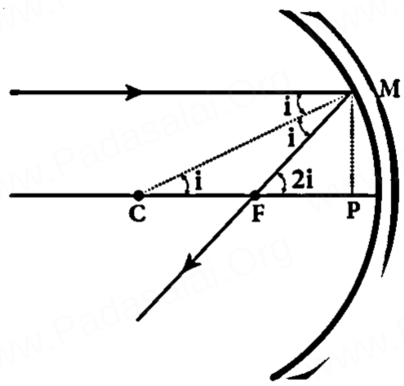
8098850809

Unit – 6 Optics

1. Derive the relation between *f* and *R* for a spherical mirror.

C - centre of curvature of the mirror.

- Consider a light ray parallel to the principal axis is incident on the mirror at *M* and passes through the principal focus *F* after reflection.
- The angles $\angle MCP = i$ and $\angle MFP = 2i$
- From right angle triangles ΔMCP and ΔMFP,



(a) Concave mirror

$\tan i = \frac{PM}{PC}$ $\qquad \tan 2i = \frac{PM}{PF}$

Angles are small so $\tan i \approx i$

$i = \frac{PM}{PC}$ $2i = \frac{PM}{PF}$

On simplification

2PF = PC

PF - focal length *f*

PC - radius of curvature *R*.

2f = R

2.What is optical path? Obtain the equation for optical path of a medium of thickness *d* and refractive index *n*.

Optical path of a medium is defined as the distance *d'* light travels in vacuum in the same time it travels a distance *d* in the medium.

consider a medium of **refractive index *n*** and **thickness *d***.

- Light travels with a speed *v* through the medium in a time *t*.

$t = \frac{d}{v}$

- In the same time, light can cover a greater distance *d'* in vacuum as it travels with greater speed *c* in vacuum

$t = \frac{d'}{c}$

- As the time taken in both the cases is the same, we can equate the time *t*

$\frac{d}{v} = \frac{d'}{c}$

$d' = \frac{c}{v} d$

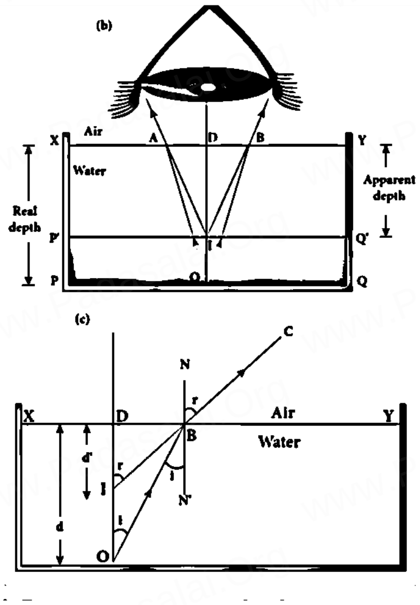
Where $n = \frac{c}{v}$

$d' = nd$

3.Obtain the equation for apparent depth.

The bottom of a tank filled with water appears raised

Light from the object *O* at the bottom of the tank passes from denser medium (water) to rarer medium (air) to reach our eye



- The refractive index of the denser medium is n_1 and rarer medium is n_2. Here, $n_1 > n_2$.
- The Snell's law in product form for this refraction is,

$$n_1 \sin i = n_2 \sin r$$

As the angles i and r are small, we can approximate, **$\sin i \approx \tan i$;**

$$n_1 \tan i = n_2 \tan r$$

In triangles ΔDOB and ΔDIB,

$\tan i = \frac{DB}{DO} \quad \tan r = \frac{DB}{DI}$

$n_1 \frac{DB}{DO} = n_2 \frac{DB}{DI}$

DO is the actual depth d a

DI is the apparent depth d'.

$n_1 = \frac{1}{d} = n_2 \frac{1}{d'}$

$\frac{d'}{d} = \frac{n_2}{n_1}$

Apparent depth becomes $d' = \frac{n_2}{n_1} d$

As the rarer medium is air and its refractive index n_2 can be taken as 1, ($n_2 = 1$). And the refractive index n_1 of denser medium could then be taken as n, ($n_1 = n$).

$d' = \frac{d}{n}$

The bottom appears to be elevated by d-d',

$$d - d' = d = \frac{d}{n}$$

4. Derive the equation for effective focal length for lenses in contact.

1. Consider two lenses (1) and (2) of focal length f_1 and f_2 are placed coaxially in contact with each other so that they have a common principal axis.
2. PO be object distance u and PI' be the image distance (v') for the first lens (1) and object distance for the second lens (2) and $PI = v$ be the image distance for the second lens (2)

lens equation for first lens (1)

$\frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1}$.......(1)

Writing the lens equation for second lens (2)

$\frac{1}{v} - \frac{1}{u'} = \frac{1}{f_2}$.......(2)

(1) + (2)

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_2} + \frac{1}{f_1}$ ....(3)

If the combination acts as a single lens of focal length f so that for an object at the position O it forms the image at I then,

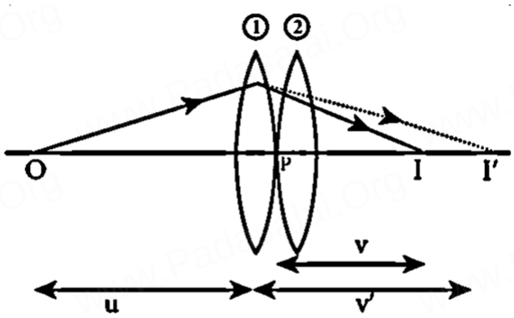


Figure. 6.37 Lenses in contact

$\frac{1}{v} - \frac{1}{u} = \frac{1}{F}$.......(4)

Comparing (3) and (4)

$$\frac{1}{F} = \frac{1}{f_2} + \frac{1}{f_1}$$

5. State and obtain Malus' law.

It states that when a beam of plane polarised light of intensity I_0 is incident on an analyser, the light transmitted of intensity I from the analyser varies directly as the square of the cosine of the angle θ between the transmission axis of polariser and analyser

$$I = I_0 cos^2\theta$$

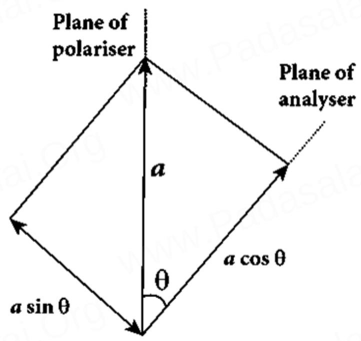
1) consider the plane of polariser and analyser are inclined to each other at an angle θ .
   I_0 - intensity
   a - the amplitude of the electric vector transmitted by the polariser.
2) The amplitude a of the incident light has two rectangular components, ($a$cosθ) and ($a$sinθ) which are the parallel and perpendicular components to the axis of transmission of the analyser.
3) Only the component ($a$cosθ) will be transmitted by the analyser. The intensity of light transmitted from the analyser is proportional to the square of the component of the amplitude transmitted by the analyser.

$I \alpha\ (acos\ \theta)^2$

$I = k\ (acos\ \theta)^2$

$I = k\ a^2 cos^2\theta$

$\boldsymbol{I = I_0 cos^2\theta}$ **where** $\boldsymbol{I_0 = ka^2}$

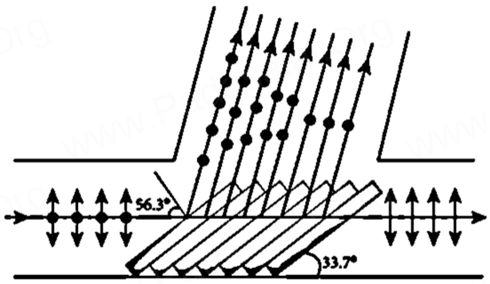


6. List the uses of polaroids.

1. Polaroids are used in goggles and cameras to avoid glare of light.
2. Polaroids are useful in three dimensional motion pictures i.e., in holography.
3. Polaroids are used to improve contrast in old oil paintings.
4. Polaroids are used in optical stress analysis.
5. Polaroids are used as window glasses to control the intensity of incoming light.
6. Polarised laser beam acts as needle to read/write in compact discs (CDs).
7. Polaroids produce polarised lights to be used in liquid crystal display (LCD).

7. Discuss about pile of plates.

1) The phenomenon of polarisation by reflection is used in the construction of pile of plates.



2) It consists of a number of glass plates placed one over the other in a tube .
3) The plates are inclined at an angle of 33.7° to the axis of the tube.
4) A beam of unpolarised light is allowed to fall on the pile of plates along the axis of the tube.
5) So, the angle of incidence of light will be at 56.3° which is the polarising angle for glass.
6) The vibrations perpendicular to the plane of incidence are reflected at each surface and those parallel to it are transmitted.
7) The larger the number of surfaces, the greater is the intensity of the reflected plane polarised light.
8) The pile of plates is used as a polarizer and also as an analyser.

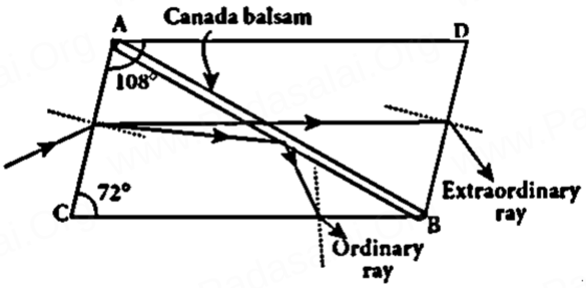
8.Discuss about Nicol prism.

1) Nicol prism is an optical device incorporated in optical instruments both for producing and analysing plane polarised light.
2) The construction of a Nicol prism is based on the **phenomenon of Double refraction**
3) It consists of calcite crystal which is a double refracting crystal with its length three times its breadth.
4) It is cut into two halves along the diagonal so that their face angles are 72° and 108° . The two halves are joined together by a layer of *canada balsam*, a transparent cement.
5) Consider a ray of unpolarised light from monochromatic source such as a sodium vapour lamp is incident on the face *AC* of the Nicol prism. Double refraction takes place and the ray is split into ordinary and extraordinary rays.
6) They travel with different velocities. The refractive index of the crystal for the ordinary ray (monochromatic sodium light) is 1.658 and for extraordinary ray is 1.486.
7) The refractive index of canada balsam is 1.523. Canada balsam does not polarise light.
8) The ordinary ray is total internally reflected at the layer of canada balsam and is prevented from emerging from the other face. The extraordinary ray alone is transmitted through the crystal which is plane polarised.'

Uses of Nicol prism

(i) It produces plane polarised light and functions as a polariser

(ii) It can also be used to analyse the plane polarised light i.e used at an analyser.



