Chapter-9
RAY OPTICS

Q.1 What is optics ?
Q.2 What is Light ?
Q.3. write the properties of Light.

Ans.1) optics :- This is the branch of physics which deals about the light. Phenomena of

optics have 2 branch -

a) Ray optics
b) Wave optics

a) Ray optics :- Also known as Geometrical optics.

if the property of light is explained by the ~~help~~ form of ray is called ray optics.

b) Wave optics :- If the properties of light is explained by the wave is called wave optics, also known as physical optics.

Ans.2) light is the medium in its present we can seen all object.

There are 9 phenomena of light :-

i) Recti - linear propagation of light :- light

always travel in straight line.

Q.4 What is mirror? write its type. and define it.

Q.5 Write the sign convention of light.

Q.6 Define the following:-

a) Pole
b) centre of curvature
c) principle axis
d) Normal
e) Incident ray
f) Reflacted ray
g) Angle of incident
h) Angle of reflection
I) Radius of curvature
J) Focus point
K) Focal length

~~Q.7.)~~
~~Ans.4.)~~ What do you understand by the refraction of light?

Q.8) Prove that the multiplication of relative refractive ~~dess~~ index and absolute refractive index always equal to 1.

Q.9) Derive the relation b/w real depth, Apparent depth and refractive index of medium.

Q.10) Derive an expression of refracting formula for spherical surface.

Ans. 7) Refraction of light :- when a ray travel from one medium to another medium then path of light changed, this phenomena is called refraction of light.

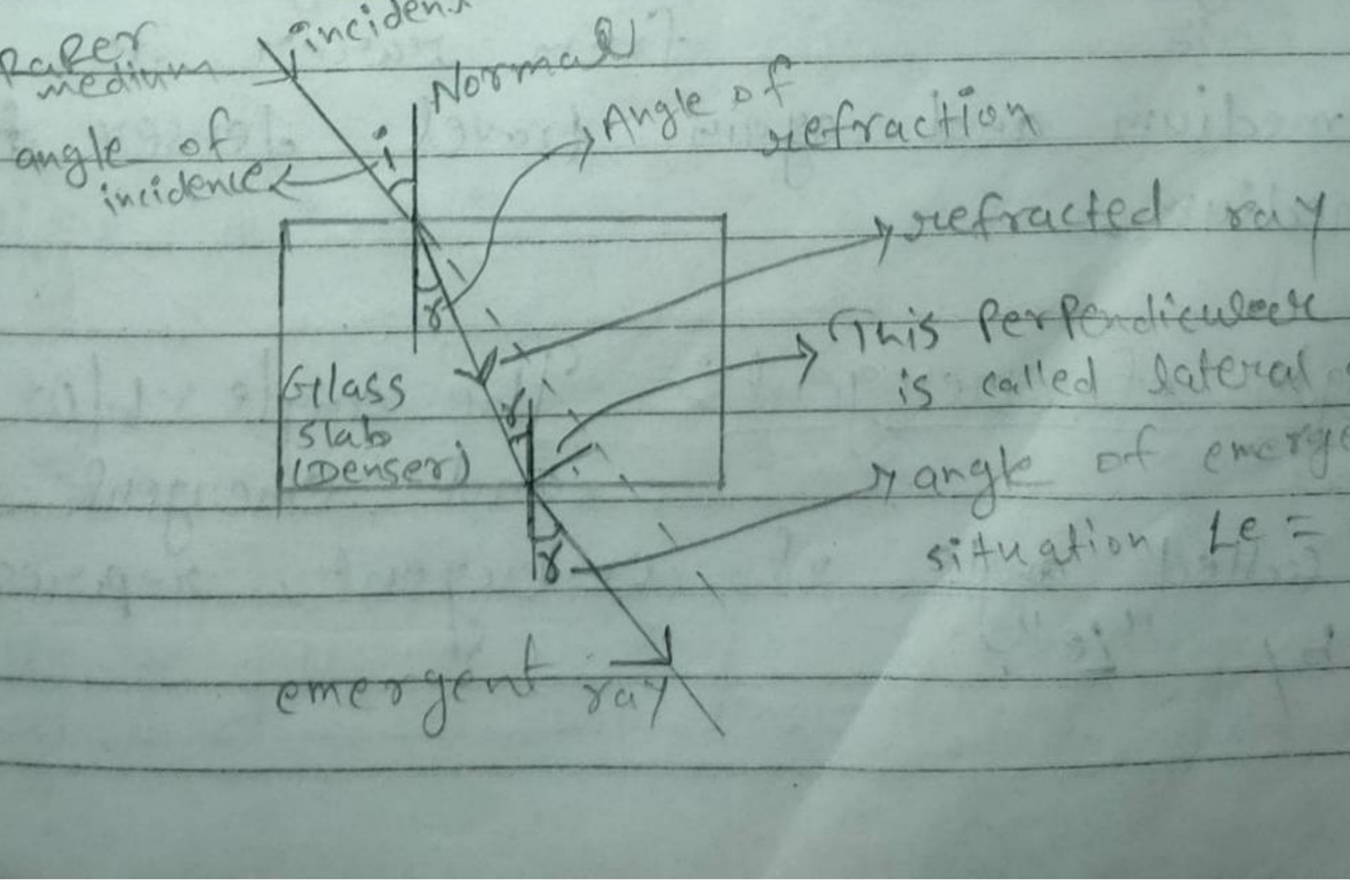
laws :- i) Normal, incident ray and refracted ray always lie in same surface.

ii) The ratio of sin of angle of incident and sin of angle of refraction is always remain constant.

$$\frac{\sin i}{\sin r} = \text{constant.}(\mu)$$

iii) light travel from rarer medium to denser then it bend towards the normal and travel denser to rarer medium then it bend away from normal. ray

Ans. 8.



Incident ray :- The incoming ray of light towards the surface is called incident ray.

Refracted ray :- when a light come from one medium to another medium then light change it's path and the ~~changed path~~ light ray travel in new path is called refracted ray.

Angle of incidence :- The angle b/w normal and incident ray is called angle of incidence, represented by "∠i".

Angle of refraction :- The angle b/w normal and refracted ray is called angle of refraction, representation :- "∠r".

Normal :- The perpendicular line drawn in surface is called normal.

Emergent ray :- when a light ray come from rarer to denser medium and again travel denser to rarer medium.

Angle of emergent :- The angle b/w normal and emergent ray is called angle of emergent, represented by "∠e".

Absolute refractive index :-

When light ray travel from air to any denser medium this is called absolute refractive index, represented by "μ"

$a\mu_g$ = absolute refractive index {air to glass}

Relative refractive index :-

When light ray travel from denser to air (rarer) this is called relative refractive index, represented by "μ".

