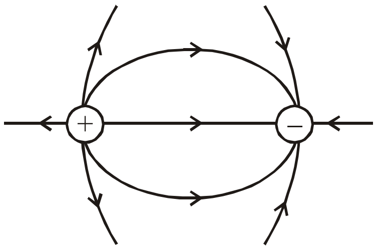
MODEL PAPER-2 (SOLUTIONS) 2020-21

(PHYSICS)

SECTION – A

1. (i) Nuclear fusion will occur when the kinetic energy of colliding nuclei is enough to overcome the strong electrostatic forces of repulsion between the protons. For this, high temperature is required.

(ii) The density of nuclei should also be very high to increase the number of collisions. **[1]**

2.  **[1]**

OR

Dielectric constant (or relative permittivity) of a medium is the ratio of the absolute permittivity of a medium to the permittivity of free space.

$$K\ (\text{or } \varepsilon_r) = \varepsilon/\varepsilon_0$$

Value of K is more than 1 for any dielectric medium. As it is a ratio so it has no unit.

3. $r_n \propto n^2 \Rightarrow r_2 / r_1 = 4/1$ **[1]**

4. (i) Band gap (ii) Biasing. **[1]**

5. Manganin is an alloy of copper with manganese and nickel. Since the manganese and nickel have resistivity greater than copper, the pure copper has lower resistivity as compared to alloy manganin. For the same resistance and equal length manganin wire is thicker than copper. [$\because \rho \propto A$] **[1]**

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

OR

Relaxation time is the time interval between two successive collisions of electrons in a conductor, when current flows.

6. When AC is connected to capacitor, due to continous change of polarity of the applied voltage there will be continuous change of polarity of capacitor plates. This causes the charge to flow (dq/dt) across capacitor. **[1]**

In steady state, capacitor acts as open circuit as reactance offered by it to flow of dc (f = 0) is infinite.

As $$X_C = \frac{1}{2\pi f C} = \infty$$

7. $i = 8A,\ \theta = 30°,\ B = 0.15T,\qquad F/\ell = ?$ **[1]**

$F = i\ \ell\ B\ \sin\theta$

$F/\ell = i\ B\ \sin\theta = 8 \times 0.15\ \sin 30° = 1.20 \times 1/2 = 0.6$ N/m

8. Not necessarily. True only if the source of the field has a net non-zero magnetic moment. This is not so for a toroid or even for a straight infinite conductor. **[1]**

9. (a) Water purification → Ultraviolet radiation **[1]**

(b) Eye surgery → Ultraviolet radiation [LASIK LASER]

OR

An accelerated charge produces an oscillating electric field in space which produces an oscillating magnetic field, which is again a source of oscillating electric field and so as a result electro magnetic wave is produced.

10. Locus of all the points vibrating in the same phase is called wave front. **[1]**

11. (a) **[1]**

12. (c) **[1]**

13. (c) **[1]**

14. (d) **[1]**

SECTION – B

15. (i) c, (ii) a, (iii) c, (iv) c, (v) b **[4 × 1 = 4]**

16. (i) a, (ii) c, (iii) d, (iv) c, (v) c **[4 × 1 = 4]**

SECTION – C

17. Let $C_1 = x$ and $C_2 = 2x$ **[2]**

equivalent capacitance in series combination

$$C_S = \frac{C_1C_2}{C_1+C_2} = \frac{x \times 2x}{x+2x} = \frac{2x}{3} \qquad \therefore C_S = \frac{2x}{3}$$

equivalent capacitance in parallel combination

$$C_P = C_1 + C_2 = x + 2x = 3x$$

Now given that energy stored in series combination = Energy stored in parallel combination

