

PRAYAS

JEE 2025



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Lecture - 7

Physics

Ray Optics

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Topics *to be covered*

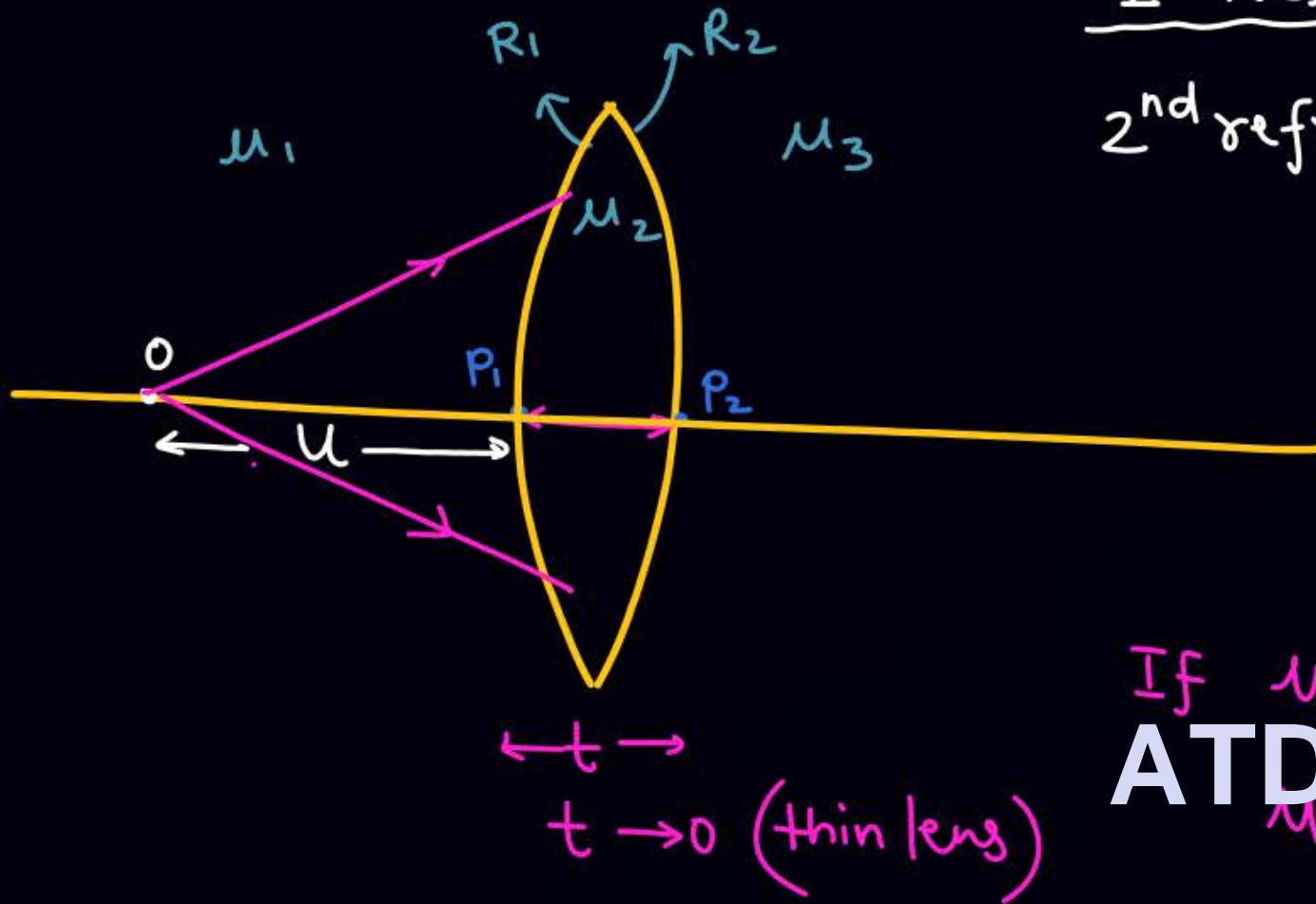
1 *Lens formula*

2

3

4

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1st Refraction

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

2nd refraction

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

Add

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

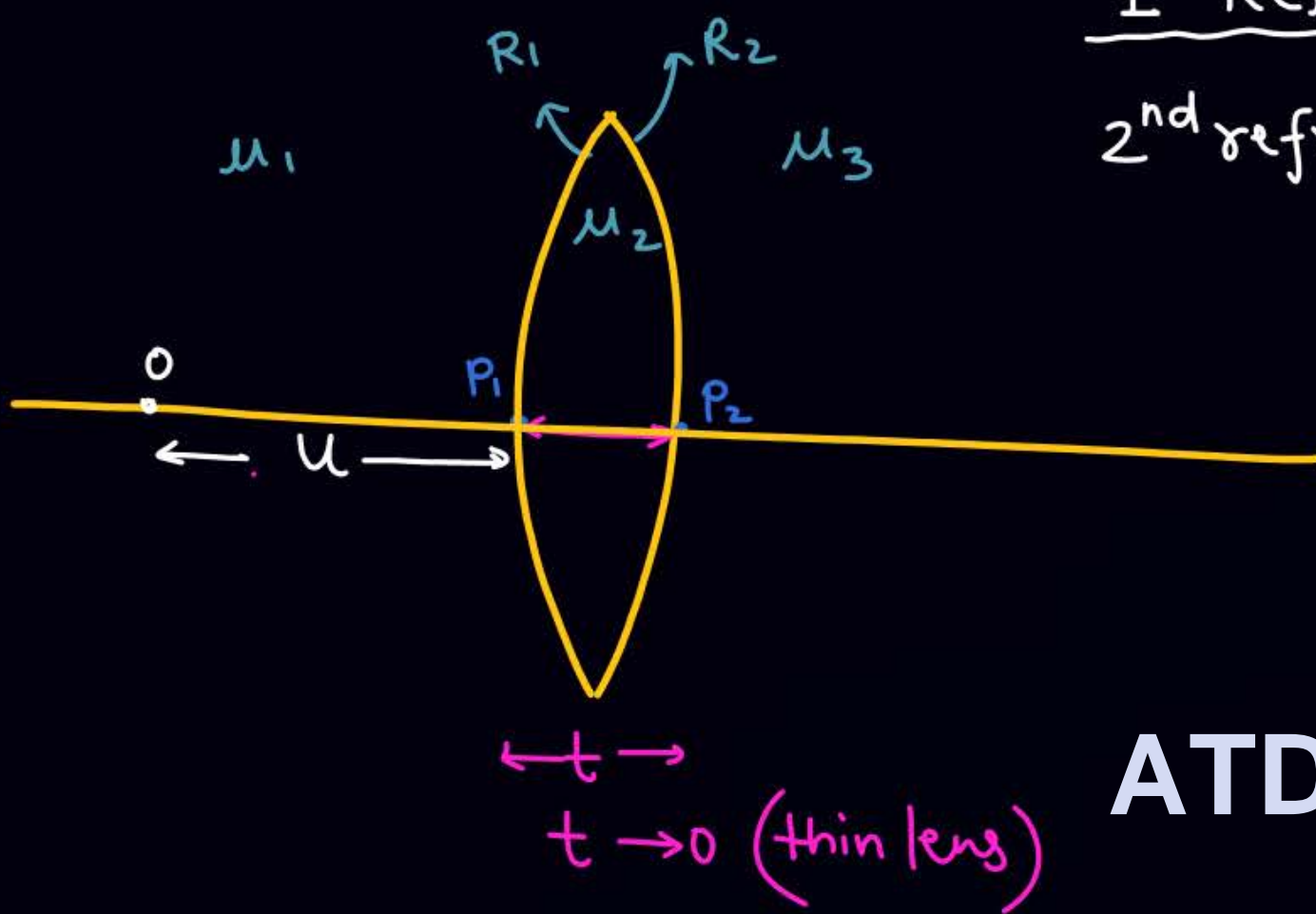
$t \rightarrow 0$ (thin lens)

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

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

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

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



1st Refraction
 2nd refraction

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

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

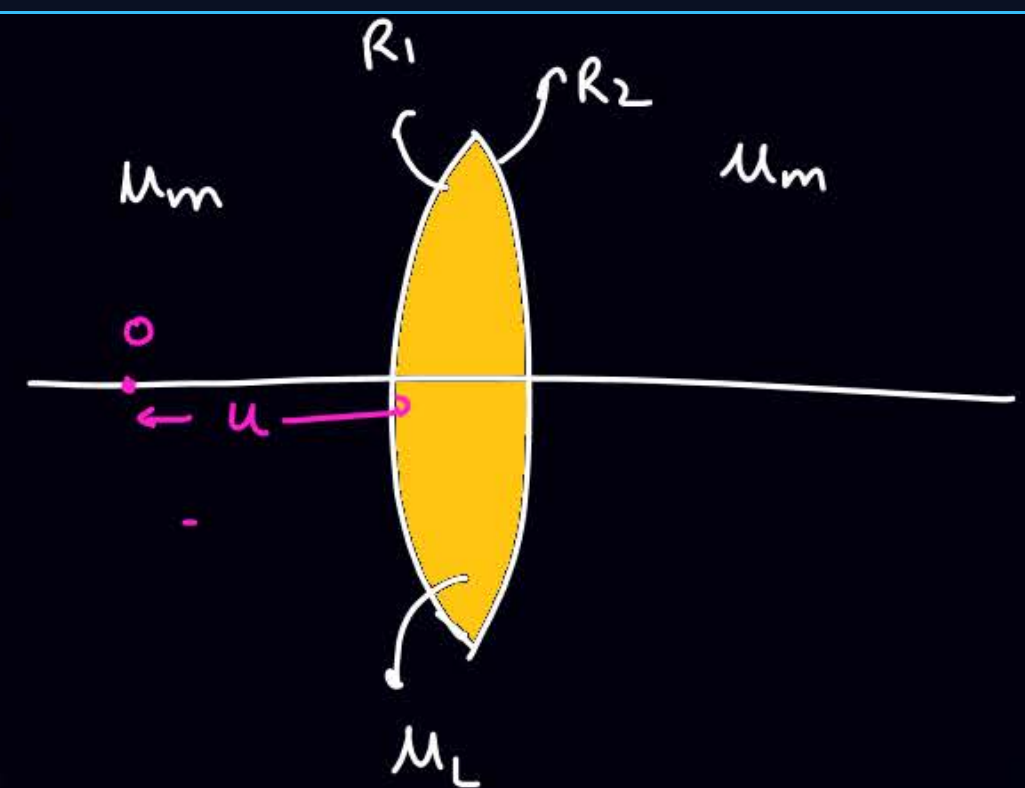
~~$$\frac{1}{v_f} - \frac{1}{u} = \frac{1 - \mu}{R_2} + \frac{\mu - 1}{R_1}$$~~

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

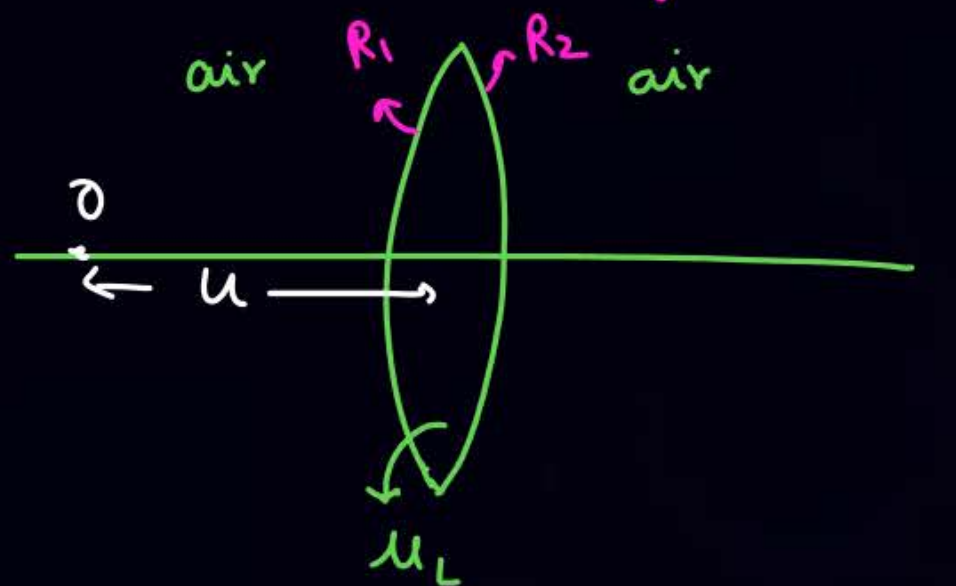
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If obj is at ∞ $u = -\infty$, $v = f$

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



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



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

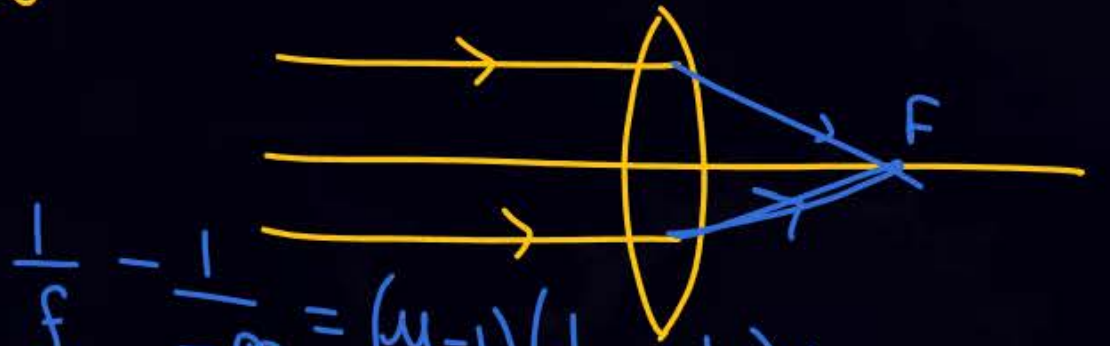
$$\frac{1}{v_f} - \frac{1}{u} = \left(\frac{\mu_L}{\mu_m} - 1 \right) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