9. Derive the mirror equation and the equation for lateral magnification.

- The mirror equation establishes a relation among object distance *u*, image distance *v* and focal length *f* for a spherical mirror.
- An object *AB* is considered on the principal axis of a concave mirror beyond the center of curvature *C*.
- consider three paraxial rays from point *B* on the object.
- The first paraxial ray *BD* travelling parallel to principal axis is incident on the concave mirror at *D*, close to the pole *P*.

- After reflection the ray passes through the focus *F*.
- The second paraxial ray *BP* incident at the pole *P* is reflected along *PB´*.
- The third paraxial ray *BC* passing through centre of curvature *C*, falls normally on the mirror at *E* is reflected back along the same path.
- The three reflected rays intersect at the point B′ .
- A perpendicular drawn$A'B'$ as to the principal axis is the real, inverted image of the object *AB*.
- By law of reflection, the angle of incidence $\angle BPA$ is equal to the angle of reflection $\angle B'P'A'$
- The triangles ΔBPA and $\Delta B'P'A'$are similar. Thus, from the rule of similar triangles,

$\frac{A'B'}{AB} = \frac{PA'}{PA}$……….(1)

The other set of similar triangles are, ΔDPF and $\Delta D'P'F'$. (*PD* is almost a straight vertical line)

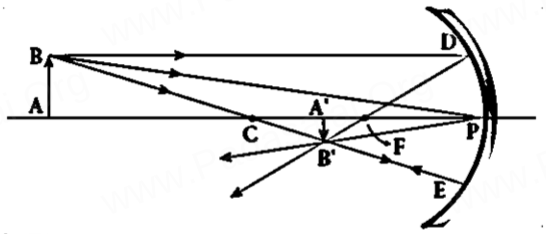


Figure 6.12 Mirror equation

$$\frac{A'B'}{PD} = \frac{A'F}{PF}$$

PD = AB

$\frac{A'B'}{AB} = \frac{A'F}{PF}$………(2)

From (1) & (2)

$$\frac{PA'}{PA} = \frac{A'F}{PF}$$

$$A'F = PA' - PF$$

$$\frac{PA'}{PA} = \frac{PA' - PF}{PF}$$

By applying the sign conventions for the various distances

PA =-u $PA' = -v$ $PF = -f$

$$\frac{-v}{-u} = \frac{-v + f}{-f}$$

On further simplification

$$\frac{v}{u} = \frac{v}{f} - 1$$

Dividing either side with v and rearranging

$$\mathbf{\frac{1}{v} + \frac{1}{u} = \frac{1}{f}}$$

lateral or transverse magnification

The **lateral or transverse magnification** is defined as the ratio of the height of the image to the height of the object

Magnification(m)= $\frac{\textbf{height of image } (h')}{\textbf{height of object } (h)}$

$$m = \frac{h'}{h}$$

$$\frac{A'B'}{AB} = \frac{PA'}{PA}$$

$A'B' = -h, AB = h, PA' = -v$,

$PA = -u$

$$\frac{-h}{h} = \frac{-v}{-u}$$

On simplifying we get

$$m = \frac{h'}{h} = \frac{-v}{u}$$

Using mirror equation,

$$\boldsymbol{m = \frac{h'}{h} = \frac{f-v}{f} = \frac{f}{f-u}}$$

10. Describe the Fizeau's method to determine speed of light.

Construction

- The light from the source *S* was first allowed to fall on a partially silvered glass plate *G* kept at an angle of 45° to the incident light from the source.
- The light then was allowed to pass through a rotating toothed-wheel with *N* teeth and *N* cuts of equal widths whose speed of rotation could be varied through an external mechanism .

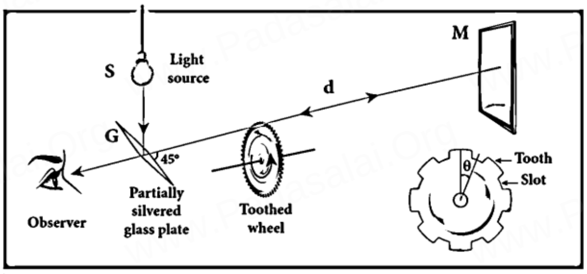


Figure 6.13 Speed of light by Fizeau's method

- The light passing through one cut in the wheel will get reflected by a mirror *M* kept at a long distance *d*, about 8 *km* from the toothed wheel.

Working:

The angular speed of rotation of the toothed wheel was increased from zero to a value ω until light passing through one cut would completely be blocked by the adjacent tooth.

This is ensured by the disappearance of light while looking through the partially silvered glass plate.

Expression for speed of light:

The speed of light in air *v* is equal to the ratio of the distance the light travelled from the toothed wheel to the mirror and back 2*d* to the time taken *t*.

$$\boldsymbol{v = \frac{2d}{t}} \ldots \ldots (1)$$

The angular speed ω of the toothed wheel when the light disappeared for the first time is,

$$\omega = \frac{\theta}{t} \ldots\ldots..(2)$$

$$\theta = \frac{total\ angle\ of\ circle\ in\ radian}{number\ of\ teeth + number\ of\ cuts}$$

$$\theta = \frac{2\pi}{2N} = \frac{\pi}{N} \ldots\ldots(3)$$

Sub (3) in (2)

$$\omega = \frac{\frac{\pi}{N}}{t}$$

Rearranging for t

$t = \frac{\pi}{\omega N}$.......(4)

Sub (4) in (1) and we get

$$v = \frac{2dN\omega}{\pi}$$

11.Obtain the equation for radius of illumination (or) Snell's window.

- When a light source like electric bulb is kept inside a water tank, the light from the source travels in all direction inside the water.
- The light that is incident on the water surface at an angle less than the critical angle will undergo refraction and emerge out from the water.
- The light incident at an angle greater than critical angle will undergo total internal reflection.
- The light falling particularly at critical angle graces the surface.
- Thus, the entire surface of water appears illuminated when seen from outside .
- On the other hand, when light entering the water from outside is seen from inside the water, the view is restricted to a particular angle equal to the critical angle i_c.
- The restricted illuminated circular area is called *Snell's window*

Light is seen from a point *A* at a depth *d*.

$n_1 \sin i_c = n_2 \sin 90°$

$\sin i_c = \frac{n_2}{n_1}$.............(1)

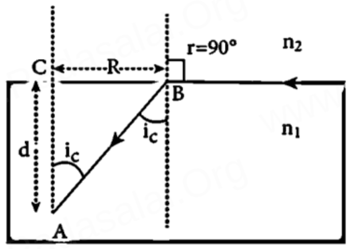


Figure 6.27 Radius of Snell's window

From the right angle triangle ΔABC,

$\sin i_c = \frac{CB}{AB} = \frac{R}{\sqrt{d^2+R^2}}$.........(2)

Equating (1) & (2)

$$\frac{n_2}{n_1} = \frac{R}{\sqrt{d^2+R^2}}$$

Squaring on both sides

$$\frac{R^2}{R^2+d^2} = \frac{{n_2}^2}{{n_1}^2}$$

Taking reciprocal

$$\frac{R^2+d^2}{R^2} = \frac{{n_1}^2}{{n_2}^2}$$

On further simplification

$$\boldsymbol{\frac{d^2}{R^2} = \frac{{n_1}^2}{{n_2}^2} - 1 = \frac{{n_1}^2 - {n_2}^2}{{n_2}^2}}$$

Again taking reciprocal and rearranging

$$R^2 = d^2\left(\frac{{n_2}^2}{{n_1}^2 - {n_2}^2}\right)$$

The radius of illumination is,

$$\boldsymbol{R = d\sqrt{\left(\frac{{n_2}^2}{{n_1}^2 - {n_2}^2}\right)}}$$

If the rarer medium outside is air, then,

n_2 = 1, and we can take **n_1=*n***

$$\boldsymbol{R = \frac{d}{\sqrt{n^2 - 1}}}$$

12.Derive the equation for refraction at single spherical surface.

1) Consider two transparent media having refractive indices n_1 and n_2 are separated by a spherical surface.
2) Let C be the centre of curvature of the spherical surface.
3) Let a point object O be in the medium n_1. The line OC cuts the spherical surface at the pole P of the surface.
4) Light from O falls on the refracting surface at N.
5) As $n_2 > n_1$, light in the denser medium deviates towards the normal and meets the principal axis at I where the image is formed.

Snell's law in product form for the refraction at the point N

$n_1 \sin i_c = n_2 \sin r$.......(1)

Angles are small

$\sin i = i; \sin r = r$

$n_1 i = n_2 r$ ....(2)

Let the angles,

$\angle NOP = \alpha$, $\angle NCP = \beta$, $\angle NIP = \gamma$

$$\tan\alpha = \frac{PN}{PO};\ \tan\beta = \frac{PN}{PC};\ \tan\gamma = \frac{PN}{PI}$$

As these angles are small, tan of the angle could be approximated to the angle itself.

$\alpha = \frac{PN}{PO}; \beta = \frac{PN}{PC}; \gamma = \frac{PN}{PI}$

For the triangle, ΔONC,

$i = \alpha + \beta$

For the triangle, ΔINC,

$r = \beta - \gamma$

Sub i and r values in (2)

$n_1(\alpha + \beta) = n_2(\beta - \gamma)$

$n_1\alpha + n_2\gamma = (n_2 - n_1)\beta$

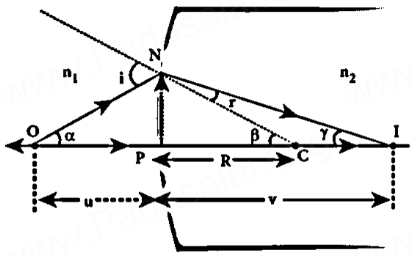


Figure 6.31 Refraction at single spherical surface

Substituting for α, β and γ

$n_1 \frac{PN}{PO} + n_2 \frac{PN}{PI} = (n_2 - n_1)\frac{PN}{PC}$

Further simplifying by cancelling PN,

$\frac{n_1}{PO} + \frac{n_2}{PI} = \frac{n_2 - n_1}{PC}$

Following sign conventions,

$PO = -u$, $PI = +v$ and $PC = +R$

$\frac{n_1}{-u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$

After rearranging, finally we get,

$$\boldsymbol{\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}}$$

If the first medium is air then, $n_1 = 1$ and the second medium is taken just as $n_2 = n$, then the equation is reduced to,

$$\frac{n}{v} - \frac{1}{u} = \frac{n-1}{R}$$

13.Obtain lens maker's formula and mention its significance.

