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Radiant pressure

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

$$p = \left(\frac{h}{\lambda}\right)$$

↳ Momentum of photon

$$N = \left(\frac{E\lambda}{hc}\right)$$

↓

(Total no of photon incident per second.)

E = Total Energy of light beam incident per second i.e (Power)

$$E = N\left(\frac{hc}{\lambda}\right)$$

$\frac{hc}{\lambda}$ = Energy of one photon

N = Total no of Photon incident per second.

$$(E = P)$$

$$P = \frac{E}{t}$$

t → Per Second

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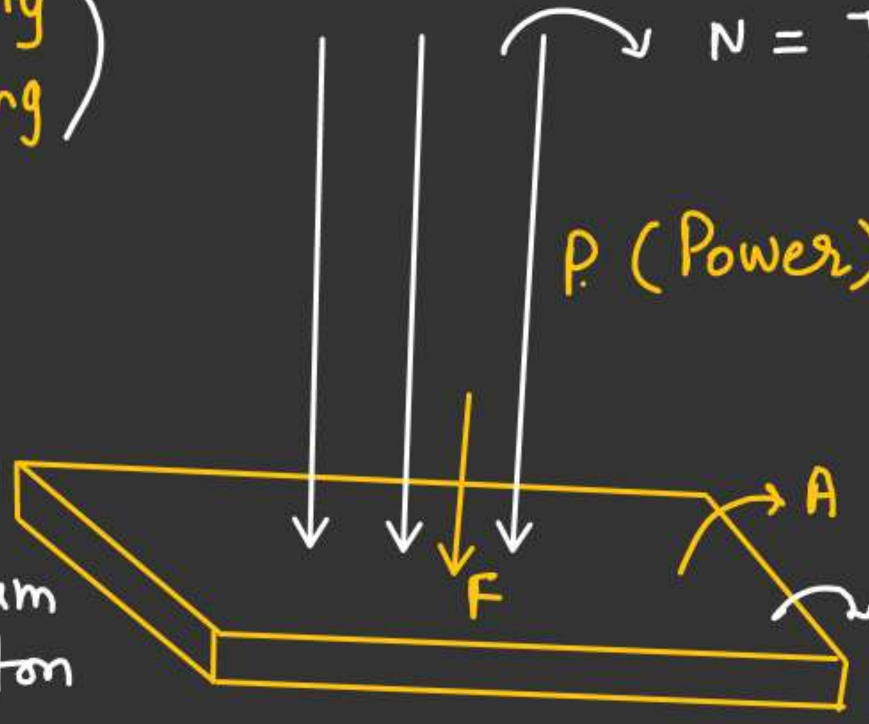
Case of Normal incidence

(Perfectly Absorbing)



N = Total no of photon incident per second.

Perfectly Absorbing.