$$\frac{1}{2}C_sV_1^2 = \frac{1}{2}C_PV_2^2$$

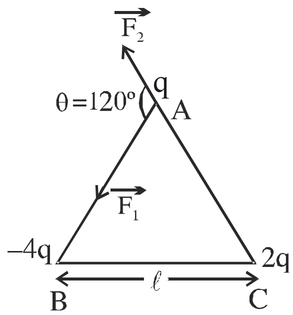
$$\frac{1}{2}\times\left(\frac{2x}{3}\right)V_1^2 = \frac{1}{2}\times 3x \times V_2^2$$

$$\Rightarrow \boxed{\frac{V_1}{V_2} = \frac{3}{\sqrt{2}}}$$

OR

Force on charge q due to the charge 4 q

$$F_1 = \frac{1}{4\pi\epsilon_0}\left(\frac{4q^2}{\ell^2}\right), \text{ along AB}$$



Force on the charge q due to the charge 2 q

$$F_2 = \frac{1}{4\pi\epsilon_0}\left(\frac{2q^2}{\ell^2}\right), \text{ along CA}$$

F_1 and F_2 are inclinded to each other at an angle of 120º

Hence, resultant electric force on charge q

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120^\circ}$$

$$= \sqrt{F_1^2 + F_2^2 - F_1F_2}$$

$$= \left(\frac{1}{4\pi\in_0}\frac{q^2}{\ell^2}\right)\sqrt{16+4-8}$$

$$= \frac{1}{4\pi\in_0}\left(\frac{2\sqrt{3}q^2}{\ell^2}\right)$$

18. **(i) Root mean square value of alternating current :** It is equal to that value of steady current which when passed through same resistance for same time then same amount of heat get produced.

(ii) Quality factor in electrical resonance : It is that factor which represents the sharpness of resonance of series LCR circuit. It is given by - **[2]**

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

19. Using $V_d = \frac{I}{neA}$, We get **[2]**

$$V_d = \frac{3}{(8.5\times10^{28})(1.6\times10^{-19})(2\times10^{-6})} = 1.1 \times 10^{-4}\ \text{m s}^{-1}$$

Time taken, $t = \frac{l}{V_d} = \frac{3}{1.1\times10^{-4}} = 2.72 \times 10^4$ s

20. A light-emitting diode (LED) is a heavily doped p–n junction diode that emits light when forward biased. When a suitable voltage is applied, electrons recombine with holes thereby releasing energy in the form of photons $\le E_g$. **[2]**

21. Here, number of turns per unit length, **[2]**

$n = N/l = 15$ turns/cm=1500 turns/m

$A = 2\ cm^2 = 2 \times 10^{-4}\ m^2$

$dI/dt = (4 - 2)/0.1$ or $dI/dt = 20\ As^{-1}$

$$|e| = \frac{d\phi}{dt} = \frac{d}{dt}(BA) \qquad \left[\because B = \frac{\mu_0 NI}{l}\right]$$

$$|e| = \frac{Ad}{dt}\left(\mu_0\frac{NI}{l}\right) = A\mu_0\left(\frac{N}{l}\right)\frac{dI}{dt}$$

$$|e| = (2 \times 10^{-4}) \times 4\pi \times 10^{-7} \times 1500 \times 20\ V$$

$$|e| = 7.5 \times 10^{-6}\ V$$

OR

(i) **Mutual Inductance** : It is numerically equal to the magnetic flux linked with one coil (secondary coil) when a unit current flows through the other coil (primary coil).

(ii) Magnetic flux

$\phi_1 = MI_1$

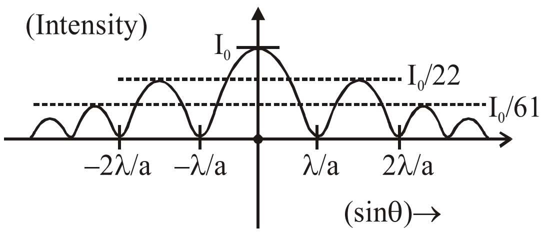
As $I_1 = 0$

$\therefore \phi_1 = 0$

$\phi_2 = MI_2 = 1.5 \times 20 = 30$

Change in flux $d\phi = \phi_2 - \phi_1 = 30 - 0 = 30$ weber.