$g\mu_a$ = relative refractive index (glass to air)

→ Now,

from diagram

Absolute refractive index ($a\mu_g$) = $\frac{\sin i}{\sin r}$ → (1)

relative refractive index ($g\mu_a$) = $\frac{\sin r}{\sin i}$ → (2)

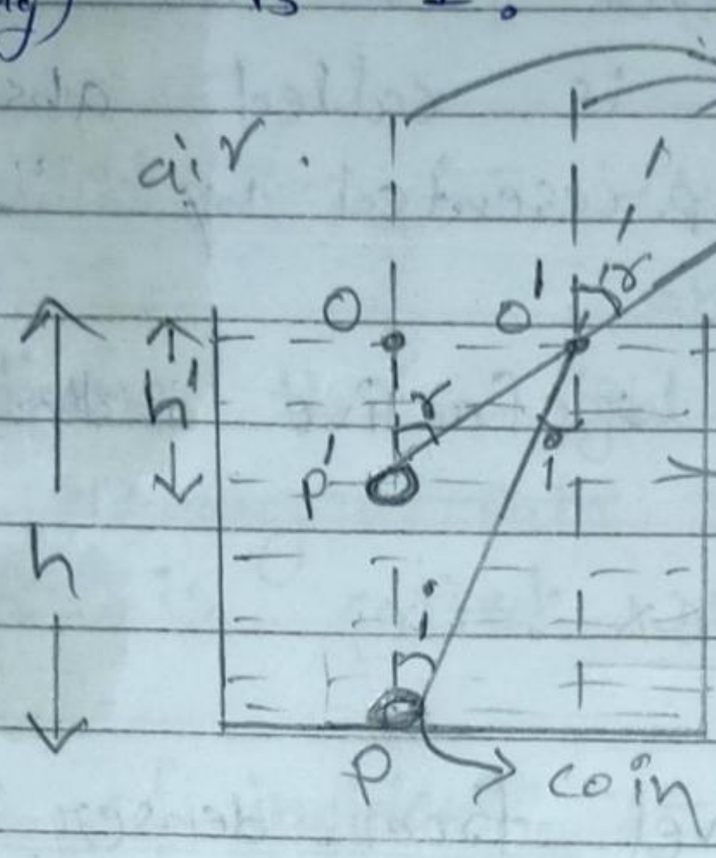
multiply eq^n (1) & (2),

$\Rightarrow a\mu_g \times g\mu_a = \frac{\sin i}{\sin r} \times \frac{\sin r}{\sin i}$

$\Rightarrow \boxed{a\mu_g \times g\mu_a = 1}$

Hence the multiplication of relative refractive index ($_g\mu_a$) and absolute refractive index ($_a\mu_g$) is 1.

Ans. 9)



In diagram, h' → Apparent depth
h → real depth

In $\triangle OO'P'$,

$$\sin r = \frac{OO'}{O'P'} \rightarrow (1)$$

Now In $\triangle OO'P$,

$$\sin i = \frac{OO'}{O'P} \rightarrow (2)$$

we know that, relative refractive index (water to air)

$$\Rightarrow {}_w\mu_a = \frac{\sin i}{\sin r}$$

$$\Rightarrow {}_w\mu_a = \frac{\left(\frac{OO'}{O'P}\right)}{\left(\frac{OO'}{O'P'}\right)} \quad \{\text{from } (1), (2)\}$$

$\Rightarrow \omega \sin\alpha = \frac{o'p'}{o'p}$

$\Rightarrow \omega \sin\alpha = \frac{op'}{op}$ {By using similar triangle theorem (SAS) then we get $o'p' = op'$ $\Rightarrow o'p = op$ }

$\Rightarrow \frac{1}{\alpha \sin\omega} = \frac{h'}{h}$

$\Rightarrow \boxed{\alpha \sin\omega = \frac{h}{h'}}$

$\Rightarrow \boxed{\mu = \frac{h}{h'}}$

Ans.6) a) Pole :- Mid-Point of the ~~(surface)~~ mirror is called pole.

b) centre of curvature :-

Spherical mirror is formed by sphere and center of that sphere is called centre of curvature.

c) principle axis :- A line passing through pole & centre of curvature is called principle axis.

d) Normal :- perpendicular line drawn in any surface is called normal.

e) Incident ray :- The incoming ray of light towards the surface is called incident ray.

f) Reflected ray :- when a light ray incident at mirror surface and get back in same medium by making some angle with normal & surface, that reflected light ray is called reflected ray.

g) Angle of incident :- The angle b/w normal & ~~surface~~ → incident ray is called angle of incident.

h) Angle of reflection :- The angle b/w normal & reflected ray is called angle of reflection.

I) Radius of curvature :- The distance b/w pole & centre of curvature is called Radius of curvature.

J) ~~Focus point :-~~ length :- distance b/w pole and focus point is called focal length.

for concave surface

from diagram,

$PC = -R$

$PI = -V$

$PO = -U$

$$\Rightarrow \frac{1}{PC} - \frac{1}{PO} = n\left(\frac{1}{PC} - \frac{1}{PI}\right)$$

$$\Rightarrow \frac{1}{-R} + \frac{1}{U} = n\left(\frac{1}{-R} + \frac{1}{V}\right)$$