Momentum of photon

$p = \frac{h}{\lambda}$

$N\left(\frac{hc}{\lambda}\right) = P$

$N = \left(\frac{P\lambda}{hc}\right)$

Total change in momentum per second $= N \cdot (p)$

$\Downarrow$

$\underline{F}$

$= \frac{P\lambda}{hc} \times \frac{h}{\lambda}$

$= \left(\frac{P}{c}\right)$ ✓

$$\boxed{F = \frac{P}{c}}$$

I = Intensity of light beam

$I = \frac{\text{Energy}}{(\text{time})(\text{Area})}$

↳ Always ⊥ to light beam. i.e perpendicular to wave propagation

$I = \frac{P}{A}$

$(P = IA)$

$$\boxed{F = \frac{IA}{c}}$$

$$\boxed{\text{Pressure} = \frac{F}{A} = \frac{I}{c}}$$

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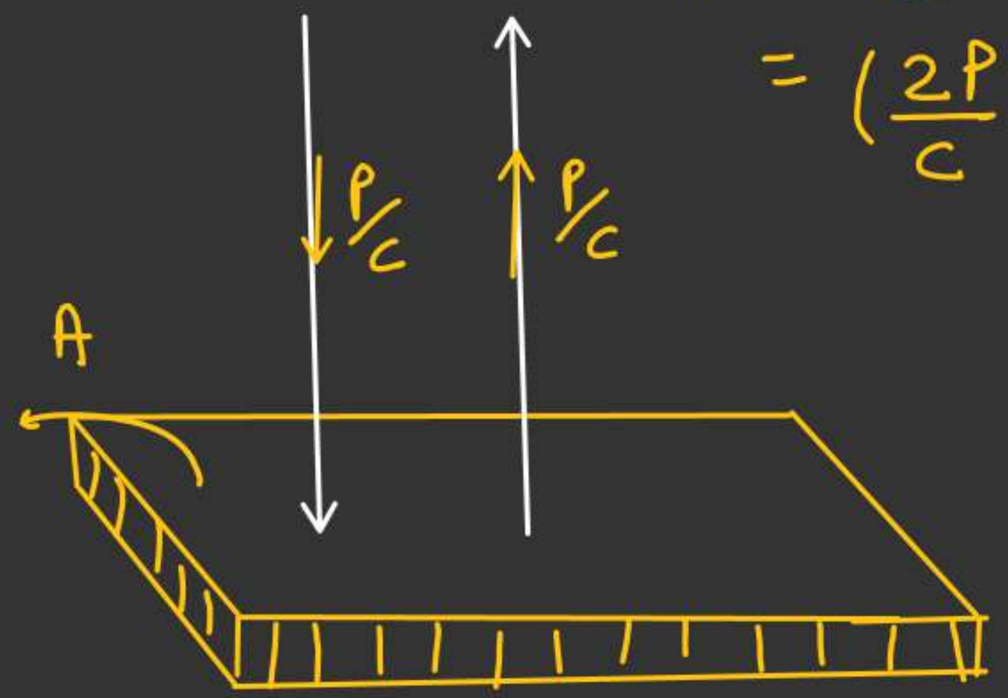
Perfectly Reflecting (Normal incidence)

$F = \Delta p =$ Change in Momentum per second.