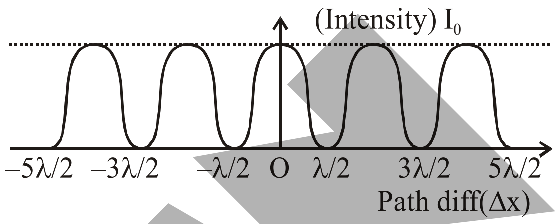
22. **[2]**



Diffraction

(1) Intensity decreases rapidly

(2) Fringes are of unequal width.



Interference

(1) Intensity remains constant most of the time

(2) Fringes are of equal width.

23. It is much easier to detect optical signal in reverse bias of photodiode because fractional change in conc. of minority charge carriers is very higher as compare to majority carriers. **[2]**

From, $\lambda = \frac{12400}{\Delta E_{(ev)}} \text{Å}$

$= \frac{12400}{0.3} = 41400\text{Å}$

24. $f_O = 192$ cm and $f_e = 8$ cm **[2]**

Magnifying power

$$M = \frac{f_0}{f_e} = \frac{192}{8} \Rightarrow M = 24$$

Distance between two lenses -

$L = f_O + f_e$

$L = 192 + 8$

$L = 200$ cm

25. Given $B_H = 0.26$ G **[2]**

$$\cos 60° = \frac{B_H}{B}$$

$$B = \frac{B_H}{\cos 60°} = \frac{0.26}{(1/2)} = 0.52G$$

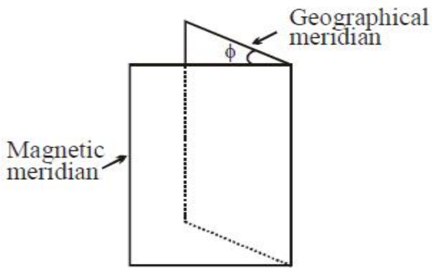
OR

Earth's magnetic components :-

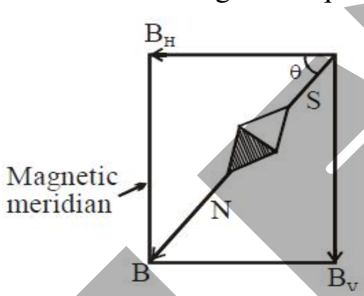
(1) Declination Angle (2) Dip Angle or Angle of inclination

(3) Horizontal Component of earth's magnentic field

(1) Angle of declination (ϕ) :- It is the acute angle between magnetic meridian and geographical meridian at a given place.



(2) Dip Angle(θ) :- It is direction horizontal resultant magnetic field of earth in magnetic meridian. Dip angle at magnetic pole of earth is 90° and at magnetic equator it is 0°.



$B \Rightarrow$ resultant magnetic field of earth's magnetism

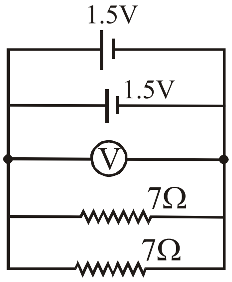
$B_H \Rightarrow$ Horizontal component

$B_V \Rightarrow$ Vertical component

SECTION – D

26. A high resistance voltmeter means that no current flow through the voltmeter (practically very less current). When two batteries are connected in parallel, then **[3]**

$$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$$



Here $r_1 = r_2 = r$

$E_1 = E_2 = 1.5V$ (given)

$$E_{eq} = \frac{1.5 \times r + 1.5 \times r}{2r}$$

$E_{eq} = 1.5$ V

Now $\left.\begin{array}{l} R_1 = 7\Omega \\ R_2 = 7\Omega \end{array}\right]$ given