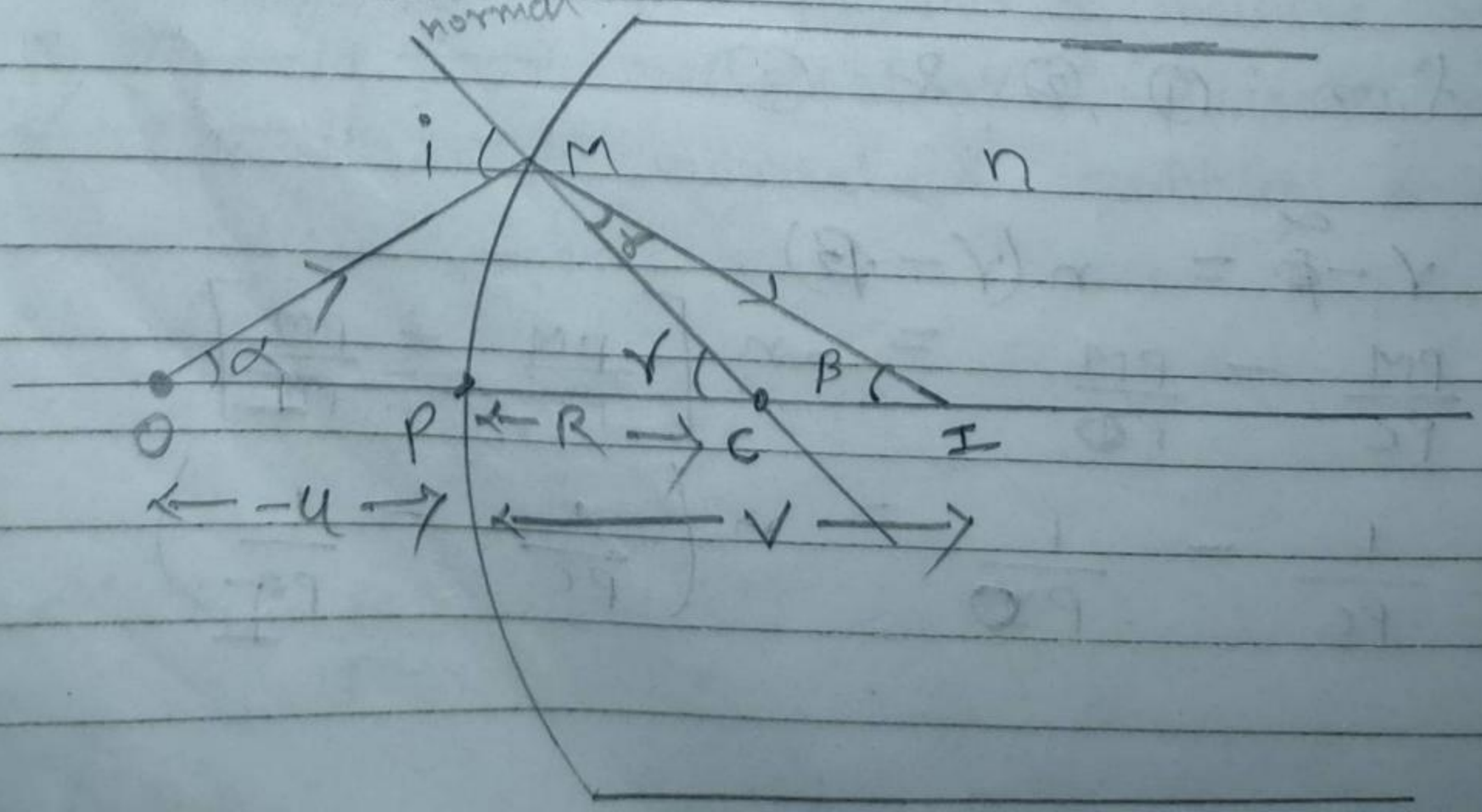
$$\Rightarrow \frac{n}{V} - \frac{1}{U} = \frac{1}{-R} + \frac{n}{R}$$

$$\Rightarrow \boxed{\frac{n}{V} - \frac{1}{U} = \frac{n-1}{R}}$$

↗ refracting surface formula applicable for both concave & convex surface.

Q.11 Derive the refracting formula for convex surface.

Ans. 11



where, $n \rightarrow$ refractive index

Now,

$$PC = +R$$
$$PI = +V$$
$$PO = -u$$

$\therefore \quad \theta = \frac{l\ (arc)}{R\ (radius}$

$$\Rightarrow \alpha = \frac{PM}{PO}$$

$$\Rightarrow \beta = \frac{PM}{PI}$$

$$\Rightarrow \gamma = \frac{PM}{PC}$$

$\therefore \quad n = \frac{\sin i}{\sin r}$

$$n = \frac{i}{r}$$

$$\Rightarrow \quad i = nr \longrightarrow (1)$$

In $\triangle OCM$

$$i = \gamma + \alpha \longrightarrow (2)$$

In $\triangle ICM$

$$r = \gamma - \beta \longrightarrow (3)$$

from (1), (2) and (3)

$$\Rightarrow \gamma + \alpha = n(\gamma - \beta)$$
$$\Rightarrow \gamma + \alpha = n\gamma - n\beta$$

$$\Rightarrow \frac{PM}{PC} + \frac{PM}{PO} = n\left(\frac{PM}{PC}\right) - n\left(\frac{PM}{PI}\right)$$

$$\Rightarrow \frac{1}{R} + \left(\frac{1}{-u}\right) = \frac{n}{R} - \frac{n}{v}$$

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

Q.12 What is lens? write its type.

Ans.12. lens is of transparent medium which is surrounded by two spherical surface is called lens

There are 2 types of lens :-

i) conven lens → ()

ii) concave lens →][

optical centre :- The centre of the lens is called optical centre, represented by "O"

Q.13. Define focus point and focal length.

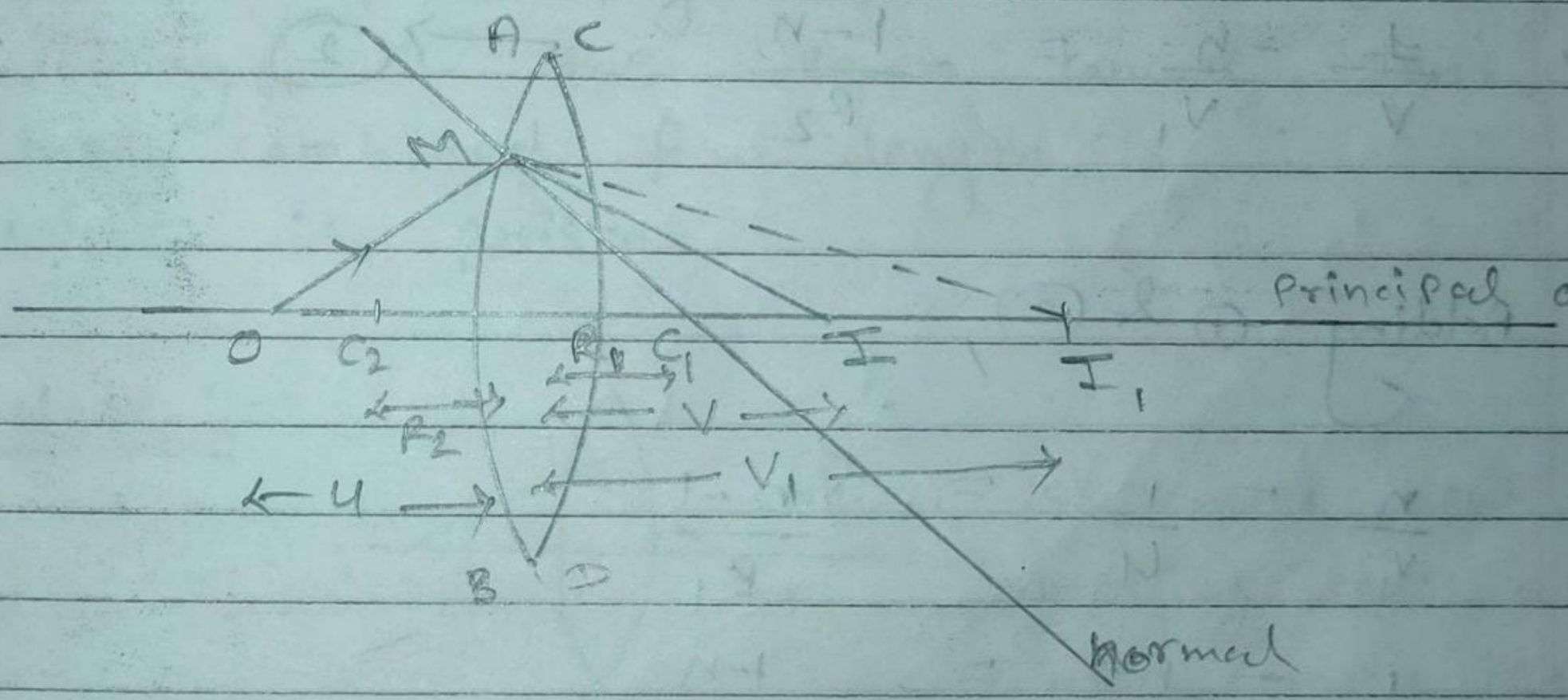
Q.14 write and Prove the lens maker formula.

