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PRAYAS

JEE 2025

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Lecture - 7

Physics

Ray Optics

By- Saleem Ahmed Sir

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Topics to be covered

1. Lens formula
2.
3.
4.

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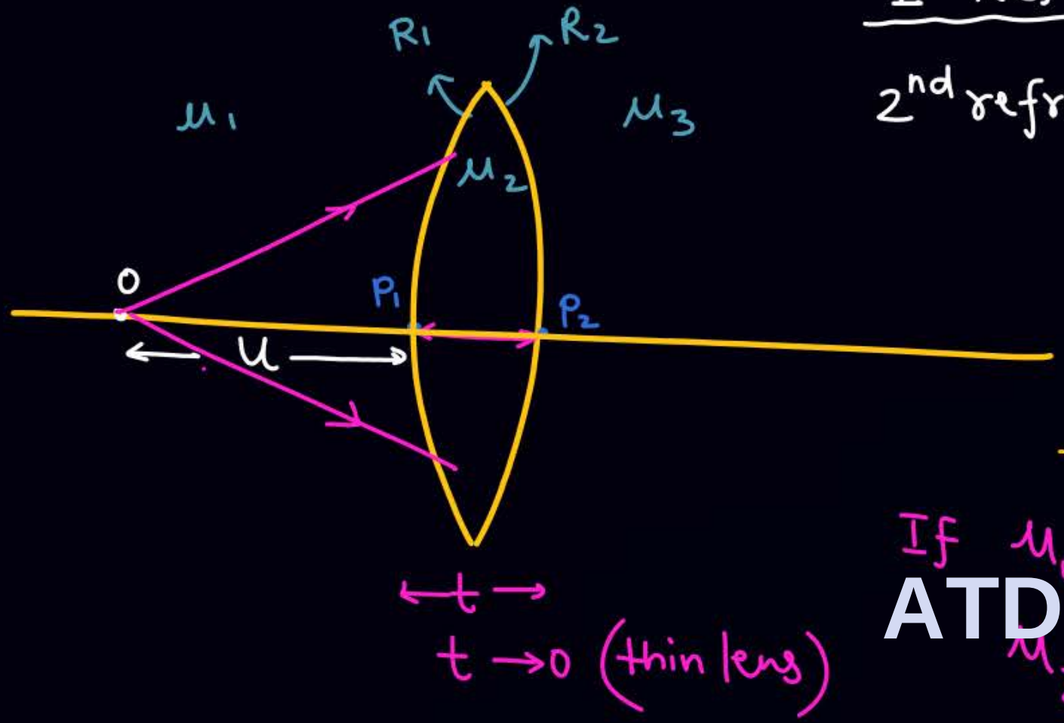

1st Refraction $\quad \frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R_1}$

2nd refraction $\quad \frac{\mu_3}{v_f} - \frac{\mu_2}{v} = \frac{\mu_3 - \mu_2}{R_2}$

Add $\quad \frac{\mu_3}{v_f} - \frac{\mu_1}{u} = \frac{\mu_3 - \mu_2}{R_2} + \frac{\mu_2 - \mu_1}{R_1}$

If $\mu_1 = \mu_3 = \mu_m$, $\mu_2 = \mu_L$

$$\frac{\mu_m}{v_f} - \frac{\mu_m}{u} = \frac{\mu_m - \mu_L}{R_2} + \frac{\mu_L - \mu_m}{R_1}$$

$$\mu_m \left(\frac{1}{v_f} - \frac{1}{u}\right) = (\mu_L - \mu_m)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v_f} - \frac{1}{u} = \left(\frac{\mu_L}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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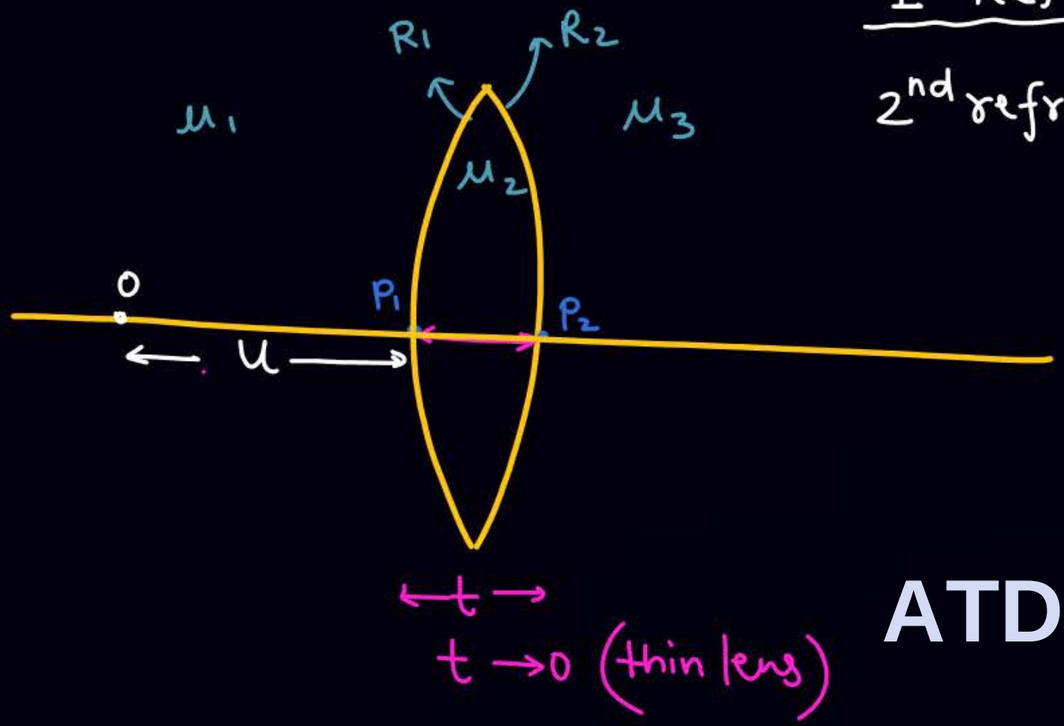

1st Refraction

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R_1}$$

2nd refraction

$$\frac{\mu_3}{v_f} - \frac{\mu_2}{v} = \frac{\mu_3 - \mu_2}{R_2}$$

$$\frac{1}{v_f} - \frac{1}{u} = \frac{1-\mu}{R_2} + \frac{\mu - 1}{R_1}$$

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

If obj is at ∞ $u = -\infty$, $v = f$

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

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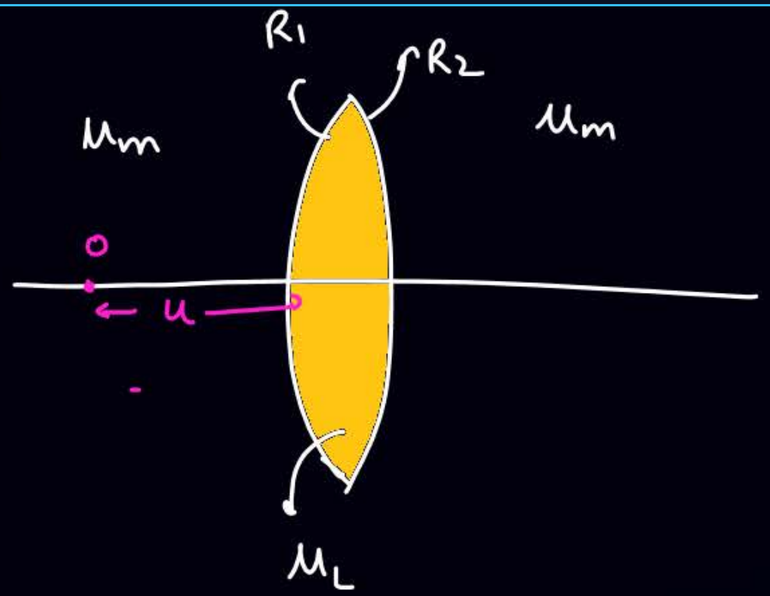
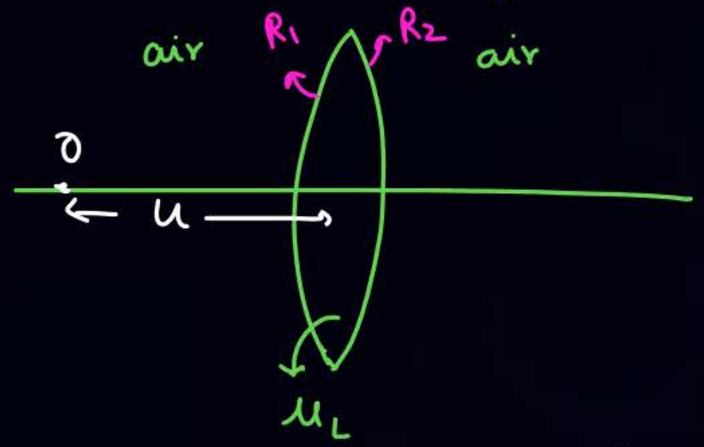


$$\frac{1}{v_f} - \frac{1}{u} = \left(\frac{\mu_L}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

If $\mu_m = 1$ (surrounding is air)



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

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

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

If obj is at ∞

$u = -\infty$

$v = f$

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

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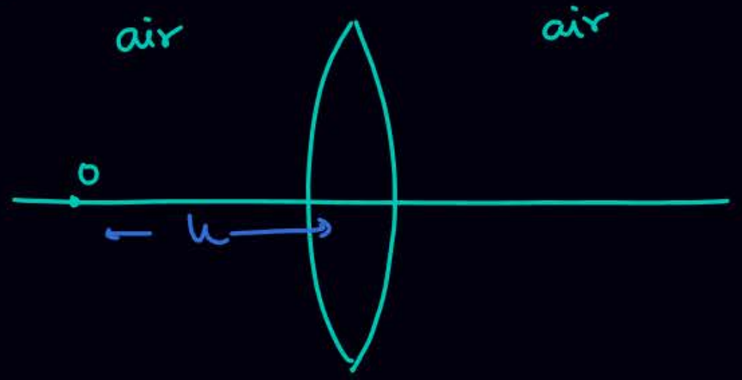
Results

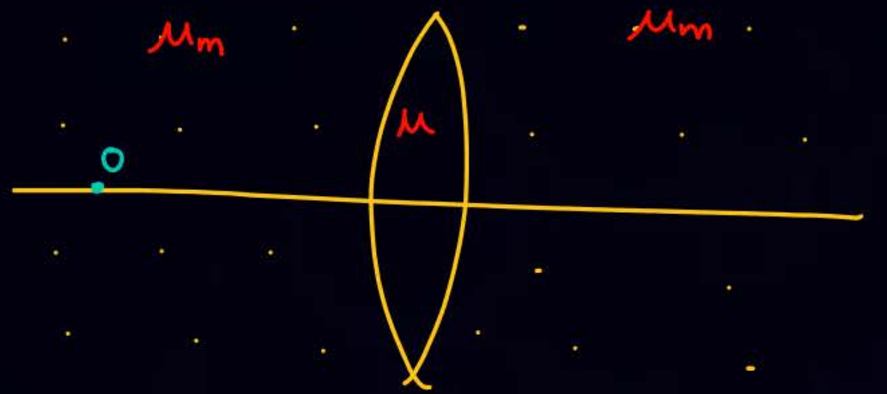


$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

1. → f निकालना $\Rightarrow \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
2. → $u = \checkmark$, $v = ?$, $m = ?$, Nothing