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

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

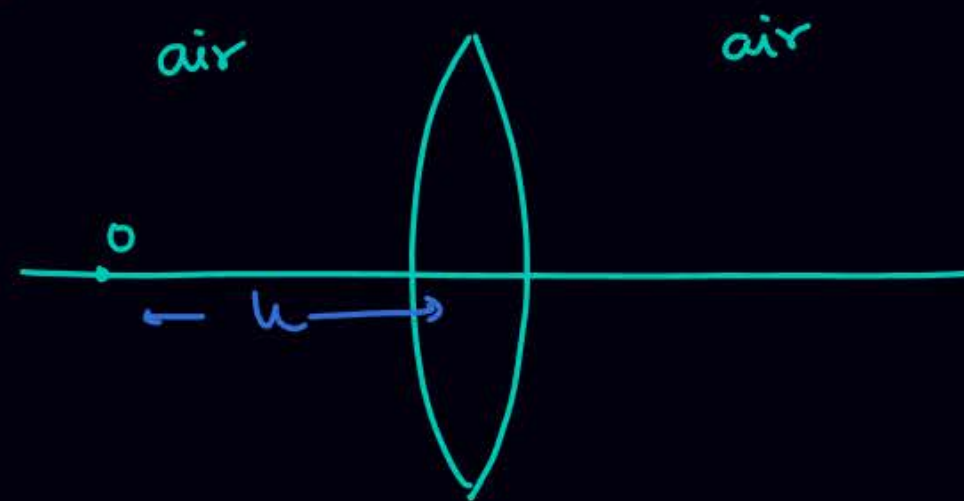
If obj is at ∞
 $u = -\infty$
 $v = f$



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



Results



lens in medium/water



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

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

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1

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

2

$u = \checkmark$

$v = ?$

$m = ?$

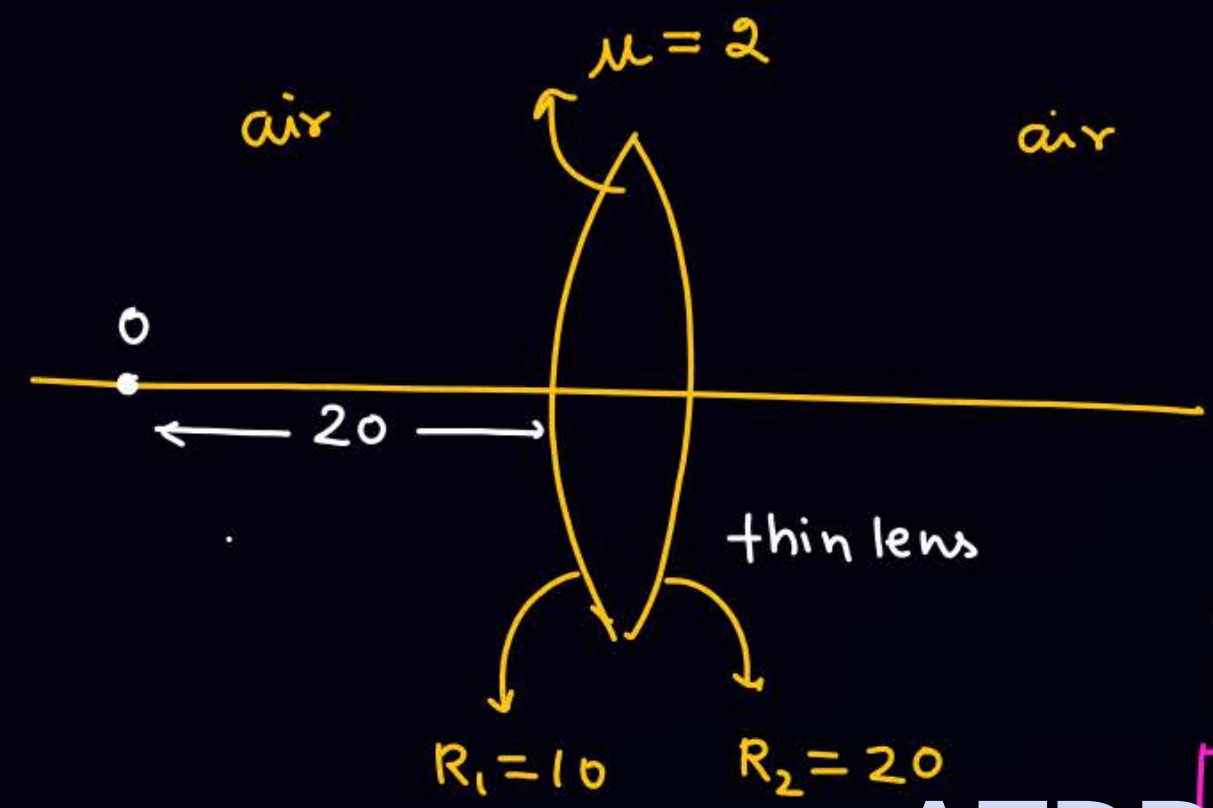
Nature

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

$(u, v, f \equiv \text{with sign})$
 $\left\{ \begin{matrix} \leftarrow \leftarrow \leftarrow \leftarrow \leftarrow \leftarrow \end{matrix} \right.$



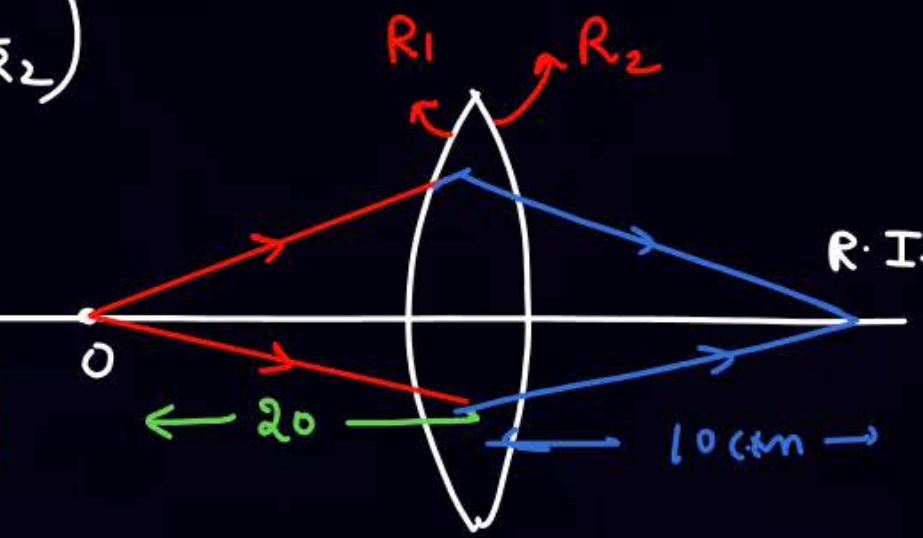
Q



* ① find focal length

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

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



ATDB.uno $f = \frac{20}{3}$

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

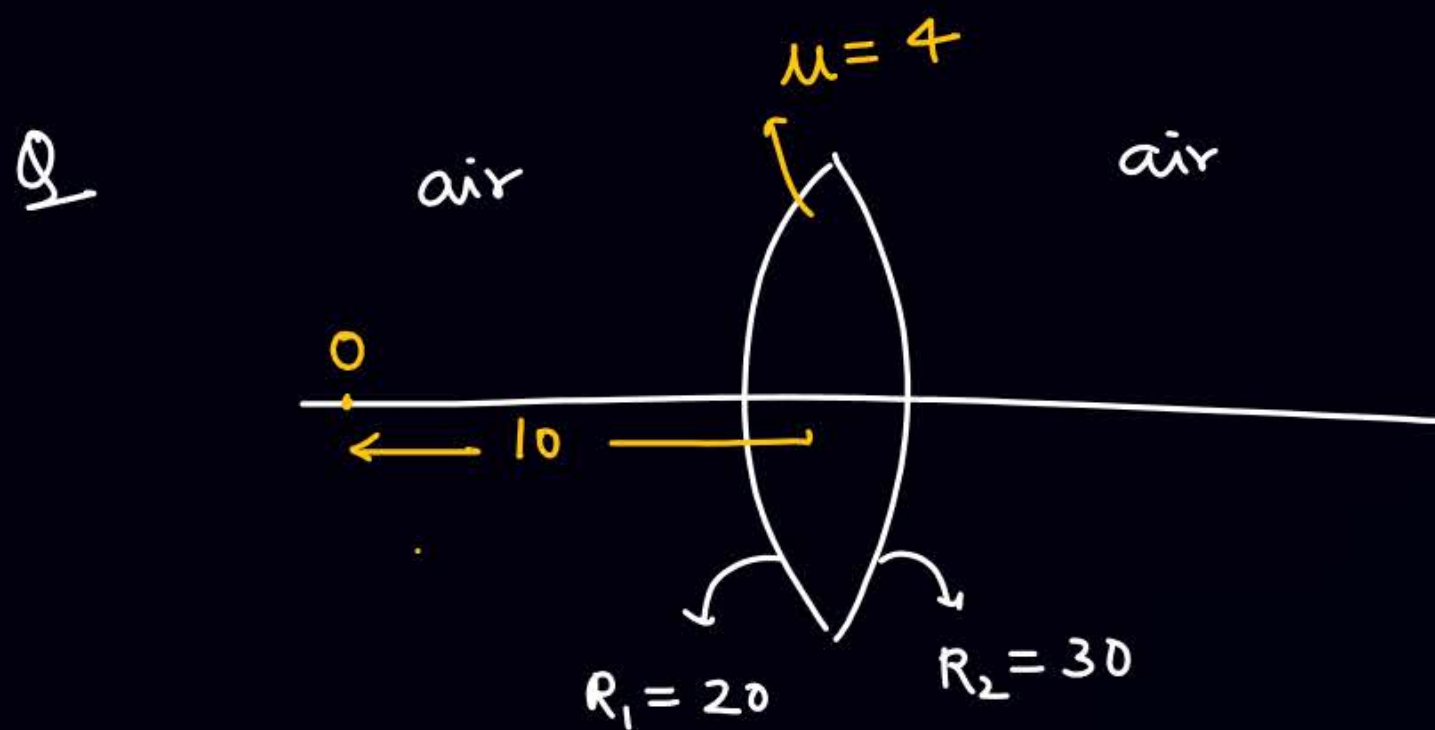
② find location of image

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

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

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

$$v = +10$$



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

$$f = 4$$

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

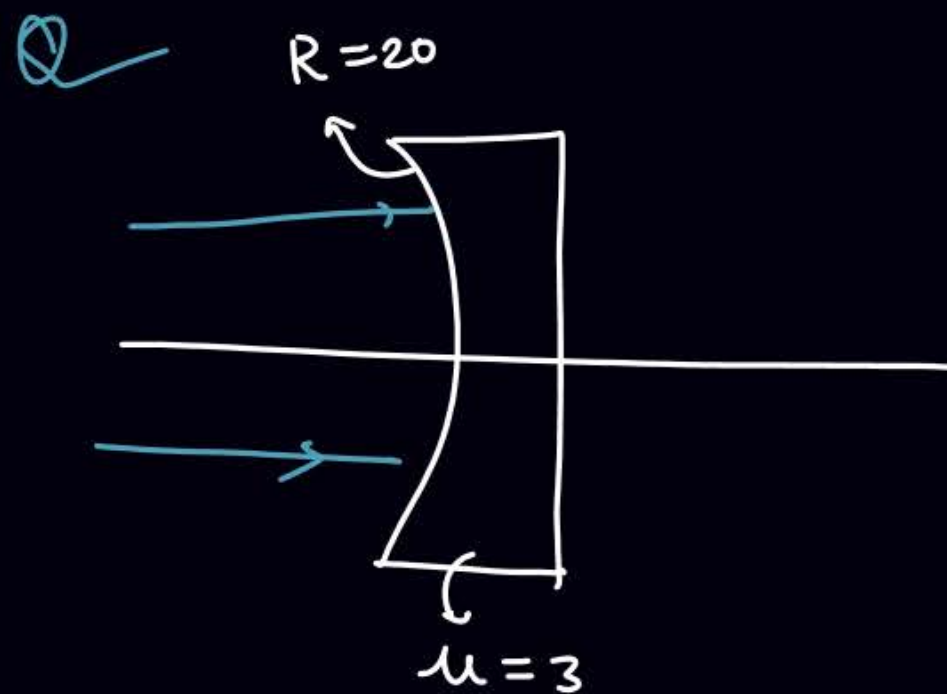
$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{4}$$

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

① $f = ?$

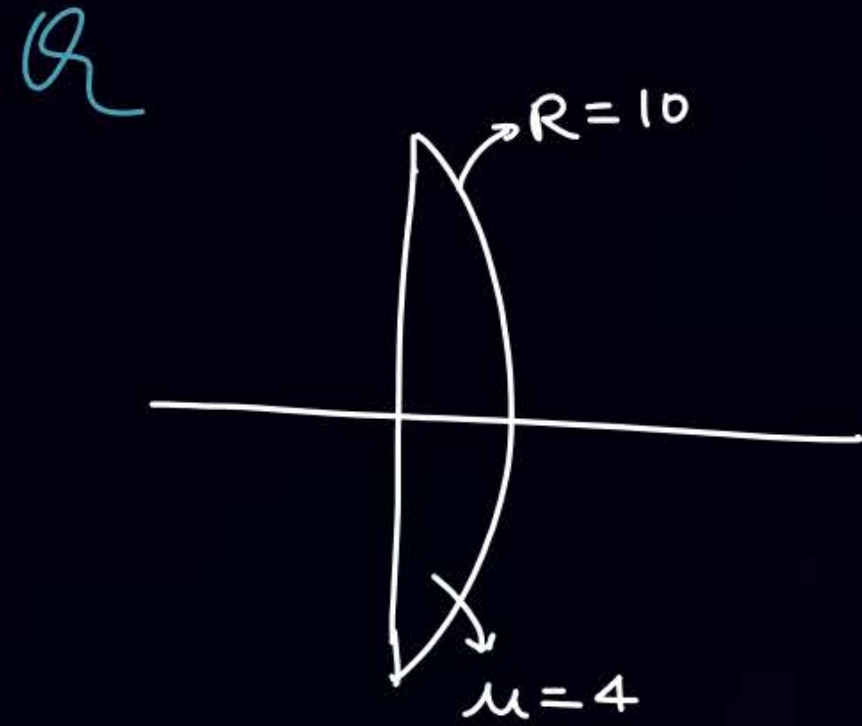
② $v = ?$

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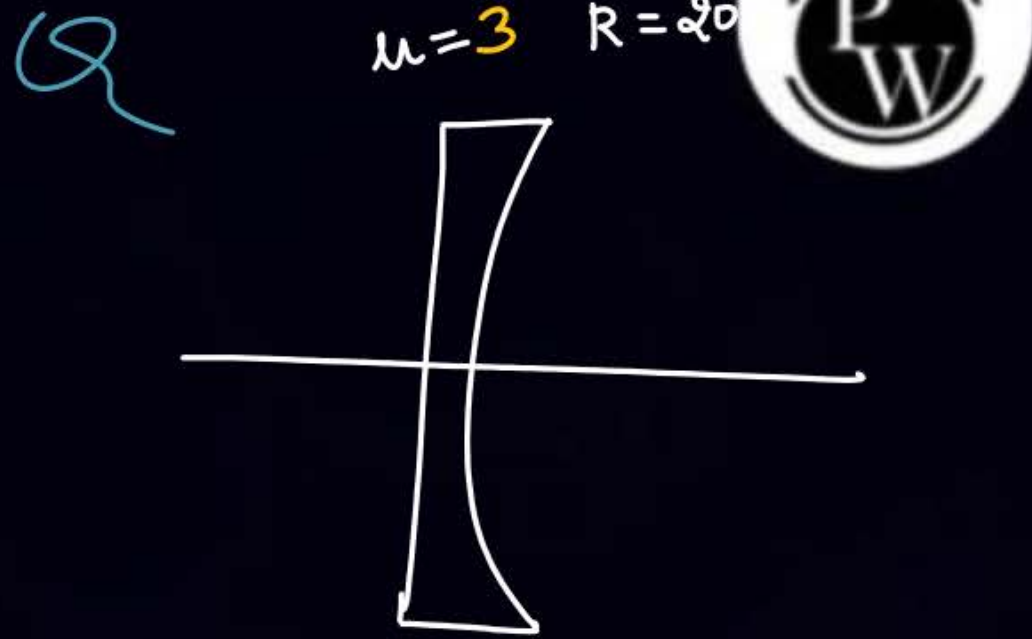
$$\frac{1}{f} = (3-1) \left(\frac{1}{-20} - \frac{1}{\infty} \right)$$

