Rao IIT Academy
Symbol of Excellence and Perfection

# XII - CBSE Baord

## CODE (55/3/MT) SET - 3

Date: 09.03.2015

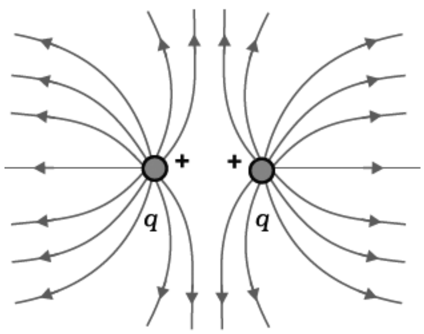
## PHYSICS - SOLUTIONS

1. The component $I_v \sin\phi$ contributes to reactive powers $\left(i.e.\ E_v I_v \sin\phi\right)$ which is neither consumed in the circuit nor it does any useful work, It merely flows back and forth in both directions.
2. Repeaters are used to increase range and strength of signals.
3. Resistivity of B is more

$$\because \quad R = \frac{\rho \cdot l}{A}$$

As $l$ and A are same

4. 




Electro field lines due to two positive charges.

5. AB in the ray diagram represent concave lense as the rays are diversing.
6. $E_1 = 2V$

$R_{AB} = 15\Omega$

$L_{AB} = 1m = 100\,cm$

$E_2 = 75\,mV = 75 \times 10^{-3}\,V$

$L_{AP} = 30\ cm$

$R = ?$

$$\sigma = \frac{R_{AB}}{L_{AB}} = \frac{15\Omega}{100} = 0.15\ \Omega/cm$$

$$R_{AP} = \sigma \cdot L_{AP} = 0.15 \times 30 = 4.5\Omega$$

$$\sum I = \frac{E_2}{R_{AP}} = \frac{75 \times 10^{-3}}{4.5} = 16.67 \times 10^{-3}$$

$$E_1 = I\left(R_{AB} + r + R_n\right)$$

$$r = 0$$

$$2 = 16.67 \times 10^{-3}\left(15 + 0 + R\right)$$

$$15 + R = \frac{2}{16.67} \times 10^3$$

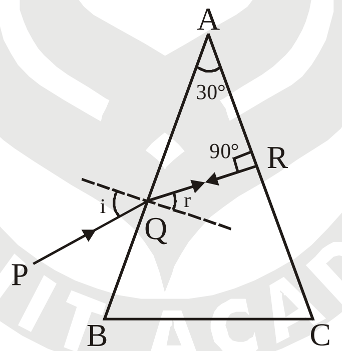
$$= 0.12 \times 10^3 - 15$$

$$R = 120 - 15 = 105\,\Omega$$

7. Modulation index $= \frac{A_{max} - A_{min}}{A_{max} + A_{min}} = \frac{10-2}{10+2} = \frac{8}{12} = \frac{2}{3}$

If $E_c$ is zero kodulation index will be $\infty$. If it is more than 1 carrier wave will show distortion so it must be kept low.

8.




The ray will retrace it's path at the silvered face when it is incident normally on it.

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin r}$$

$$\mu = \frac{\sin 2A}{\sin 0}$$

$$\mu = \sin 2A$$

$$2A = \sin^{-1}\mu$$

$$A = \frac{1}{2}\sin^{-1}\mu$$

**OR**

For convex lens

$f = 30\,\text{cm}$

$u = 30\,\text{cm}$

$v = ?$

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

$$\frac{1}{30} = \frac{1}{v} - \frac{1}{-40}$$

$$\frac{1}{v} = \frac{1}{30} - \frac{1}{40}$$

$$\frac{1}{v} = \frac{10}{1200}$$

$$\boxed{v = 120\ cm}$$

If concave lens placed in between convex lens and image formed 20 cm from convex lens then

for 2nd case $u' = 100\,cm$

$f' = -50\,cm$

$v' = ?$

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

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

$$= \frac{1}{-50} + \frac{1}{100}$$

$$= \frac{100-50}{-5000} = \frac{50}{-5000}$$

$$\frac{1}{v'} = -\frac{1}{100}$$

$v' = -100$

So image shifts towards left by 20 cm.