- Consider a thin lens made up of a medium of refractive index n_2 is placed in a medium of refractive index n_1. Let R_1 and R_2 be the radii of curvature of two spherical surfaces (1) and (2)
- P be the pole
- Consider a point object O on the principal axis. The ray which falls very close to P, after refraction at the surface (1) forms image at I'. Before it does so, it is again refracted by the surface (2). Therefore the final image is formed at I.
- General equation for the refraction at a spherical surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

For the refracting surface (1) , the light goes from n_1 to n_2

$$\frac{n_2}{v'} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \text{..........(1)}$$

For the refracting surface (2) , the light goes from n_2 to n_1

$$\frac{n_2}{v} - \frac{n_1}{v'} = \frac{n_2 - n_1}{R_2} \text{.........(2)}$$

Adding (1) & (2)

$$\frac{n_1}{v} - \frac{n_1}{u} = n_2 - n_1\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

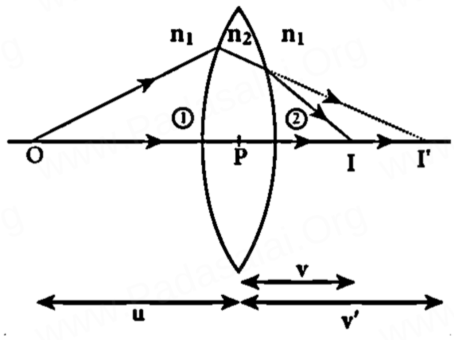


Figure 6.34 Refraction through thin lens

Further simplifying and rearranging,

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \text{........(1)}$$

If the object is at infinity, the image is formed at the focus of the lens. Thus, for $u = \infty$, $v = f$. Then the equation becomes.

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \text{........(2)}$$

If the refractive index of the lens is n_2 and it is placed in air, then $n_2 = n$ and $n_1 = 1$

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

The above equation is called the **lens maker's formula**,

By comparing (1) and (2)

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

This equation is known as **lens equation**

14.Derive the equation for effective focal length for lenses in out of contact.

- Two lenses of focal length f_1 and f_2 arranged coaxially but separated by a distance d

- For a parallel ray that falls on the arrangement, the two lenses produce deviations δ_1 and δ_2 respectively

The net deviation δ is

$\delta = \delta_1 + \delta_2$.......(1)

$\delta_1 = \frac{h_1}{f_1}$; $\delta_2 = \frac{h_2}{f_2}$; $\delta = \frac{h_1}{f}$

$\frac{h_1}{f} = \frac{h_1}{f_1} + \frac{h_2}{f_2}$.........(1)

From the geometry,

$h_2 - h_1 = P_2G - P_2C = CG$

$h_2 - h_1 = BG \tan\delta_1 = BG\delta_1$

$h_2 - h_1 = d\frac{h_1}{f_1}$

$h_2 = h_1 + d\frac{h_1}{f_1}$.........(2)

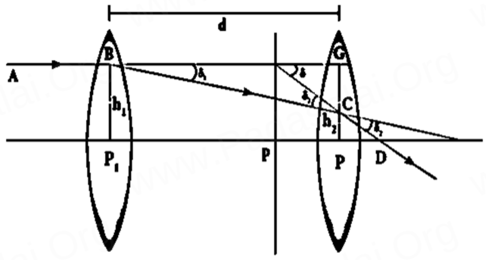


Figure 6.39 Lens in out of contact

Sub (2) in (1)

$$\frac{h_1}{f} = \frac{h_1}{f_1} + \frac{1}{f_2}\left(h_1 + d\frac{h_1}{f_1}\right)$$

On further simplification,

$$\mathbf{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_1 f_2}}$$

15. Obtain the equation for bandwidth in Young's double slit experiment.

<u>Condition for bright fringe (or) maxima</u>

The condition for the constructive interference or the point P to be have a bright fringe is,

Path difference, $\delta = n\lambda$

Where n = 0 , 1,2

$$\frac{dy}{D} = n\lambda$$

$$\mathbf{y_n = \frac{n\lambda D}{d}}$$

<u>Condition for dark fringe (or) minima</u>

The condition for the destructive interference or the point P to be have a dark fringe is,

$\delta = (2n-1)\frac{\lambda}{2}$

where, n = 1, 2, 3 . . .

$$\frac{dy}{D} = (2n-1)\frac{\lambda}{2}$$

$$\mathbf{y_n = \frac{(2n-1)}{2}\frac{\lambda D}{d}}$$

<u>Equation for bandwidth</u>

The *bandwidth* (β) is defined as the distance between any two consecutive bright or dark fringes.

The distance between $(n+1)^{th}$ and n^{th} consecutive bright fringes from O is given by,

$$\beta = y_{n+1} - y_n = (n+1)\frac{\lambda D}{d} - \frac{n\lambda D}{d} \qquad = \frac{\lambda D}{d}$$

The distance between $(n+1)^{th}$ and n^{th} consecutive dark fringes from O is given by,

$$\beta = y_{n+1} - y_n$$

$$= \frac{(2(n+1)-1)}{2}\frac{\lambda D}{d} - \frac{(2n-1)}{2}\frac{\lambda D}{d}$$

$$= \frac{\lambda D}{d}$$

By bandwidth equation bright and dark fringes are of same width equally spaced on either side of central bright fringe

16. Explain about compound microscope and obtain the equation for magnification.

- The lens near the object, called the ***objective***, forms a real, inverted, magnified image of the object.
- This serves as the object for the second lens which is the ***eyepiece***.
- Eyepiece serves as a simple microscope that produces finally an enlarged and virtual image.
- The first inverted image formed by the objective is to be adjusted close to, but within the focal plane of the eyepiece so that the final image is formed nearly at infinity or at the near point.
- The final image is inverted with respect to the original object.

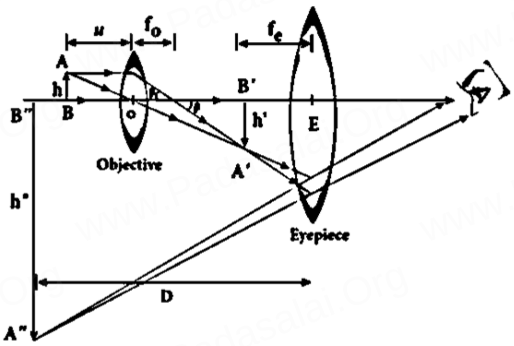


Figure 6.85 Compound microscope

Magnification of compound microscope

From the ray diagram, the linear magnification due to the objective

$$m_o = \frac{h'}{h}$$

$$\tan\beta = \frac{h}{f_o} = \frac{h'}{L}$$

$$\frac{h'}{h} = \frac{L}{f_o}$$

$$m_o = \frac{L}{f_o}$$

- The distance L is between the first focal point of the eyepiece to the second focal point of the objective.
- This is called the tube length L of the microscope as f_o and f_e are comparatively smaller than L.
- If the final image is formed at P (near point focussing), the magnification m_e of the eyepiece is,

$$m_e = 1 + \frac{D}{f_e}$$

The total magnification m in near point focusing is,

$$\boldsymbol{m = m_0 m_e = \left(\frac{L}{f_o}\right)\left(1 + \frac{D}{f_e}\right)}$$

17.Discuss about simple microscope and obtain the equations for magnification for near point focusing and normal focusing.

Simple microscope is a single magnifying (converging) lens of small focal length. The idea is to get an erect, magnified and virtual image of the object. For this the object is placed between F and P on one side of the lens and viewed from other side of the lens

Magnification in near point focusing

Object distance u is less than f.

The image distance is the near point D. The magnification m is given by the relation,

$$m = \frac{v}{u}$$

lens equation $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$m = 1 - \frac{v}{f}$$

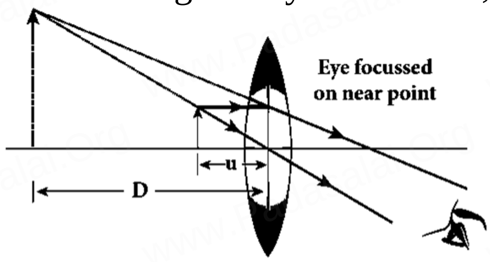


Figure 6.82 Near point focusing

$v = -D$

$$\boldsymbol{m = 1 + \frac{D}{f}}$$

Magnification in normal focusing (angular magnification)

The ratio of height of image to height of object $\left(m = \frac{h'}{h}\right)$ was taken .

The angular magnification is defined as the ratio of angle θ_i subtended by the image with aided eye to the angle θ_o subtended by the object with unaided eye

$$m = \frac{\theta_i}{\theta_o}$$

For unaided eye

$$\boldsymbol{\tan\theta_o \approx \theta_o = \frac{h}{D}}$$

For aided eye

$$\boldsymbol{\tan\theta_i \approx \theta_i = \frac{h}{f}}$$

The angular magnification is

$$m = \frac{\theta_i}{\theta_o} = \frac{h/f}{h/D}$$

$$\boldsymbol{m = \frac{D}{f}}$$

This is the magnification for normal focusing.

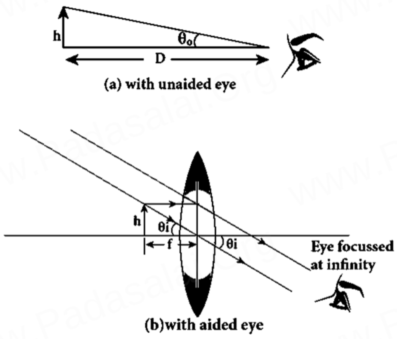


Figure 6.83 Normal focusing

Unit – 7 DUAL NATURE OF RADIATION AND MATTER

1.List out the laws of photoelectric effect.

i) For a given frequency of incident light, the **number of photoelectrons** emitted is directly **proportional to the intensity of the incident light**. The saturation current is also directly proportional to the intensity of incident light.

ii) Maximum **kinetic energy** of the photo electrons is **independent of intensity** of the incident light.

iii) Maximum **kinetic energy** of the photo electrons from a given metal is directly **proportional** to the **frequency** of incident light.

iv) For a given surface, the **emission of photoelectrons** takes place only if the frequency of incident light is **greater than a certain minimum frequency** called the threshold frequency.

v) There is **no time lag** between incidence of light and ejection of photoelectrons.

2.Obtain Einstein's photoelectric equation with necessary explanation.