$$f = -10$$



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

$$f = 10/3$$



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

$$f = -10$$





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

Solⁿ

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



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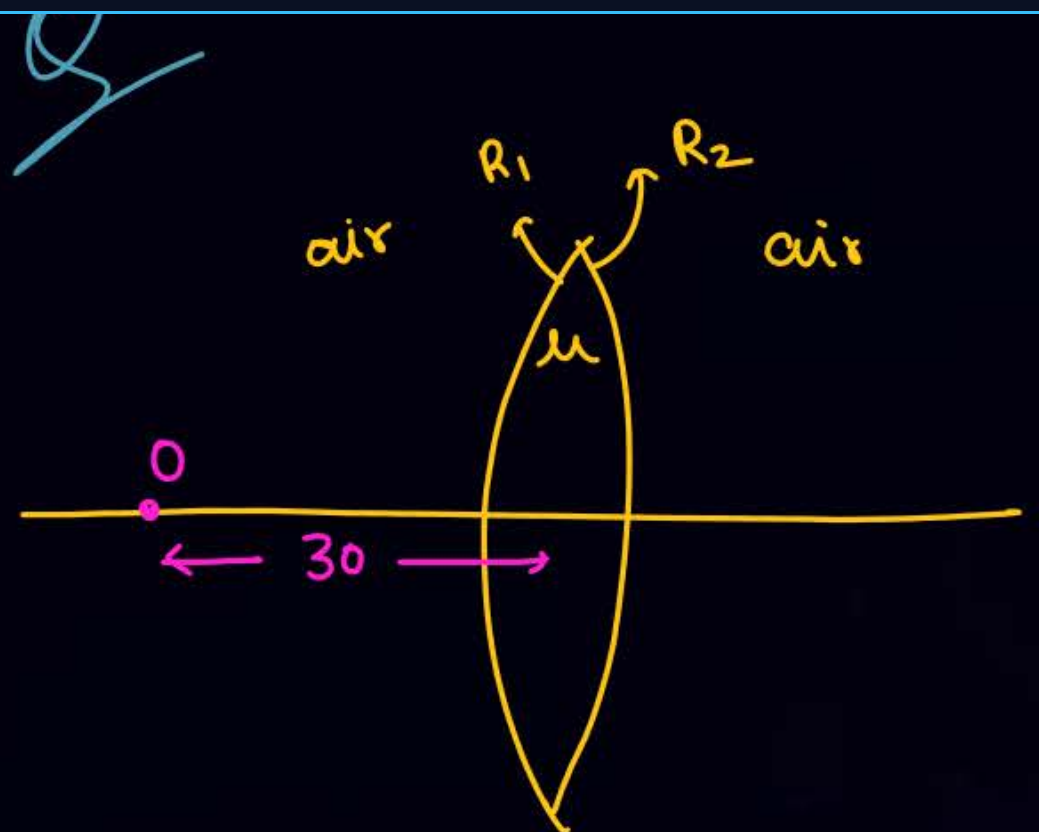
$$\text{air } \frac{1}{10} = (4 - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

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

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



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



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$$f = +20$$

find v

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

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

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

(*) $V = 60$





Lens formula

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

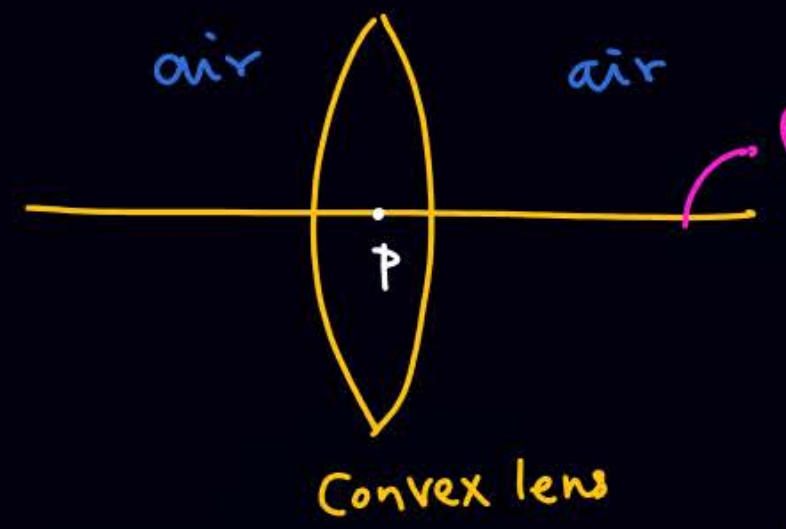
* $m = \frac{\text{height of image}}{\text{height of obj}} = \frac{h_I}{h_o} = \frac{v}{u}$

* paraxial rays

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

Sign Conventions

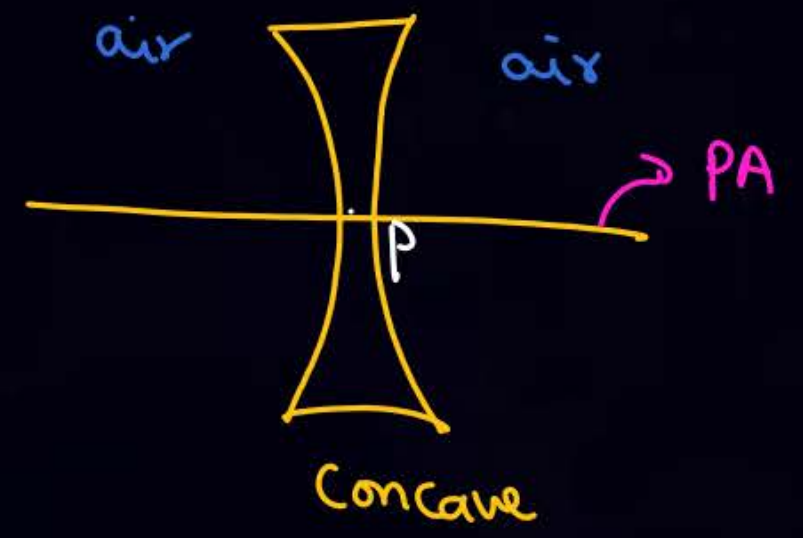
- * Dirⁿ of incident ray \rightarrow +ve
- * \overrightarrow{PI} measurement \overrightarrow{PI} से ✓



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

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

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

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

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



note

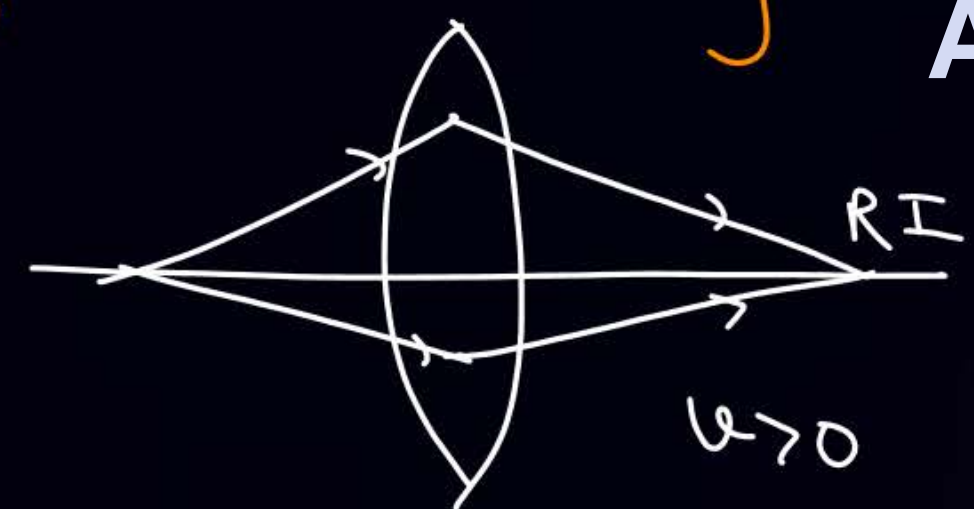
Lens

$$u < 0 \longrightarrow R \cdot 0$$

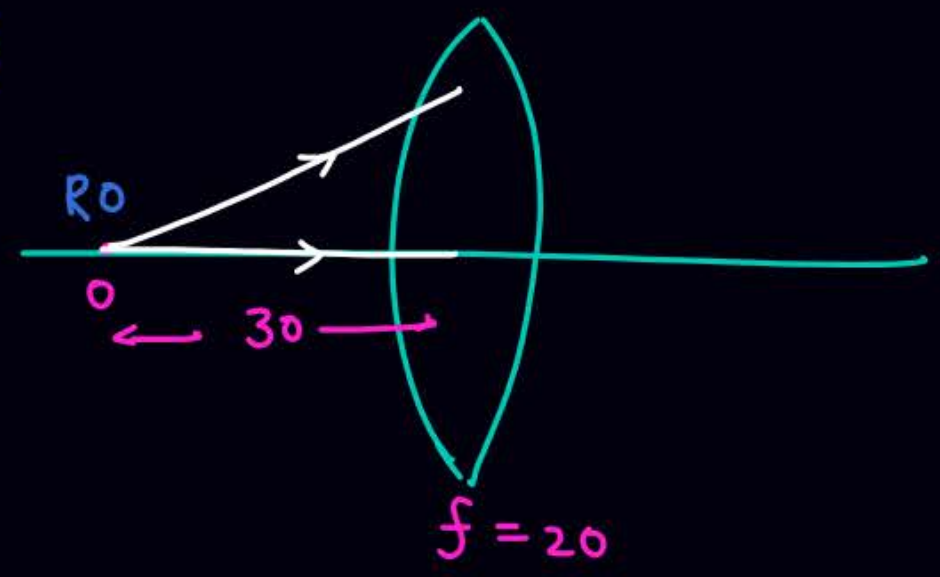
$$u > 0 \longrightarrow V \cdot 0$$

$$\left\{ \begin{array}{l} u > 0 \longrightarrow R \cdot I \\ u < 0 \longrightarrow V \cdot I \end{array} \right\}$$