9. $$\lambda = \frac{h}{\sqrt{2mE}}$$

For deuterons

$$\lambda_D = \frac{h}{\sqrt{2(m)(E)}} \qquad \text{.......(1)}$$

For $\alpha$ particles

$$\lambda_\alpha = \frac{h}{\sqrt{2(2m)\ E}} \qquad \text{......(2)}$$

Divide 1 by (2)

$$\frac{\lambda_D}{\lambda_\alpha} = \frac{1}{\sqrt{2}}$$

$$\boxed{\lambda_D : \lambda_\alpha = 1:1.414}$$

10. $$\frac{\lambda \text{ shortest lyman}}{\lambda \text{ shortestbalmer}} = \frac{R\left(\frac{1}{12} - \frac{1}{\infty^2}\right)}{R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)} = \frac{R}{\frac{R}{4}}$$

$$\lambda = 4:1$$

Lyman series C & E

Balmer series D & B

11. Given:

$$V = 220V,\ f = 50\ Hz,\ R = 100\ \Omega,\ C = \frac{100}{\pi} \times 10^{-6}\ F$$

$$z = \sqrt{R^2 + \left(\frac{1}{2\pi\ fC}\right)^2}$$

$$= \sqrt{100^2 + \left(\frac{1}{2\pi} \cdot \frac{100}{\pi} 10^{-6} \times 50\right)^2}$$

$$= \sqrt{100^2 + \left(\frac{1}{10^{-2}}\right)^2}$$

$$= \sqrt{100^2 + (100)^2}$$

$$\boxed{z = \sqrt{2} \cdot 100}$$

$$i = \frac{V}{\sqrt{2}} = \frac{220}{100\sqrt{2}} = \boxed{1.56\,A}$$

$$V_R = iR$$

$$= 1.56 \times 100$$

$$\boxed{V_R = 156V}$$

$$V_C = iR$$

$$= 1.56 \times 100$$

$$V_C = X_C \cdot i$$

$$= \frac{1}{2\pi fC} 5\, i$$

$$= \frac{1}{2\pi \times \frac{100}{\pi} \times 10^{-6} \times 50} \times 1.56$$

$$= 100 \times 1.56$$

$V_C + V_R = 312$ but $V$ *is* $220\,V$.

$\therefore V_C + V_R > V$

This is because $V_C$ and $V_R$ are not in same phase.

12. When potential difference is applied to conductor electron moves with drift velocity, opposite to external field i.e. from –ve to +ve terminal of battery.

**Drift velocity :** It is velocity with which electron moves from –ve to +ve terminal in conductor when potential difference is applied to it.

Ohm's Law, $i = \frac{V}{R}$

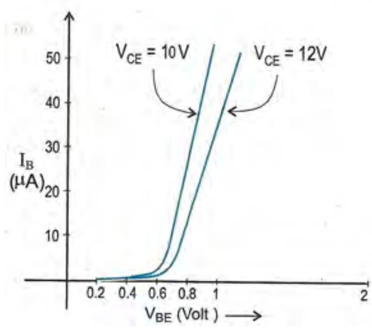
$$= \frac{E \cdot l}{R}$$

$$= \frac{E.V.A}{\rho V}$$

$$\frac{i}{A} = \frac{E}{\rho}$$

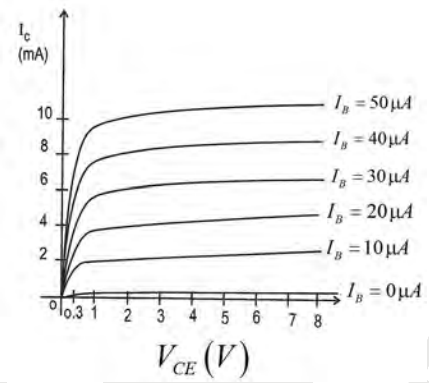
$$\boxed{J = \sigma \bar{E}}$$

13. **Input characteristics :**




When collector emitter voltage is constant and graph drawn by changing Bose-emitter voltage and noting base current, graph so obtained called.