Q.15 Prove that lens formula

Note :-

i) convex lens is also called "converging lens".
ii) concave lens is also called "diverging lens."
iii) Two refracted ray intersect at principal axis, at that intersection point is position of image of object.

Ans.(4) The relation b/w focal length, refractive index and radius of curvature is known as the lens maker formula.



Where, O → object
I_1 → image of object for AB
I_1 → also object for CD.
I → Image of object for CD.
U → distance of object fo AB
V → distance of image for CD.
V_1 → distance of object for CD.

then,

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

for AB surface,

$$\Rightarrow \quad \frac{n}{v_1} - \frac{1}{u} = \frac{n-1}{R_1} \longrightarrow (1).$$

for CD surface, $\boxed{n = \frac{1}{n}}$

$$\Rightarrow \frac{\frac{1}{n}}{v} - \frac{1}{v_1} = \frac{\frac{1}{n} - 1}{R_2}$$

multiply both side by "n",

$$\Rightarrow \quad \frac{1}{v} - \frac{n}{v_1} = \frac{1-n}{R_2} \longrightarrow (2).$$

Adding (1) & (2),

$$\Rightarrow \quad \frac{n}{v_1} - \frac{1}{u} = \frac{n-1}{R_1}$$

$$\frac{1}{v} - \frac{n}{v_1} = \frac{1-n}{R_2}$$

(+) (+) (+)

$$\frac{1}{v} - \frac{1}{u} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \longrightarrow (III)$$

Now, $u = \infty$, $v = f$

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

$$\Rightarrow \boxed{\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)} \quad \text{---(4)}$$

→ lens maker formula.

Ans. '15' Taking (3) & (4)

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

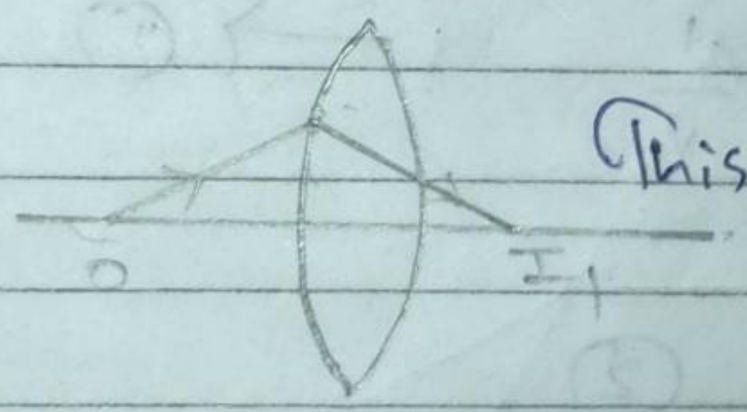
→ lens formula.

Q.16 Derive an expression for combined focal length for 2 contact lens.

Q.17. 20 cm focal length of a convex lens is joining with the 30 cm concave lens, find the combined focal length.

Q.18 What is prism.

Note :-



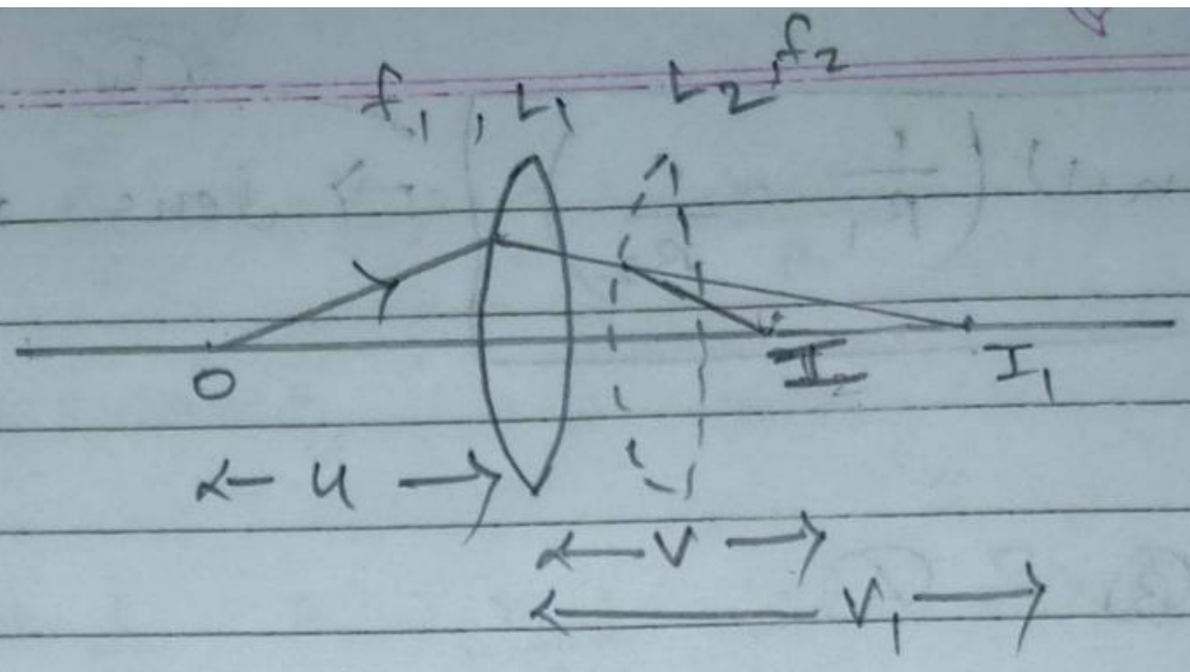
This is convex lens, converging lens and double convex lens.