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SSSD
①

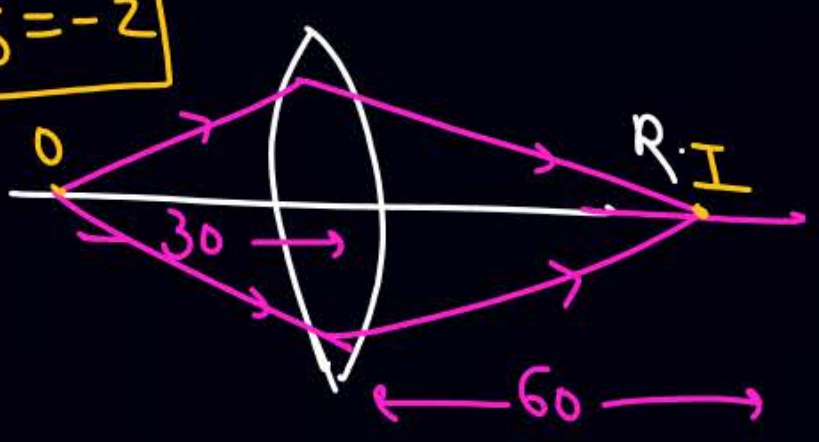


$$u = -30$$

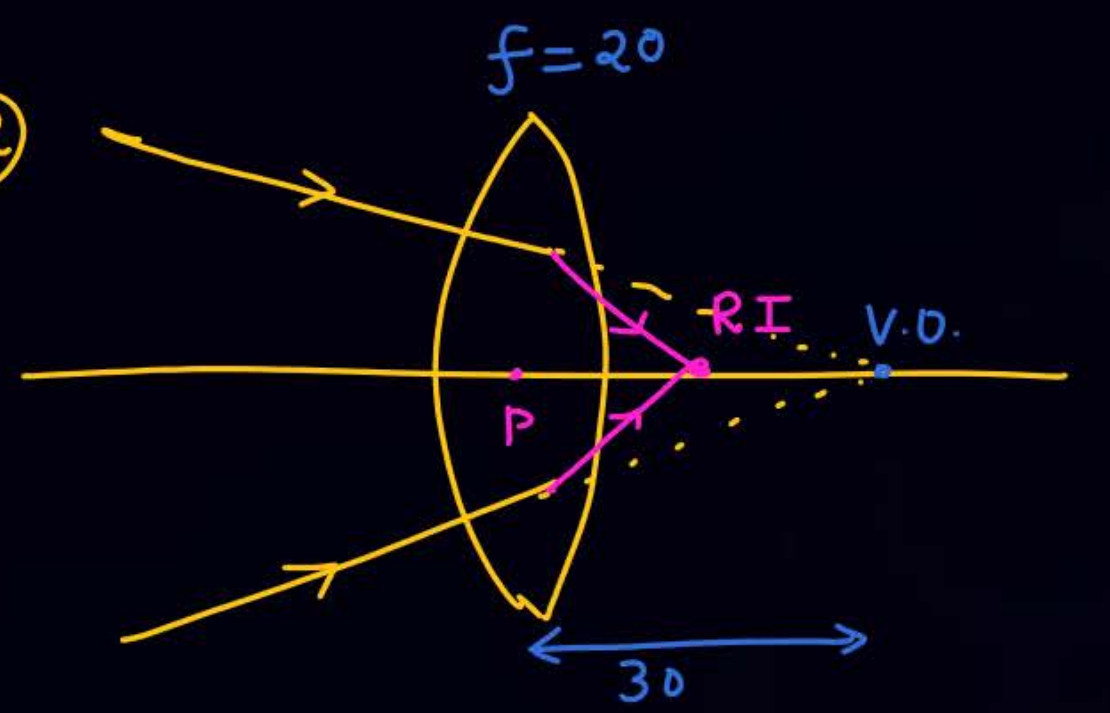
$$f = +20$$

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

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



②



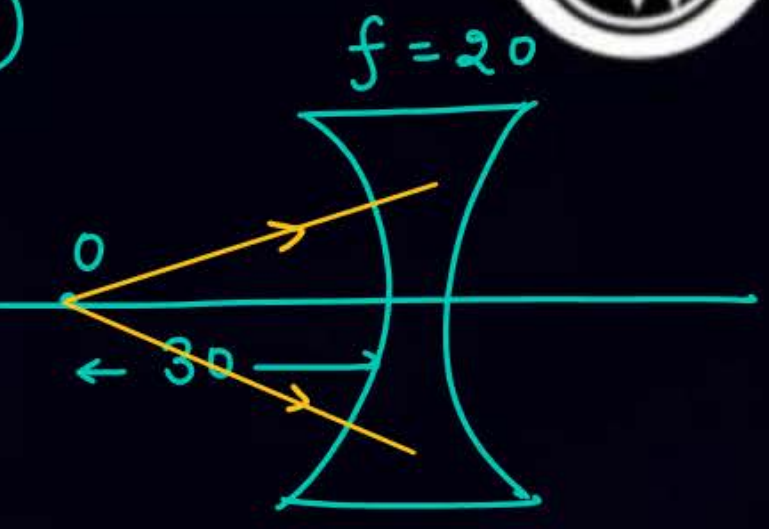
$$u = +30$$

$$f = +20$$

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

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③



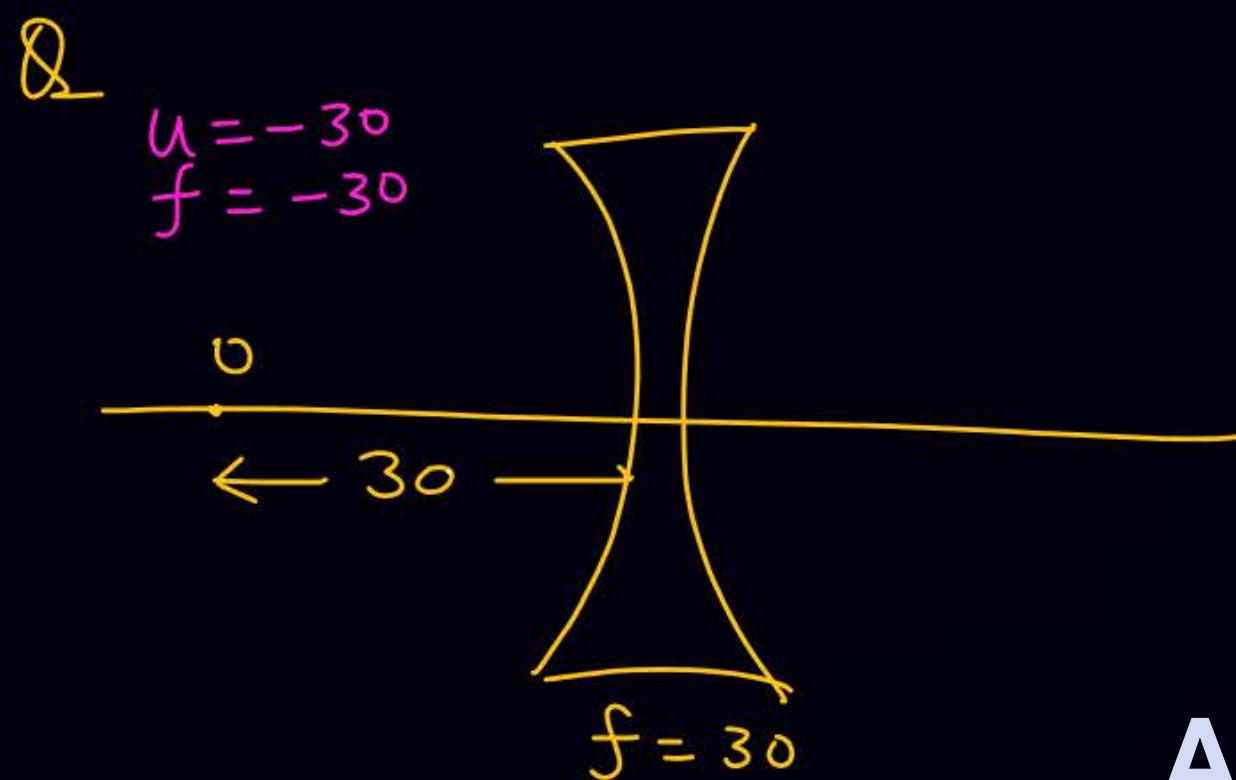
$$u = -30$$

$$f = -20$$

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

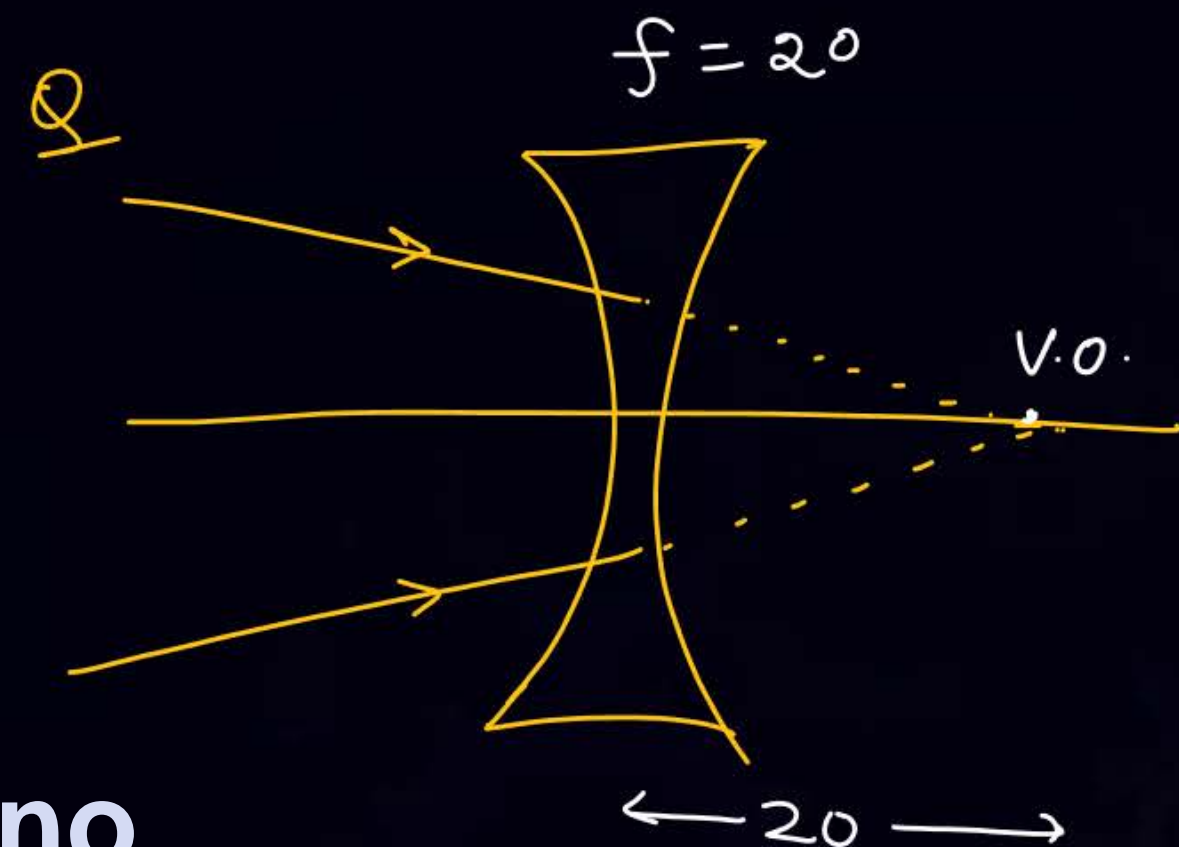
$$v = -12$$





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