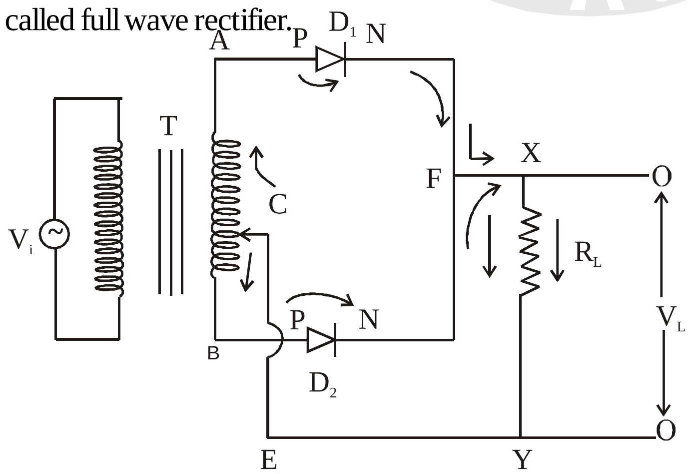
**Output characteristics:**




When base current kept constant and graph made by changing collector emitter voltage and noting collector current graph called out put characteristic.

**OR**

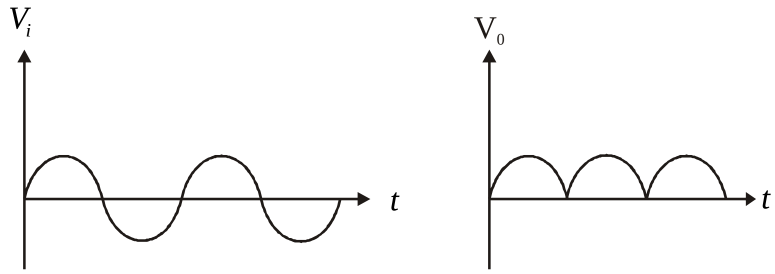
A device whcih converts A.C to D.C. is called rectifier. In this case output exists for both cycle hence it is called full wave rectifier.




T ----- Transformer
$D_1$ & $D_2$ ---- Diode
$V_0$ ---- output voltage
V ---- input voltage
$R_L$ ---- Load resistance
C ---- Central taps

**Construction :** The circuit diagram of a full wave rectifier using a junction diode is as shown in fig. The altenating voltage source is connected to the primary coil of a transformer. The secondary coil has centre - tap. The two terminals of secondary coils are connected to anodes of the junction diode $D_1$ & $D_2$. The cathodes of the two diodes are connected together. A load resistance $R_L$ is connected between this point and centre-tap.

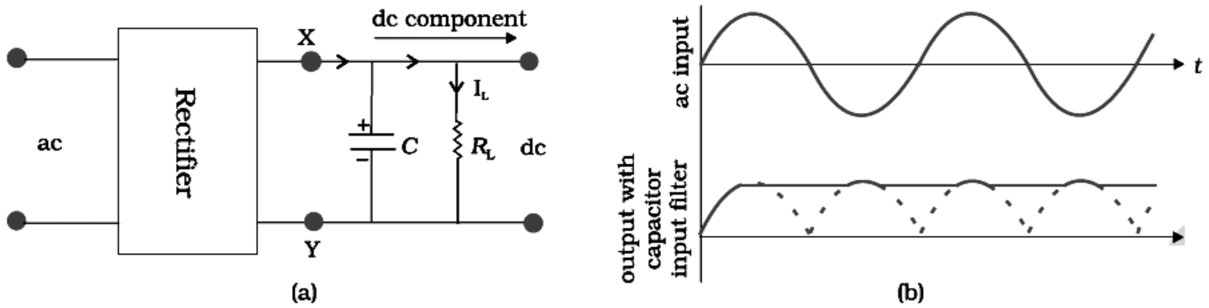
**Working :** During first positive half cycle of input wave, the anode of the diode $D_1$ is positive w.r.t. the centre - tap, while the anode of the diode $D_2$ is negative w.r.t. centre - tap. Thus $D_1$ conducts the current and allows the current 'i' in direction AFXYECA. Hence current flows through load resistance from X to Y give P.D. $iR_L.D_2$ does not conduct any current. It is called as output voltage. During next half cycle of input wave, the anode of the diode $D_1$ is negative w.r.t. the centre - tap, while the anode of the diode $D_2$ is positive w.r.t. centre - tap. Thus $D_1$ is in reversed - biased where as $D_2$ is forward - biased. Hence $D_2$ conducts the current and allows the current 'i' in direction BFXYECB. Hence current




flows through load resistance from X to Y give P.D. $iR_L.D_1$ does not conduct any current. Hence in both cycle, output voltage is obtained and the current through load resistance is unidirectional. Hence the circuit is called full wave rectifier.