$\left.\begin{matrix} u = \checkmark \\ v = ? \\ m = ? \\ \text{Nothing} \end{matrix}\right\}$ $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ ($u, u, f \equiv$ with sign रखना है)

Lens in medium/water



$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} = \left(\frac{\mu}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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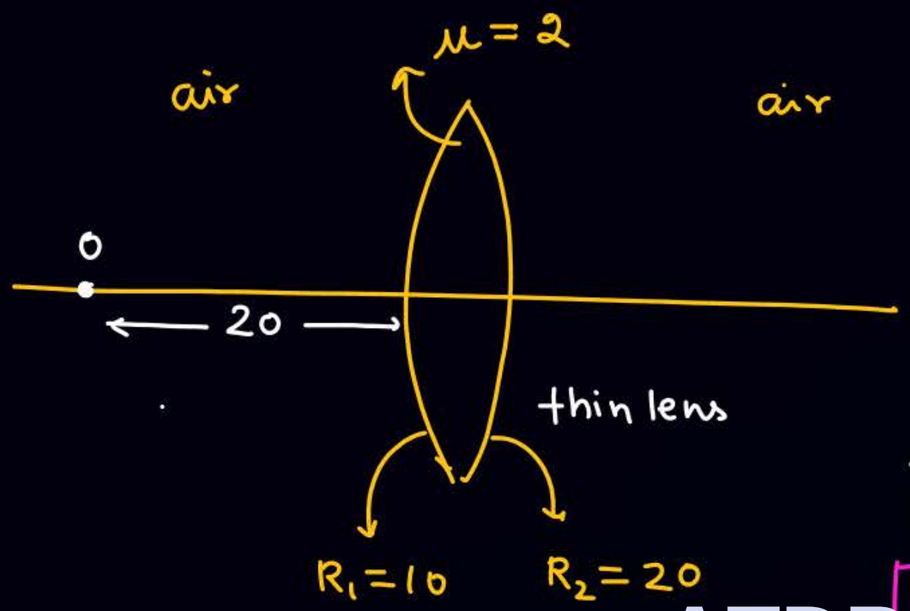
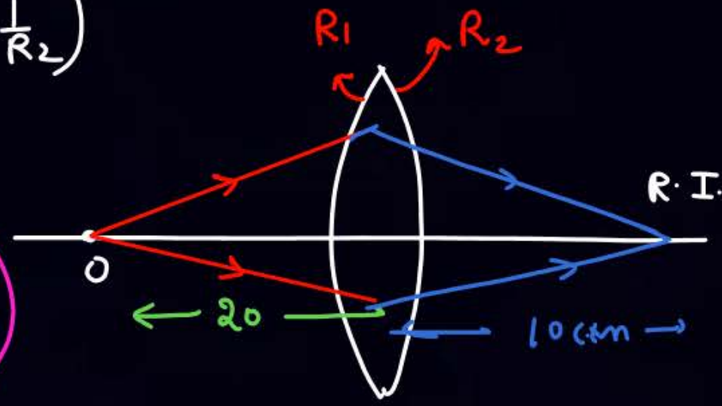


$$\frac{1}{V} - \frac{1}{u} = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(*) ① find focal length

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



$$\frac{1}{f} = (2-1)\left(\frac{1}{+10} - \frac{1}{-20}\right)$$

$$f = \frac{20}{3}$$

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② find location of image

$$\frac{1}{V} - \frac{1}{u} = \frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{V} - \frac{1}{-20} = (2-1)\left(\frac{1}{10} - \frac{1}{-20}\right)$$

$$\frac{1}{V} + \frac{1}{20} = \frac{3}{20}$$

$$V = +10.$$

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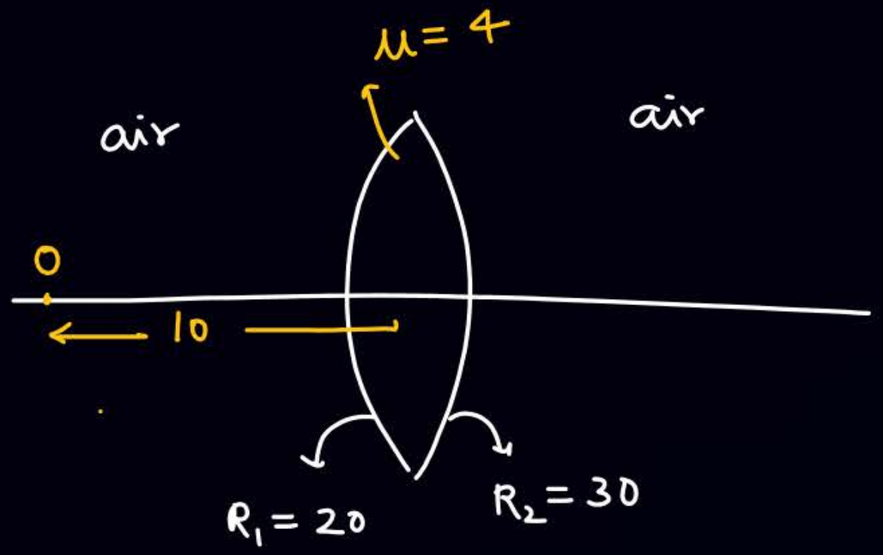

① $f = ?$

② $v = ?$

$$\frac{1}{f} = (4-1)\left(\frac{1}{+20} - \frac{1}{-30}\right) = 3 \times \frac{50}{600}$$

$$f = 4$$

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

$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{4}$$

$$V = 20/3$$

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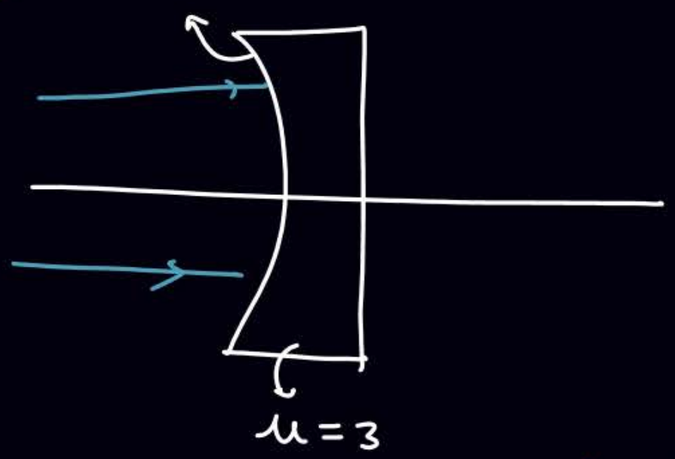
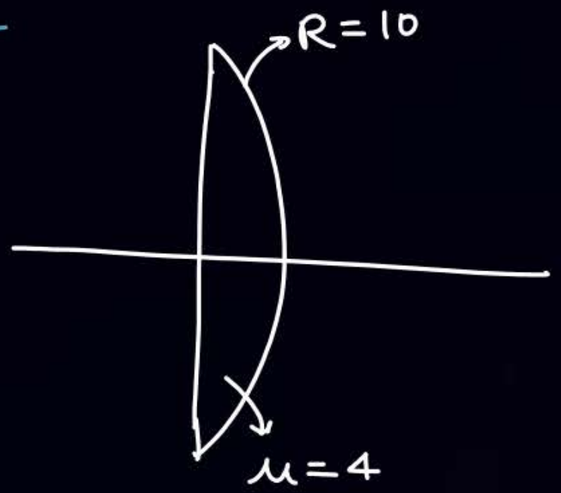


$$\frac{1}{f} = (3-1)\left(\frac{1}{-20} - \frac{1}{\infty}\right)$$

$f = -10$

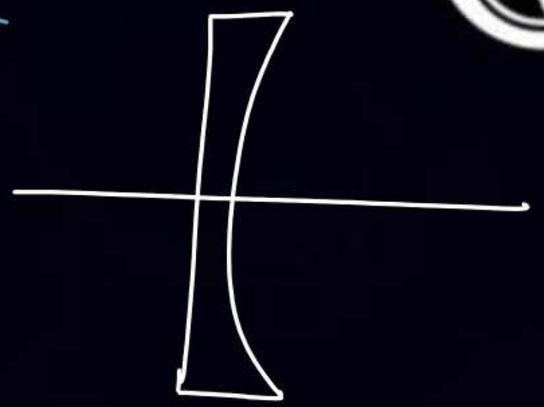
Q



$$\frac{1}{f} = (4-1)\left(\frac{1}{\infty} - \frac{1}{-10}\right)$$

$f = 10/3$

Q



$$\frac{1}{f} = (3-1)\left(\frac{1}{\infty} - \frac{1}{+20}\right)$$

$f = -10$

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Q If focal length of the lens $\mu_L = 4$ in air is $+10$ find focal length of this lens in water $\mu_w = 4/3$ find focal length of this lens in water

Sol^n

air $\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

air $\frac{1}{10} = (4-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

In medium $\frac{1}{f_m} = \left(\frac{\mu}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f_m} = \left(\frac{4}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