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

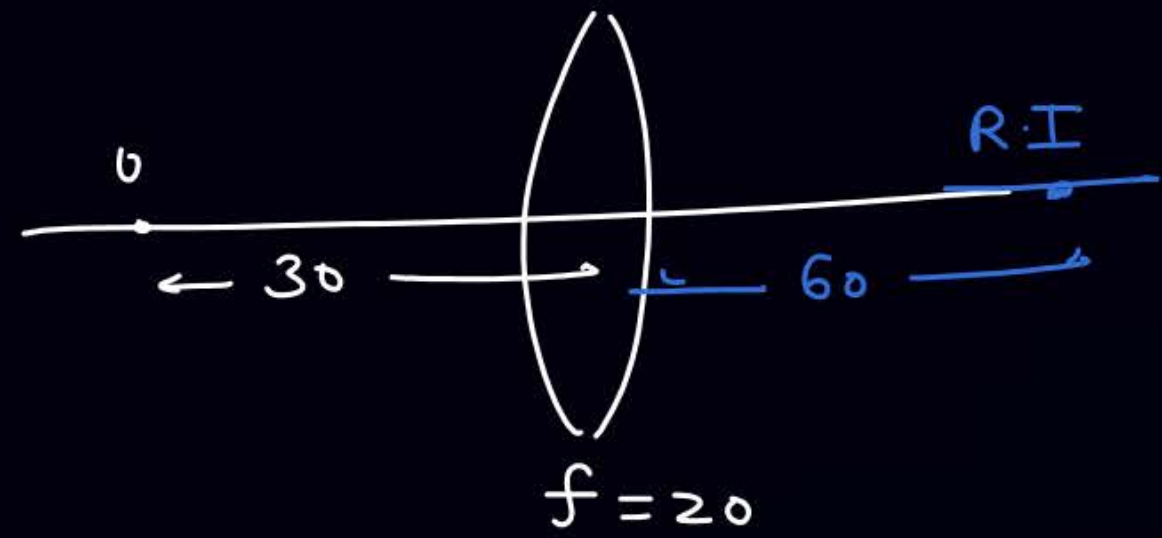


$$v = \frac{+20 \times (-20)}{(+20) + (-20)} = \infty$$

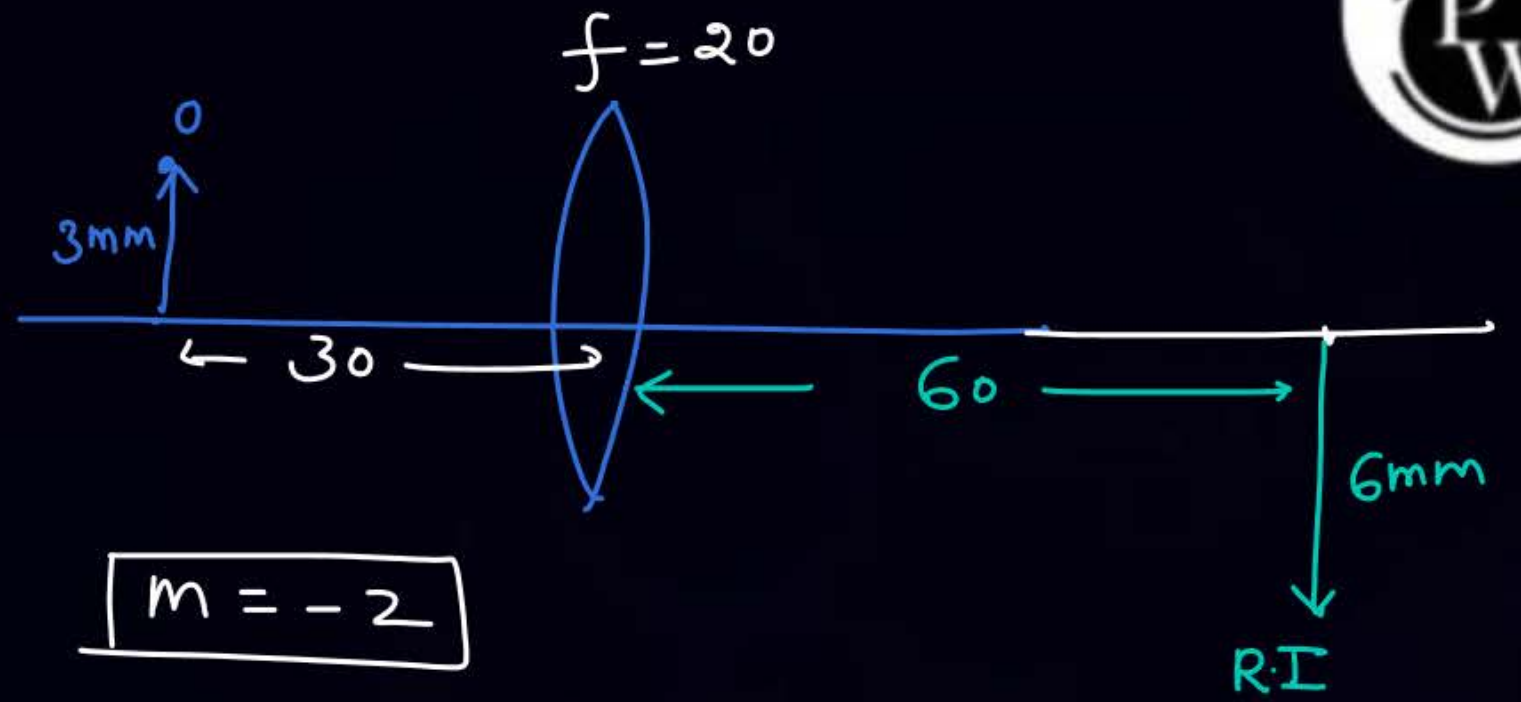
ATDB.uno



Q



①

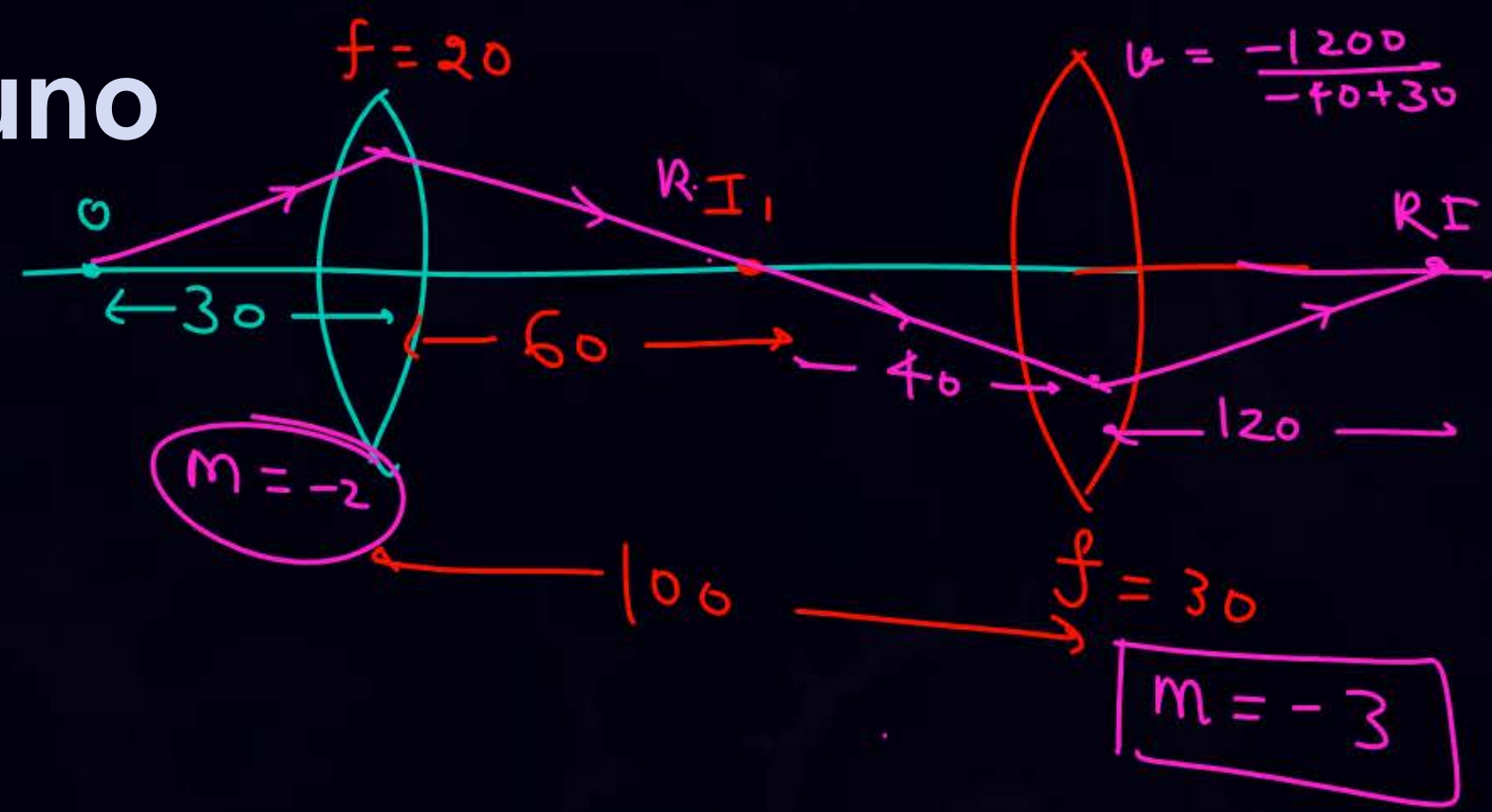


$v = +60$
 $m = -2$
 $m = \frac{60}{-30} = -2$

ATDB.uno

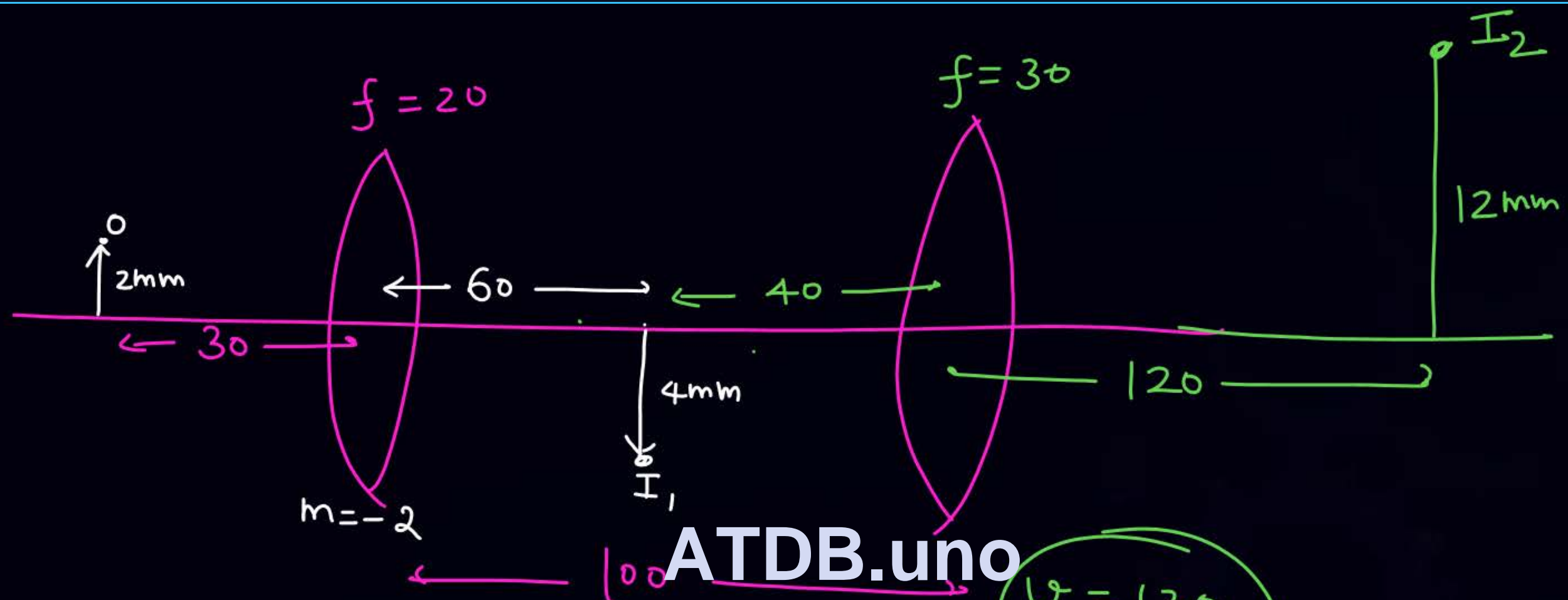
②

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





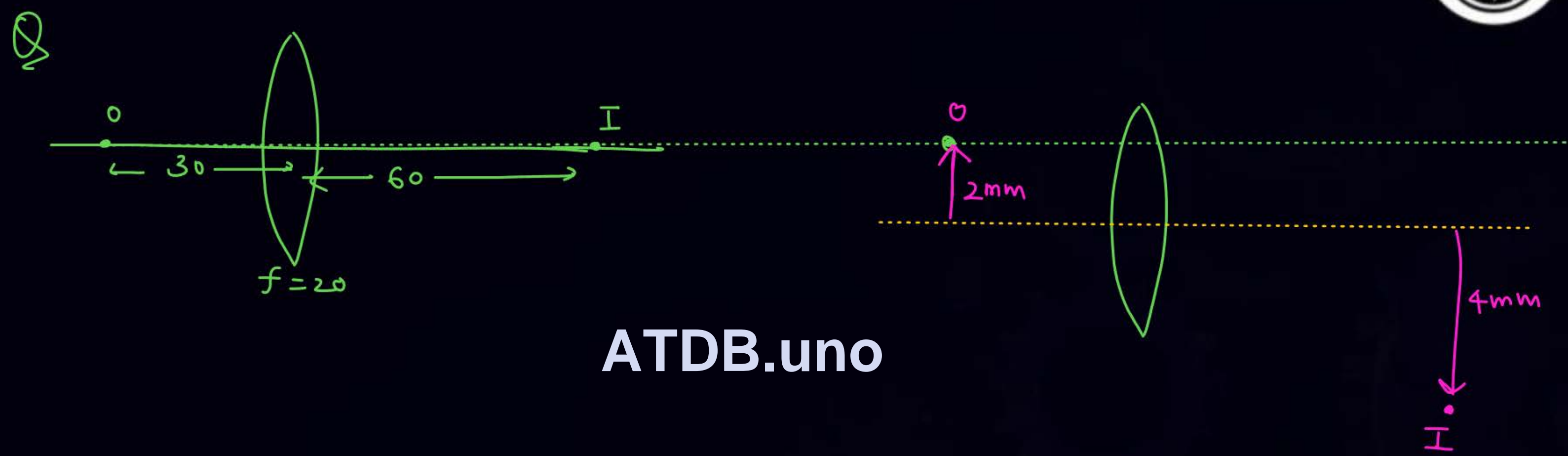
③



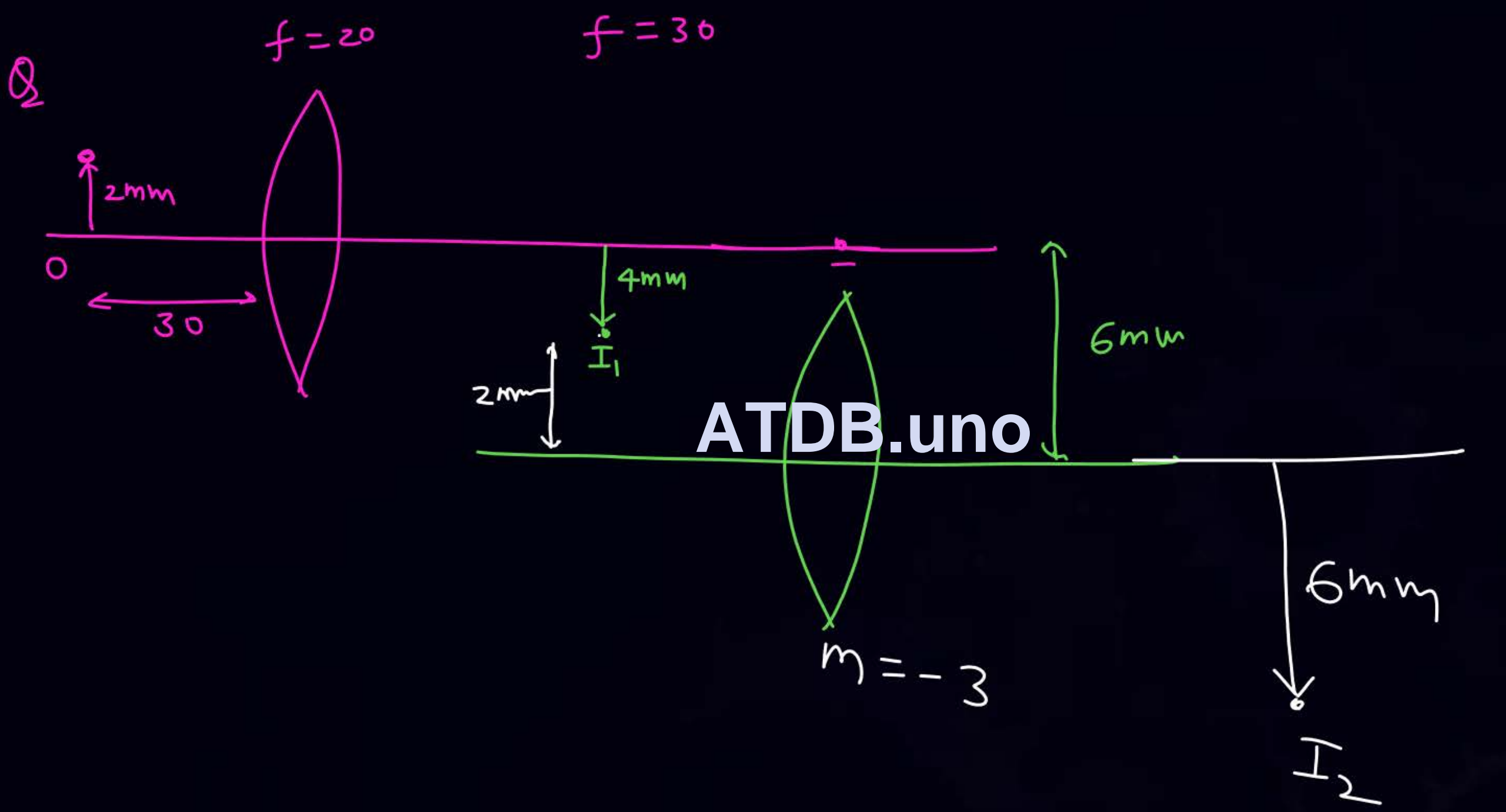
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$$\begin{aligned} u &= 120 \\ f & \\ m &= -3 \end{aligned}$$

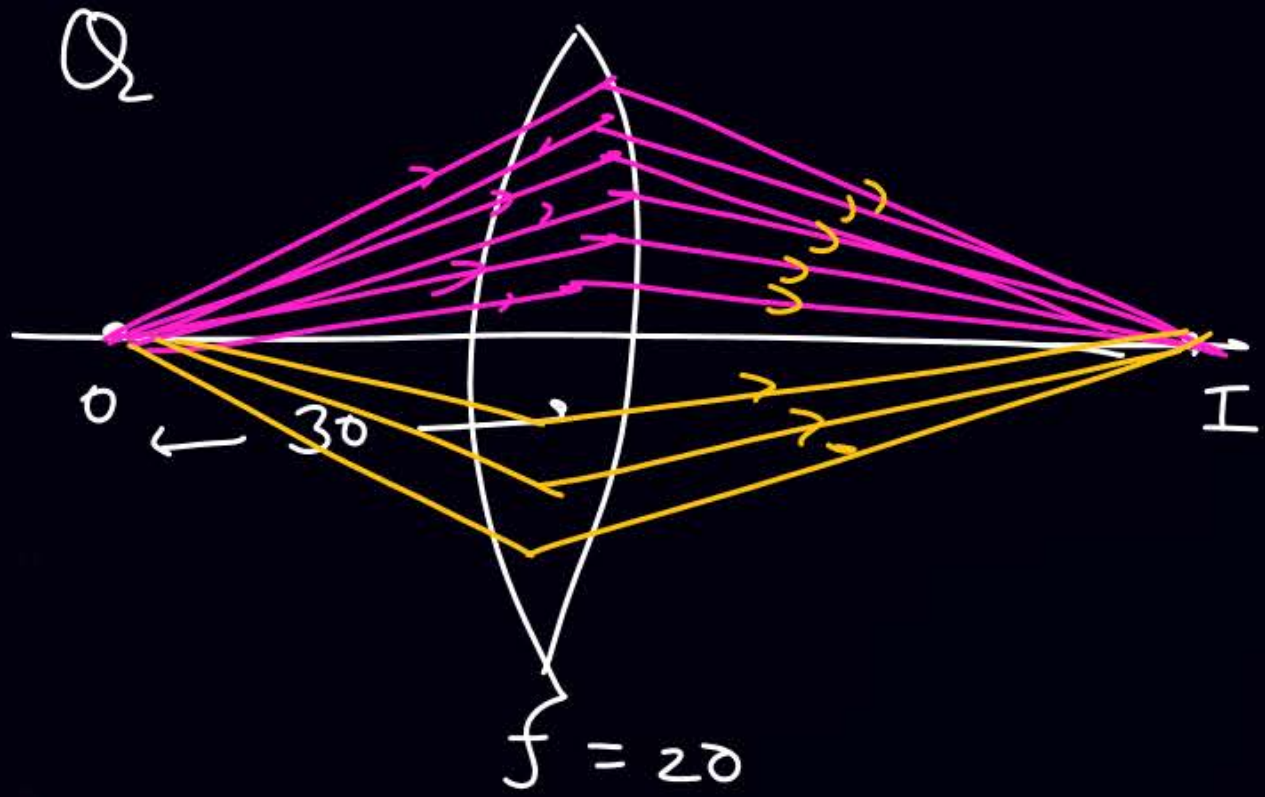
$$m_{\text{net}} = m_1 \times m_2 = (-2) \times (-3) = +6$$