**Discuss the role of capacitor in filtering.**

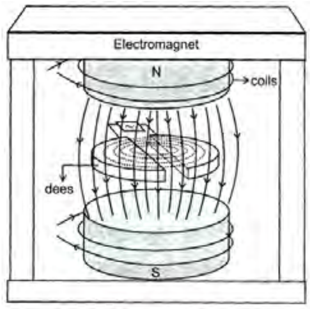
When the voltage across the capacitor is rising, it gets charged. If there is no external load, it remains charged to the peak voltage of the rectified output. When there is a load, it gets discharged through the load and the voltage across it begins to fall. In the next half-cycle of rectified output it again gets charged to the peak value. The rate of fall of the voltage across the capacitor depends upon the inverse product of capacity *C* and the effective resistance *RL* used in the circuit and is called the *time constant*. To make the time constant large value of *C* should be large. So capacitor input filters use large capacitors. The *output voltage* obtained by using capacitor input filter is nearer to the *peak voltage* of the rectified voltage. This type of filter is most widely used in power supplies.

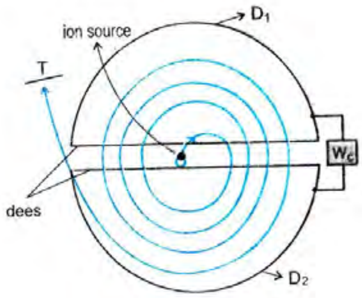



14. **<u>Cyclotron :</u>**

**<u>Principle:</u>** An electric field is used to accelerate a charged particle while magnetic field is used to produce circular motion of the particle.

**<u>Construction :</u>** The cyclotron consists of a flat, cylindrical copper box, divided into two parts by cutting it along its diamter. Each part is called a 'Dee' The two parts are kept separated from each other by a small gap inside an evacuated steel box. The dees are connected to a high frequency oscillator to which a high alternating voltage $\left(10^4 V, 10^7 Hz\right)$ is applied between dees. The steel box is placed between the poles of strong magnet.




**Working :** Suppose that a positive charged particles is introduce in the gap between the dees at an instant when the dee $D_2$ is at a postive potential and the dee $D_1$ is at negative potential.The particle repelled by the dee $D_2$and attracted by the dee $D_1$ .Therefore the particle is accelerated towards the dee $D_1$. Since magnetic field is at right angle to motion of particle, the particle moves in circular path inside the dee $D_1$.When it completes semicircle, it enters the gap between the dees. At this instant, electric field reverse its direction, so that $D_2$ becomes negative and $D_1$ becomes positive. Therefore the particle is accelerated towards $D_2$ with increasing speed. Inside $D_2$ the particle moves along a semicircle with a greater radius since speed is more. This process goes on repeating.

During the motion every times the radius of the circular path increases with the increase in the velocity of the particle. The particle covers each semicircle in the same time-interval and enters the gap when electric field is reversed since the time period is independent of speed and radius. Finally the particle emerges from cyclotron with a very high speed with high energy of the order of 25 MeV.

Let $q$ be charge, $r$ be the radius of motion $\omega$ be angular velocity and $v$ is linear velocity of charge particle, B be the magnetic induction

we have $F = qvB$ also $F = \dfrac{mv^2}{r}$

$$\therefore\ qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$

$$\omega = \frac{v}{r}$$

$$\frac{2\pi}{T} = \frac{qB}{m}$$

$$\boxed{\therefore T = \frac{2\pi m}{qB}}$$

or $\boxed{f = \dfrac{qB}{2\pi m}}$ cyclotronic frequency

15. $y_1 = a\cos\omega t \quad y_2 = a\cos(\omega t + \phi)$

By super position theorm

$$y = a\cos\omega t + a\cos(\omega t + \phi)$$

$$= 2a\cos\left(\frac{\omega t + \omega t + \phi}{2}\right)\cos\left(\frac{\omega t - \omega t - \phi}{2}\right)$$

$$y = 2a\cos\frac{\phi}{2}\cos\left(\omega t + \frac{\phi}{2}\right)$$

So amplitude $A = 2a\cos^2\frac{\phi}{2}$

Intensity $= A^2$ *i.e.* $\boxed{4a^2\cos^2\frac{\phi}{2}}$

$$I_1 = i + I + 2\sqrt{II}\cos\times\frac{2n}{\lambda}$$

$$\boxed{I_1 = 4I = k}$$

Now $I_2 = I + I + 2\sqrt{II}\cos\frac{\lambda}{4}\times\frac{2\pi}{\lambda}$

$$\boxed{I_2 = 2I = \frac{k}{2}}$$

16. Though there are many problems in transmission of an electronic signals in the audio frequency important three problems that may be

(a) size of antena

(b) Effective power radiated by atenna

(c) Mixing up of the signals from different transmitters.