÷

$\frac{f_m}{10} = \frac{3}{2} \Rightarrow \boxed{f_m = 15}$

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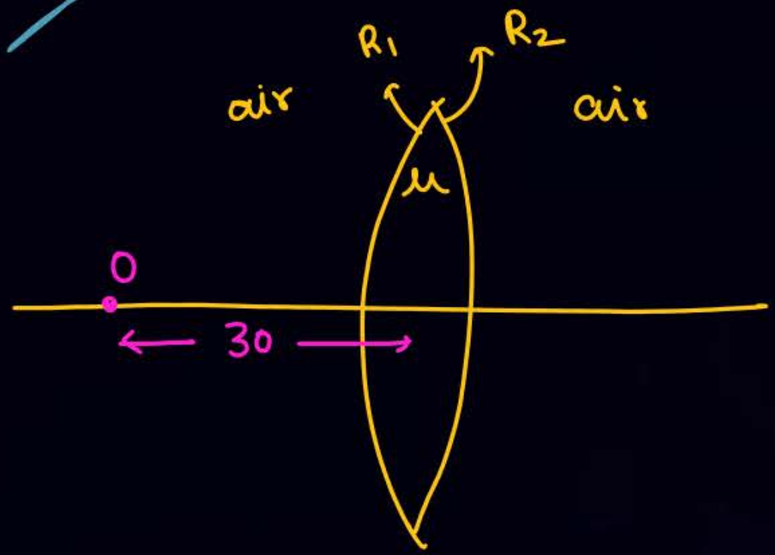

find v

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

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

$$\frac{1}{v} = -\frac{1}{30} + \frac{1}{20} \Rightarrow$$

$$V = 60$$

$f = +20$

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Lens formula

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

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

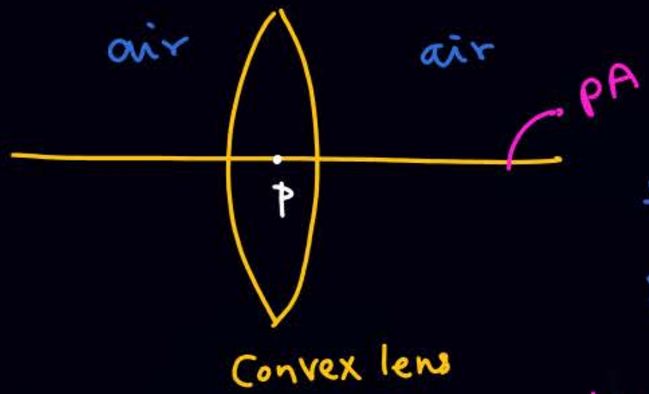
* $m = \frac{\text{height of image}}{\text{height of obj}} = \frac{h_I}{h_o} = \frac{v}{u}$

* paraxial rays

* $u, v, f \Rightarrow$ with sign

Sign convention

* Dirⁿ of incident ray ⟶ +ve
* सारे measurement 'P' से ✓



Convex lens

* Convex lens in air $f > 0$
* Concave lens in air $f < 0$

$u \longrightarrow$ dist. of obj from 'P' along PA
$v \longrightarrow$ " image " "

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

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

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

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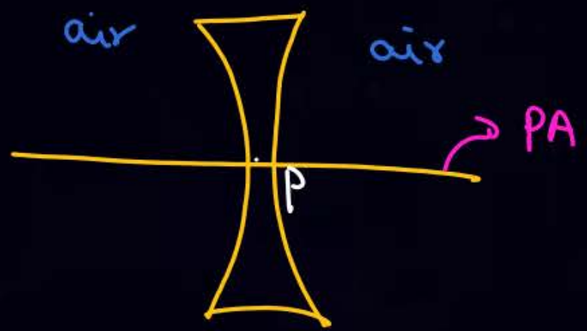

Concave

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note

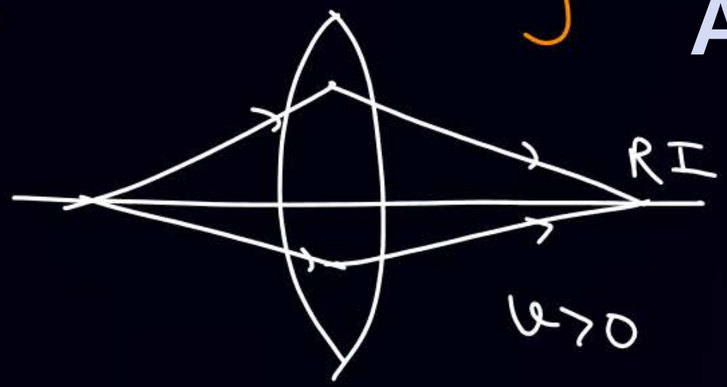
Lens

$u < 0 \longrightarrow R \cdot O$

$u > 0 \longrightarrow V \cdot O$

$v > 0 \longrightarrow R \cdot I$

$v < 0 \longrightarrow V \cdot I$



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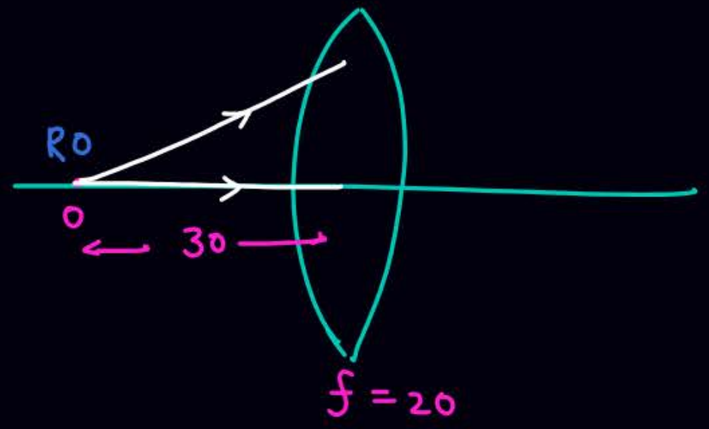
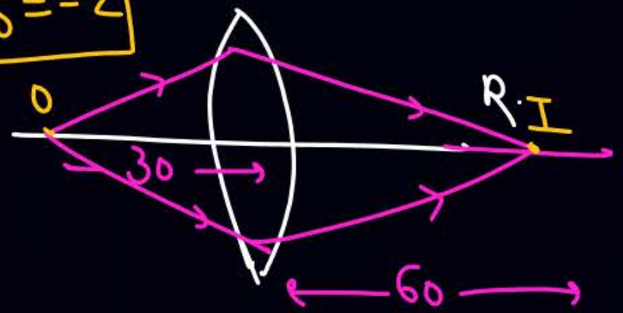
SSSD

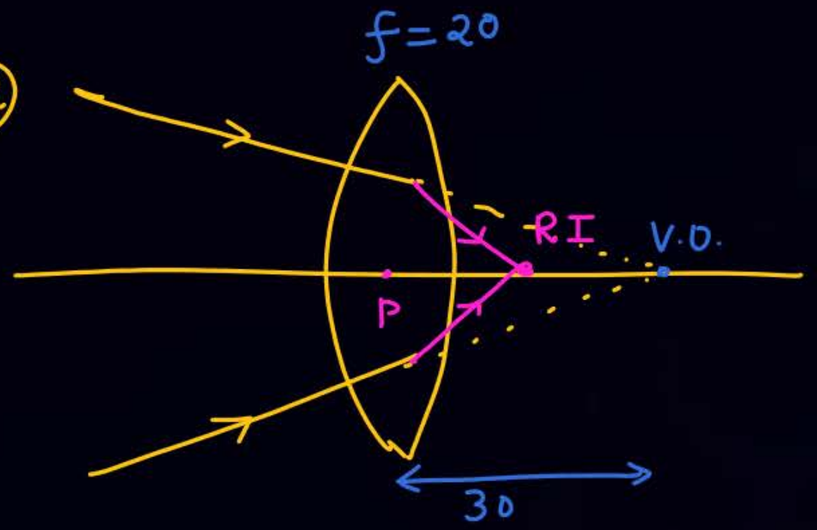
① 

$u = -30$
$f = +20$

$$v = \frac{uf}{u+f} = \frac{-30 \times 20}{-30+20} = +60$$

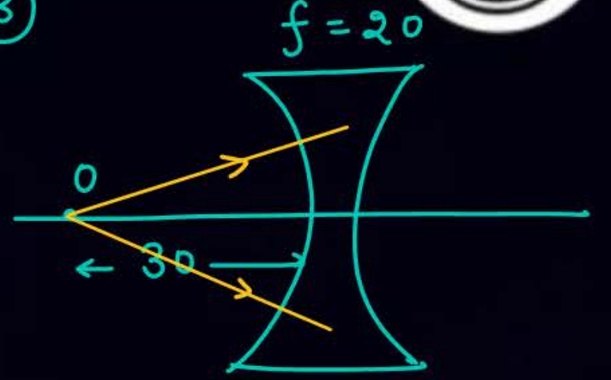
$$m = \frac{V}{u} = \frac{60}{-30} = -2$$



② 

$u = +30$
$f = +20$

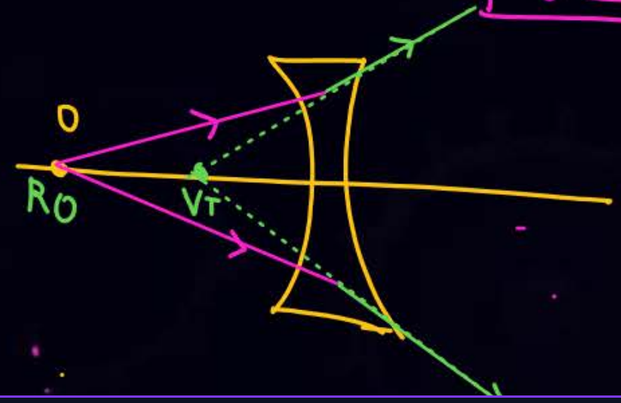
$$v = \frac{600}{50} = +12$$

③ 

$u = -30$
$f = -20$

$$v = \frac{uf}{u+f} = \frac{(-30)(-20)}{(-30)+(-20)}$$

$v = -12$



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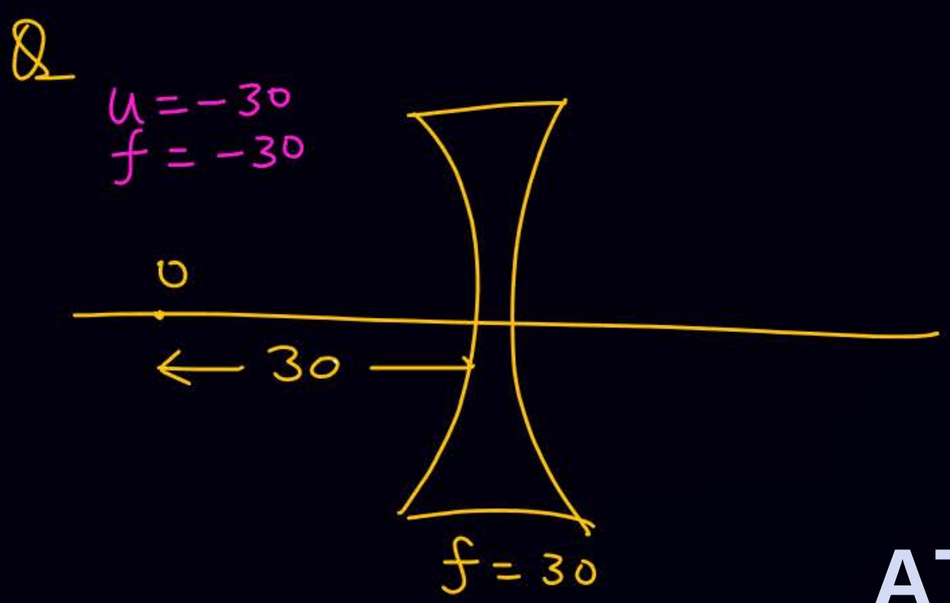
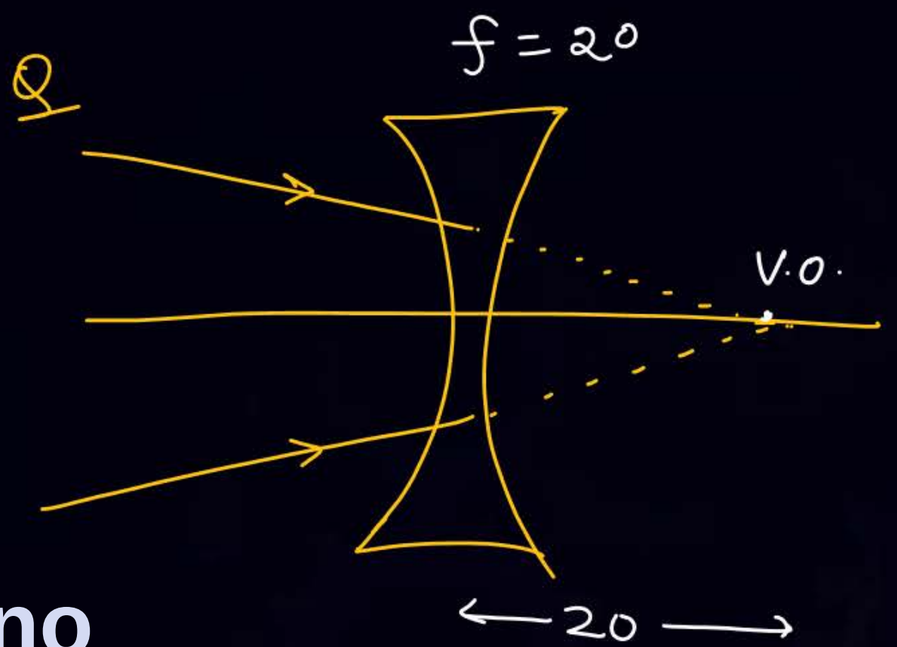