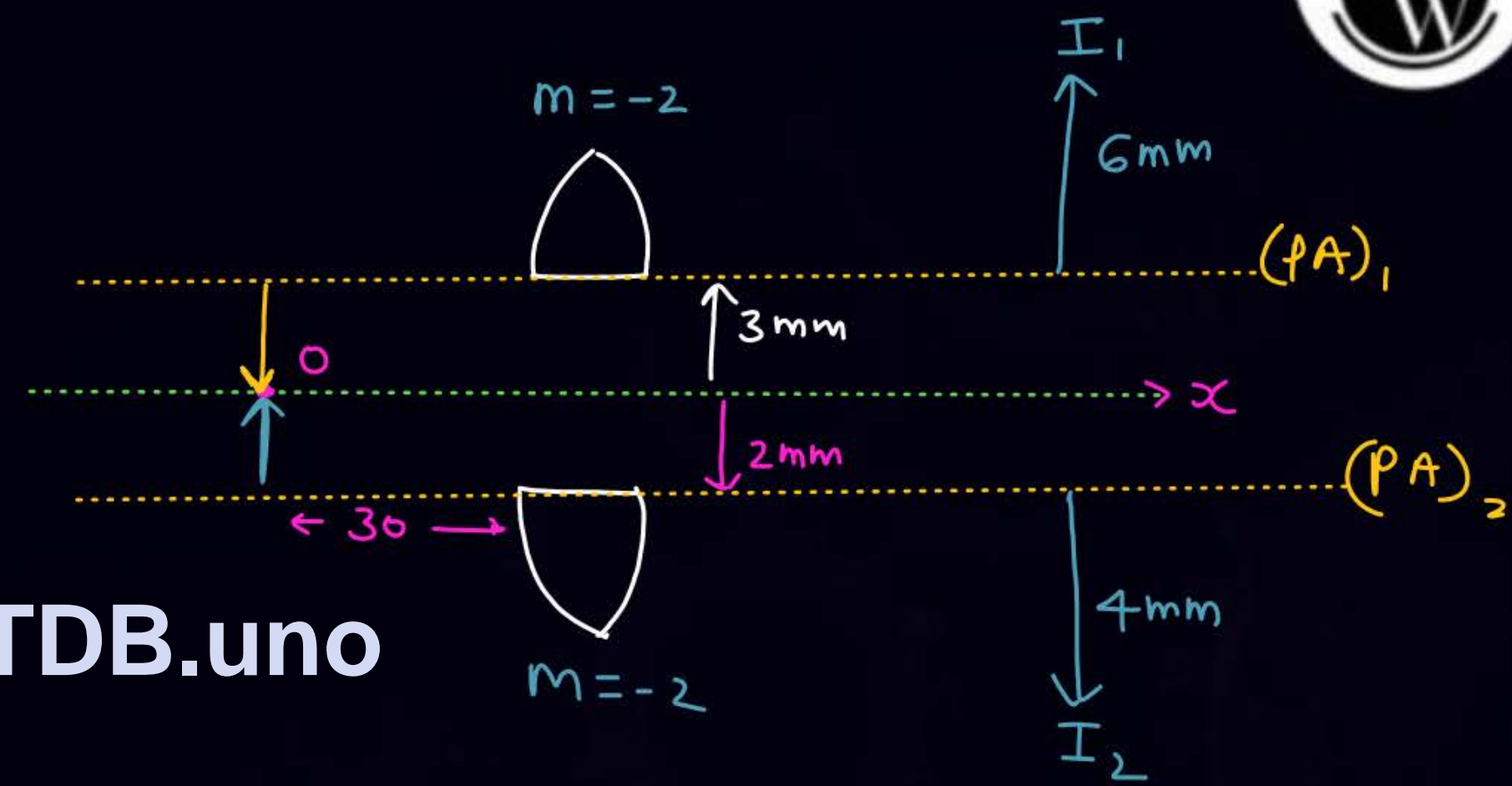
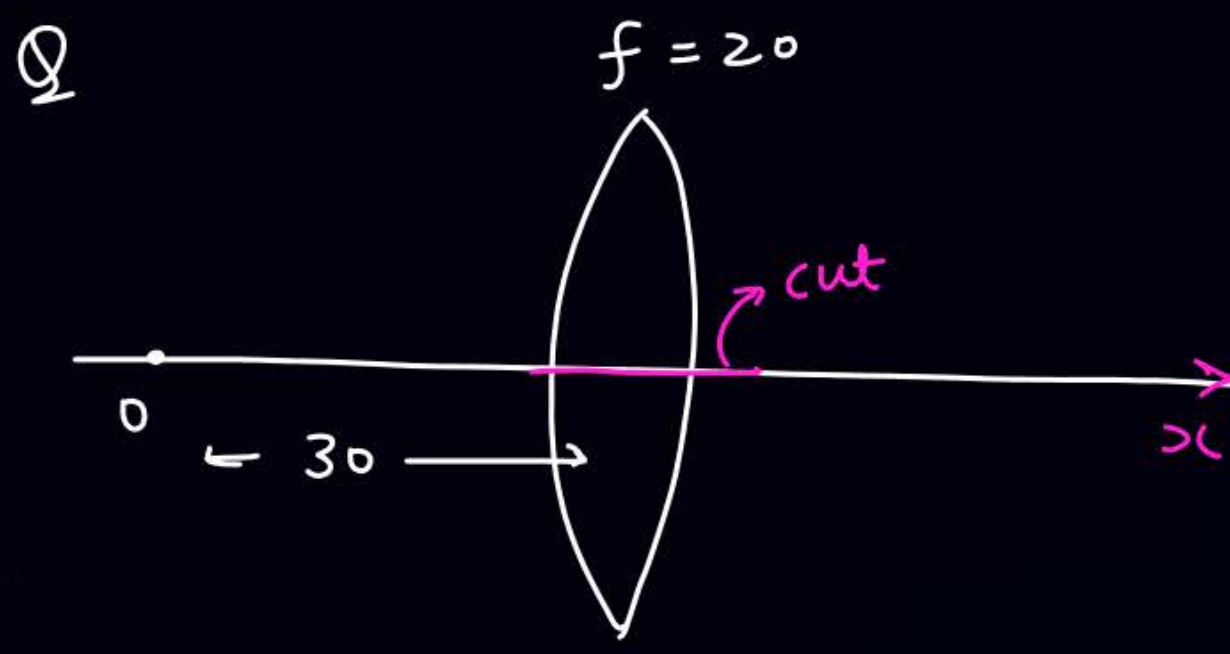
ATDB.uno