We can overcome all above problems by modulating waves.

17. For case I the energy stored by the capacitor

$$U = \frac{1}{2}CV^2 = \frac{1}{2}600\times10^{-12}\times(200)^2$$

$$U = 12\times10^{-6}\ J = \frac{1}{2}CV$$

Energy stored in capacitor is $12\times10^{-6}\ J$

For case II the two capacitors have their positive plates at the same potential where batter is replaced by capacitor 300 pF. The charge on each capacitor then $\phi' = CV'$, By charge conservation $\phi' = \frac{\phi}{2}$.

Total energy of the system is $U = \frac{1}{2}qV = \frac{1}{2}\frac{q}{2}V = \frac{1}{2}\left[\frac{1}{2}qv\right]$

$$= \frac{1}{2}\times12\times10^{-6}$$

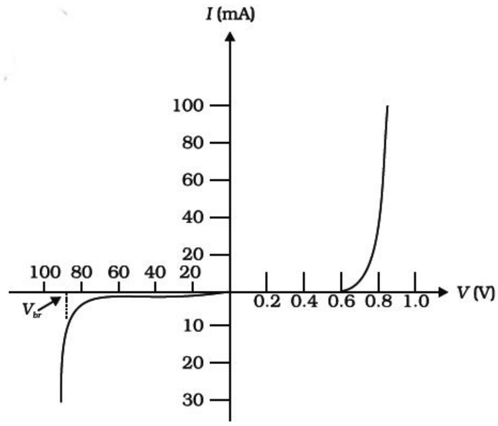
$$U = 6\times10^{-6}\ J$$

Hence the loss in energy is $6\times10^{-6}J$ which is 50 %.

18. Microwaves are produced by oscillator electronic circuits and are used in cooking, food and study of molecular structure.

Infrared rays are produced by excitation of atoms and molecules of hot bodies are used in TV remote and night camers.

19. **V – I characteristics of a silicon diode:**




(i) **Minority carriers in forward bias**

In the forward bias condition the e's and holes penetrate through the depletion layet and this is minority injection informad bias.

(ii) **Breakdown voltage** :The sudden increase in the voltage of zener diode which is reverse bias produces the current this is known as breakdown voltage.

20. (a) According to Einstein light is shower of packets called quanta. Each quanta has energy hr. During collision of photons from light and electrons from metals is absorbed by electrons. Electrons release themselves from atom by giving energy which is called as work function with removing energy electrons run with maximum energy.

Energy – $W_o$ = K $E_{max}$

$$h\upsilon - h\upsilon_o = \frac{1}{2} m v_{max}^2$$

(b) On simplyfication

$$v_{max}^2 = \left(\frac{2h}{m}\right)\upsilon - \frac{2W_o}{m}$$

Thus the graph $v_{max}^2$ as $\upsilon$ is a straight line

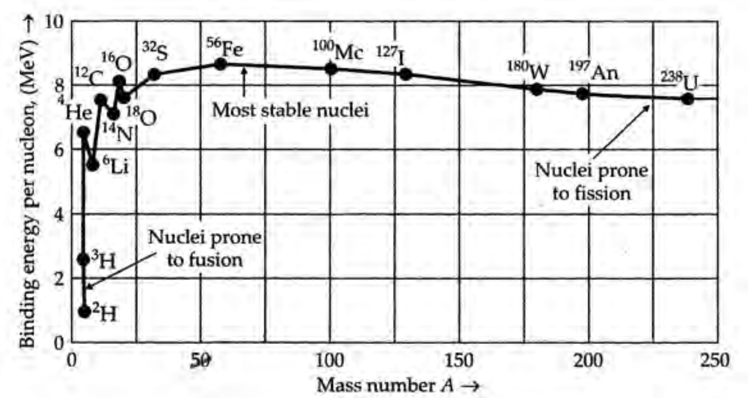
$$\text{slope of graph} = \frac{2h}{m} = \frac{l}{n}$$

$$\text{Intercept on } v_{max}^2 = \frac{2W_o}{m} = l$$

$$\therefore \text{ planck constant } = h = \frac{lm}{2n}$$

$$\therefore \text{ Work function } = W_o = \frac{m \cdot l}{2}$$

21. (a)




Binding energy per nucleon as a function of mass number A.