$$v = \frac{(-30)(-30)}{(-30)+(-30)} = -15$$

$$m = \frac{v}{u} = \frac{-15}{-30} = \frac{1}{2}$$



$$v = \frac{+20 \times (-20)}{(+20)+(-20)} = \infty$$

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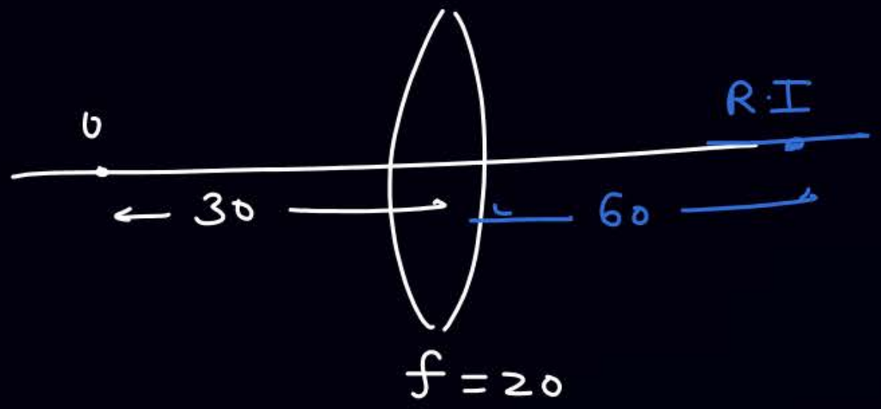
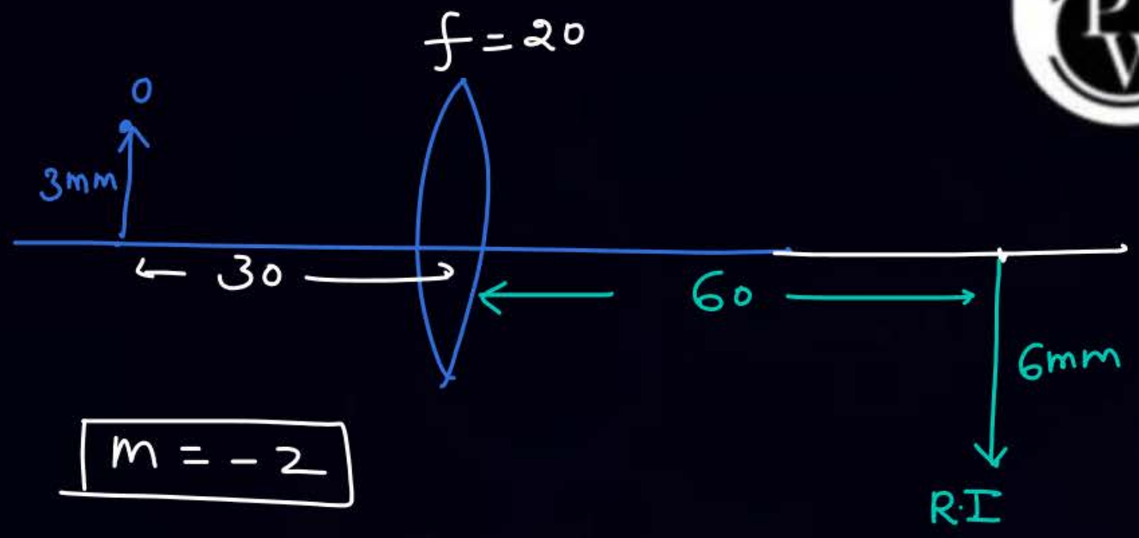


$v = +60$

$m = -2$ $\quad m = \frac{60}{-30} = -2$

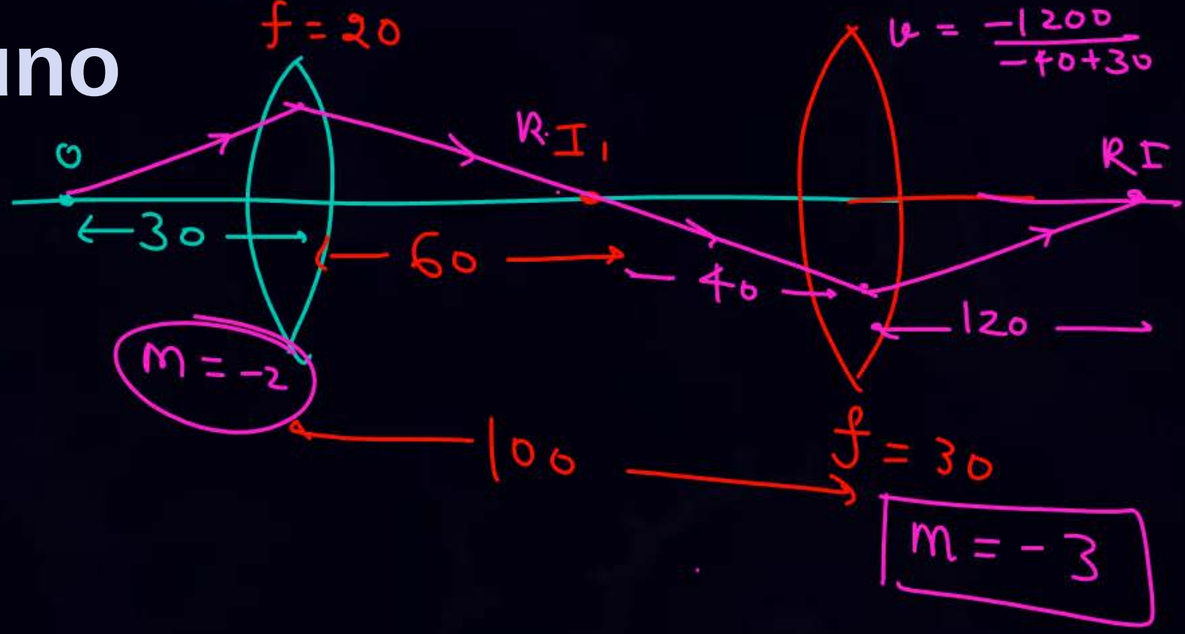
$v = \frac{-30 \times 20}{-30 + 20} = +60$

①



$m = -2$

②



$m = -3$

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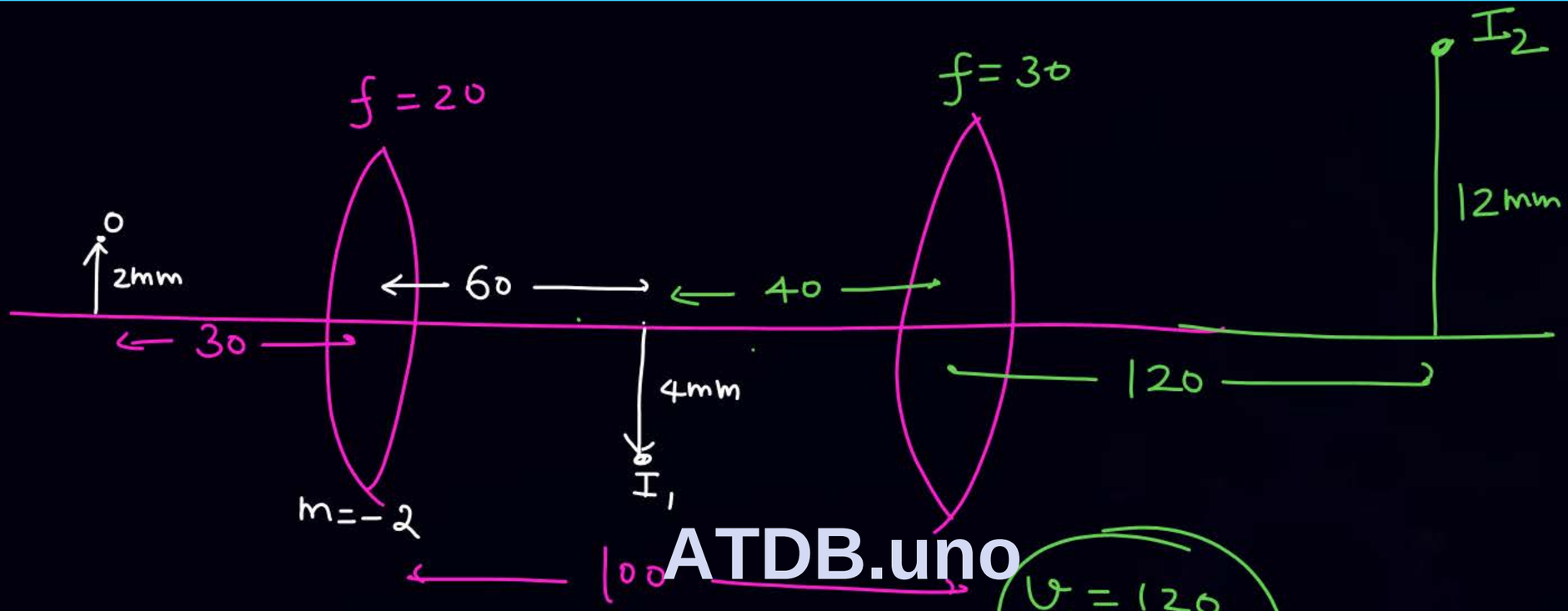