- When a photon of energy $h\upsilon$ is incident on a metal surface, it is completely absorbed by a single electron and the electron is ejected.
- In this process, a part of the photon energy is used for the ejection of the electrons from the metal surface (photoelectric work function ϕ_0) and the remaining energy as the kinetic energy of the ejected electron. From the law of conservation of energy,

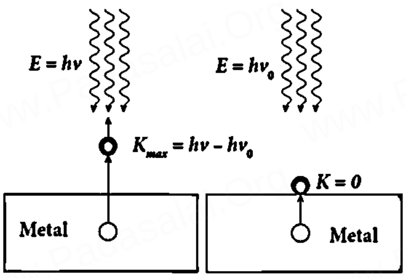


Figure 7.13 Emission of photoelectrons

$$h\upsilon = \emptyset_o + \frac{1}{2}mv^2 \quad \ldots\ldots\ldots\ldots(1)$$

m - mass of the electron **v** – velocity

- If we reduce the frequency of the incident light, the speed or kinetic energy of photo electrons is also reduced.
- At some frequency v_0 of incident radiation, the photo electrons are ejected with almost zero kinetic energy .

K.E = 0

By (1) $h\upsilon_o = \emptyset_o$ **.............(2)** υ_o -Threshold frequency

Sub (2) in (1) we get

$$h\upsilon = h\upsilon_o + \frac{1}{2}mv^2 \quad \ldots\ldots\ldots(3)$$ **– Einstein's photoelectric equation**

3.Derive an expression for de Broglie wavelength of electrons.

An electron of mass *m* is accelerated through a potential difference of *V* volt. The kinetic energy acquired by the electron is given by

$$\frac{1}{2}mv^2 = eV$$

the speed υ of the electron is

$$v = \sqrt{\frac{2eV}{m}}$$

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2eV}}$$

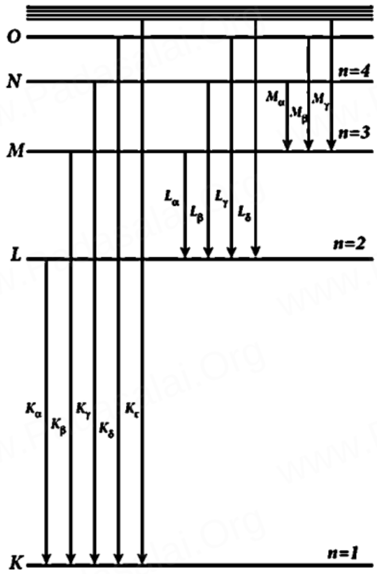
Substituting the known values

$$\lambda = \frac{6.626\times10^{-34}}{\sqrt{2V\times9.1\times10^{-31}\times1.6\times10^{-19}}}$$

$$\lambda = \frac{\mathbf{12.27}}{\sqrt{V}}\ \tilde{\text{Å}}$$

4. Explain about origin of Characteristic x – ray spectra

- The intensity of the x-rays when plotted against its wavelength gives a curve called **x-ray spectrum**
- X – ray spectra show some narrow peaks at some well – defined wavelengths when the target is hit by fast electrons.
- The line spectrum showing these peaks is called **characteristic x – ray spectrum**. This x – ray spectrum is due to the electronic transitions within the atoms.
- When an energetic electron penetrates into the target atom and removes some of the *K*-shell electrons.
- Then the electrons from outer orbits jump to fill up the vacancy so created in the *K*-shell.
- During the downward transition, the energy difference between the levels is given out in the form of x– ray photon of definite wavelength. Such wavelengths, characteristic of the target, constitute the line spectrum.



- From the Figure it is evident that *K*-series of lines in the x-ray spectrum of an element arises due to the electronic transitions from *L*, *M*, *N*, . . levels to the *K*-level.
- Similarly, the longer wavelength *L*-series originates when an *L*-electron is knocked out of the atom and the corresponding vacancy is filled by the electronic transitions from *M*, *N*, *O*,... and so on.

5. Derive an expression for de Broglie wavelength of matter waves

The momentum of photon of frequency *v* is given by $p = \frac{h\upsilon}{c} = \frac{h}{\lambda}$ **since c = υλ**

The wavelength of a photon in terms of its momentum is

$\lambda = \frac{h}{p}$ **……….(1)**

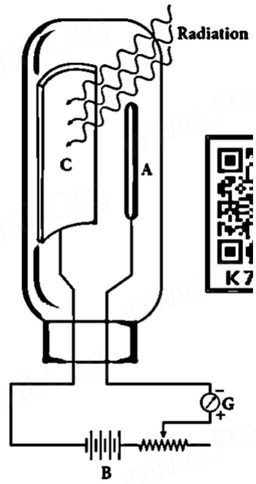
According to de Broglie, the above equation is completely a general one and this is applicable to material particles as well.

Therefore, for a particle of mass *m* travelling with speed v , the wavelength is given by

$\lambda = \frac{h}{mv}$ **……..(2)**

This wavelength of the matter waves is known as **de Broglie wavelength**

6. Give the construction and working of photo emissive cell.



Construction:

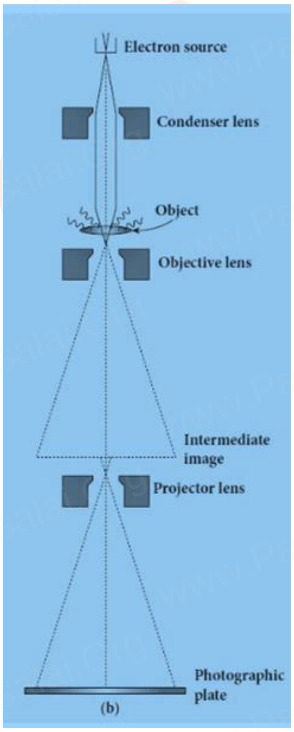
- It consists of an evacuated glass or quartz bulb in which two metallic electrodes – a cathode and an anode are fixed .
- The cathode *C* is semi-cylindrical in shape and is coated with a photo sensitive material.
- The anode *A* is a thin rod or wire kept along the axis of the semi-cylindrical cathode.
- A potential difference is applied between the anode and the cathode through a galvanometer *G*.

Working:

- When cathode is illuminated, electrons are emitted from it.
- These electrons are attracted by anode and hence a current is produced which is measured by the galvanometer.
- For a given cathode, the magnitude of the current depends on
- the intensity to incident radiation and
- the potential difference between anode and cathode.

7.Briefly explain the principle and working of electron microscope.

Principle



The wave nature of electrons is used in construction of microscope

- It is direct application of **wave nature of particles**
- The resolving power of a microscope is directly proportional to wavelength of the radiation used for illuminating the object under study.

Working

- The construction and working of an electron microscope is similar to that of an optical microscope except that in electron microscope focussing of electron beam is done by the **electrostatic or magnetic lenses.**
- The electron beam passing across a suitably arranged either electric or magnetic fields undergoes divergence or convergence thereby focussing of the beam is done
- The electrons emitted from the source are accelerated by **high potentials.**
- The beam is made parallel by magnetic condenser lens.
- When the beam passes through the sample whose magnified image is needed, the beam carries the image of the sample.
- With the help of magnetic objective lens and magnetic projector lens system, the magnified image is obtained on the screen.

8. Describe briefly Davisson – Germer experiment which demonstrated the wave nature of electrons.

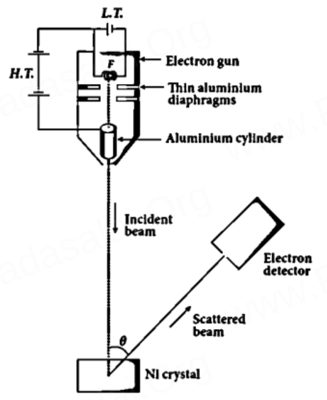


Figure 7.17 Experimental set up of Davisson – Germer experiment

De Broglie hypothesis of matter waves was experimentally confirmed by Clinton Davisson and Lester Germer

Working

- The filament *F* is heated by a low tension (L.T.) battery.
- Electrons are emitted from the hot filament by **thermionic emission.**
- They are then accelerated due to the potential difference between the filament and the anode aluminium cylinder by a high tension (H.T.) battery.
- Electron beam is collimated by using two thin aluminium diaphragms and is allowed to strike a single crystal of Nickel.
- The electrons scattered by Ni atoms in different directions are received by the electron detector which measures the intensity of scattered electron beam.
- The detector is rotatable in the plane of the paper so that the angle ϕ between the incident beam and the scattered beam can be changed at our will.
- The intensity of the scattered electron beam is measured as a function of the angle θ.
- Scattered wave shows a peak at an angle of **50°** to the incident electron beam.
- From the known interplanar spacing of Nickel , the wavelength of the electron wave has been experimentally calculated as **1.65 Å**
- By $\lambda = \frac{12.27}{\sqrt{V}}$ Å where V = 54 V , wavelength found to be **1.67Å**
- This value agree well with experimentally observed wavelength of 1.65Å.
- Thus this experiment directly verifies de Broglie's hypothesis of the wave nature of moving particles

9.Explain how frequency of incident light varies with stopping potential.

- The intensity of the incident light is kept constant.
- The variation of photocurrent with the collector electrode potential is studied for radiations of different frequencies and a graph drawn between them.
- From the graph, it is clear that stopping potential vary over different frequencies of incident light.
- Greater the frequency of the incident radiation, larger is the corresponding stopping potential.

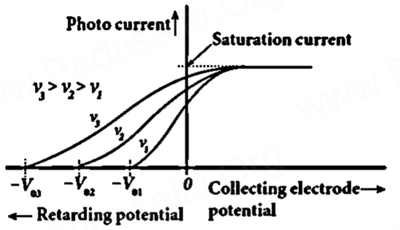


Figure 7.11 Variation of photocurrent with collector electrode potential for different frequencies of the incident radiation

- This implies that as the frequency is increased, the photoelectrons are emitted with greater kinetic energies so that the retarding potential needed to stop the photoelectrons is also greater.
- A graph is drawn between frequency and the stopping potential for different metals
- From this graph, it is found that stopping potential varies linearly with frequency.
- Below a certain frequency called threshold frequency, no electrons are emitted; hence stopping potential is zero for that reason. But as the frequency is increased above threshold value, the stopping potential varies linearly with the frequency of incident light.

Unit – 8 ATOMIC AND NUCLEAR PHYSICS

1.Write the properties of cathode rays.

1) When the cathode rays are allowed to fall on matter, they produce heat. They affect the photographic plates and also produce fluorescence when they fall on certain crystals and minerals.
2) When the cathode rays fall on a material of high atomic weight, x-rays are produced.
3) Cathode rays ionize the gas through which they pass.
4) The speed of cathode rays is up to $\left(\frac{1}{10}\right)^{th}$ of the speed of light.
5) Cathode rays possess energy and momentum and travel in a straight line with high speed of the order of 10^7m s^{-1}. The direction of deflection by electric field and magnetic field indicates that they are negatively charged particles.