The value of binding energy per nucleon of a nuclear gives a measure of the stability of that nucleous greater is the binding energy per nucleon of nucleus, more stable is the nucleus.

This constant when implies that the nuuclear force is independent of charge it does not obey inverse squarl law.

(b) $A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\gamma} A_3$

The reaction can be given as follows:

$^{176}_{69}A_3 \xleftarrow{\gamma} A_2 \xleftarrow{\beta} A_1 \xleftarrow{\alpha} A$

$\gamma$ does not affect A & Z.

$A_2 = A_3$

$\therefore\ ^{176}_{69}A_2$

$A_1$ is emitting $\beta$

$\therefore A_2\ is\ ^{176}_{70}A_1$

A is emitting $\alpha$

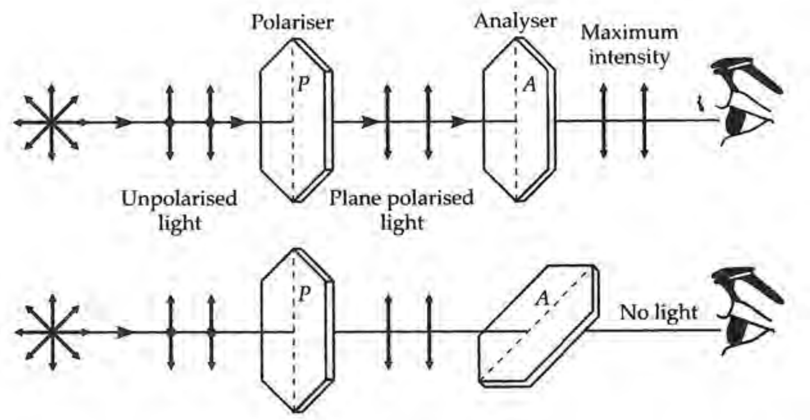
$\therefore A\ \ is\ ^{180}_{72}A$

22. When a beam of completely plane polarised light is pased through analyser, the intensity "I" of transmitted light varies directly as the square of the cosine of the angle '$\theta$' between the transmission directions of polariser and analser. This statement is know as the law of Malus.

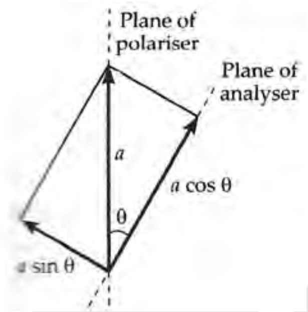
Mathematically,

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

Here $I_0$ is the maximum itensity of transmitted light. It may be noted that $I_0$ is equal to half the intensity of unpolarised light incident on the polariser.




**Explanation of the law:** As shown in figure suppose that the planes of polariser and analyser are inclined to each other at an angle $\theta$. Let I0 be the itensity and a the amplitude of the plane polarised light transmitted by the polariser.




The amplitude a of the light inciden on the analyser has two rectangular components:

(a) $a\cos\theta$, parallel to the plane of transmission of the analyser, and

(b) $a\ \sin\theta$, perpendicular to the plane of transmission of the analyser.

So only the component $a\cos\theta$ is transmitted by the analyser. The intensity of light transmitted by the analyser is $I = k\left(a\cos\theta\right)^2 = ka^2\ \cos^2\theta$

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

where, $I_0 = ka^2$, is the maximum intensity of light transmitted by the analyser $\left(when\ \theta = 0°\right)$. The above equaiton is the law of Malus.

Special Cases:

(a) When $\theta = 0°$ or $180°$, $\cos\theta = \pm 1$, so that $I = I_0$

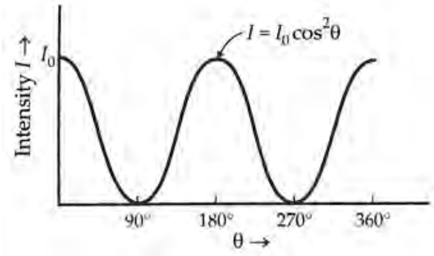
(b) When $\theta = 90°$, $\cos\theta = 0$, so that $I = 0$

(c) When a beam of unpolarised light is incident on the polariser,

$$I = I_0\overline{\cos^2\theta} = I_0 \times \frac{1}{2}\overline{\left(1+\cos 2\theta\right)}$$

$$= \frac{1}{2}I_0\left(1+\overline{\cos 2\theta}\right) = \frac{1}{2}I_0\left(1+0\right) = \frac{1}{2}I_0$$

**Intensity curve :** As the angle '$\theta$' between the transmission directions of polariser and analyser is varied the intensity 'I' of the light transmitted by the analyser varies as a function of $\cos^2\theta$, as shown in figure.