$$\Delta p = P/c - (-P/c)$$
$$= \left(\frac{2P}{c}\right) \checkmark$$



$$F = \frac{2P}{c} = \frac{2IA}{c} \quad [P = IA]$$

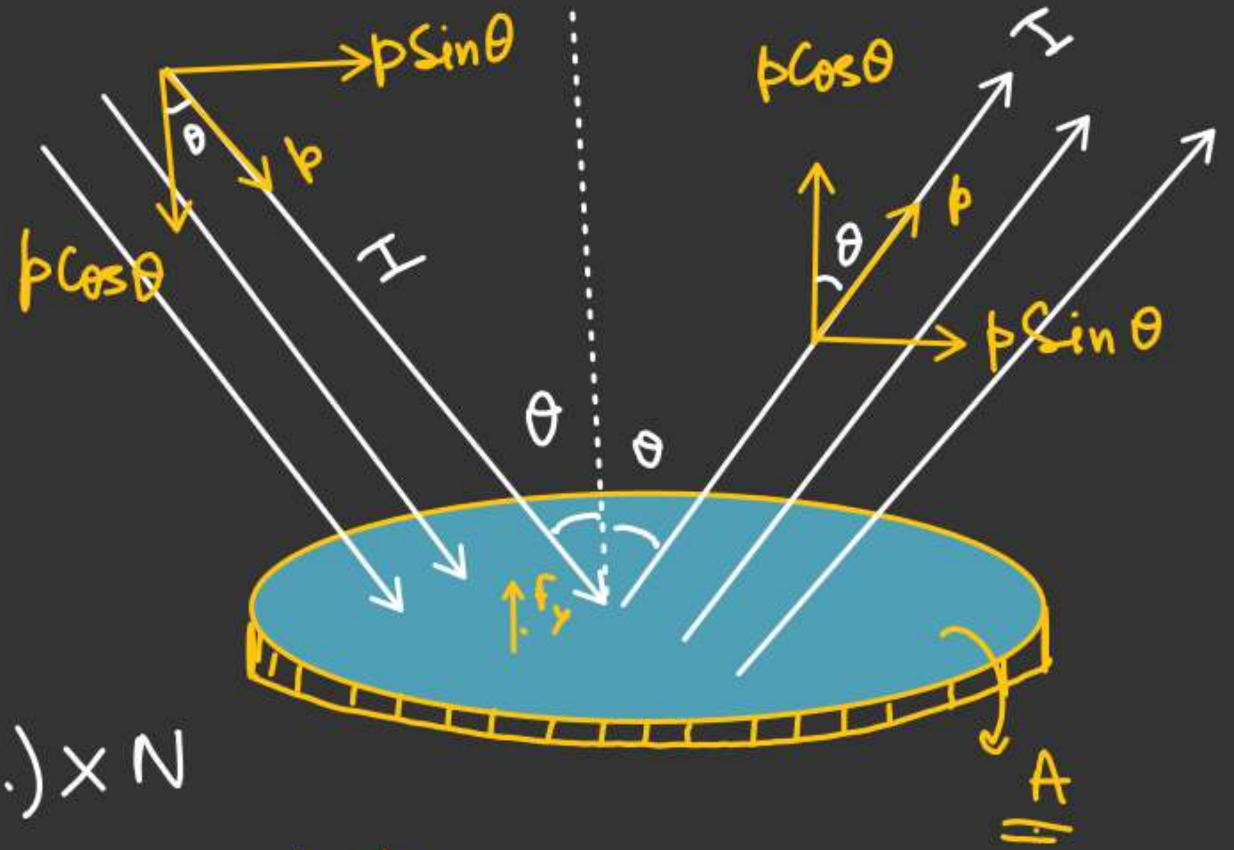
P → Power

$$\boxed{\text{Pressure} = F/A = \frac{2I}{c}}$$

N = No of photon incident per second.

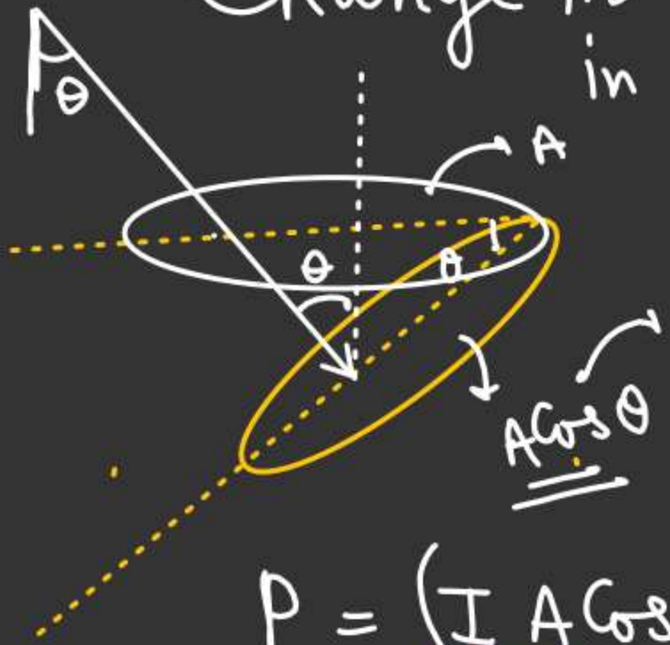
$$N\left(\frac{hc}{\lambda}\right) = P.$$

$$N = \left(\frac{P\lambda}{hc}\right)$$



Change in Momentum per second in y-direction $= \left(\frac{2h}{\lambda}\cos\theta.\right) \times N$

$$= \frac{2\cancel{h}}{\cancel{\lambda}}\cos\theta \times \frac{P\cancel{\lambda}}{\cancel{h}c}$$



⊥ to light beam.

$$\boxed{F_y. = \frac{2P\cos\theta}{c}}$$

$$P = (I A \cos\theta)$$

$$F_y = \frac{2IA\cos^2\theta}{c} \Rightarrow \boxed{\text{Pressure} = \frac{F_y}{A} = \frac{2I\cos^2\theta}{c}}$$

$$(\Delta p)_x = 0$$

$$(\Delta p)_y = p\cos\theta - (-p\cos\theta)$$

$$= 2p\cos\theta.$$

$$\downarrow$$

$$\left(P/c\right)$$

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If perfectly Absorbing.