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$v_f = 120$

$m = -3$

$$m_{net} = m_1 \times m_2 = (-2) \times (-3) = +6$$

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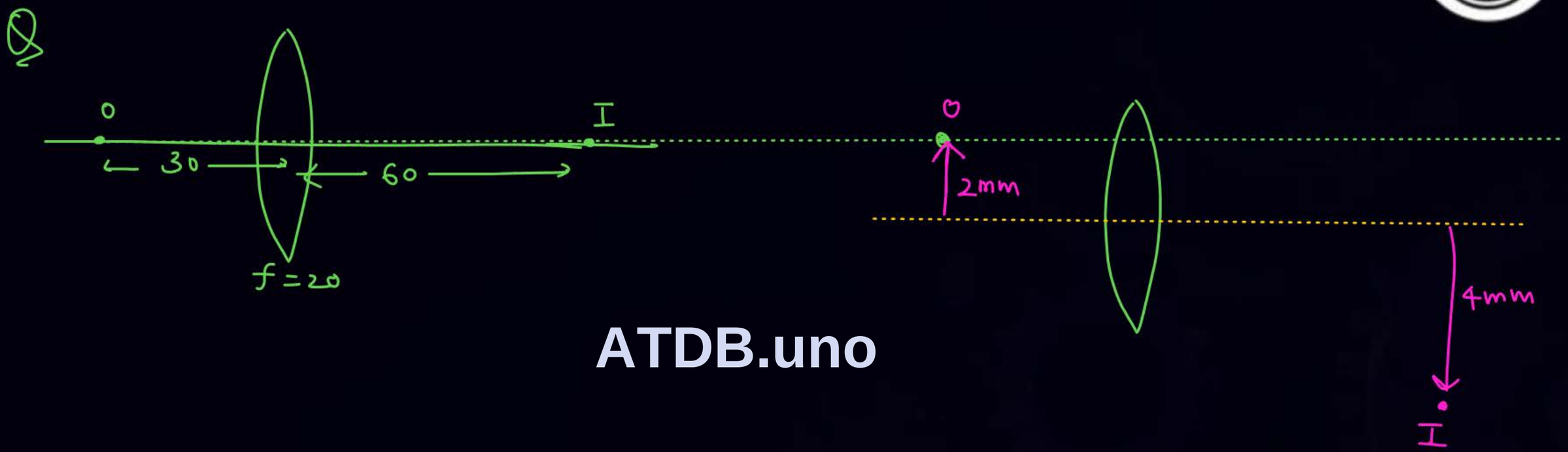

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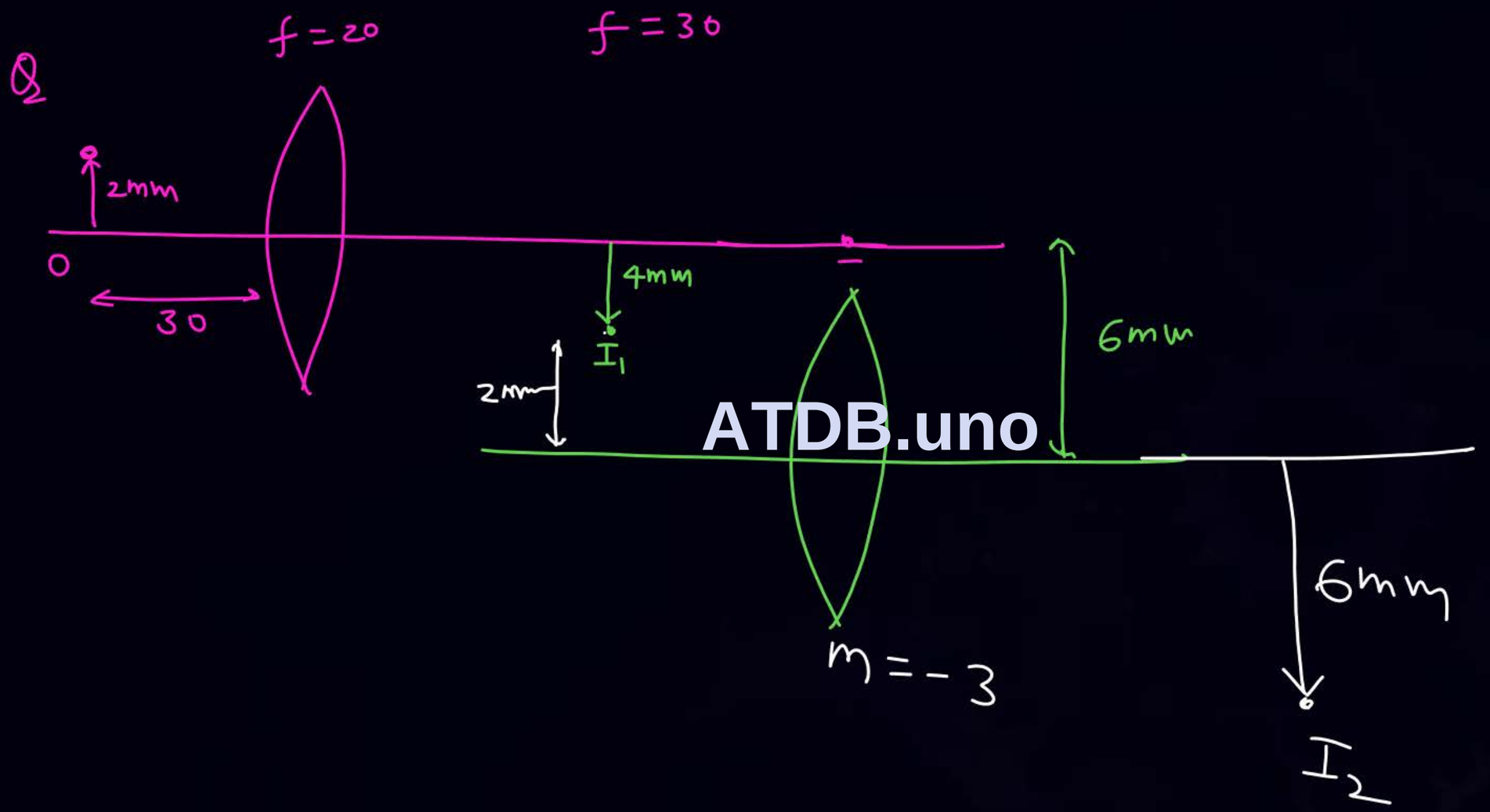

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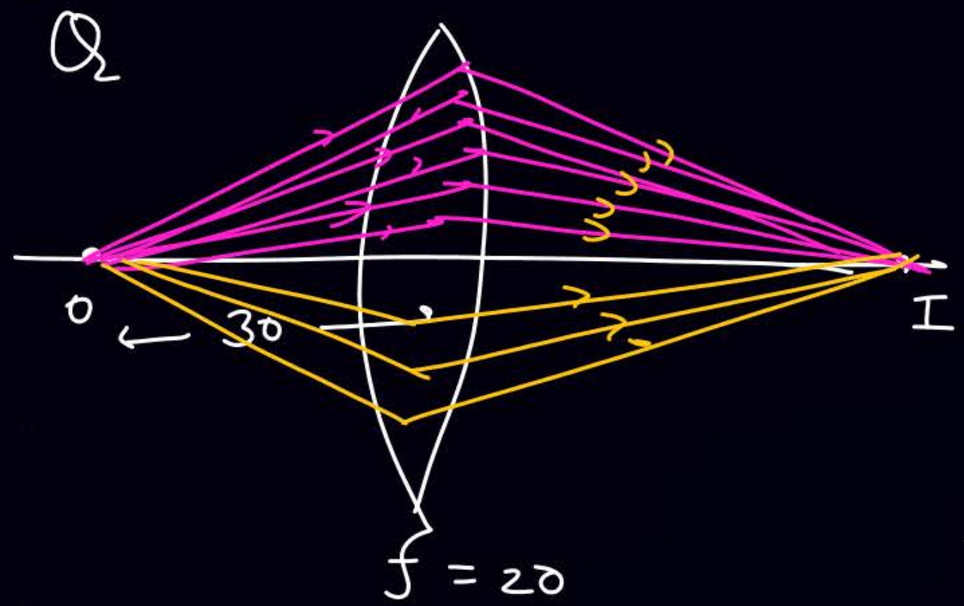

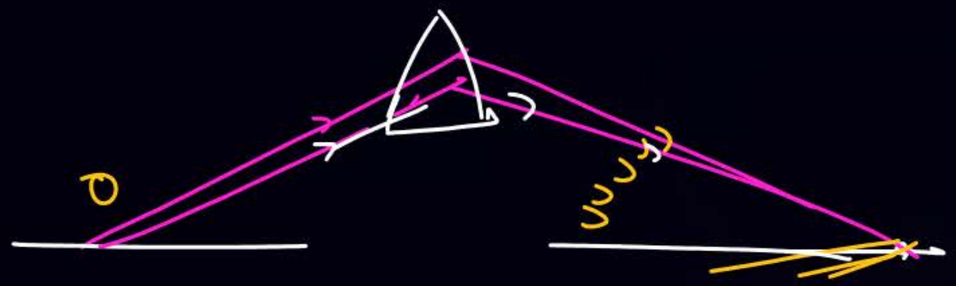

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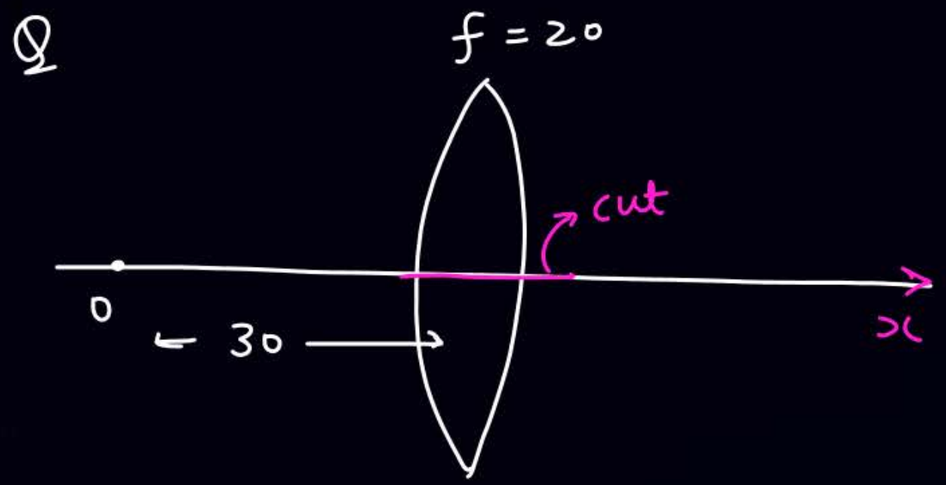