Graph of intensity I through analyser versus angle $\theta$ between polariser and analyser.

23. (a) Deepika and Ruchika are curious student. The teacher is very good as she explains the device before experiment.

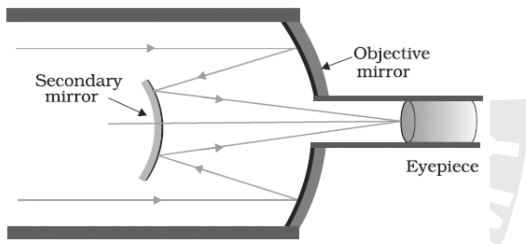
(b) $I \propto \theta$ ........(1) for a galvanometer.

(c) Shape of magnet is horsehoe shape. As horse shoe magnet makes the field radial. Magnetic lines start from N pole and end on south pole and before they coverage at the centre in radial field torque is maximum.

24. (a) (i) Focal length of objective is more than focal length of eyepiece.

(ii) Objective should allow maximum light to enter i.e. diameter is large.

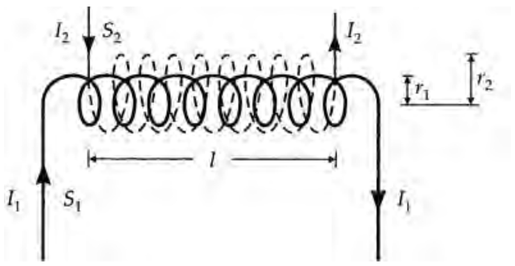
(b)




$$M.P = \frac{\beta}{\alpha} = \frac{\text{Angle made by the eyepiece final image}}{\text{Angle made by the eye with image at } \infty \text{ with naked eye}}$$

(c) By using reflecting telescope we avoid chromatic aberations and weight of device.

25.




*Let* $S_2$ & $S_1$ are wound

$$B_2 = \mu_o n_2 I_2$$

$$n_2 = \frac{N_2}{L} = \text{number of turns per unit length}$$

$$\phi_1 = B_2 A N_1 = \mu_o n_2 I_2 \; A N_1$$

$$M_{12} = \frac{\phi_1}{I_2} = \mu_0 n_2 A N_1 = \frac{\mu_0 N_1 N_2 A}{l}$$

$\therefore\ B_1 = \mu_0 n_1 I_1$

We can clearly see $M_{12} = M_{21}$

When current in coil (2) is changed, then magnetic flux will changed in coil (1) and induce Emf will generate in it called mutal induction.

Magnetic induction at centre of coil 2,

$$B_2 = \frac{\mu_o N_2 i_2}{l} \ \{l \to \text{length of solenoids}\}$$

$$\phi_1 = B_2\ A_1 \cdot N_1$$

$$\frac{\mu_o N_2 i_2}{l} \cdot \pi\, r_1^2 \cdot N_1$$

$$\phi_1 = \frac{\pi\, \mu_o\, N_1 N_2 i_2 r_1^2}{l}$$

But $\phi = Mi \quad (M \to \text{coefficient of mutual induction})$

$$\therefore\ Mi_2 = \frac{\pi\mu_o}{l}\ N_1 N_2\, i_2\ r_1^2$$

$$\therefore \boxed{M = \frac{\pi\, \mu_o \cdot N_1 N_2\, r_1^2}{l}}$$

(c) We have, $\phi, \alpha\ i_2$

also $e_1 = \dfrac{d\phi_1}{dt}$

$$e_1 \alpha\ -\frac{di_2}{dt}$$

$$e_1 = -\,M\ \frac{di_2}{dt}$$

$(M \to \text{coefficient of mutual induction})$

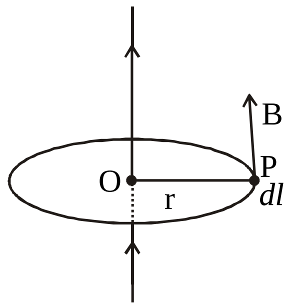
If $\dfrac{di_2}{dt} = 1$ $\boxed{e_1 = -M}$

So induce Emf in coil 1 is defined as coeficient of mutual induction, when there is unit rate of change in current in coil.