$$\boxed{\text{Pressure} = \left(\frac{I}{c}\cos^2\theta\right)}$$

Special Case

$$dS = (2\pi R\sin\theta)\, R\,d\theta$$

$$= \underline{2\pi R^2 \sin\theta . d\theta .}$$

$$dF = \frac{2 I\, dA \cos\theta}{c}$$

$$P = I\,dA$$

P ↓ Power

dA ⇓ Effective area ⊥ to light beam

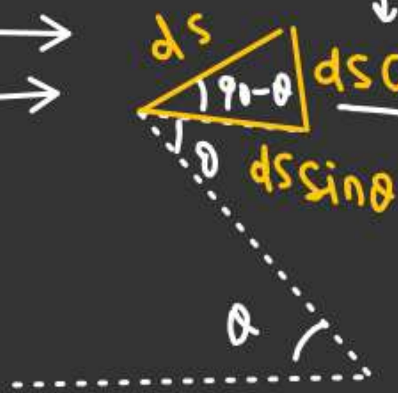
$$dF = \frac{2P\cos\theta}{c}$$

$$dF = \frac{2I}{c}\, ds \cos^2\theta$$

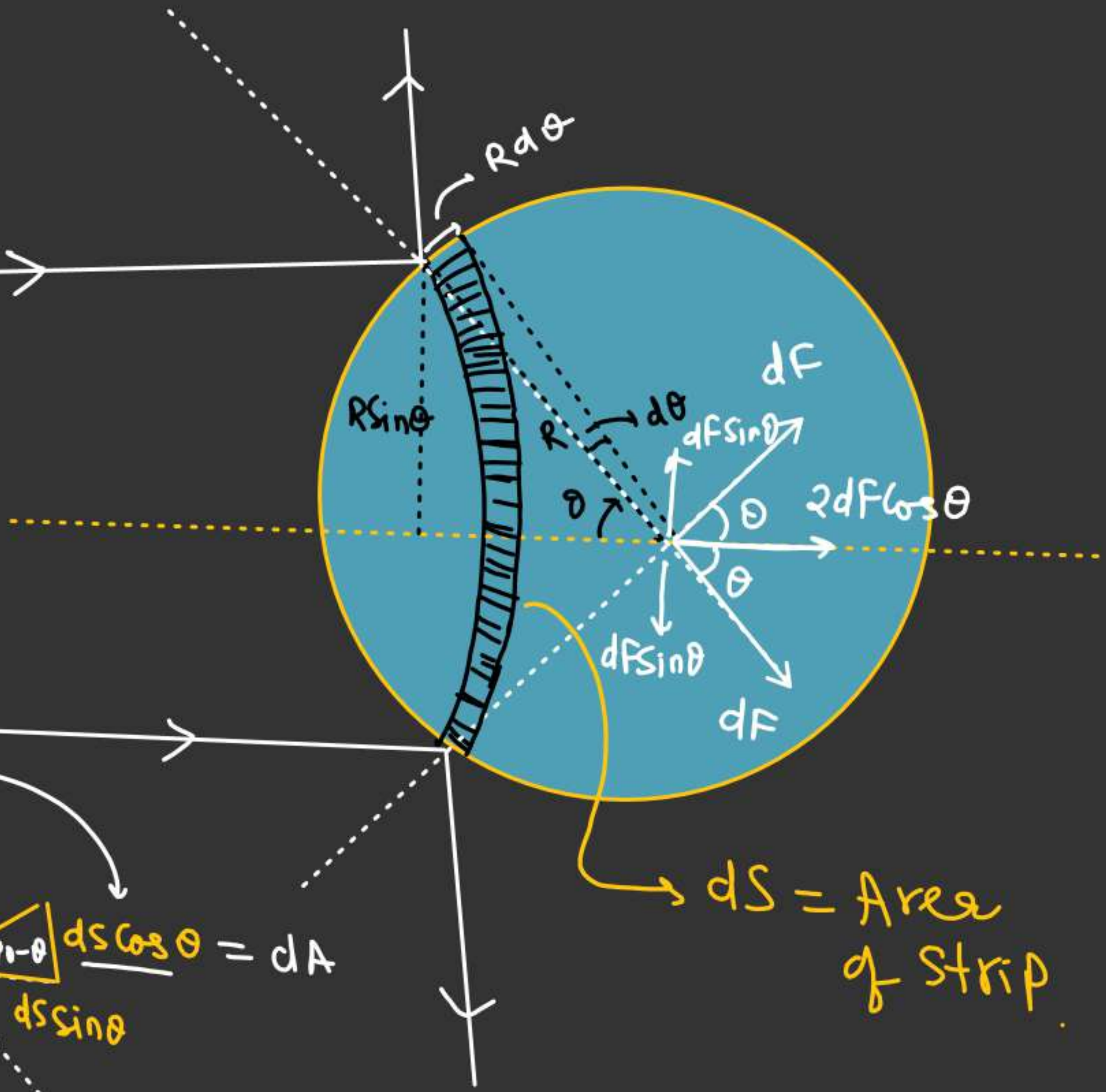
$$dF = \frac{2I}{c} \times 2\pi R^2 \sin\theta \cos^2\theta . d\theta$$