2.Explain the J.J. Thomson experiment to determine the specific charge of electron.

Principle

In the presence of electric and magnetic fields, the cathode rays are deflected. By the variation of electric and magnetic fields, mass normalized charge or the specific charge (charge per unit mass) of the cathode rays is measured.

Construction

- A highly evacuated discharge tube is used and cathode rays (electron beam) produced at cathode are attracted towards anode disc A.
- Anode disc is made with pin hole in order to allow only a narrow beam of cathode rays.
- These cathode rays are now allowed to pass through the parallel metal plates, maintained at high voltage.
- Further, this gas discharge tube is kept in between pole pieces of magnet such that both electric and magnetic fields are perpendicular to each other.

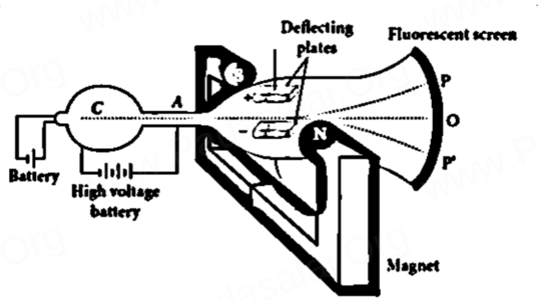


Figure 8.3 Arrangement of J.J. Thomson experiment to determine the specific charge of an electron

- When the cathode rays strike the screen, they produce scintillation and hence bright spot is observed. This is achieved by coating the screen with zinc sulphide.

Working

Determination of velocity of cathode rays

- For a fixed electric field between the plates, the magnetic field is adjusted such that the cathode rays (electron beam) strike at the original position O
- This means that the magnitude of electric force is balanced by the magnitude of force due to magnetic field .

Let e be the charge of the cathode rays,

Force due to electric field = eE

Force due to magnetic field = Bev

$$Ee = Bev$$

$$v = \frac{E}{B}$$

Determination of specific charge

Deflection of charge only due to uniform electric field

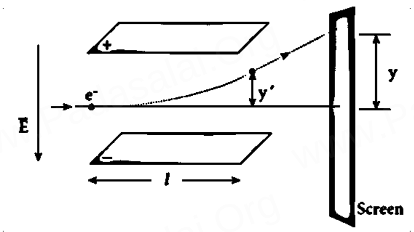


Figure 8.5 Deviation of path by applying uniform electric field

When the magnetic field is turned off, the deflection is only due to electric field. The deflection in vertical direction is due to the electric force.

$\boldsymbol{F_e = eE}$……..(1)

From Newton's second law of motion, acceleration of the electron is $a_e = \frac{1}{m} F_e$

sub (1) in above equation

$\boldsymbol{a_e = \frac{1}{m}\ eE}$**……..(2)**

y - deviation produced from the original position on the screen .

Let the initial upward velocity be u = 0 before entering the parallel plates.

t - Time taken to travel in electric field

l – length of the one of the plates

$\boldsymbol{t = \frac{l}{v}}$

deflection $\boldsymbol{y' = ut + \frac{1}{2}at^2}$

Here u = 0 $a_e = \frac{1}{m}\ \boldsymbol{eE}$

$\boldsymbol{y' = \frac{1}{2}\frac{1}{m}\ eE\left(\frac{l}{v}\right)^2}$

Therefore , the deflection of the cathode ray $\boldsymbol{y\ \alpha\ y'}$ → y = C$\boldsymbol{y'}$

C – Proportionality constant depends on the geometry of the discharge tube

Sub $\boldsymbol{y'}$in above equation

y = $\boldsymbol{C\ \frac{1}{2}\frac{1}{m}\ eE\left(\frac{l}{v}\right)^2}$

$\boldsymbol{\frac{e}{m} = \frac{2yE}{Cl^2B^2}}$

Sub known values in above equation

$\boldsymbol{\frac{e}{m} = 1.7 \times 10^{11} Ckg^{-1}}$

3. Derive the energy expression for hydrogen atom using Bohr atom model.

- Consider an atom which contains the nucleus at rest and an electron revolving around the nucleus in a circular orbit of radius r_n
- Nucleus is made up of protons and neutrons. Since proton is positively charged and neutron is electrically neutral, the charge of a nucleus is purely the total charge of protons.
- Let *Z* be the atomic number of the atom, then +*Ze* is the charge of the nucleus.
- Let –*e* be the charge of the electron.

$U_n = \frac{1}{4\pi\varepsilon_0}\frac{(+Ze)(-e)}{r_n}$……..(1)

$Sub\ r_n = \left(\frac{\varepsilon_0 h^2}{\pi m e^2}\right)\frac{n^2}{Z}\ in\ (1)$

$\boldsymbol{= -\frac{1}{4\varepsilon_0^2}\frac{Z^2me^4}{h^2n^2}}$**…….(2)**

The kinetic energy for the n^{th} orbit is

$$K.E_n = \frac{1}{2}mv_n^2..........(3)$$

Sub $v_n = \frac{h}{2\pi m a_0}\frac{Z}{n}$ in (3)

$$= \frac{1}{8\varepsilon_0^2}\frac{Z^2me^4}{h^2n^2}.........(4)$$

From (2) & (4)

$$U_n = -2K.E_n.......(5)$$

Total energy $E_n = K.E_n + U_n.......(6)$

From (5)

$$E_n = K.E_n - 2K.E_n = -K.E_n$$

$$E_n = -\frac{1}{8\varepsilon_0^2}\frac{Z^2me^4}{h^2n^2}.........(7)$$

For hydrogen atom Z = 1

$$E_n = -\frac{1}{8\varepsilon_0^2}\frac{me^4}{h^2n^2} joule.........(8)$$

n - principal quantum number.

The negative sign in equation (8) indicates that the electron is bound to the nucleus. Substituting the values of mass and charge of an electron (*m* and *e*), permittivity of free space ε_0 and Planck's constant *h* and expressing in terms of *eV*, we get

$$E_n = 13.6\frac{1}{n^2}$$

4.Discuss the spectral series of hydrogen atom.

In each series, the distance of separation between the consecutive wavelengths decreases from higher wavelength to the lower wavelength, and also wavelength in each series approach a limiting value known as the series limit.

Lyman series	Balmer series	Paschen series	Brackett series	Pfund series
Electron jumps from any of the outer orbits **(m = 2 , 3, 4…)** to the first orbit **(n= 1)**	Electron jumps from any of the outer orbits **(m = 3, 4…)** to the first orbit **(n= 2)**	Electron jumps from any of the outer orbits **(m = 4…)** to the first orbit **(n= 3)**	Electron jumps from any of the outer orbits **(m = 5…)** to the first orbit **(n= 4)**	Electron jumps from any of the outer orbits **(m = 6…)** to the first orbit **(n= 5)**
$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{m^2}\right)$	$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{m^2}\right)$	$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{m^2}\right)$	$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{m^2}\right)$	$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{m^2}\right)$
Ultraviolet region	**Visible region**	**Near IR**	**Middle IR**	**Far IR**

5.Obtain the law of radioactivity.

At any instant *t*, the number of decays per unit time, called rate of decay $\left(\frac{dN}{dt}\right)$ proportional to the number of nuclei (*N*) at the same instant.

$$\frac{dN}{dt} \alpha N$$

$$\frac{dN}{dt} = -\lambda N...........(1)$$

λ – Decay constant

Decay constant is different for different radioactive sample and the negative sign in the equation implies that the *N* is decreasing with time.

Here *dN* represents the number of nuclei decaying in the time interval *dt*.
t = 0 $N = N_o$
By integrating the equation (1), we can calculate the number of undecayed nuclei *N* at any time *t*.

$$\int_{N_o}^{N} \frac{dN}{N} = -\int_{0}^{T} \lambda\, dt$$

$$[\ln N]_{N_o}^{N} = -\lambda t$$

$$\ln\left[\frac{N}{N_o}\right] = -\lambda t$$

Taking exponentials on both sides, we get

$$\mathbf{N = N_o e^{-\lambda t} ....(2)}$$

Eq(2) is called the law of radioactive decay.

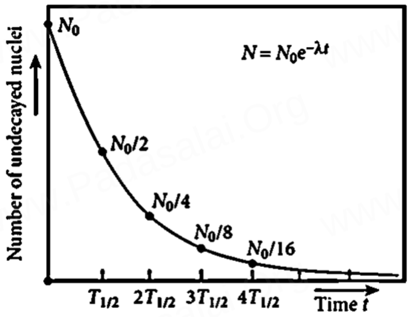


Figure 8.26 Law of radioactive decay

Number of atoms is decreasing exponentially over the time. This implies that the time taken for all the radioactive nuclei to decay will be infinite.

6.State Bohr postulate .Obtain the radius of n^th^ orbit oh hydrogen atom based on Bohr's theory

1) The electron in an atom **moves around nucleus in circular orbits** under the influence of Coulomb electrostatic force of attraction. This Coulomb force gives necessary centripetal force for the electron to undergo circular motion.
2) Electrons in an atom revolve around the nucleus only in certain discrete orbits called stationary orbits where it does not radiate electromagnetic energy. Only those discrete orbits allowed are stable orbits
3) Energy of orbits are not continuous but discrete. This is called the quantization of energy.
4) An electron can jump from one orbit to another orbit by absorbing or emitting a photon whose energy is equal to the difference in energy (ΔE) between the two orbital levels

$$\Delta E = E_{final} - E_{initial} = h\upsilon = h\frac{c}{\lambda}$$

5) Only those orbits are permitted for which the angular momentum of the electron is integral multiple of $\frac{h}{2\pi}$ $\mathbf{L = \frac{nh}{2\pi}}$ where n =0, 1, 2, 3….

