Radiation Pressure

- No of photons per sec (N_p) $\longleftrightarrow$ Power (P)
- Photon flux (ϕ_p) $\longleftrightarrow$ Intensity (I)
- Photon density (ρ_p) $\longleftrightarrow$ Energy density (E)
- Momentum of a photon = h/λ
- Momentum of a light beam = U/c

$E = \frac{hc}{\lambda}$, $p = h/\lambda$

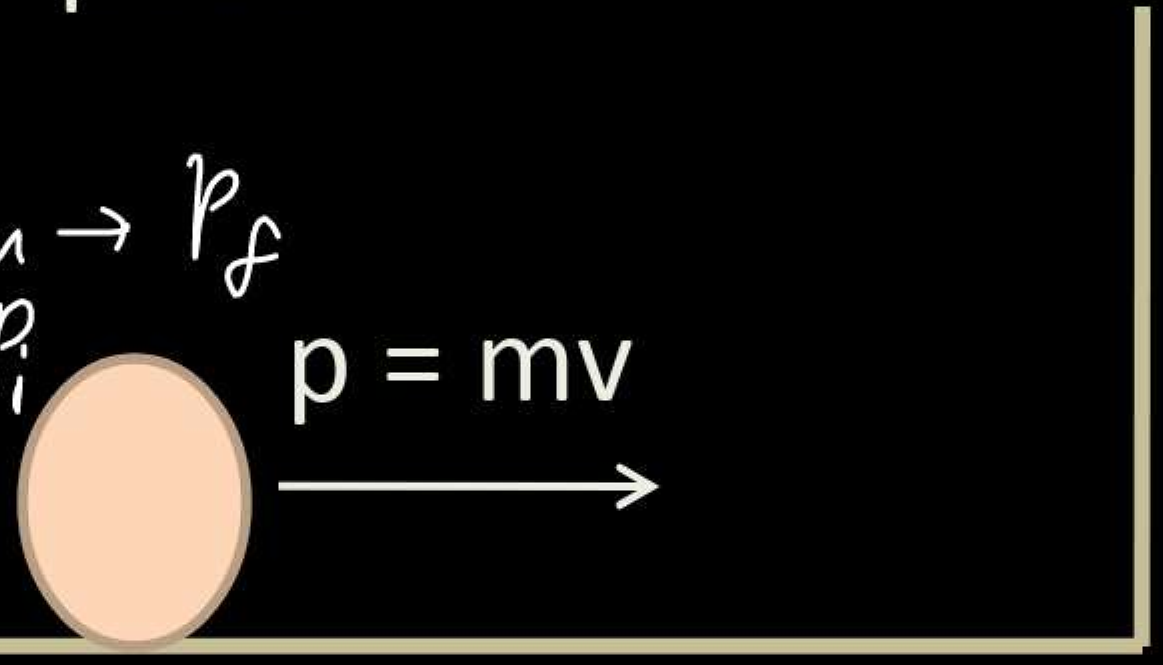
$p = E/c$

Force exerted during collision

Assuming elastic collision, what is the impulse exerted by the ball on the wall ?

final momentum → p_f

initial — " — → p_i



A). 2mv B). mv

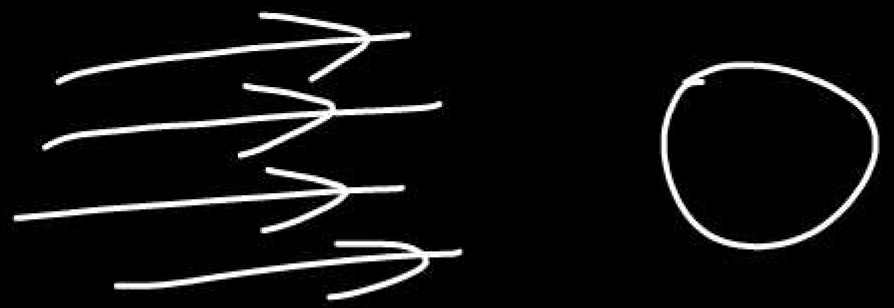
C). 0 D). mv/2

$$p_f = p_i - J$$

$$J = (p_i - p_f) = -(p_f - p_i) \Rightarrow$$

$$F(\Delta t) = \Delta p = 2mv$$

$$F = 2mv/\Delta t$$



Q 1). A pulse of light of duration 100 ns is absorbed completely by a small object initially @ rest. Power of the pulse is 30 mW & c = 3X10^{8} m/s. The final momentum of the object (in kg-m/s) is:

$P = 30 \times 10^{-3}$ J/s

$P_{light} = \frac{P \times 100 \times 10^{-9}}{3 \times 10^{8}}$

$= \frac{30 \times 10^{-3} \times 100 \times 10^{-9}}{3 \times 10^{8}}$

A). 0.3X10^{-17} B). 1.0X10^{-17} ✓

C). 3.0X10^{-17} D). 5.0X10^{-17}

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Q 2). Bulb 1 → Emits red light → 1800J in1hr. → $\frac{1800}{3600}$ J/s

Bulb 2 → Emits blue light → 20mJ in 1sec.