Two refracted ray intersect at that point we get the position of image

Same lens is contact with each other than focal length is decreases.

Different lens is contact with each other than focal length decreases.

Ans. 16.



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

for L_1,

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

$\Rightarrow$ for L_2,

$$\Rightarrow \frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1} \longrightarrow (2)$$

Adding (1) & (2),

$$\Rightarrow \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \boxed{\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{F}}$$ where,

F → combined focal length,

Ans.17) for combination and concave,

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

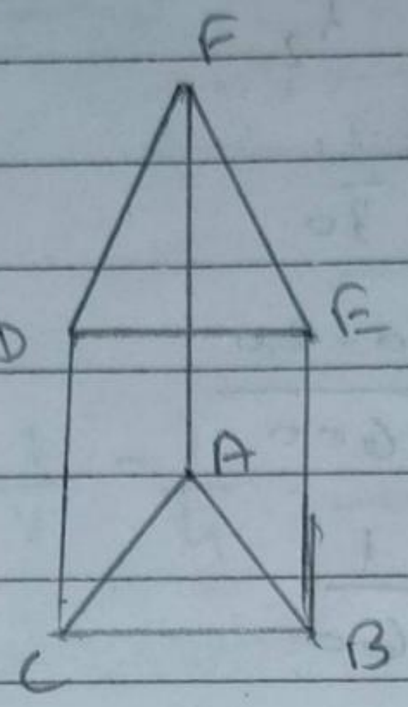
$$= \frac{1}{20} - \frac{1}{30}$$

$$= \frac{30 - 20}{600}$$

$$\frac{1}{F} = \frac{1}{60}$$

$$\Rightarrow \boxed{F = 60 \text{ cm}}$$ Ans.

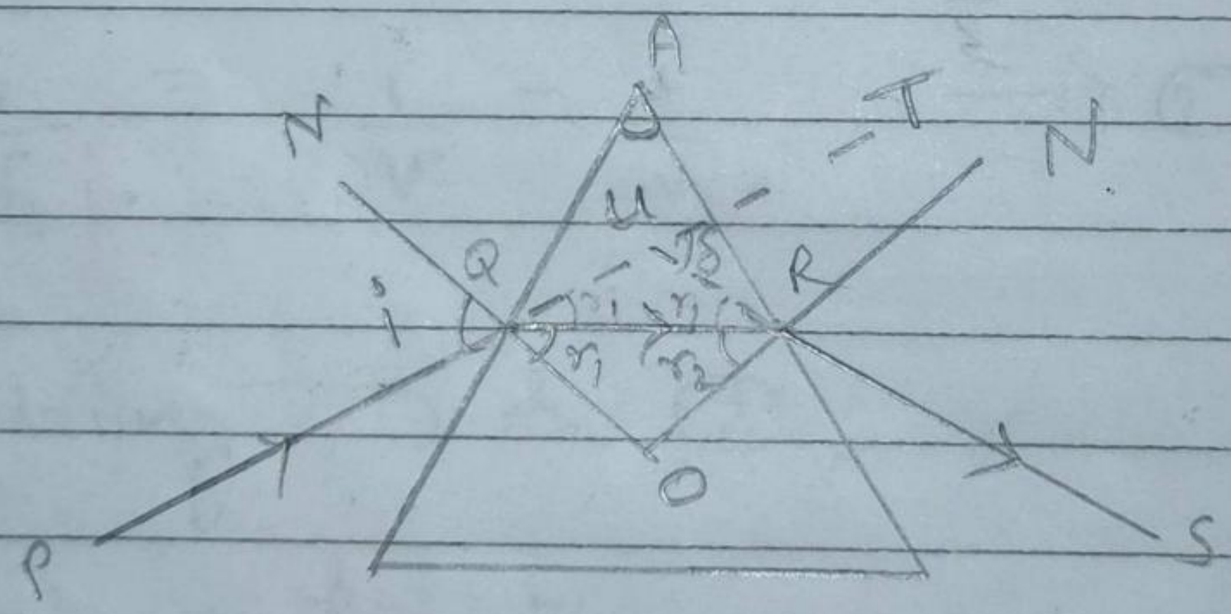
Prism :- Prism is a transparent medium which is bounded by three rectangular and 2 triangular surface.



Q.19 Derive an expression for refractive index of prism.

Q.20. Write the formula for deviation angle for thin prism.

Ans. 19.



where,

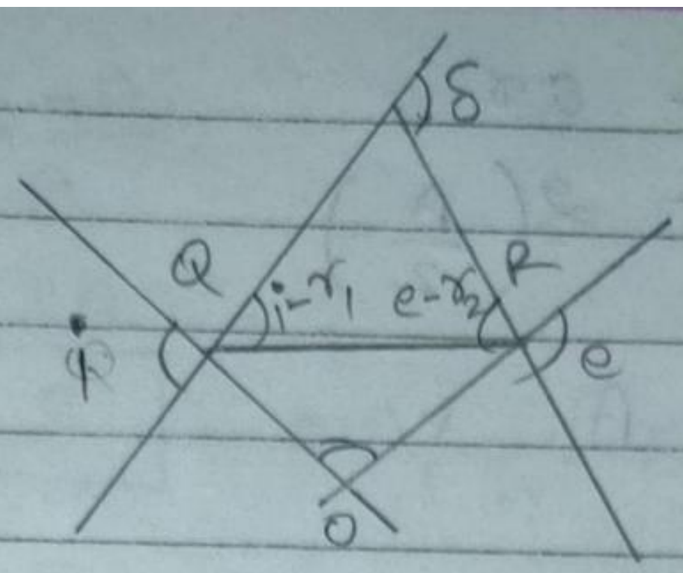
δ → Angle of deviation

δ_m → mimimum angle of deviation,

Condition for δ_m :-

i) $i = e$

ii) $r_1 = r_2$



$\delta = \angle TUR = \angle TUS$

In ΔQRU,

$\Rightarrow \delta = \angle UQR + \angle URQ$ {Exterior angle = sum of other 2 angle}

$\Rightarrow \delta = i - r_1 + e - r_2$

$\Rightarrow \delta = (i + e) - (r_1 + r_2)$

for δ_m, i) $i = e$

ii) $r_1 = r_2 = r$.