$$\left(dF = \frac{4\pi R^2 I}{c} \sin\theta . \cos^2\theta . d\theta \right)$$

light beam



$$ds\cos\theta = dA$$



dS = Area of strip

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$$\left(dF = \frac{4\pi R^2 I}{c}\sin\theta\cdot\cos^2\theta\cdot d\theta\right)$$

$$F_{net} = \int dF\cos\theta.$$

$$F_{net} = \frac{4\pi R^2 I}{c}\int_0^{\pi/2}\cos^3\theta\cdot\sin\theta.d\theta. \checkmark$$

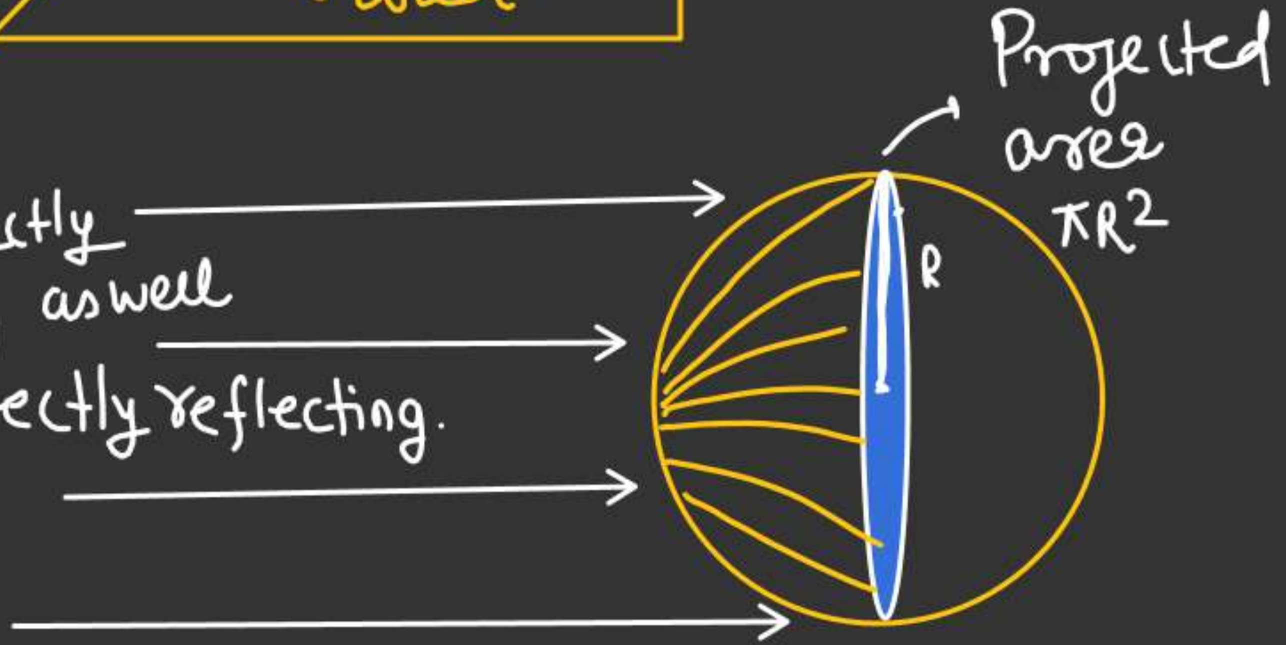
$$= -\frac{4\pi R^2 I}{c}\int_0^{\pi/2} t^3\cdot dt$$