- Consider an atom which contains the nucleus at rest and an electron revolving around the nucleus in a circular orbit of radius r_n
- Nucleus is made up of protons and neutrons. Since proton is positively charged and neutron is electrically neutral, the charge of a nucleus is purely the total charge of protons.
- Let *Z* be the atomic number of the atom, then +*Ze* is the charge of the nucleus.
- Let –*e* be the charge of the electron. From Coulomb's law, the force of attraction between the nucleus and the electron is

$$\vec{F}_{coulomb} = \frac{1}{4\pi\varepsilon_0}\frac{(+Ze)(-e)}{r_n^2}\hat{r}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n^2}\hat{r}$$

This force provides necessary centripetal force

$$\vec{F}_{centripetal} = \frac{mv_n^2}{r_n}\hat{r}$$

m – Mass of electron

v_n – velocity of electron in a circular orbit

$$|\vec{F}_{coulomb}| = |\vec{F}_{centripetal}|$$

$$\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r_n^2} = \frac{mv_n^2}{r_n}$$

Multiply and divide by m

$$\boldsymbol{r_n = \frac{4\pi\varepsilon_0(mv_nr_n)^2}{Zme^2}} \quad \textbf{.........(1)}$$

From Bohr's assumption, the angular momentum quantization condition $mv_nr_n = n\hbar$

Sub $mv_nr_n = n\hbar$ in (1)

$$r_n = \frac{4\pi\varepsilon_0(n\hbar)^2}{Zme^2}$$

$$= \left(\frac{\varepsilon_0h^2}{\pi me^2}\right)\frac{n^2}{Z} \qquad \left(\hbar = \frac{h}{2\pi}\right)$$

n ϵ natural number

ε_0 , h , e and π are constant

$$r_n = a_0\frac{n^2}{Z}$$

$$r_n \alpha\, n^2$$

$$\boldsymbol{a_0 = \frac{\varepsilon_0h^2}{\pi me^2} = 0.529\text{Å}}$$

This is known as Bohr radius which is the smallest radius of the orbit in an atom. Bohr radius is also used as unit of length called Bohr. 1 Bohr = 0.53 Å

For hydrogen atom (Z = 1), the radius of n^{th} orbit is

$$\boldsymbol{r_n = a_0n^2}$$

7.What is nuclear reactor ? Explain the function of (i) Moderator (ii) Control rod

Moderators

- The moderator is a material used to convert fast neutrons into slow neutrons.
- Usually the moderators are chosen in such a way that it must be very light nucleus having mass comparable to that of neutrons. Hence, these light nuclei undergo collision with fast neutrons and the speed of the neutron is reduced
- Most of the reactors use **water, heavy water (D_2O) and graphite** as moderators.
- The blocks of uranium stacked together with blocks of graphite (the moderator) to form a large pile

Control rod :

- The control rod are use to adjust the reaction rate .
- During each fission, on an average 2.5 neutrons are emitted and in order to have the controlled chain reactions, only one neutron is allowed to cause another fission and the remaining neutrons are absorbed by the control rod .
- **Control rods :** cadmium or boron These rods are inserted into the uranium blocks
- The nuclear reactors are maintained in critical stage(the average number of neutrons produced per fission is equal to one) by suitable adjustment of control rod .

Cooling system:

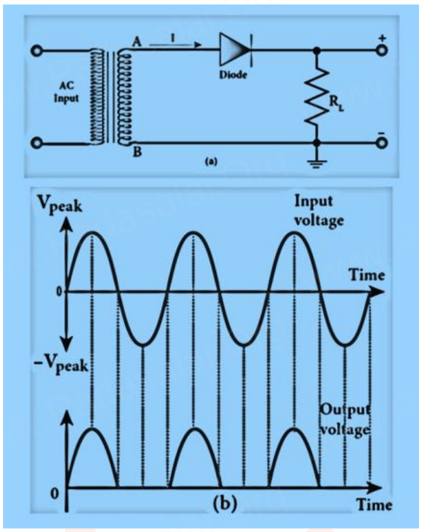
- It removes the heat generated in the reactor core.
- Cooling system :Ordinary water, heavy water and liquid sodium
- Coolant should have very high specific heat capacity and have large boiling point under high pressure. This coolant passes through the fuel block and carries away the heat to the steam generator through heat exchanger
- The steam runs the turbines which produces electricity in power reactors.

Unit – 9 SEMICONDUCTOR ELECTRONICS

1. Draw the circuit diagram of a half wave rectifier and explain its working

Construction

1. The circuit consists of a transformer, a p-n junction diode and a resistor.
2. In a half wave rectifier circuit, either a positive half or the negative half of the AC input is passed through while the other half is blocked.
3. Only one half of the input wave reaches the output. Therefore, it is called half wave rectifier.
4. Here, a p-n junction diode acts as a rectifying diode.



Working

During the positive half cycle

1. When the positive half cycle of the ac input signal passes through the circuit, terminal A becomes positive with respect to terminal B.
2. The diode is forward biased and hence it conducts. The current flows through the load resistor R_L nd the AC Voltage developed across R_L constitutes the output voltage V_o

During the negative half cycle

- When the negative half cycle of the ac input signal passes through the circuit, terminal A is negative with respect to terminal B.
- Now the diode is reverse biased and does not conduct and hence no current passes through R_L. The reverse saturation current in diode is negligible.
- Since there is no voltage drop across R_L, the negative half cycle of ac supply is supressed at the output.
- Output of the half wave rectifier is not a steady dc voltage but a pulsating wave .
- Efficiency of half wave rectifier is **40.6 %**

2. Explain the construction and working of a full wave rectifier.

Positive and negative half cycles of the AC input signal passes through the full wave rectifier circuit and hence it is called the full wave rectifier.

Construction

1. It consists of two p-n junction diodes, a centre tapped transformer, and a load resistor R_L .
2. The centre is usually taken as the ground or zero voltage reference point.
3. Due to the centre tap transformer, the output voltage rectified by ac diode is only one half of the total secondary voltage.

During the positive half cycle

- When the positive half cycle of the ac input signal passes through the circuit, terminal M is positive, G is at zero potential and N is at negative potential.
- This forward biased diode D_1 and reverse biased diode D_2.

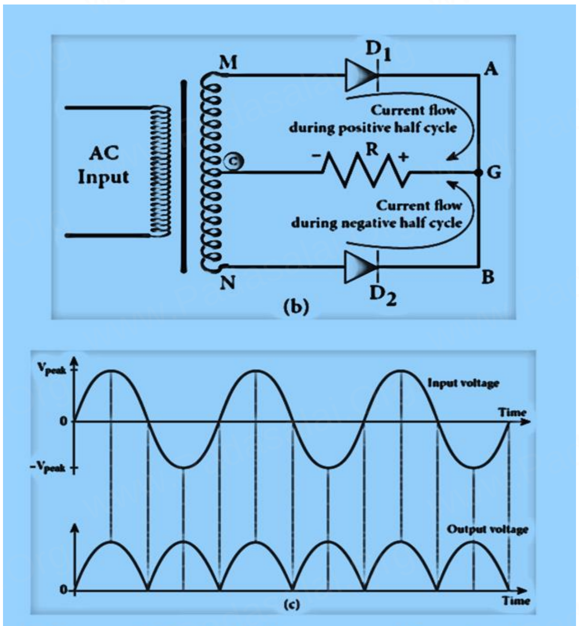


Figure 9.18 (a) Full wave rectifier circuit (b) Input and output waveforms

- Hence, being forward biased, diode D_1 conducts and current flows along the path $MD_1 AG C$.
- As result, positive half cycle of the voltage appears across R_L in the direction G to C

During the negative half cycle

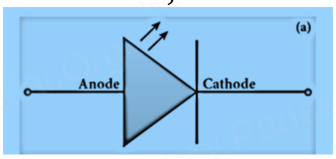
1. When the negative half cycle of the ac input signal passes through the circuit, terminal N is positive, G is at zero potential and M is at negative potential.
2. This forward biased diode D_2 and reverse biased diode D_1.
3. Hence, being forward biased, diode D_2 conducts and current flows along the path ND_2BGC .
4. As a result, negative half cycle of the voltage appears across R_L In the same direction from G to C
5. Although both positive and negative half cycles of ac input are rectified, the output is still pulsating in nature.
6. Efficiency of half wave rectifier is **81.2 %**

3. What is an LED? Give the principle of operation with a diagram.

- LED is a p-n junction diode which **emits visible or invisible light** when it is forward biased.
- Since, electrical energy is converted into light energy, this process is also called **electroluminescence.**

Construction

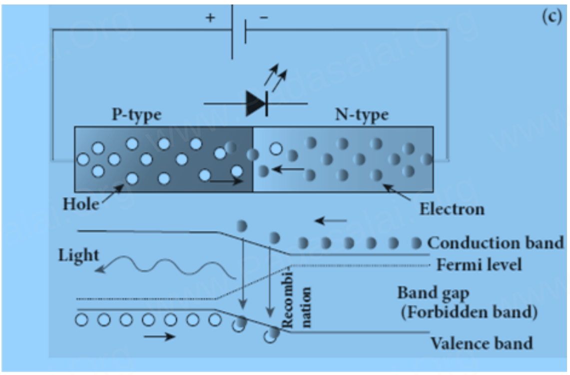
- It consists of a p-layer, n-layer and a substrate. A transparent window is used to allow light to travel in the desired direction.
- An external resistance in series with the biasing source is required to limit the forward current through the LED.
- In addition, it has two leads; anode and cathode.



Working

1. When the **p-n junction is forward biased,** the conduction band electrons on n-side and valence band holes on p-side diffuse across the junction. When they cross the junction, they become excess minority carriers (electrons in p-side and holes in n-side).

2. These excess minority carriers recombine with oppositely charged majority carriers in the respective regions, i.e. the electrons in the conduction band recombine with holes in the valence band
3. During recombination process, energy is released in the form of light (radiative) or heat (non-radiative). For radiative recombination, a photon of energy is *hv* emitted.



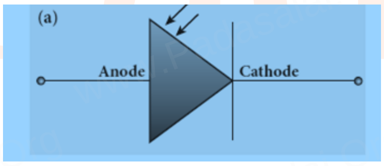
4. For non-radiative recombination, energy is liberated in the form of heat.

4. Write notes on Photodiode.

- A p-n junction diode which converts an optical signal into electric current is known as photodiode.
- Thus, the operation of photodiode is exactly opposite to that of an LED.
- Photo diode words in reverse bias.

Construction

1. The device consists of a p-n junction semiconductor made of photosensitive material kept safely inside a plastic case
2. It has a small transparent window that allows light to be incident on the p-n junction. Photodiodes can generate current when the p-n junction is exposed to light and hence are called as light sensors.



Working

1. When a photon of sufficient energy *hv* strikes the depletion region of the diode, some of the valence band electrons are elevated into conduction band, in turn holes are developed in the valence band.
2. This creates electron-hole pairs. The amount of electron-hole pairs generated depends on the intensity of light incident on the p-n junction.
3. These electrons and holes are swept across the
4. p-n junction by the electric field created by reverse voltage before recombination takes place. Thus, holes move towards the n-side and electrons towards the p-side.
5. When the external circuit is made, the electrons flow through the external circuit and constitute the photocurrent.
6. When the incident light is zero, there exists a reverse current which is negligible.
7. This reverse current in the absence of any incident light is called dark current and is due to the thermally generated minority carriers.

Applications

- Alarm system

- Count items on a conveyer belt
- Photoconductors
- Compact disc players, smoke detectors
- Medical applications such as detectors for computed tomography etc.