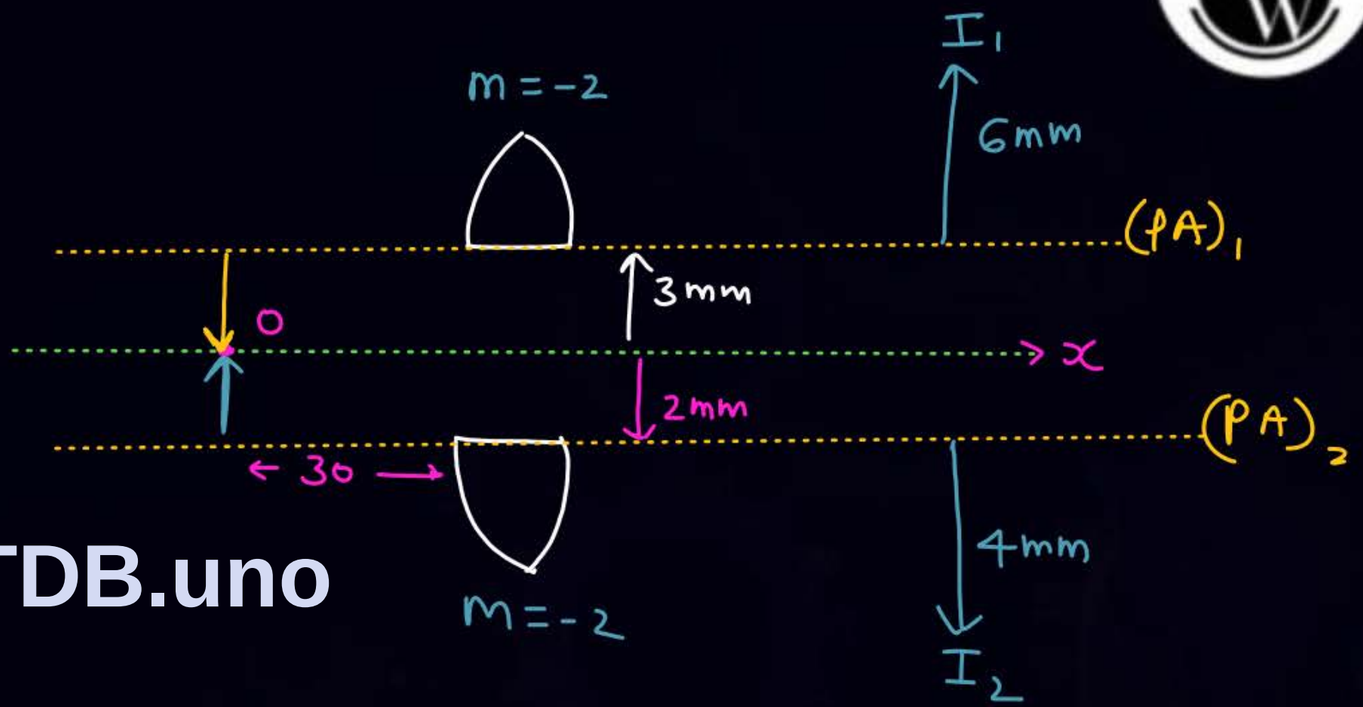

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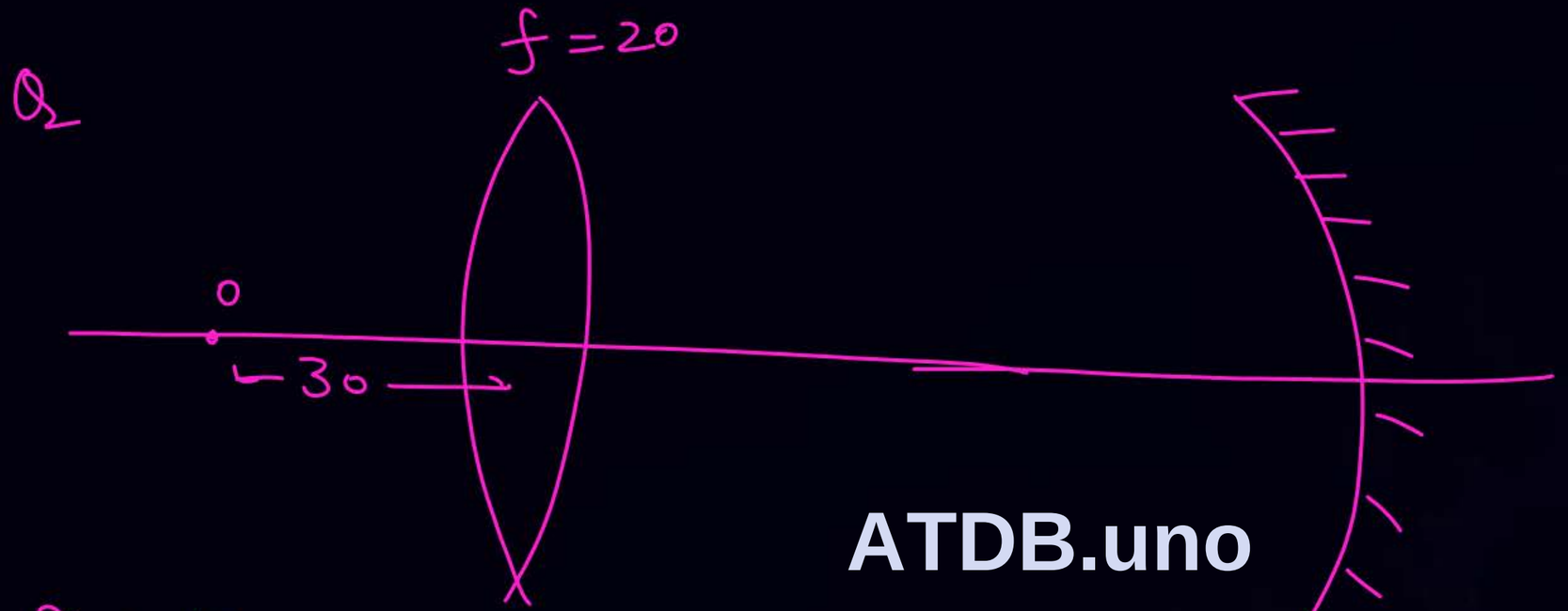

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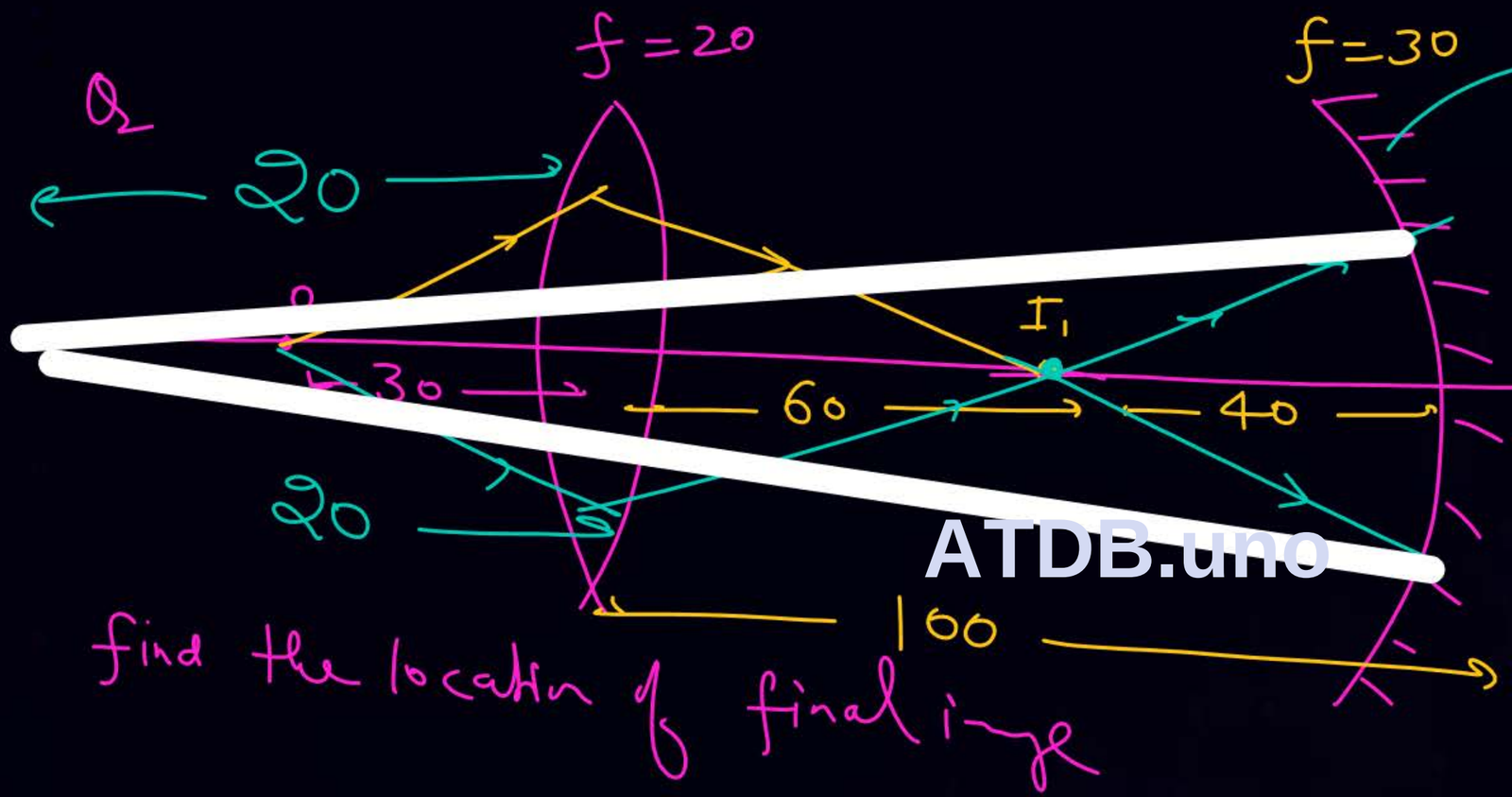

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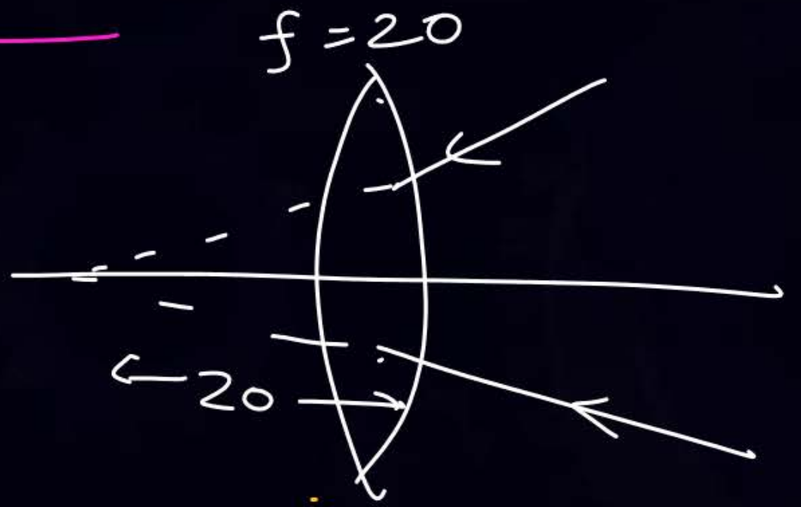
$u = -40$