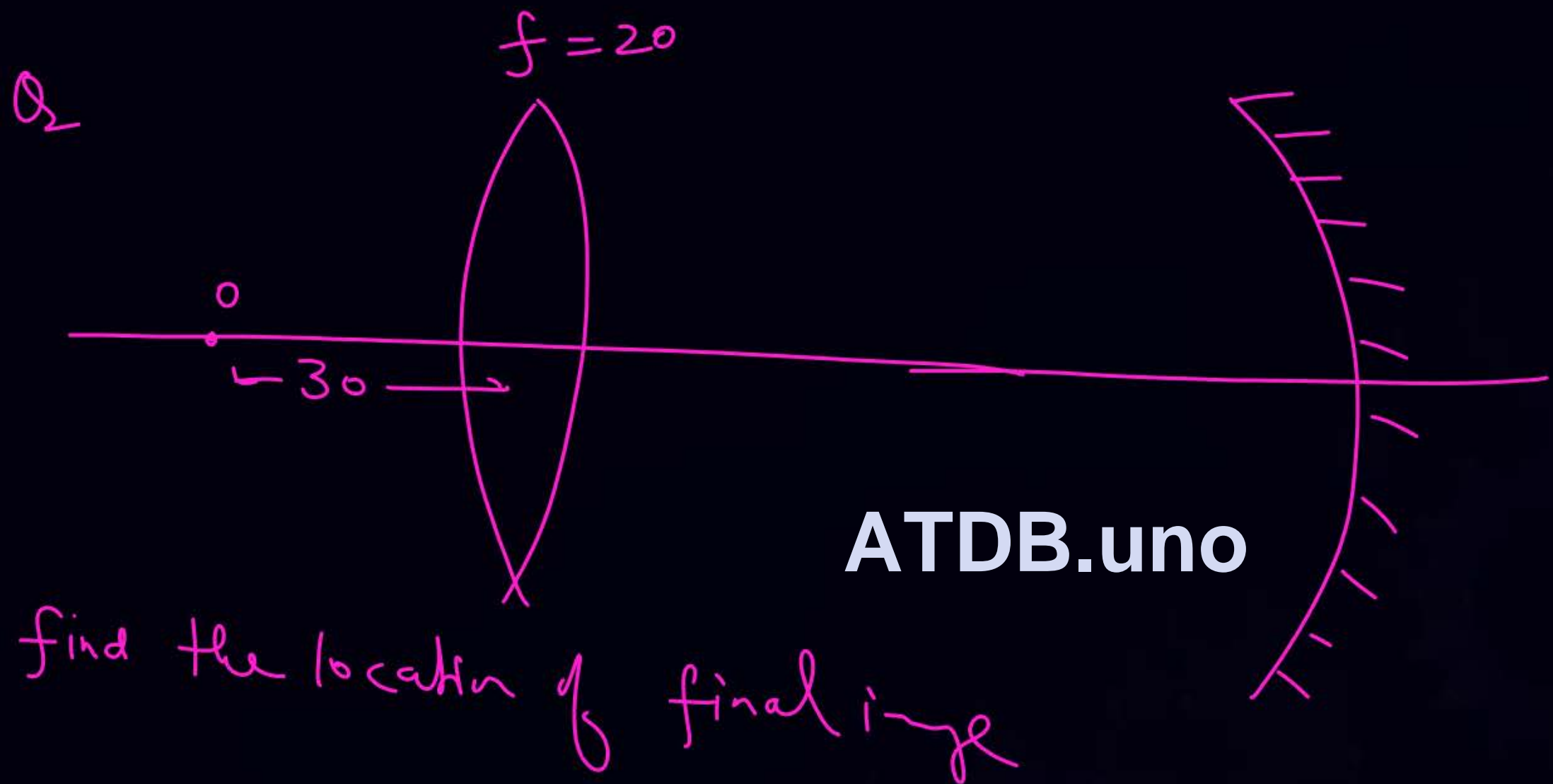
ATDB.uno

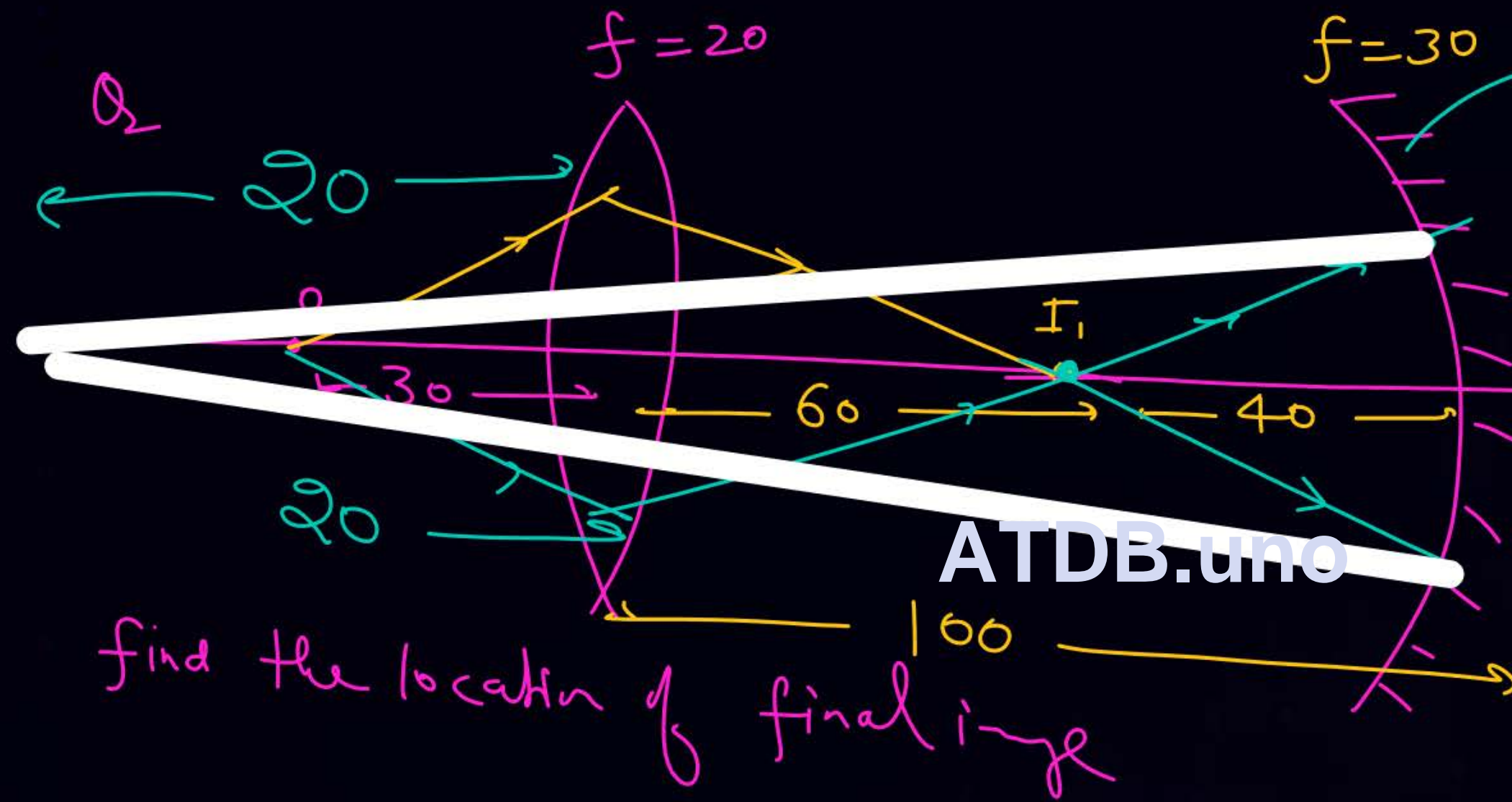


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ATDB.uno



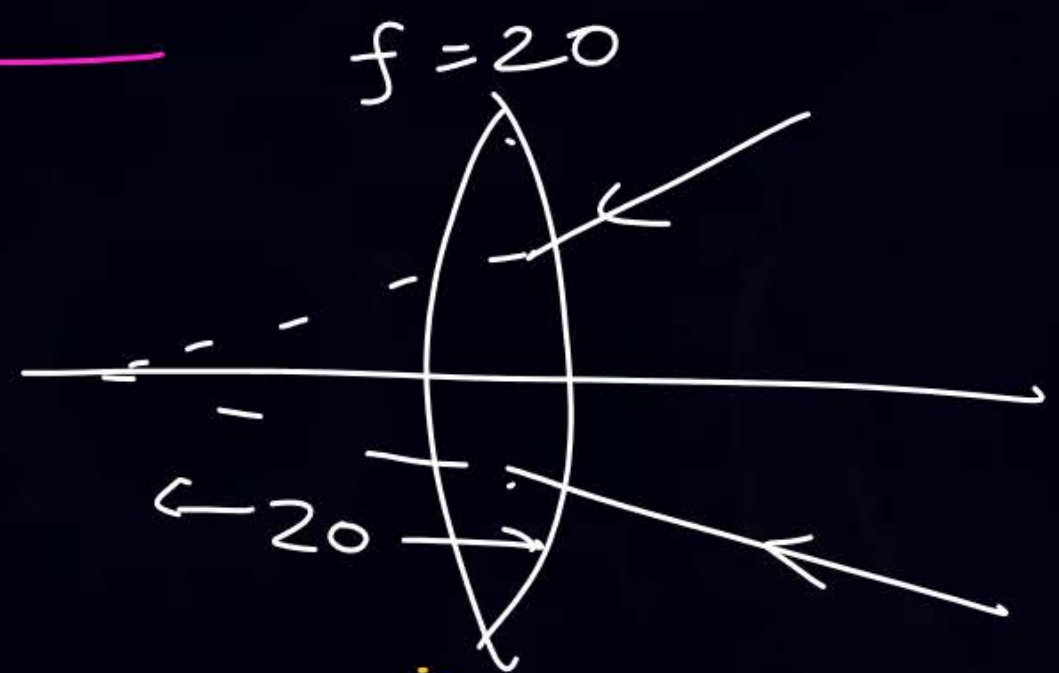


find the location of final image

$$u = -40$$

$$f = -30$$

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

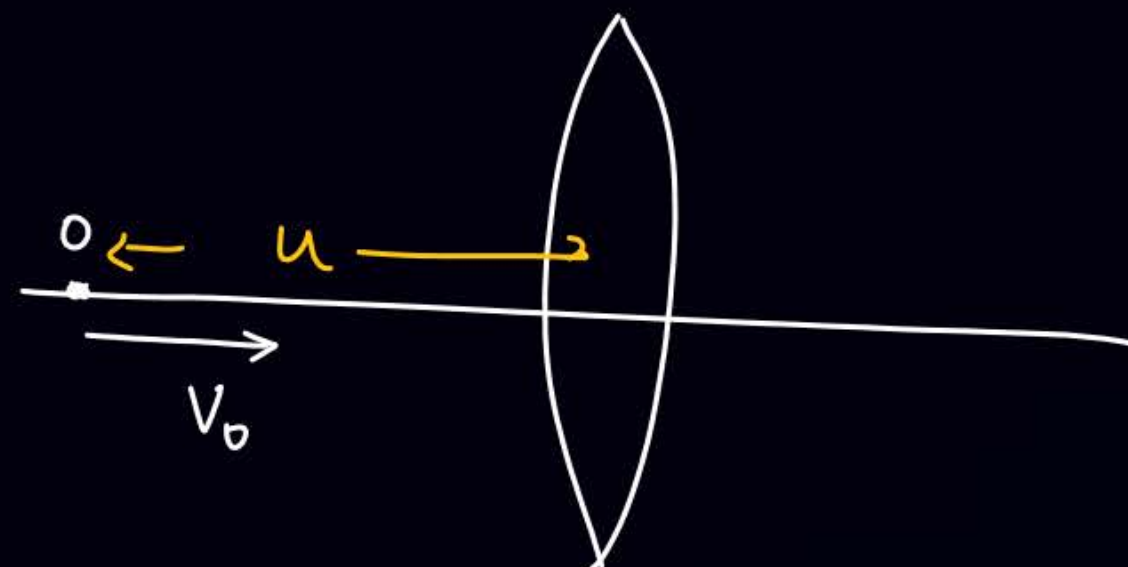


$$u = +20$$

$$f = +20$$



$$V_{\text{image}} = ?$$



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

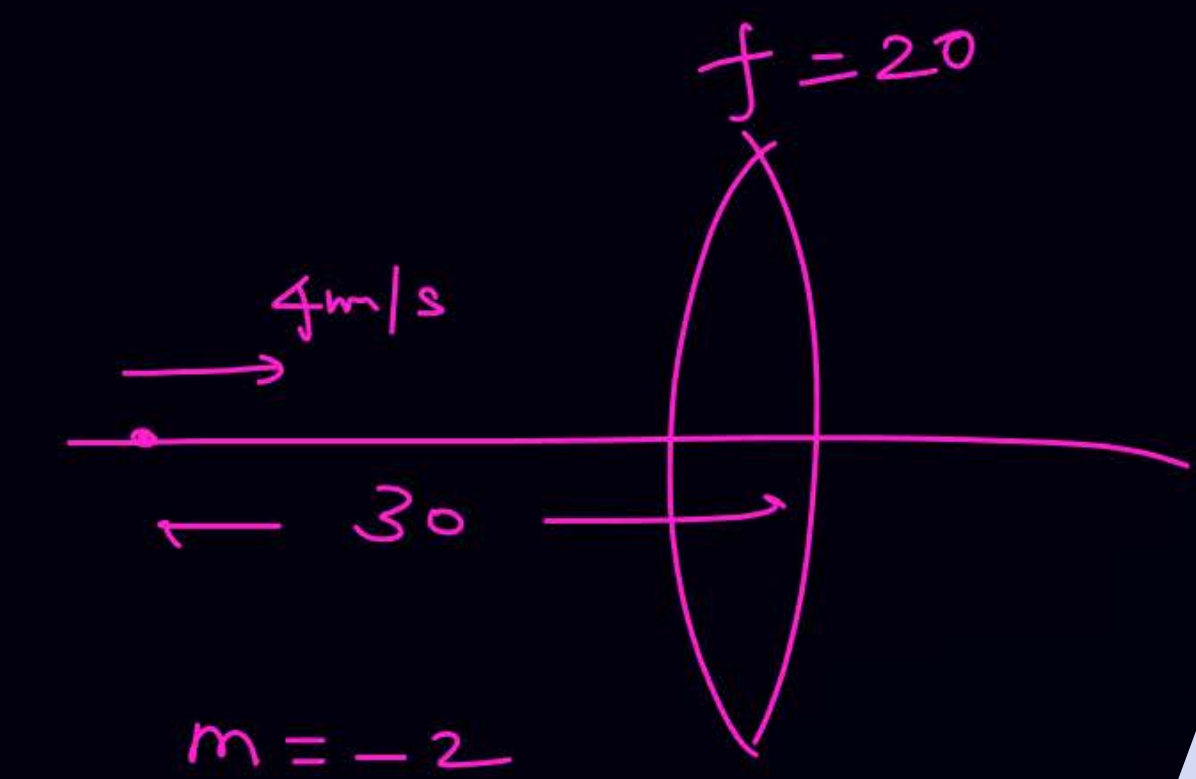
$$-\frac{1}{v^2} \frac{dv}{dt} - \frac{1}{-u^2} \frac{du}{dt} = 0$$

$$\frac{1}{v^2} \left(\frac{dv}{dt} \right) = \frac{1}{u^2} \left(\frac{du}{dt} \right)$$