$\Rightarrow \delta_m = (i + i) - (r + r)$

$\delta_m = 2i - 2r$

$\because \angle A + \angle O = 180^\circ$

and $r_1 + r_2 + \angle O = 180^\circ$

comparing both eq^n

$\Rightarrow (\angle A + \angle O) = r_1 + r_2 + \angle O$

$\Rightarrow A = r_1 + r_2$

$\Rightarrow A = r + r$

$\Rightarrow$ $\boxed{r = \frac{A}{2}}$

dispersion

$$\Rightarrow \delta_m = 2i - 2r$$

$$= 2i - 2\left(\frac{A}{2}\right)$$

$$\Rightarrow \delta_m = 2i - A$$

$$\Rightarrow \boxed{\frac{\delta_m + A}{2} = i}$$

* Snell's law(n) $= \dfrac{\sin i}{\sin r}$

$$\boxed{n = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}}$$

Note:-

$$\delta = i + e - (r_1 + r_2)$$

$$\delta = i + e - A$$

$$\boxed{\delta + A = i + e}$$

Ans 20) For thin prism,

$$\boxed{A < 10^\circ}$$

$\sin\theta \approx \theta$.

Now, $n = \dfrac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\frac{A}{2}}$

i) , ii) $\Rightarrow n = \dfrac{\frac{\delta + A}{2}}{\frac{A}{2}}$

$$\Rightarrow \quad n = \frac{\delta + A}{A}$$

$$\Rightarrow \quad nA = \delta + A$$

$$\Rightarrow \quad \boxed{(n-1)A = \delta} \quad \text{only for thin prism.}$$

Q.21 Refractive index of a given prism is $\sqrt{2}$ find out the minimum deviation angle.

Sol.21)

$$\Rightarrow \quad n = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\Rightarrow \quad \sqrt{2} = \frac{\sin\left(\frac{\delta_m + 60}{2}\right)}{\sin 30^\circ}$$

$$\Rightarrow \quad \frac{\sqrt{2}}{2} = \sin\left(\frac{\delta_m + 60}{2}\right)$$

$$\Rightarrow \quad \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = \frac{\delta_m + 60}{2}$$

$$\Rightarrow \quad 2 \times 45 = \delta_m + 60$$

$$\Rightarrow \quad \delta_m = 30$$

Q. 22 Define the disperson of light?

(or)

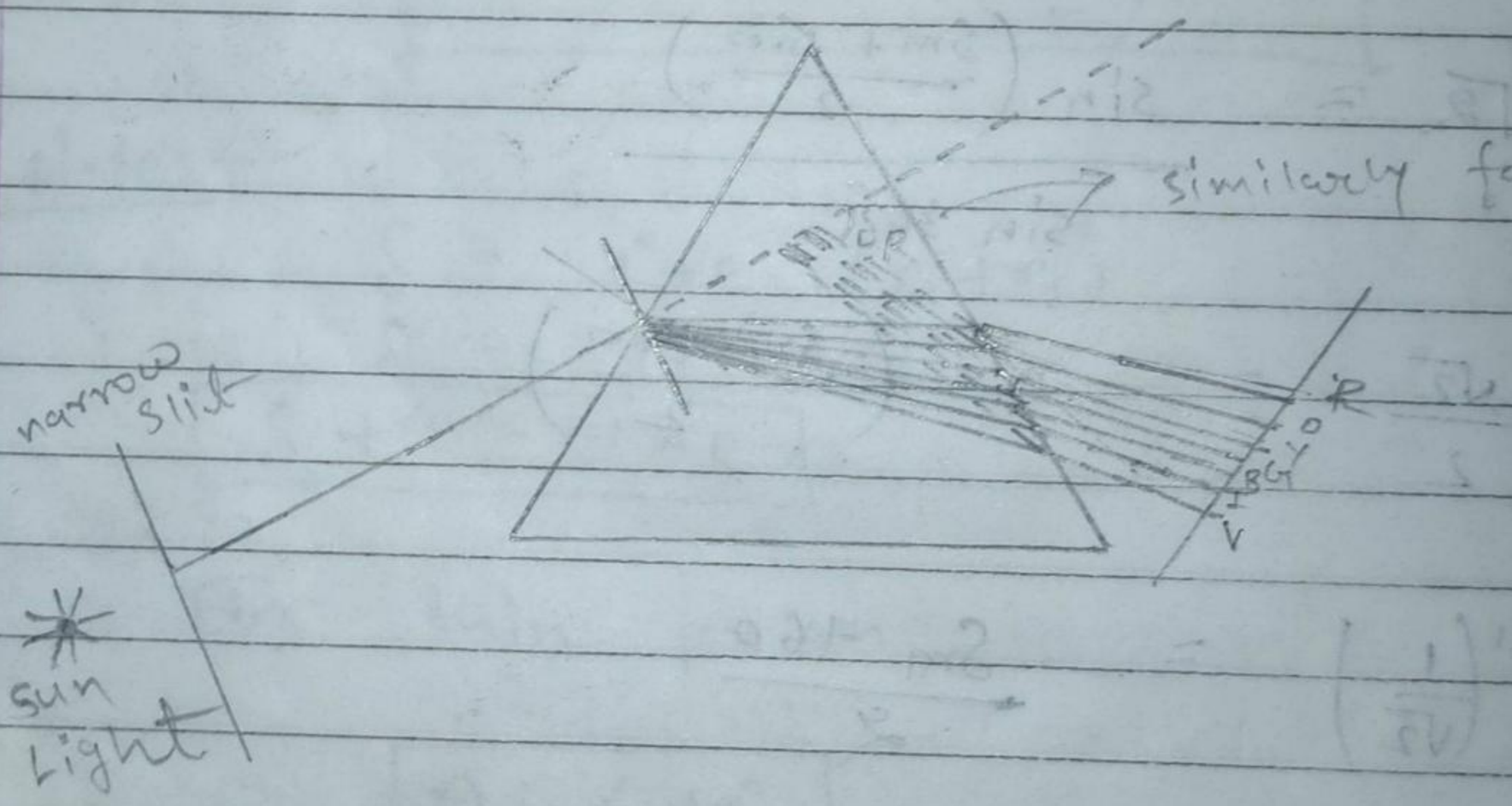
What is the meaning of disperson of light?

Q. 23) What is spectrum?
Q. 24) What is the meaning of Angular disperson?
Q. 25) What is dispersive power?

Ans. 22) **Dispersion** :- This is the property of light, to spliting the white light into 7 constituent colour is called dispersion.

(or)

when the sun light is passes through the narrow slit then the sun light split 7 constituent colour (VIBGYOR), This phenomena is called Disperson.



Ans. 23) **Spectrum** :- The group of colur (VIBGYOR) is called spectrum.

Ans. 24) Difference b/w 2 colour of angle of deviation is called Angular disperson, which is represented by 'θ'

$$\theta = \delta_V - \delta_R$$

Relation b/w refractive index and angle of deviation :-

$\Rightarrow \delta_v = (n_v - 1) A$

$\Rightarrow \delta_y = (n_y - 1) A$

Similarly for all colour.