So $$\frac{1}{R_{eq}} = \left(\frac{1}{7} + \frac{1}{7}\right)\Omega$$

$$R_{eq} = \frac{7}{2} = 3.5\Omega$$

$\because \quad I = \dfrac{\text{terminal voltage}}{\text{equivalent resistance}}$

V = terminal voltage = 1.4 (given) = voltmeter reading

So $\quad I = \dfrac{1.4}{3.5} = 0.4 \text{ A}$

Now $\quad V = E_{eq} - I \times r_{eq}$

$1.4 = 1.5 - 0.4 \times r_{eq}$

$0.4 \times r_{eq} = 0.1$

$r_{eq} = 0.25\ \Omega$

As $r_{eq} = r/2 \qquad \left(\because \dfrac{1}{r_{eq}} = \dfrac{1}{r} + \dfrac{1}{r}\right)$

So r of each cell = 0.5Ω

OR

During charging,

V= E + I (r + R)

$$I = \frac{E - V}{r + R} = \frac{120 - 8}{0.5 + 15.5} = \frac{112}{16} = 7A$$

Terminal Voltage,

= 8 + 7 × 0.5 = 11.5 V

The series resistor limits the current drawn from the external source. In its absence, the current will be dangerously high.

27. Fringe width in young's double slit experiment is given by $\boxed{\beta = \dfrac{\lambda D}{d}}$ **[3]**

λ = wavelength of light

d = separation between slits

D = distance between screen and plane of the slits.

(a) When D is increased, β also increases. Thus the size of each fringe increases. There will be lesser dark and bright fringes on the screen.

(b) If the separation between slits is increased, fringe width decreases $\boxed{\beta \propto \dfrac{1}{d}}$.

Thus, the size of each fringe decreases.

(c) For interference fringes to be seen, the condition $\dfrac{s}{S} < \dfrac{\lambda}{d}$ should be satisfied. As the

$\begin{cases} s \Rightarrow \text{ size of slit} \\ S \Rightarrow \text{ distance between source slit and plane of the two slits} \end{cases}$

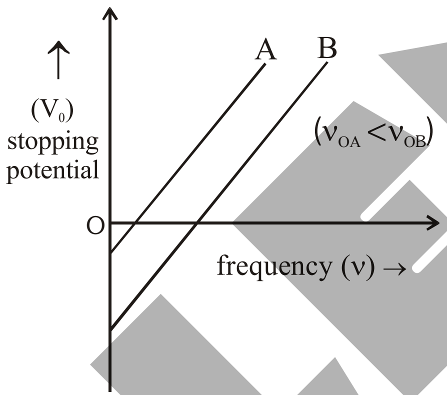
If the source slit is moved towards or closer to the double slit then the above condition is not satisfied. As a result, interference fringes will overlap and interference pattern will be less sharp & have low intensity.

28. (i) Energy of a photon is proportional to the freq. of light. ($\because E = h\nu$) **[3]**

(ii) Photons are quanta or discrete carriers of energy.

Stopping potential :- In experiment of photoelectric effect, the value of negative potential of anode at which photoelectric current reduces to zero is called stopping potential for the given freq. of incident radiation.

Threshold freq. :- For a given material, there exist a certain min. frequency below which no photoelectron can come out from the metal surface. This is called threshold ferquency.



OR

Cut off frequency – The min. freq. of light which can emit photoelectrons from a material is known as cut-off frequency.

From eq. $KE_{max} = h\nu - h\nu_0$

$$\frac{1}{2}mv_1^2 = hf \qquad ....(1)$$

$$\frac{1}{2}mv_2^2 = 4hf \qquad ....(2)$$

$$\therefore \quad \frac{v_1^2}{v_2^2} = \frac{1}{4} \Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$$

29. Ground state energy of hydrogen atom as –13.6 eV, **[3]**

$$E_n = \text{Total energy} = -\frac{13.6 \text{ eV}}{n^2}$$

$$\text{K.E.} = \frac{Rhc}{n^2}, \qquad \text{P.E.} = = \frac{-2Rhc}{n^2}$$

$\Rightarrow$ In ground state, (n = 1)