$f = -30$

$$v = \frac{uf}{u-f} = \frac{1200}{-40+30} = -120$$



$u = +20$

$f = +20$

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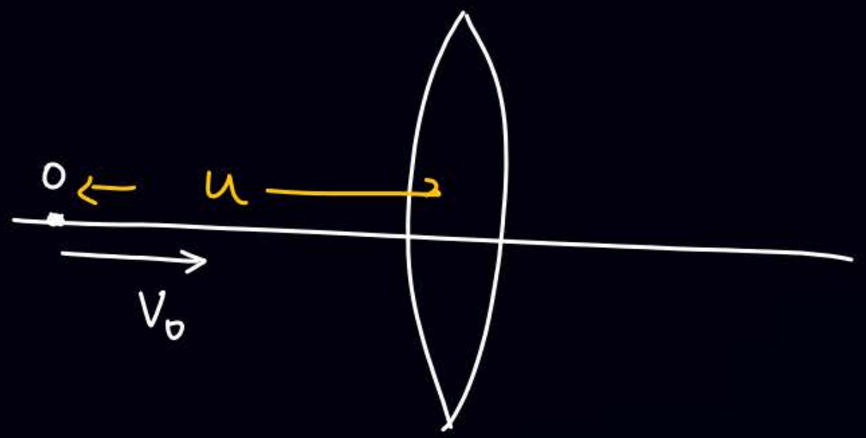
$V_{image} = ?$



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

$$-\frac{1}{v^2}\frac{dv}{dt} - \frac{1}{-u^2}\frac{du}{dt} = 0$$

$$\frac{1}{v^2}\frac{dv}{dt} = \frac{1}{u^2}\frac{du}{dt}$$

$$V_I = \frac{v^2}{u^2} V_0$$

$$\boxed{V_I = m^2 V_0}$$

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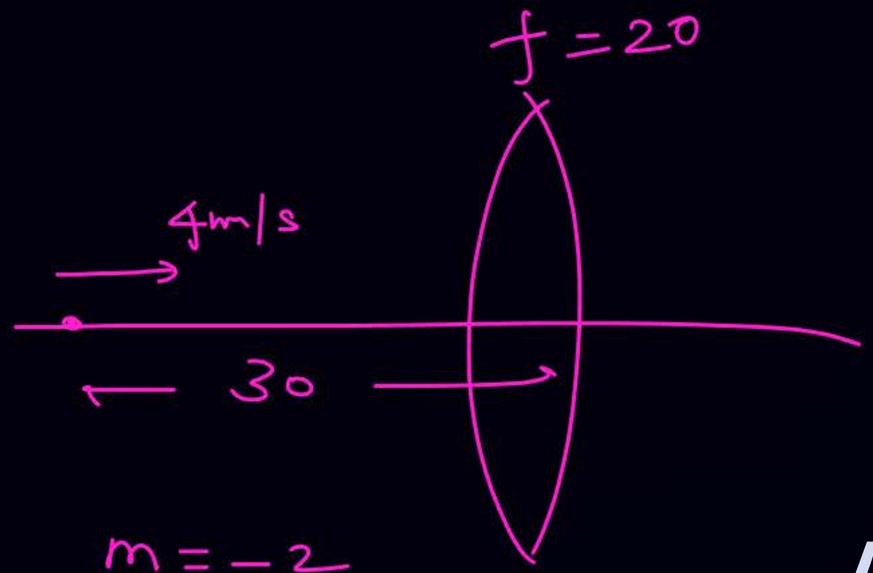
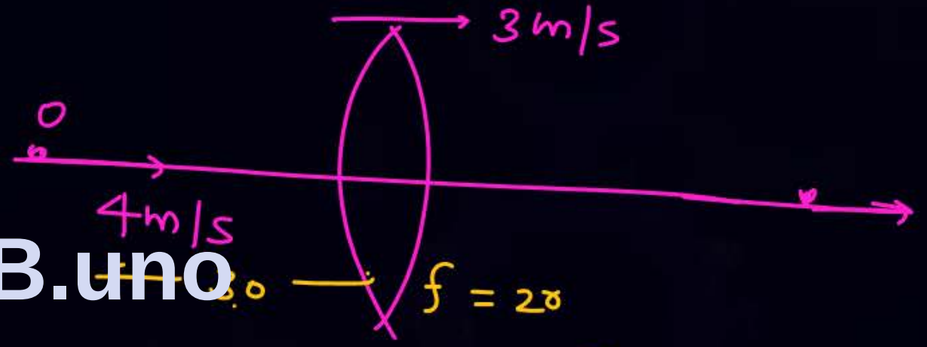


$m = -2$

$$v_I = +4 \times 4$$

$$\vec{v}_{I/L} = m^2 \vec{V}_{O/L}$$



$$(V_I - 3) = +4(V_I - 3)$$

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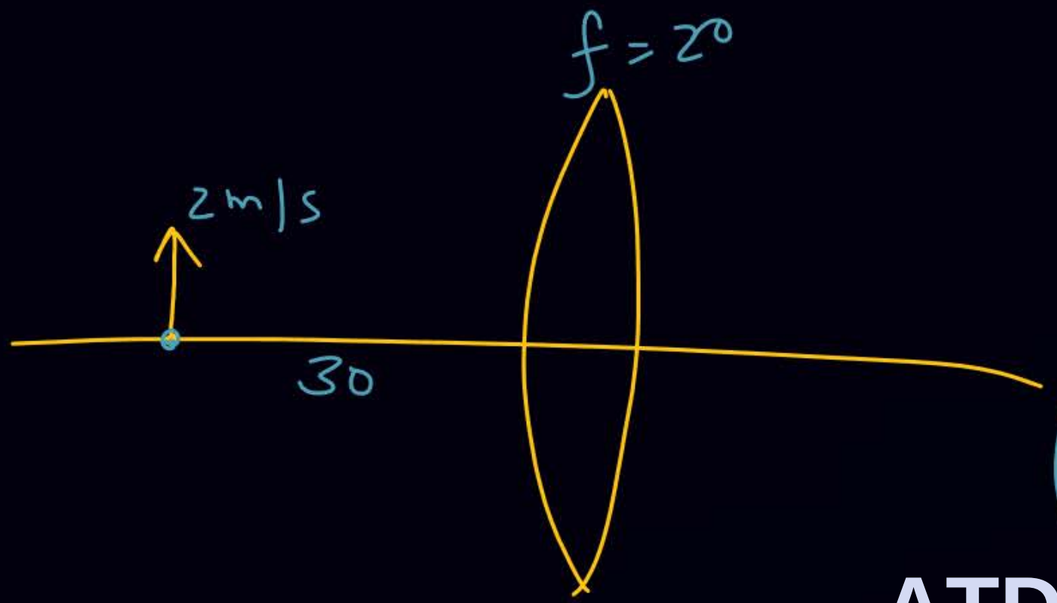

$$h_I = m\,h_o$$

$$\frac{dh_I}{dt} = m\frac{dh_o}{dt} + h_o\frac{dm}{dt}$$

$a = 0$

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

$$(V_I)_y = m(V_o)_y$$

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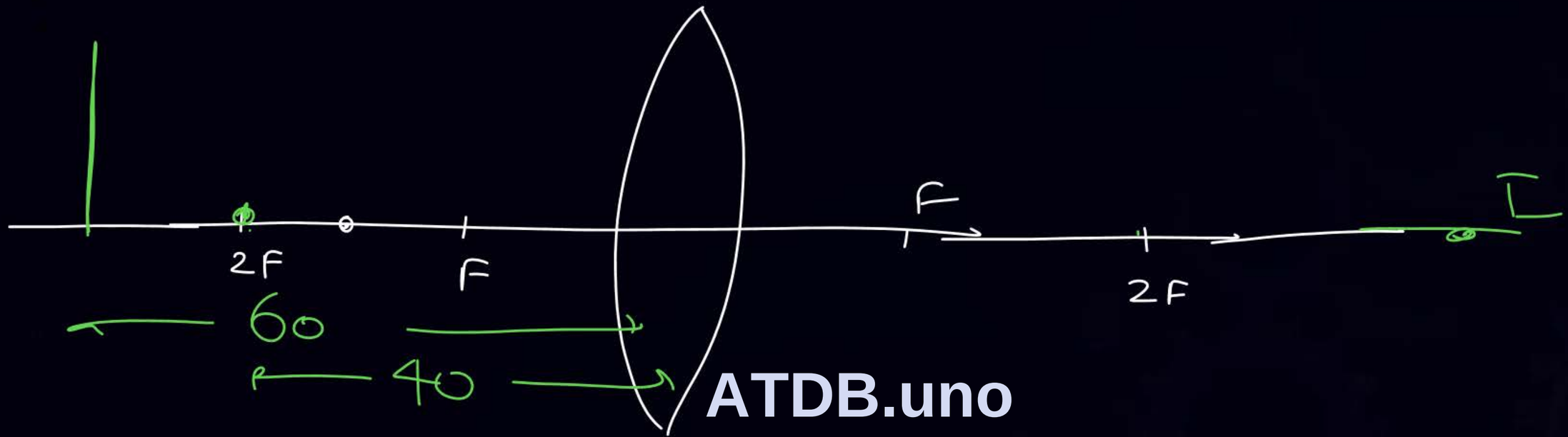