5. Explain the working principle of a solar cell. Mention its applications.

- A solar cell, also known as photovoltaic cell, converts light energy directly into electricity or electric potential difference by **photovoltaic effect**.
- It is basically a p-n junction which generates emf when solar radiation falls on the p-n junction.

1. In a solar cell, electron–hole pairs are generated due to the absorption of light near the junction.
2. Then the charge carriers are separated due to the electric field of the depletion region. Electrons move towards n–type Silicon and holes move towards p-type Silicon layer.
3. The electrons reaching the n-side are collected by the front contact and holes reaching p-side are collected by the back electrical contact. Thus a potential difference is developed across solar cell.
4. When an external load is connected to the solar cell, photocurrent flows through the load.
5. Many solar cells are connected together either in series or in parallel combination to form solar panel or module
6. Many solar panels are connected with each other to form solar arrays. For high power applications, solar panels and solar arrays are used.

Applications:

- Solar cells are widely used in calculators, watches, toys, portable power supplies, etc.
- Solar cells are used in satellites and space applications
- Solar panels are used to generate electricity.

6. Describe the function of a transistor as an amplifier with the neat circuit diagram. Sketch the input and output wave form.

- A transistor operating in the active region has the capability to amplify weak signals. **Amplification is the process of increasing the signal strength (increase in the amplitude).**

Construction

- Single stage transistor amplifier indicates that the circuit consists of one transistor with the allied components.
- An NPN transistor is connected in the common emitter configuration.
- The Q point or the operating point of the transistor is fixed so as to get the maximum signal swing at the output (neither towards saturation point nor towards cut-off).
- A load resistance R_C, is connected in series with the collector circuit to measure the output voltage.
- The capacitor C_1 allows only the ac signal to pass through.
- The emitter bypass capacitor C_E provides a low reactance path to the amplified ac signal.

- The coupling capacitor C_C is used to couple one stage of the amplifier with the next stage while constructing multistage amplifiers.
- ***V_S* -** The sinusoidal input signal source applied across the base-emitter.
- The output is taken across the collector-emitter.

Working

Collector current, $I_C = \beta I_B$ $Since\ \left(\beta = \frac{I_C}{I_B}\right)$

Applying Kirchhoff 's voltage law in the output loop, the collector-emitter voltage is given by

$$V_{CE} = V_{CC} - I_C R_C$$

During the positive half cycle

1. Input signal (V_S) increases the forward voltage across the emitter-base.
2. As a result, the base current increases. Consequently, the collector current increases β times.
3. This increases the voltage drop across R_C which in turn decreases the collector-emitter voltage . Therefore, the input signal in the positive direction produces an amplified signal in the negative direction at the output.
4. Hence, the output signal is reversed by 180˚

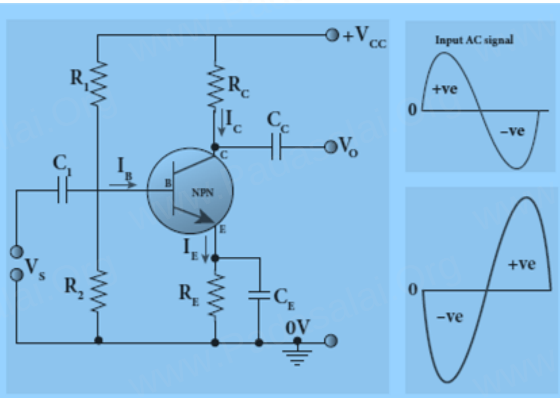


Figure 9.36 (a) Transistor as an amplifier (b) Input and output waveform showing 180⁰ phase reversal.

During the negative half cycle

1. Input signal V_s decreases the forward voltage across the emitter-base.
2. As a result, base current decreases and in turn increases the collector current .
3. The increase in collector current decreases the potential drop across R_C and increases the collector-emitter voltage .
4. Thus, the input signal in the negative direction produces an amplified signal in the positive direction at the output.
5. Therefore, 180^0 phase reversal is observed during the negative half cycle of the input signal

7.State and prove De Morgan's First and Second theorems

<u>De Morgan's First Theorem</u>

The first theorem states that the complement of the sum of two logical inputs is equal to the product of its complements

<u>Proof</u>

The Boolean equation for NOR gate is

$Y = \overline{A + B}$

The Boolean equation for a bubbled AND gate is Y = $\bar{A}.\bar{B}$

<u>Truth table</u>

A	B	A+B	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

From the table we conclude that
$\boldsymbol{\overline{A+B}} = \bar{A}.\bar{B}$
Thus De Morgan's First Theorem is proved. It also says that a NOR gate is equal to a bubbled AND gate.

De Morgan's Second Theorem

The second theorem states that the complement of the product of two inputs is equal to the sum of its complements.

Proof

The Boolean equation for NAND gate is
Y $=\overline{A.B}$
The Boolean equation for bubbled OR gate is
Y $=\bar{A}+\bar{B}$

Truth table

A	B	A.B	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

From the above truth table we can conclude
$\boldsymbol{\overline{A.B} = \overline{A} + \overline{B}}$
Thus De Morgan's First Theorem is proved. It also says, a NAND gate is equal to a bubbled OR gate.

8. How does Transistor acts as an oscillator

- **An electronic oscillator basically converts dc energy into ac energy of high frequency ranging from a few Hz to several MHz.** Hence, it is a source of alternating current or voltage. Unlike an amplifier, oscillator does not require any external signal source.
- An oscillator circuit consists of a tank circuit, an amplifier and a feedback circuit .
- The tank circuit generates electrical oscillations and acts as the ac input source to the transistor amplifier.
- Amplifier amplifies the input ac signal.
- The feedback circuit provides a portion of the output to the tank circuit to sustain the oscillations without energy loss.
- Hence, an oscillator does not require an external input signal. The output is said to be self-sustained

Amplifier

If the operating point is chosen at the middle of the dc load line (point Q), the transistor can effectively work as an amplifier.

Feedback network

- The circuit used to feedback a portion of the output to the input is called the feedback network.
- If the portion of the output fed to the input is in phase with the input, then the magnitude of the input signal increases. It is necessary for sustained oscillations.

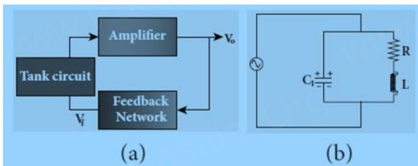


Figure 9.39 (a) Block diagram of an oscillator (b) tank circuit

Tank circuit

- The LC tank circuit consists of an inductance and a capacitor connected in parallel .
- Whenever energy is supplied to the tank circuit from a DC source, the energy is stored in inductor and capacitor alternatively.

- This produces electrical oscillations of definite frequency.
- But in practical oscillator circuits there will be loss of energy across resistors, inductor coils and capacitors.
- A small amount of energy is used up in overcoming these losses during every cycle of charging and discharging of the capacitor. Due to this, the amplitude of the oscillations decreases gradually.
- Hence, the tank circuit produces damped electrical oscillations.
- Therefore, in order to produce undamped oscillations, a positive feedback is provided from the output circuit to the input circuit.
- The frequency of oscillations is determined by the values of L and C using the equation.

$$f = \frac{1}{2\pi}\sqrt{\frac{L}{C}}$$

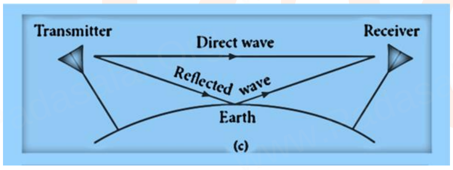
Unit – 10 COMMUNICATION SYSTEMS

1.Explain space wave propagation of radio waves

- The process of sending and receiving information signal through space is called space wave communication The electromagnetic waves of very high frequencies above 30 MHz are called as space waves.
- These waves travel in a straight line from the transmitter to the receiver.
- Hence, it is used for a line of sight communication (LOS).
- For high frequencies, the transmission towers must be high enough so that the transmitted and received signals (direct waves) will not encounter the curvature of the earth and hence travel with less attenuation and loss of signal strength.
- Certain waves reach the receiver after getting reflected from the ground.
- The communication systems like television broadcast, satellite communication, and RADAR are based on space wave propagation.
- **Microwaves having high frequencies (super high frequency band) are used against radio waves due to certain advantages**:
- larger bandwidth, high data rates, better directivity, small antenna size, low power consumption, etc.
- The range or distance (d) of coverage of the propagation depends on the height (h) of the antenna given by the equation,

$$d = \sqrt{2Rh}$$

R is the radius of the earth which is,
R = 6400 km



2.Fiber optic communication is gaining popularity among the various transmission media -justify.

- The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called fiber optic communication.
- As fibers are not electrically conductive, it is preferred in places where multiple channels are to be laid and isolation is required from electrical and electromagnetic interference.

1) Fiber cables are very thin and weigh lesser than copper cables.
2) This system has much larger band width. This means that its information carrying capacity is larger.
3) Fiber optic system is immune to electrical interferences.
4) Fiber optic cables are cheaper than copper cables.

Applications :Optical fiber system has a number of applications namely, international communication, inter-city communication, data links, plant and traffic control and defense applications.

3.Explain about RADAR and its application

- Radar basically stands for Radio Detection and Ranging System.

- The angle, range, or velocity of the objects that are invisible to the human eye can be determined.
- Radar uses electromagnetic waves for communication.
- The electromagnetic signal is initially radiated into space by an antenna in all directions.
- When this signal strikes the targeted object, it gets reflected or reradiated in many directions.
- This reflected (echo) signal is received by the radar antenna which in turn is delivered to the receiver. Then, it is processed and amplified to determine the geographical statistics of the object.
- The range is determined by calculating the time taken by the signal to travel from RADAR to the target and back.

Applications.

i) In military, it is used for locating and detecting the targets

ii) It is used in navigation systems such as ship borne surface search, air search and weapons guidance systems.

iii) To measure precipitation rate and wind speed in meteorological observations, Radars are used.

iv) It is employed to locate and rescue people in emergency situations

4. What is modulation? Explain the types of modulation with necessary diagrams.

Modulation (They will ask any one)

For long distance transmission, the low frequency baseband signal (input signal) is superimposed onto a high frequency radio signal by a process called modulation.

There are three types of modulation

(i)Amplitude modulation

(ii)Frequency modulation

(iii)Phase modulation

(i)Amplitude modulation (AM)

If the amplitude of the carrier signal is modified according to the instantaneous amplitude of the base band signal, then it is called amplitude modulation

Characteristics Frequency and the phase of the carrier signal remain constant.

Uses

It is used in radio and TV broadcasting.