What can be said about their powers ?

P_1 0.5W

P_2 20×10^{-3} W

(A) $P_1 = P_2$

(B) $P_1 > P_2$ ✓

(C) $P_1 < P_2$

(D) Data not sufficient

No. of photons per sec (N_p)

P, power of source.

$\lambda \rightarrow$ wavelength.

$$E_p = \frac{hc}{\lambda}$$

$$N_p = \frac{P}{E_p} = \frac{P\lambda}{hc}$$

Photon flux

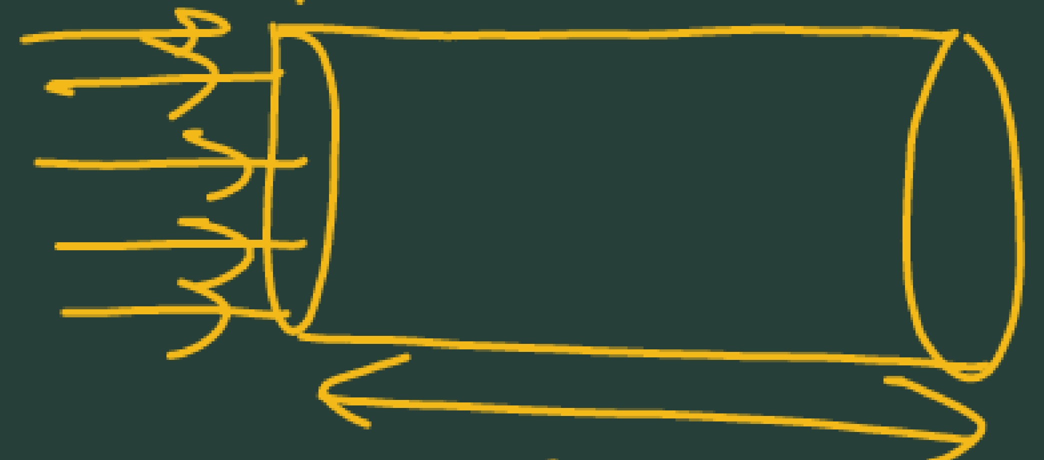
No. of photons per unit area (normal) per sec.

$$\phi_p = \frac{N_p}{A}$$

Photon density (ρ_p)

No. of photons per unit volume.

$$\rho_p = \frac{\phi_p}{c}$$



vol. of cylinder = $A\Delta t c$

$$\rho_p = \frac{\phi_p \times A \times \Delta t}{A c \Delta t} = \phi_p / c.$$

Power (Energy per sec.)

Intensity (Energy/Area-sec)

Energy density (Energy/vol.)

$$I = P/A$$

$$U = I/c$$

$\frac{P\lambda}{hc} \leftarrow N_p \equiv$ Power, P

$\left(\frac{N_p}{A}\right) \leftarrow \phi_p \equiv$ Intensity, I

$\left(\frac{\phi_p}{c}\right) \leftarrow \rho_p \equiv$ Energy density, U

Momentum of Photon

$$P_p = h/\lambda \quad , \quad E_p = \frac{hc}{\lambda}$$

$$P_p = E/c \quad \text{—} \ (1) \ \text{(for photon)}$$

Multiply both sides by N_p

$$N_p \cdot P_p = N_p \cdot E/c \quad \text{—} \ (2)$$

Total momentum per sec = $\dfrac{\text{total energy per sec}}{c}$

Momentum of Photon

$P_p = h/\lambda$, $E = \frac{hc}{\lambda}$.

$P_p = E/c$ — (1) (for photon)

Multiply both sides by N_p

$N_p \cdot P_p = N_p \cdot E/c$ — (2)

No. of photons per sec.

Momentum of light in $\Delta t = \frac{P}{c} \Delta t$

total momentum per sec (of light beam) = $\frac{\text{Total energy of light per sec}}{c}$

$N_p \cdot P_p \times \Delta t = N_p \cdot \frac{E \cdot \Delta t}{c} = \frac{P}{c}$

Momentum of light = $P \cdot \Delta t / c = U/c$