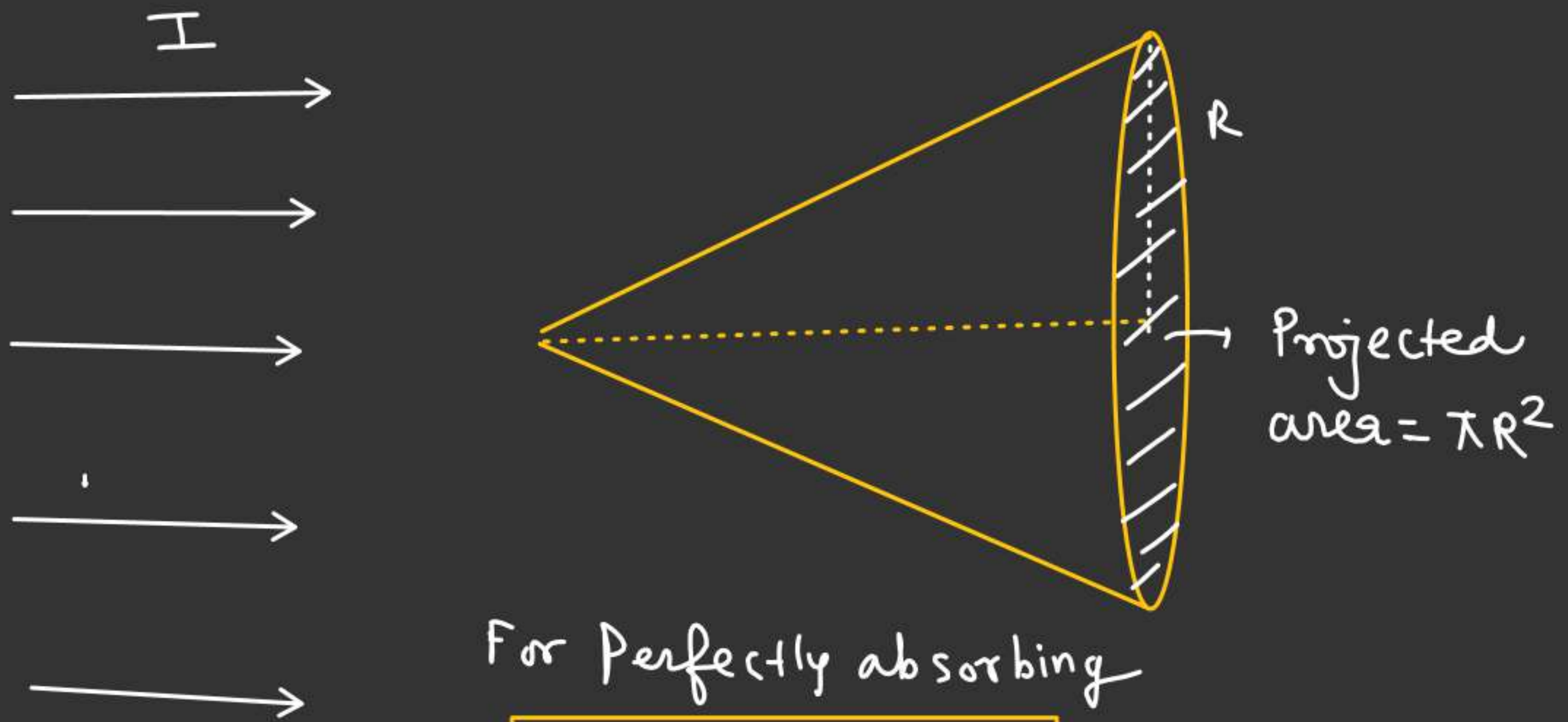
$$= -\frac{\cancel{4}\pi R^2 I}{c}\left[\frac{t^4}{\cancel{4}}\right]_0^{\pi/2} = -\frac{\pi R^2 I}{c}\left[\cos^4\theta\right]_0^{\pi/2} = \left(+\frac{\pi R^2 I}{c}\right)$$

$$\boxed{F_{net} = \pi R^2 \left(I/c\right)}$$

$\Downarrow$
Projected area.

True for both perfectly absorbing aswell as perfectly reflecting.





For Perfectly absorbing

$$\boxed{F = \frac{I(\pi R^2)}{c}}$$

For perfectly Reflecting

$$\boxed{F = \frac{2I(\pi R^2)}{c}}$$