$\because \theta = \delta_v - \delta_R$

$\Rightarrow \theta = (n_v - 1)A - (n_R - 1) A$

$\Rightarrow \boxed{\theta = (n_v - n_R) A}$

Ans. 25). Dispersive power :- The ratio of disperson and mean deviation angle is called dispersive power, represented by omega (ω)

$\Rightarrow \boxed{\omega = \frac{\theta}{\delta_y}}$

$\Rightarrow \omega = \frac{\delta_v - \delta_R}{\delta_y}$

$\Rightarrow \omega = \frac{(n_v - n_R) A}{(n_y - 1) A}$

$\Rightarrow \boxed{\omega = \frac{n_v - n_R}{n_y - 1}}$

Hence dispersive power is independent of angle of prism.

Q.26. Prove that dispersive power of a prism is independent of angle of prism.

(or)

Dispersive power does not depend on Angle of prism.

Q.27) Refractive index of violet colour is 1.64 and refractive index of red colour is 1.62 find the value of dispersive power.

Q.28) Explain Simple microscope in the following points

i) Ray Diagram
ii) principle
iii) Magnifying power :- Condition.

(a) Image form in least distance of distinct vision.

(b) Image form in infinity.

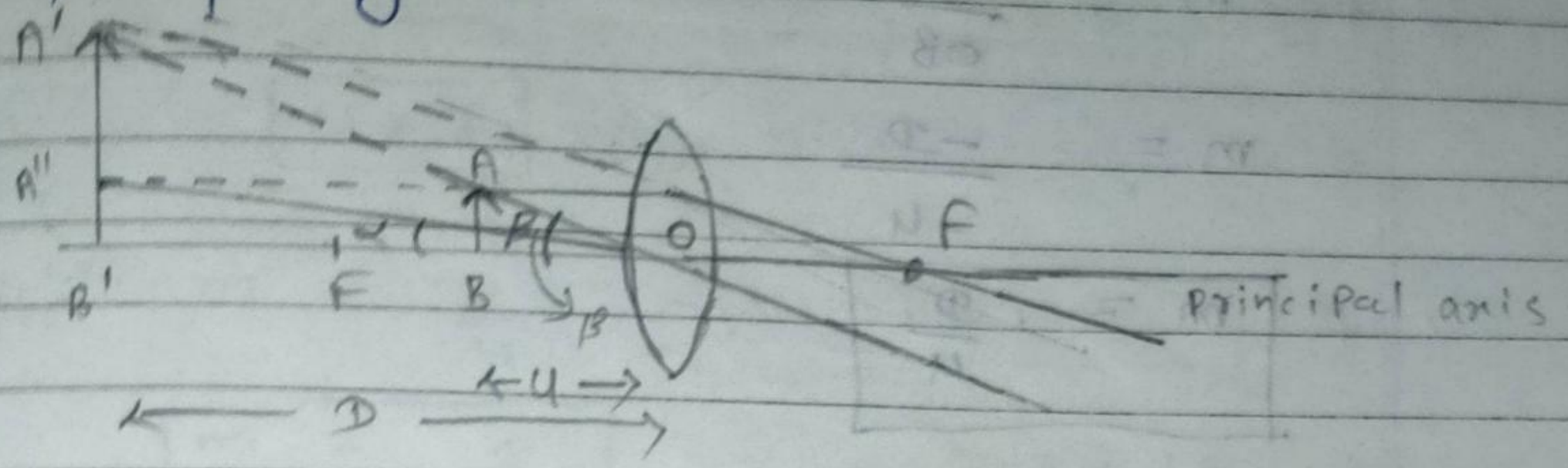
Q.29) Explain compound microscope in the following points :-

i) Ray diagram
ii) principle
iii) Magnifying power :-

(a) Image form in the least distance distinct vision
(b) Image form in infinity

Principle of Microscope :- If an object is placed b/w the optical centre and focus it's virtual image, large size image, erect image always obtained behind the object.

Ans. 28) i) Ray diagram :-



ii) Principle :- If an object is placed b/w the optical centre and focus it's virtual image, large size image, erect image alway obtained behind the object.

iii) Magnifying power :-

a) ~~Image form in least distance of distinct vision~~ :-

In $\Delta A''B'O$,

$$\tan\alpha = \frac{A''B'}{OB'}$$

In ΔABO, $\tan\beta = \frac{AB}{OB}$.

$\therefore$ magnifying power $(m) = \frac{\tan\beta}{\tan\alpha}$

$$m = \frac{\left(\frac{AB}{OB}\right)}{\left(\frac{A''B'}{OB'}\right)}$$

$\therefore A''B' = AB$.

So, $$m = \frac{\left(\frac{AB}{OB}\right)}{\left(\frac{AB}{OB'}\right)}$$

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

$$m = \frac{-D}{-u}$$

$$\boxed{m = \frac{D}{u}}$$

<u>condition a)</u> Image form in least distance of distinct vision.

$$\boxed{v = -D}$$

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

$$\Rightarrow \frac{1}{f} = \frac{1}{-D} - \frac{1}{(-u)}$$

$$\Rightarrow \frac{1}{f} + \frac{1}{D} = \frac{1}{u}$$

$$\therefore m = \frac{D}{u}$$

$$m = D \times \frac{1}{u}$$

$$m = D\left(\frac{1}{f} + \frac{1}{D}\right)$$

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

condition B) image form at infinity,

$$\boxed{u = f}$$

$$\therefore \quad m = \frac{D}{u}$$

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

Q.30 5 cm focal length of convex lens is used as a simple microscope. Calculate the magnifying power of microscope if image obtain at the least distance.