**OR**

(a) According to ampere's circuital law the line integral of the magnetic field $\vec{B}$ around any closed circuit is equal to $\mu_o$ times the total current I

i.e. $\boxed{\phi\ \vec{B}\cdot\vec{dl}=\mu_0 I}$




Consider a straight conduction carrying current I. Let P be a point at a distance *r* from 0.
Magnetic induction

$$B\ =\frac{\mu_0 I}{2\pi r} \qquad \text{..............(1)}$$

Let dl be the small part of the circel.

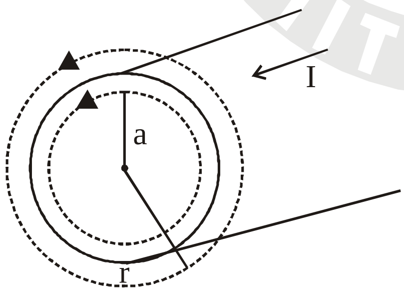
$$\vec{B}=\vec{dl}=B\ dl\ \cos\theta$$

$$=B\cdot dl\ \cos(0)$$

$$=B\cdot dl$$

$$\therefore\ \phi\vec{B}\cdot\vec{dl}=\phi\ \frac{\mu_o I}{2\pi r}\cdot dl=\mu_0 I$$

(b)




For $r>a$ for outside

$\therefore$ Length of loop $L=2\pi r$

Net current enclosed by loop = I

$$\therefore BL=\mu_0\pm$$

$$B(2\pi r)=\mu_0 I$$

$$B=\frac{\mu_o I}{2\pi r}$$

$$B\ \alpha\ \frac{1}{r}$$

For inside:

$r < a$

$$I' = \frac{\pm}{\pi a^2} \times \pi r^2 = \frac{Ir^2}{a^2}$$

Applying Law

$$BL = \mu_o I'$$

$$(2\pi r) = \mu_0 \frac{Ir^2}{a^2}$$

$$B = \left(\frac{\mu_0 I}{2\pi a^2}\right) r$$

$$B \propto r$$

26. (i) For flat faces

$$\phi_1 = \int \overline{E} \cdot ds$$

$$= \int E_o i \cdot \pi r^2 \, \hat{i}$$

$$\phi_1 = E_0 \cdot \pi r^2$$

$$\phi_2 = \int E_0 \hat{i} \cdot (-\pi r^2 \hat{i})$$

$$\phi_2 = E_0 \cdot \pi r^2$$

$$\phi_{Total} = 2E_0 \pi r^2$$

$$\phi_{Total} = \frac{q_{net}}{\epsilon_o}$$

$$q_{net} = 2\,E_o\,\pi r^2 \cdot \epsilon_o$$

(ii) For curved surface

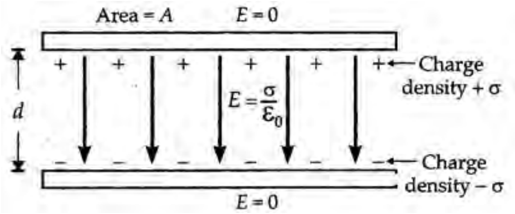
$$\phi' \int E_o i = \pi ra \cdot \hat{j}$$

$$\boxed{\phi' = 0} \quad \boxed{\because \hat{i} \cdot \hat{j} = 0}$$

(iii) Net charge inside cylincer $= 2\,E_o\,\pi r^2 \,\epsilon_o$

**OR**

(a)




Let A = area of each plate

d = Distance between two plates

$\pm\sigma$ = charge densities

$\pm Q = \pm\sigma \cdot A$ = total charge on each plate

In outer region the upper plate and lower plate, the electric fields due to the two charged plate cancells out. The net field is zero.

$$E = \frac{\sigma}{2\in_o} - \frac{\sigma}{2\in_o} = 0$$

Inside

$$E = \frac{\sigma}{2\in_o} + \frac{\sigma}{2\in_o} = \frac{\sigma}{\in_o}$$

But $v = E \cdot d$

$$v = \left(\frac{\sigma}{\in_o}\right)d$$

But $Q = c.v$

$$\therefore C = \frac{Q}{v} = \frac{\sigma A}{\sigma d / \in_o}$$

$$\boxed{C = \frac{\in_o A}{d}}$$