$R = 1.097 \times 10^7 m^{-1}$ (Rydberg's constant)
$h = 6.6 \times 10^{-34} J - s$ (Planck's constant)
$c = 3 \times 10^8 m/s$

$$K.E. = \frac{Rhc}{n^2} = Rhc$$

& P.E. = –2Rhc

⇒ In second excited state, (n = 3)

$$K.E. = \frac{Rhc}{9} \ \& \ P.E. = \frac{-2Rhc}{9}$$

30. **(i) Nuclear fission :** Nuclear fission is the phenomenon of splitting of a heavy nucleus (usually A > 230) into two or more lighter nuclei. **[3]**

Ex. $_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q$

(ii) Nuclear fusion : The process of combining of two lighter nuclei to form one heavy nucleus is called nuclear fusion.

Ex. $4\,{}_1H^1 \rightarrow {}_2He^4 + 2\,{}_1e^0 + 2\nu + 26.7\ MeV$

* Nuclear reactor is based on controled chain reaction.

OR

$$\text{Density of nucleus matter} = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$$

$$\rho = \frac{mA}{\frac{4}{3}\pi R^3}, \qquad [\ R = R_0 A^{1/3}$$

$$\rho = \frac{3m}{4\pi R_0^3}$$

$$\rho = \frac{A \times 1.66 \times 10^{27} kg}{\frac{4}{3} \times 3.14 \times \left(1.2 \times 10^{-15}\right)^3 A} \approx 10^{17}\ kg/m^3$$

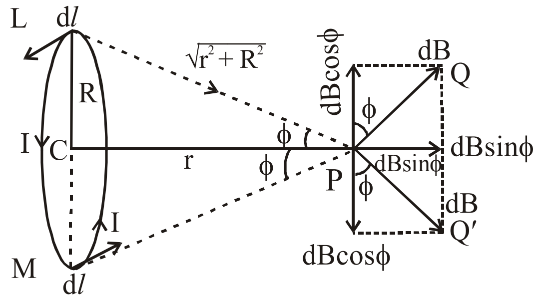
It is clear that the density of nucleus is constant.

SECTION – E

31. (a) Magnetic moment of current carrying circular coil. **[5]**

$\boxed{M = NIA}$ $[A = \pi r^2]$

(b) Let us consider a circular loop of radius R with centre C. Let the plane of the coil be perpendicular to the plane of the paper and current I be flowing in the direction shown. Suppose P is any point on the axis at distance r from the centre.



Let us consider a current element dl on top (L) where, current comes out of paper normally whereas at bottom (M) enters into the plane paper normally.

Here $\quad LP = MP = \sqrt{r^2+R^2}$

Now, magnetic field at P due to current at L accroding to Biot-Savart Law,

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin 90^o}{\left(r^2+R^2\right)}$$

Where, $\quad$ R = radius of circular loop

r = distance of point P from centre along the axis.

dBcosϕ components balance each other and net magnetic field is given by integration of dBsinϕ component.

$$B = \oint dB\sin\phi = \oint \frac{\mu_0}{4\pi}\left[\frac{Idl}{r^2+R^2}\right]\cdot\frac{R}{\sqrt{r^2+R^2}} \qquad \left[\because \sin\phi = \frac{R}{\sqrt{r^2+R^2}} \text{ in } \Delta PCM\right]$$

$$= \frac{\mu_0}{4\pi}\frac{IR}{(r^2+R^2)^{3/2}}\oint dl$$

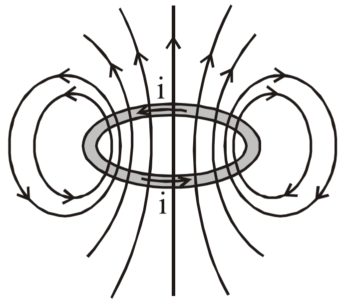
$$B = \frac{\mu_0}{4\pi}\frac{IR}{(r^2+R^2)^{3/2}}(2\pi R)$$

$$B = \frac{\mu_0 IR^2}{2\left(r^2+R^2\right)^{\frac{3}{2}}}$$

For N turns,

$$\boxed{B = \frac{\mu_0 NIR^2}{2\left(r^2+R^2\right)^{\frac{3}{2}}}}$$

Magnetic field due to circular wire carrying current I.