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$f = 20$

$$\frac{-1200}{-40} = +30$$

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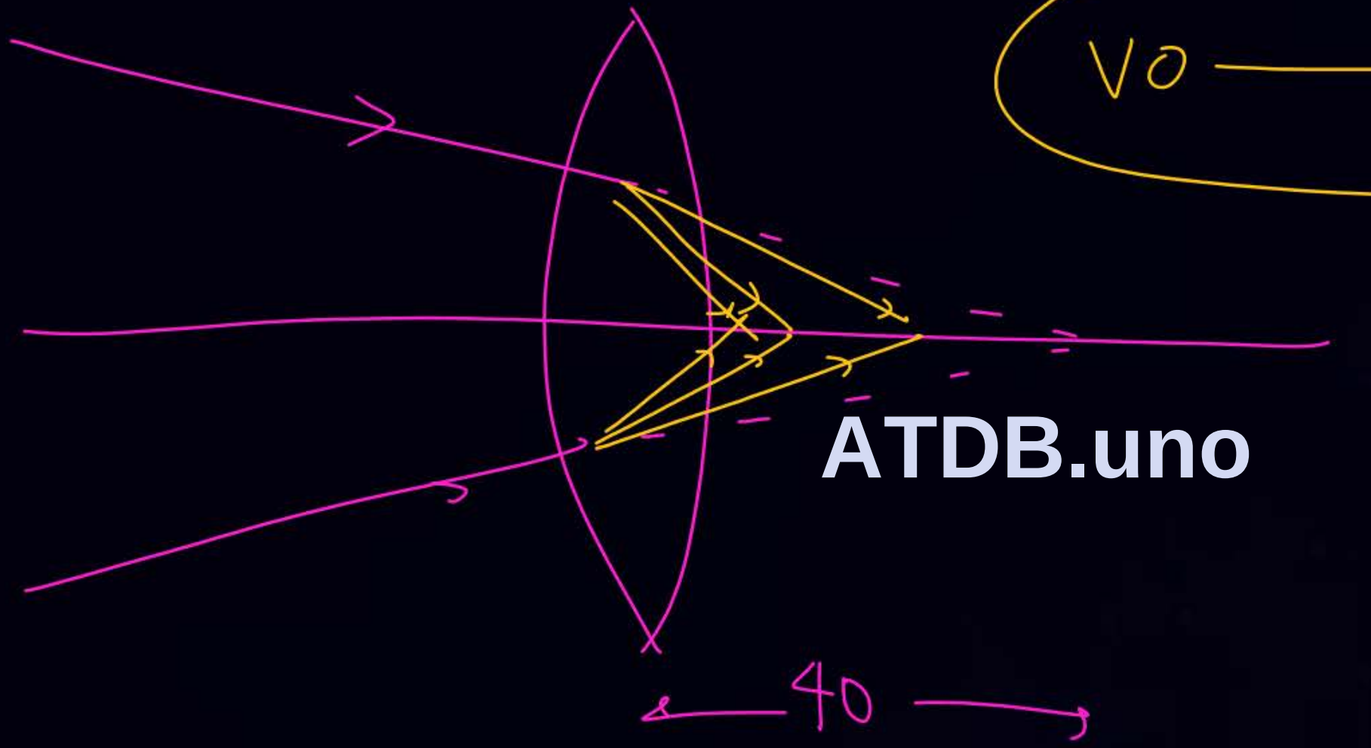

$V_0 \longrightarrow RI$

$v = \frac{uf}{uf}$ $uf > 0$

$f > 0$
$u > 0$

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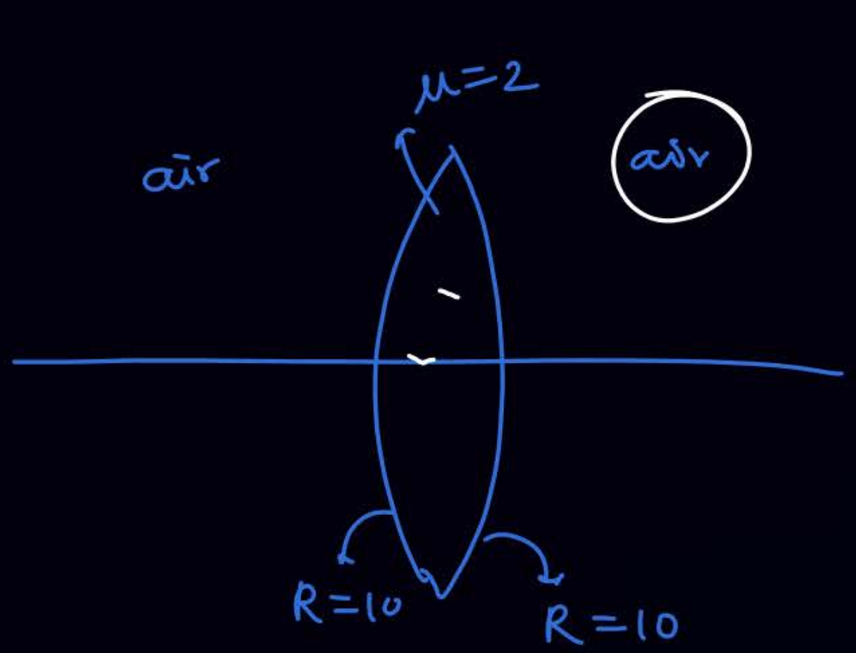
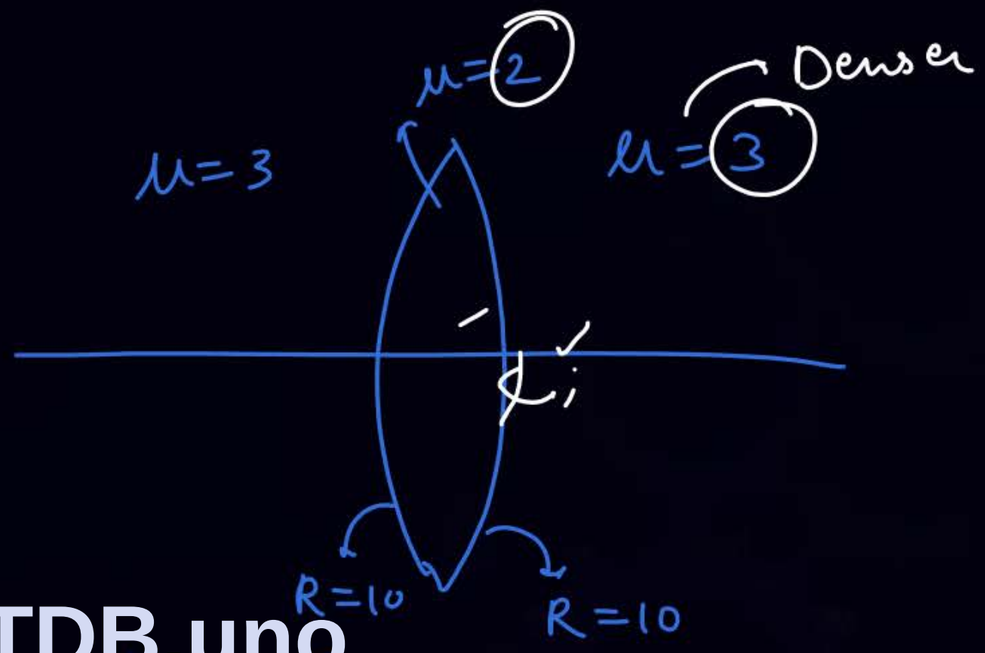


$$\frac{1}{f} = (2-1)\left(\frac{1}{10} - \frac{1}{-10}\right)$$

$$f = 5$$



$$\frac{1}{f} = \left(\frac{2}{3} - 1\right)\left(\frac{1}{10} - \frac{1}{-10}\right)$$

$$\frac{1}{f} = -\frac{1}{3} \times \frac{2}{10}$$

$$f = -15$$

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Home Work

- Revise All option class notes ques.
- MCV solved example ⇒ 15, 16, 19, 20, 21, 23, (must toys)

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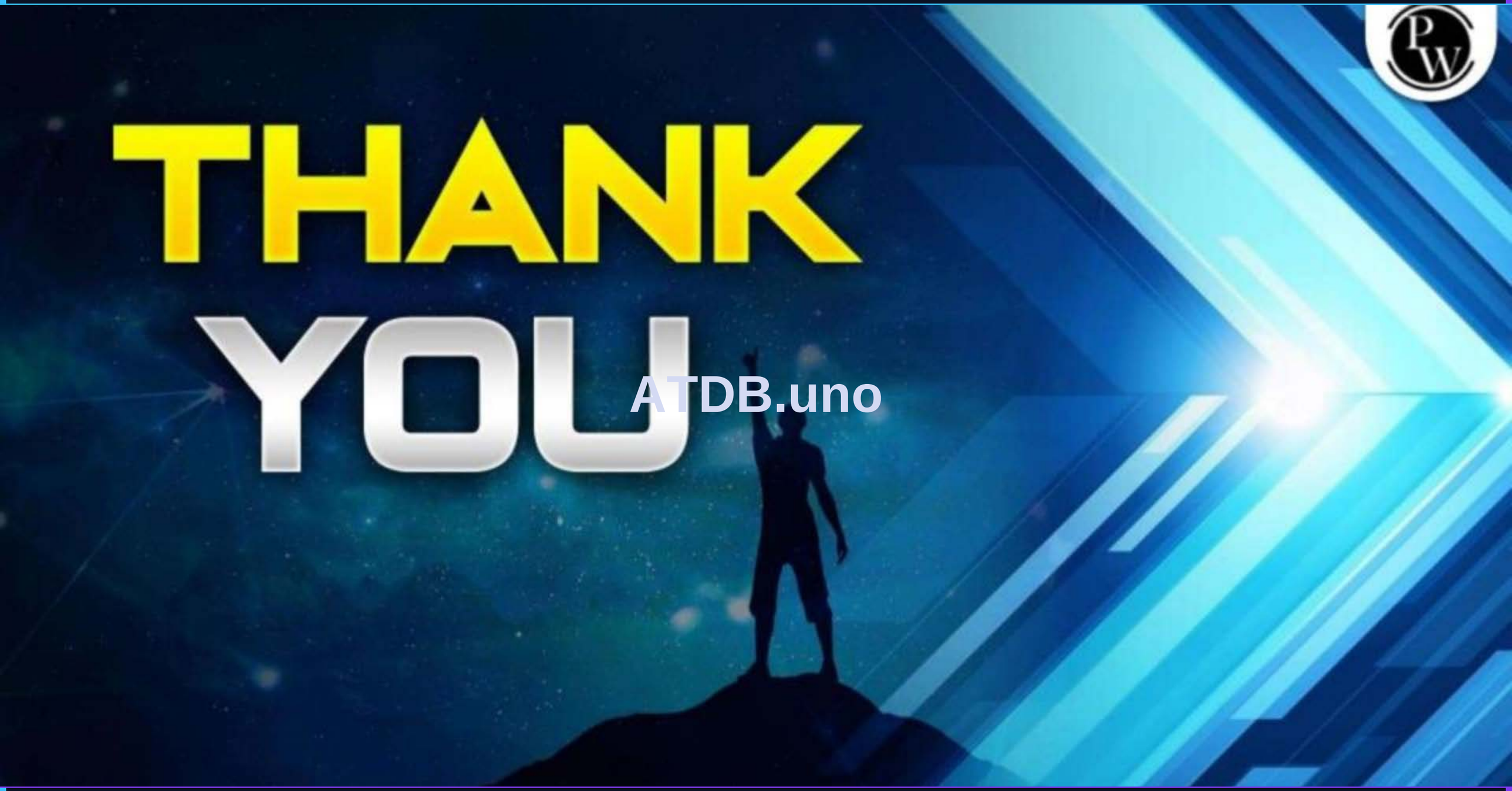

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