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

$$V_I = m^2 V_0$$

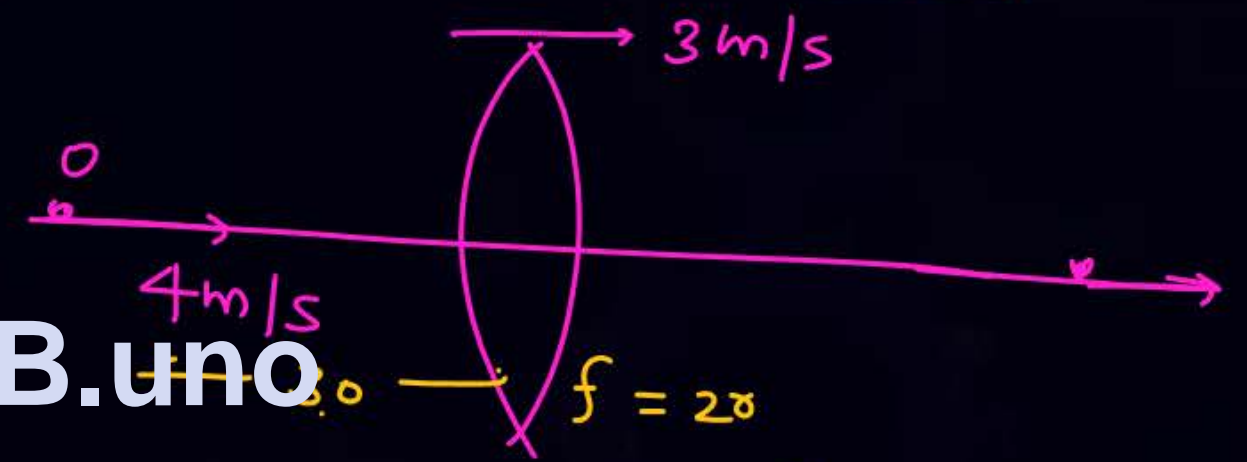
ATDB.uno



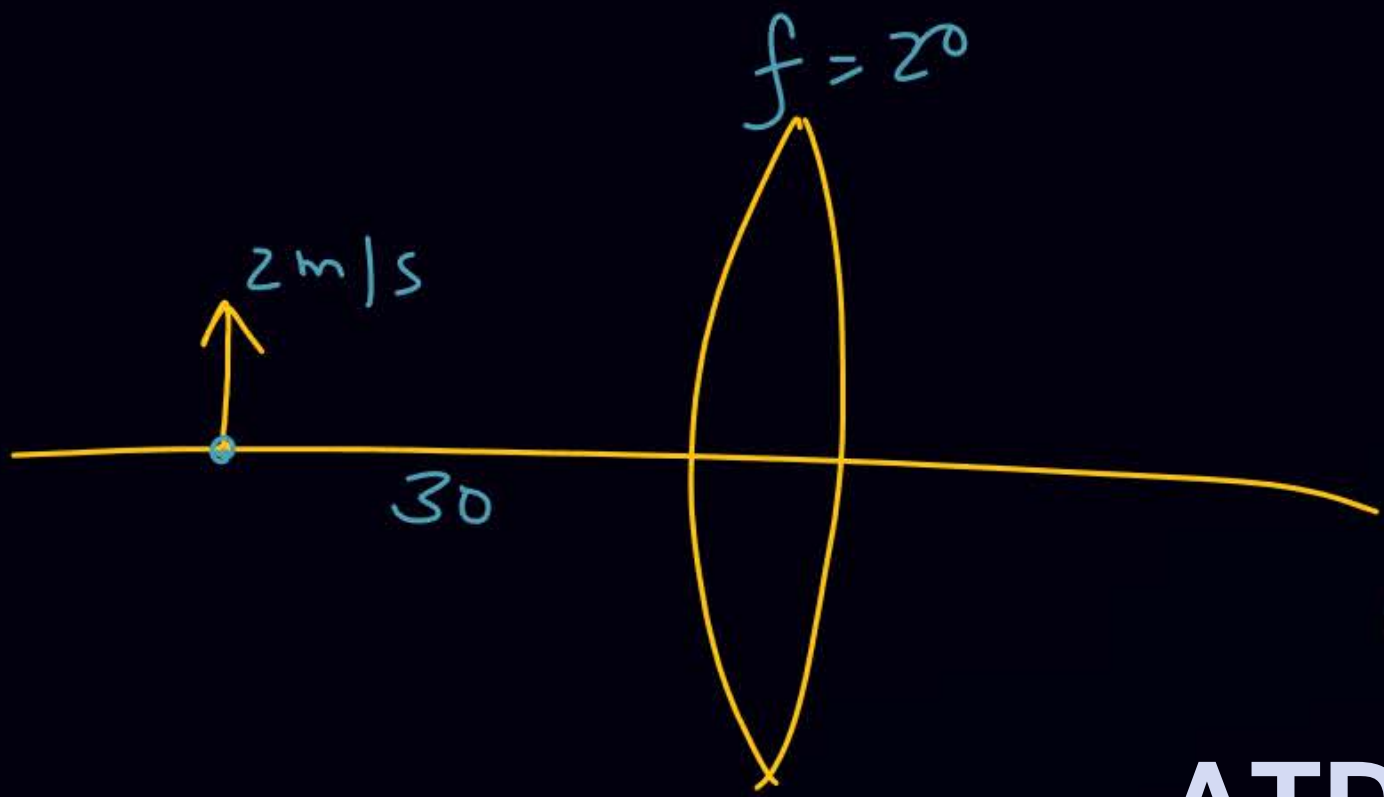
$$\vec{v}_{I/L} = m^2 \vec{v}_{O/L}$$

$$v_I = +4 \times 4$$

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



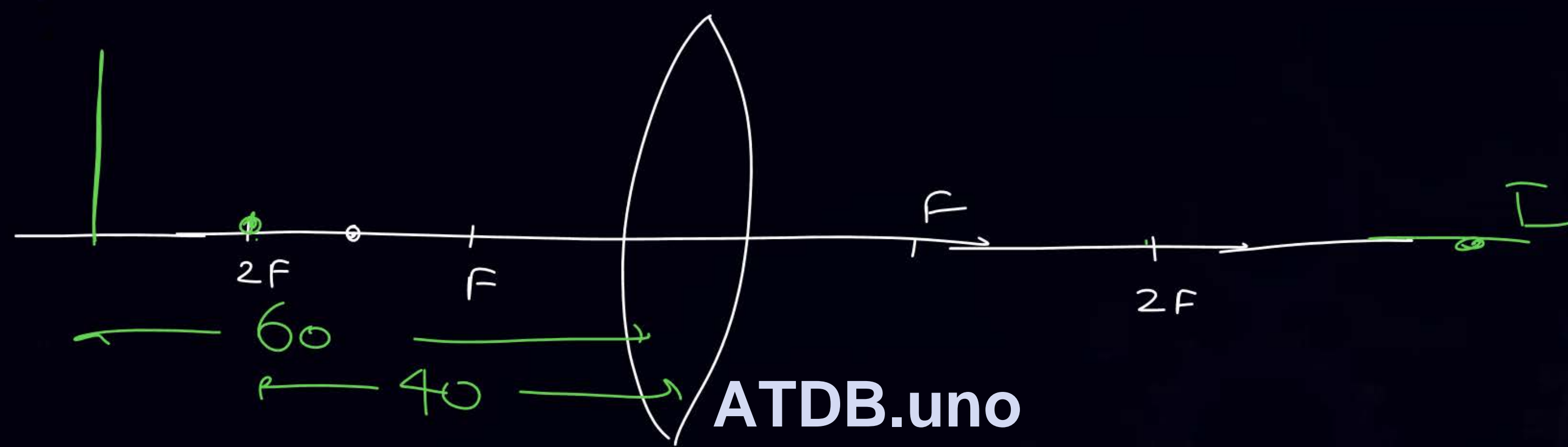
$$h_I = m h_o$$

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

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

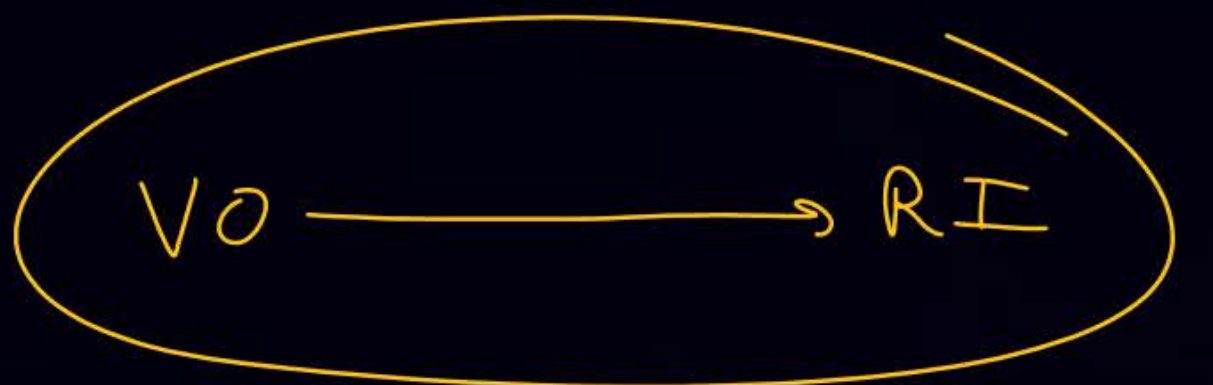
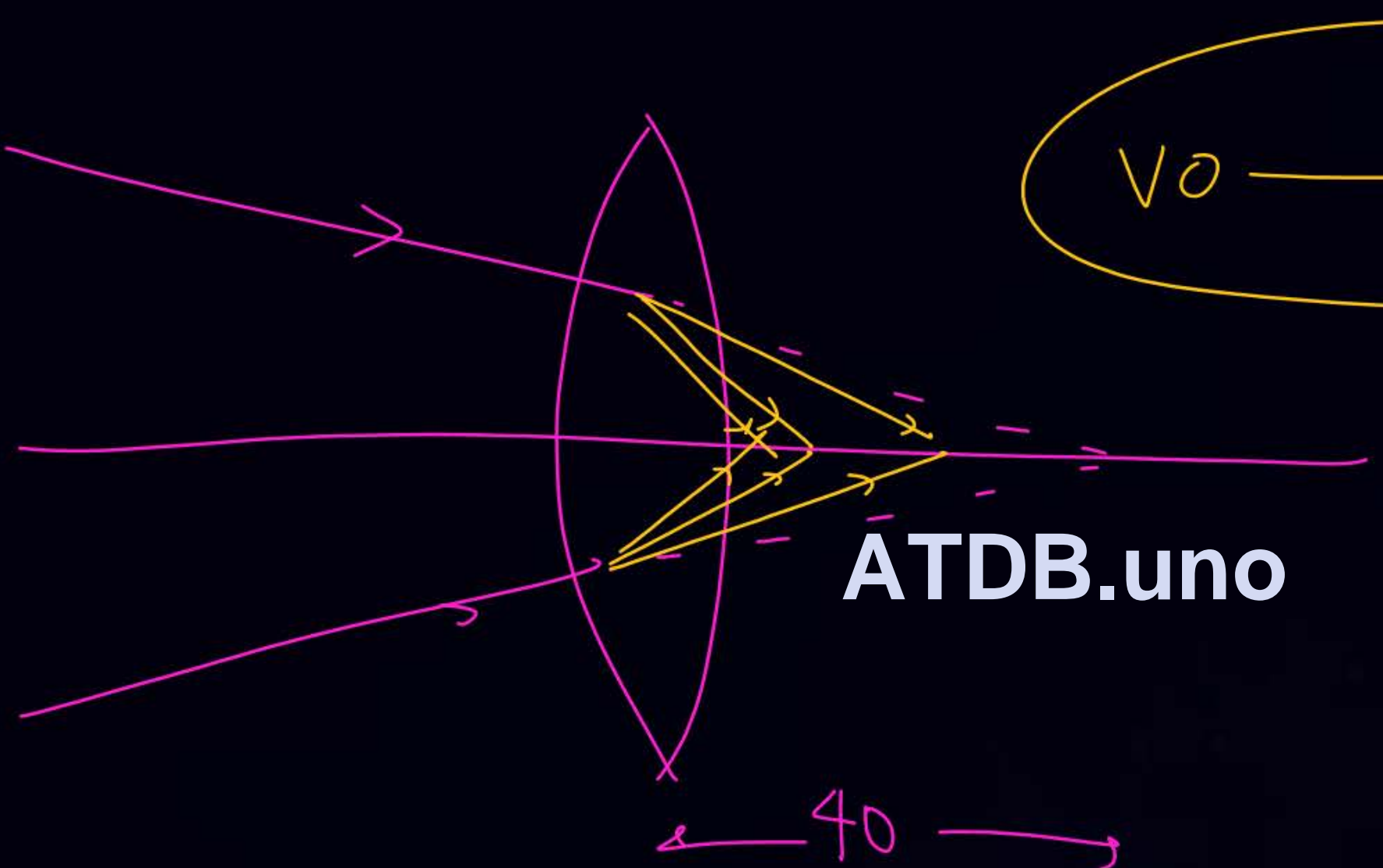
$$(v_I)_y = m (v_o)_y$$



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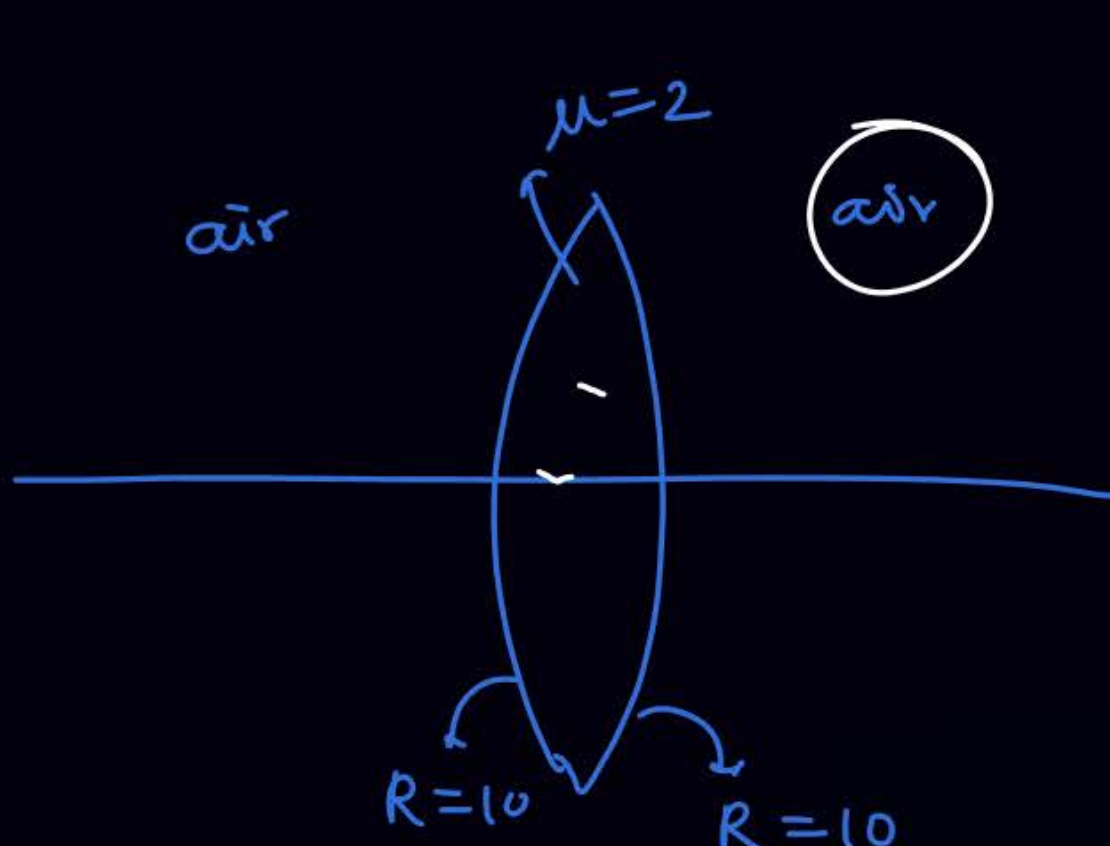
$f = 20$

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



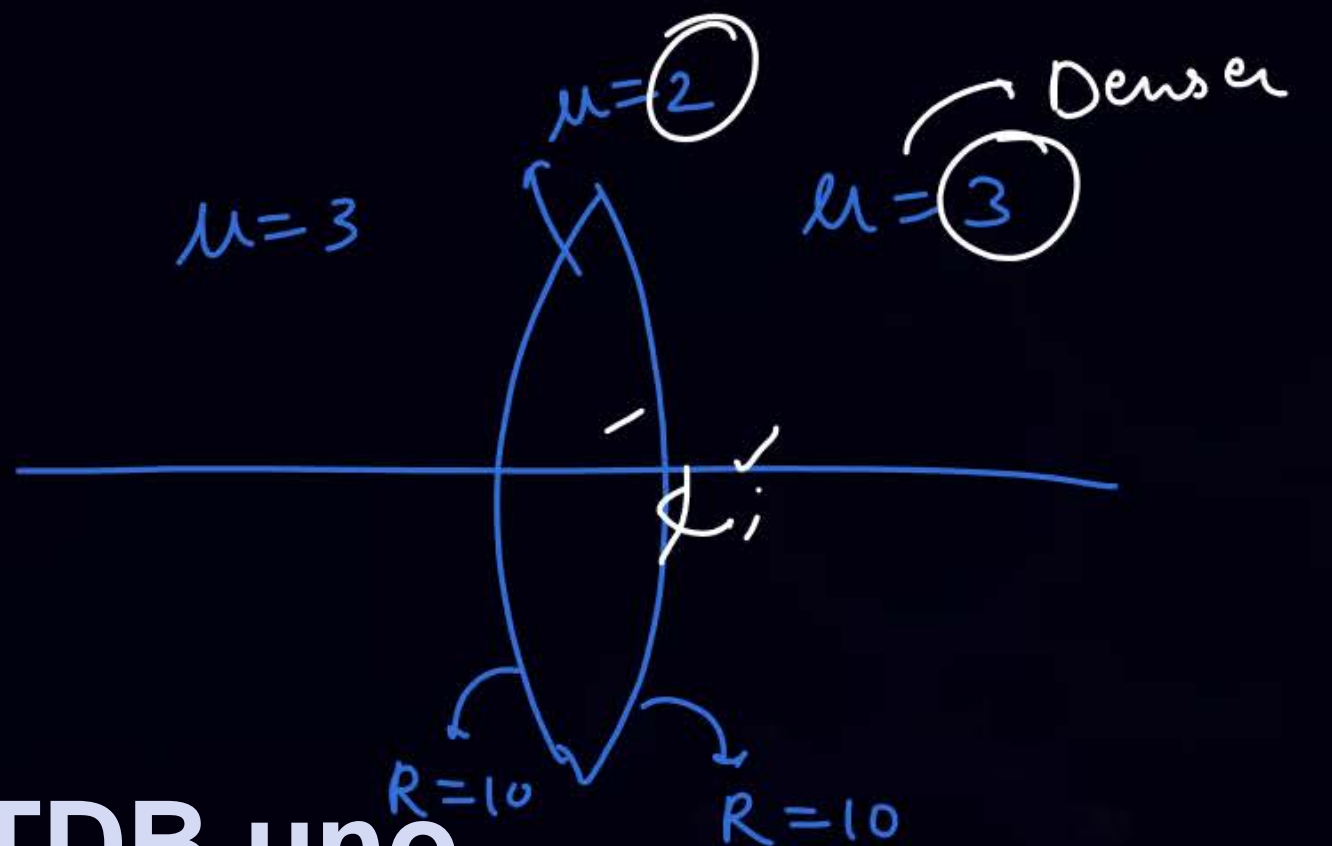
$$v = \frac{u f}{u - f} > 0$$

$$\begin{matrix} f > 0 \\ u > 0 \end{matrix}$$



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

$$f = 5$$



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

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

$$f = -15$$

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Home Work

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

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THANK YOU

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