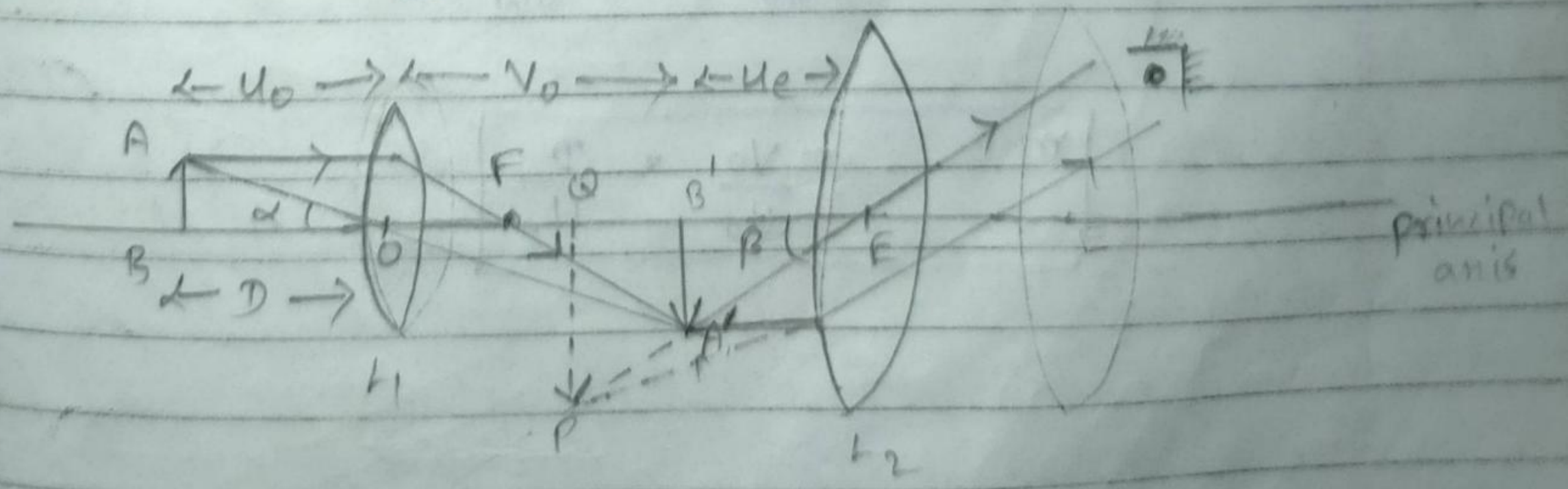
Ans.30 for image form in least distance,

$$\Rightarrow \quad m = 1 + \frac{D}{f}$$

$$\Rightarrow \quad m = 1 + \frac{25}{5}$$

$$\boxed{m = 6}$$

Ans.29) i) Ray Diagram :-



ii) Principle :- If an object is placed b/w the optical centre and focus it's virtual image, large size image, erect image always obtained behid the object.

iii) Magnifying power :- also called 'Angular Magnification.'

In $\Delta A'EB'$,

$$\tan\beta = \frac{A'B'}{EB'}$$

and In ΔABO,

$$\tan\alpha = \frac{AB}{OB}$$

magnifying power $(m) = \frac{\tan\beta}{\tan\alpha}$

$$m = \frac{\left(\frac{A'B'}{EB'}\right)}{\frac{AB}{OB}}$$

$$m = \frac{A'B'}{EB'} \times \frac{OB}{AB}$$

$$m = \frac{V_o}{-u_o} \times \frac{D}{u_e}$$

$$\boxed{m = -\frac{V_o}{u_o} \times \frac{D}{u_e}}$$

Q.31 Explain the Astronomical Telescope in the following points:-

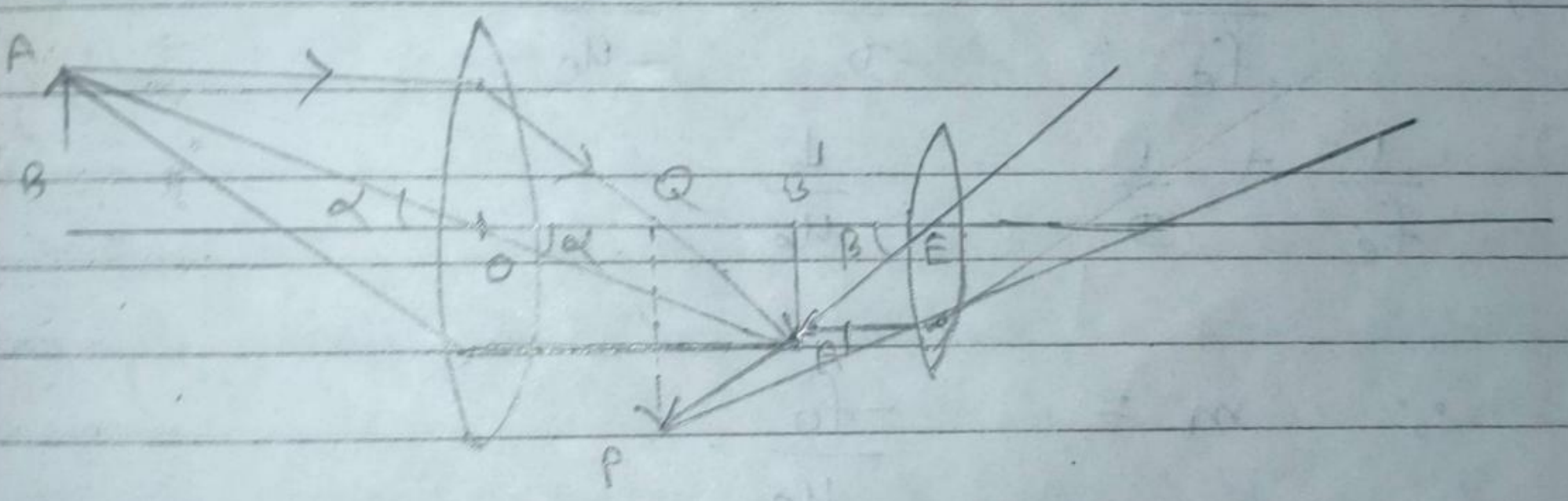
i) Ray diagram
ii) principle Magnifying power in both condition:-

a) if final image obtain in least distance of distinct vision (D)

b) if final image obtain at the infinity

Q.32 What is Telescope? write it's type.

Ans. 31)



Now,

$$\tan\beta = \frac{A'B'}{EB'}$$

and $$\tan\alpha = \frac{A'B'}{OB'}$$

since, magnifying power (m) $= \frac{\tan\beta}{\tan\alpha}$

$$= \frac{A'B'}{EB'} \times \frac{OB'}{A'B'}$$

$$= \frac{OB'}{EB'}$$

$$\boxed{m = -\frac{f_o}{u_e}}$$

Case I > image obtain in least distance of distinct vision,

$$\boxed{v_e = -D}$$

$$\therefore \quad \frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$$

$$\Rightarrow \quad \frac{1}{f_e} = \frac{1}{-D} - \frac{1}{-u_e}$$

$$\Rightarrow \quad \frac{1}{f_e} + \frac{1}{D} = \frac{1}{u_e}$$

$$\therefore \quad m = \frac{-f_o}{u_e}$$

$$= -f_o \times \frac{1}{u_e}$$

$$\boxed{m = -f_o\left(\frac{1}{f_e} + \frac{1}{D}\right)}$$

Case II > final image obtain in infinity.

$$\boxed{u_e = f_e}$$

$$\Rightarrow \quad \therefore \quad m = \frac{-f_o}{u_e}$$

$$\Rightarrow \quad \boxed{m = \frac{-f_o}{f_e}}$$