How it is done

The signal shown in Figure is the message signal or baseband signal that carries information.

The carrier wave which is high frequency wave is modified in proportion to the amplitude of the baseband signal.

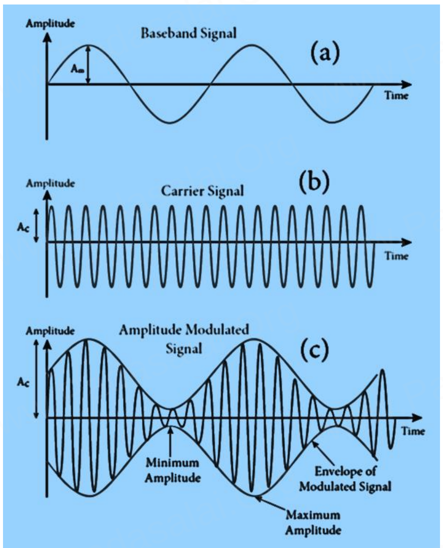


Figure 10.1 Amplitude Modulation (a) baseband signal (b) carrier signal (c) modulated signal

(ii)Frequency modulation (FM)

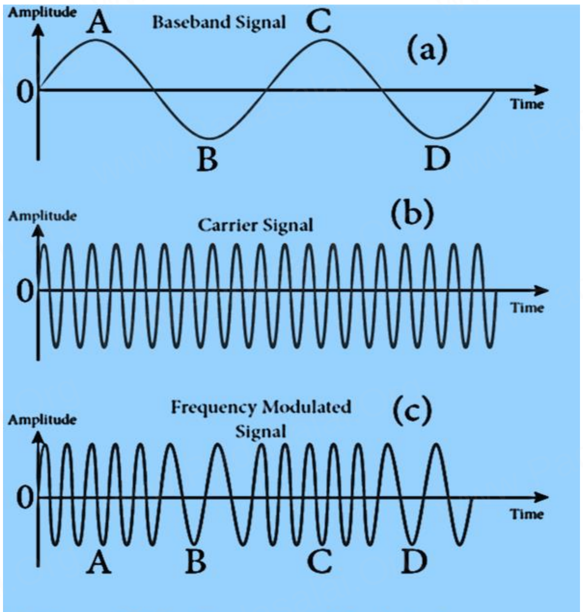


Figure 10.2 Frequency Modulation (a) baseband signal (b) carrier signal (c) frequency modulated signal

The frequency of the carrier signal is modified according to the instantaneous amplitude of the baseband signal in frequency modulation.

Characteristics

Amplitude and the phase of the carrier signal remain constant.

How it is done

- Increase in the amplitude of the baseband signal increases the frequency of the carrier signal and vice versa.
- This leads to compressions and rarefactions in the frequency spectrum of the modulated wave
- Louder signal leads to compressions and relatively weaker signals to rarefactions.
- When the amplitude of the baseband signal is zero ,the frequency of the modulated signal is the same as the carrier signal.
- The frequency of the modulated wave increases when the amplitude of the baseband signal increases in the positive direction (A, C).
- The increase in amplitude in the negative half cycle (B, D) reduces the frequency of the modulated wave .
- When the frequency of the baseband signal is zero (no input signal), there is no change in the frequency of the carrier wave. It is at its normal frequency and is called as **centre frequency or resting frequency.** Practically this is the allotted frequency of the FM transmitter.

(iii) Phase modulation (PM)

- The instantaneous amplitude of the baseband signal modifies the phase of the carrier signal keeping the amplitude and frequency constant is called phase modulation
- This modulation is used to generate frequency modulated signals. It is similar to frequency modulation except that the phase of the carrier is varied instead of varying frequency.
- carrier phase changes according to increase or decrease in the amplitude of the base band signal. When the modulating signal goes postive, the amount of phase lead increases with the amplitude of the modulating signal.
- Due to this , the carrier signal is compressed or its frequency is increased.
- On the other hand , the negative half cycle of the base band signal produces a phase lag in the
- carrier signal.
- This appears to have stretched the frequency of the carrier wave .
- Hence similar to frequency modulated wave , phase modulated wave also comprises of compressions and rarefactions.
- When the signal voltage is zero (A, C and E) the carrier frequency is changed .

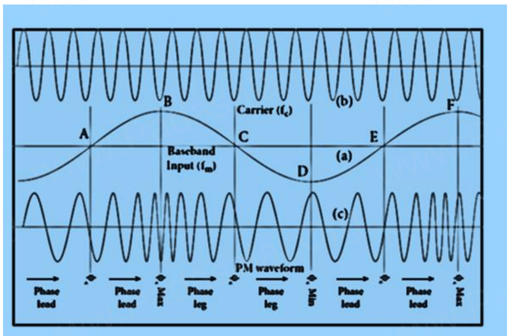


Figure 10.3 Phase Modulation (a) carrier signal (b) baseband signal (c) phase modulated signal

- The frequency shift in carrier wave frequency exists in phase modulation as well .
- The frequency shift depends on
  i)amplitude of the modulating signal
  ii)the frequency of the signal.

5.Give the applications of ICT in mining and agriculture sectors.

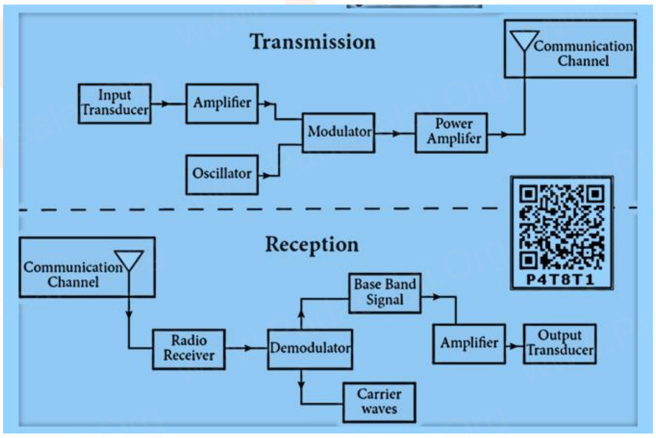
(i) Mining

a) ICT in mining improves operational efficiency, remote monitoring and disaster locating system.
b) Information and communication technology provides audio-visual warning to the trapped underground miners.
c) It helps to connect remote sites.

(ii) Agriculture

a) ICT is widely used in increasing food productivity and farm management.
b) It helps to optimize the use of water, seeds and fertilizers etc.
c) Sophisticated technologies that include robots, temperature and moisture sensors, aerial images, and GPS technology can be used.
d) Geographic information systems are extensively used in farming to decide the suitable place for the species to be planted

6.Elaborate on the basic elements of communication system with the necessary block diagram. (any five)



1.Information source

Information can be in the form of a sound signal like speech , music , pictures or computer data which is given as input to the input transducer

2. Input transducer

- A transducer is a device that converts variations in a physical quantity (pressure, temperature, sound) into an equivalent electrical signal or vice versa.
- In communication system, the transducer converts the information which is in the form of sound, music, pictures or computer data into corresponding electrical signals.
- The electrical equivalent of the original information is called the baseband signal.

Example for the transducer : Microphone that converts sound energy into electrical energy.

3. Transmitting antenna

- It radiates the radio signal into space in all directions.
- It travels in the form of electromagnetic waves with the velocity of light (3×10^8 m s^{-1}).

4. Communication channel

- Communication channel is used to carry the electrical signal from transmitter to receiver with less noise or distortion.

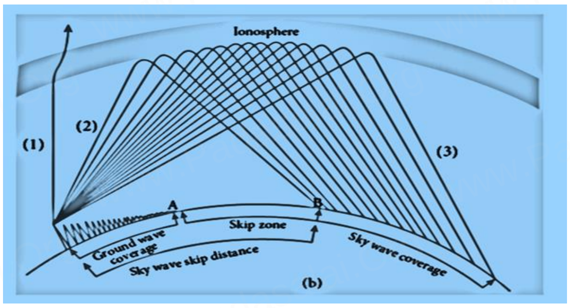
- The communication medium is basically of two types: wireline communication and wireless communication.

5.Receiver

- The signals that are transmitted through the communication medium are received with the help of a receiving antenna and are fed into the receiver.
- The receiver consists of electronic circuits like demodulator, amplifier, detector etc.
- The demodulator extracts the baseband signal from the carrier signal. Then the baseband signal is detected and amplified using amplifiers. Finally, it is fed to the output transducer.

7.Explain sky wave propagation of radiowaves

- The mode of propagation in which the electromagnetic waves radiated from antenna , directed upwards at large angles get reflected by the ionosphere back to earth is called sky wave propagation or ionospheric propagation. The corresponding waves are called sky waves
- The frequency range is 3 to 30 MHz
- It can easily penetrate through the ionosphere and does not undergo reflection.
- It is used for short wave broadcast services.
- Medium and high frequencies are for long-distance road communication.
- Ionosphere act as reflecting surface. It is at a distance of 50 Km and spreads up to 400 km above the Earth surface.
- Due to the absorption of ultraviolet rays, cosmic ray, and other high energy radiations like α, β rays from sun, the air molecules in the ionosphere get ionized.
- This produces charged ions and these ions provide a reflecting medium for the reflection of radio waves or communication waves back to earth within the permitted frequency range.
- The phenomenon of bending the radio waves back to earth is nothing but the total internal reflection.
- This is the reason why the EM waves are transmitted at a critical angle to ensure that the waves undergo total reflection and reaches the ground without escaping into space.



- **The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the skip distance** .
- The electromagnetic waves are transmitted from the ground at particular angles.
- When the angle of emission increases, the reception of ground waves decreases. At one point there will be no reception due to ground waves .
- **There is a zone in between where there is no reception of electromagnetic waves neither ground nor sky, called as skip zone or skip area.**

8.What are advantage and disadvantage of amplitude modulation , frequency modulation , phase modulation?

Amplitude modulation	**Frequency modulation**	**Phase modulation**
Advantages	**Advantages**	**Advantages**
i) Easy transmission and reception	i)Large decrease in noise. This leads to an increase in signal-noise ratio.	i)FM signal produced from PM signal is very stable.
ii) Lesser bandwidth requirements	ii) The operating range is quite large.	ii) The centre frequency called resting frequency is extremely stable.
iii) Low cost	iii)The transmission efficiency is very high as all the transmitted power is useful.	
	iv)FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio.	
Limitations	**Limitations**	**Limitations**
i)Noise level is high	i) FM requires a much wider channel.	
ii) Low efficiency	ii)FM transmitters and receivers are more complex and costly	
iii) Small operating range	iii)In FM reception, less area is covered compared to AM.	