OR

(a) Current sensitivity (CS)

Deflection per unit current in a galvanometer is called current sensitivity.

$$CS = \frac{\phi}{I}$$

$$\boxed{CS = \frac{NAB}{K}}$$

N $\Rightarrow$ No. of turns in a coil.

A $\Rightarrow$ Area of coil

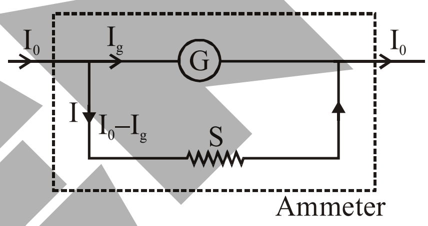
B $\Rightarrow$ Magnetic field

K $\Rightarrow$ Torsional constant of spring.

(b) (i) To convert galvanometer into an ammeter to measure current up to I_0. We connect a small resistance (S) in parallel to a galvanometer.

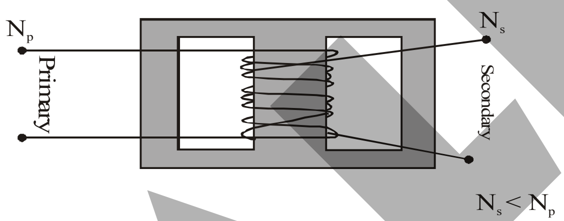
In parallel, $(I_0 - I_g)S = I_g G$

$$\boxed{S = \frac{I_g G}{I_0 - I_g}}$$



(ii) Effective resistance of this ammeter $\boxed{R_A = \frac{GS}{G+S}}$

32. (i) **[5]**



Principle: Transformer works on principle of mutual induction , in which an EMF is induced in the secondary coil by the change in magnetic flux in primary coil.

Working : When alternating current source is connected to the ends of primary coil, the current changes continuously in the primary coil, due to which magnetic flux linked with the secondary coil changes continuously. Therefore, the alternating emf of same frequency is developed across the secondary terminals.

(ii) $\frac{N_S}{N_P} = \frac{V_S}{V_P}$ $\left\{\frac{N_S}{N_P} = \text{turn ratio}\right.$

(iii) For ideal transformer

Output power = Input power

$V_S I_S = V_P I_P$

$\frac{V_S}{V_P} = \frac{I_P}{I_S}$ $\left\{\frac{V_S}{V_P} = \frac{N_S}{N_P}\right.$

$$\boxed{\frac{N_S}{N_P} = \frac{I_P}{I_S}}$$

(iv) Given $V_P = 220\ V$

$V_S = 110\ V$

$P = 550\ W$

$I_P = ?$

$$I_P = \frac{\text{Power}}{\text{Primary Voltage}} = \frac{P}{V_P}$$

$$I_P = \frac{550}{220} = 2.5\ A$$

OR

(i) Source frequency, when current is maximum is given by

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{8\times2\times10^{-6}}} \qquad \{L = 8H \text{ and } C = 2\mu F$$

$$f = \frac{1}{2\pi\times4\times10^{-3}}$$

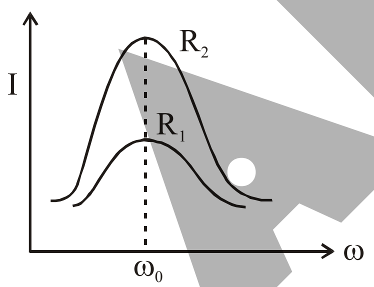
$f = 39.80$ Hz

The frequency at which current maximum, is called resonant frequency.

(ii) given $E_0 = 200V$, $R = 100\Omega$

$$I_{max} = \frac{E_0}{R} = \frac{200}{100} = 2A$$

(iii)



33. (a) & (b) Assumptions :- **[5]**

– Aperature of the spherical refracting surface is small.

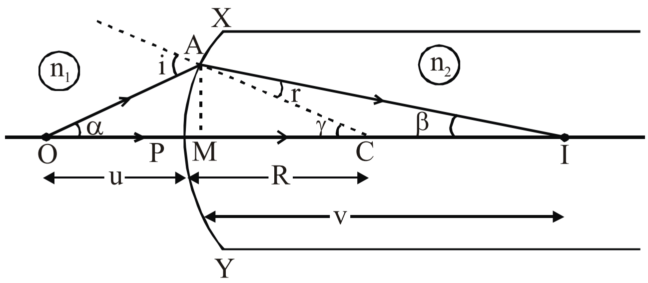
– Object is a point object & lies on the pricipal axis.

– Incident ray, refracted ray & normal to the spherical surface makes small angles with PA.

Let XPY = convex spherical refracting surface.

O = point object in rarer medium

I = real image in denser medium



From ΔAOC, $i = \alpha + \gamma$

From ΔAIC, $\gamma = r + \beta \Rightarrow r = \gamma - \beta$

From snell's law, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} \Rightarrow n_1 \sin i = n_2 \sin r$

Since the angles are small, $\therefore n_1 i = n_2 r$

Substituting for i & r, in the above eqn, we get

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

or $$n_1\left\{\frac{AM}{PO} + \frac{AM}{MC}\right\} = n_2\left\{\frac{AM}{MC} - \frac{AM}{MI}\right\}$$

Since the aperature is small,

$\therefore$ MC = PC, MI = PI

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

Acc. to sign convention, PO = –u, PC = R, PI = v

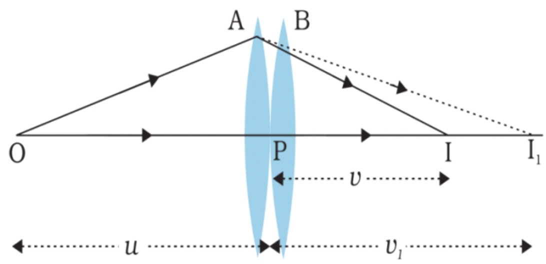
$$\therefore \left\{\frac{n_1}{-u} + \frac{n_1}{R}\right\} = \left\{\frac{n_2}{R} - \frac{n_2}{v}\right\}$$

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

OR

(a) Combination of thin lenses in contact -

Image I_1 made up by lens L_1 is work as a object for lens L_2 which made up final image I.



$f_1 \Rightarrow$ Focal length of lens L_1

$f_2 \Rightarrow$ Focal length of lens L_2

For lens L_1

Using lens formula

$$\frac{1}{v_1}-\frac{1}{(-u)}=\frac{1}{f_1}$$

$$\frac{1}{v_1}+\frac{1}{u}=\frac{1}{f_1} \qquad \ldots\ldots(1)$$

For lens L_2

Using lens formula

$$\frac{1}{v}-\frac{1}{v_1}=\frac{1}{f_2} \qquad \ldots\ldots(2)$$

eq^n (1) + eq^n (2)

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f_1}+\frac{1}{f_2} \qquad \ldots\ldots(3)$$

If the two lens system is regarded as equivalent to a single lens of focal length f.

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \qquad \ldots\ldots(4)$$

From eq^n (4) & eq^n (3)

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2} \qquad \ldots\ldots(5)$$

equivalent focal length

$$f=\frac{f_1 f_2}{(f_1+f_2)} \qquad \ldots\ldots(6)$$

(b) Magnifying power, M= $\frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)=-\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$