Physicsaholics

DPP – 1 (PEE)

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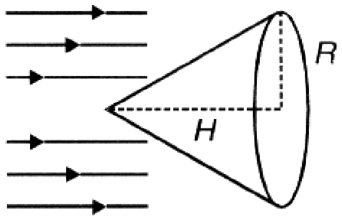
Q 1. We wish to observe a particle which is 2.5 Å in size. The minimum energy photon that can be used (to observe a particle maximum required wavelength is equal to size of object) -

(a) 5 KeV (b) 8 KeV (c) 10 KeV (d) 12 KeV

Q 2. The radiation force experienced by body exposed to radiation of intensity l assuming surface of body to be perfectly absorbing is



(a) $\frac{\pi I R^2}{c}$

(b) $\frac{2\pi I R^2}{c}$

(c) $\frac{4\pi I R^2}{c}$

(d) *None of these*

PASSAGE (Q3. to Q5)

The light sensitive compound on most photographic films is silver bromide {AgBr). A film is exposed when the light energy absorbed dissociates this molecule into its atoms, (the actual process is more complex, but the quantitative result does not differ with this assumption). The energy of dissociation of AgBr is 10^5 J/mol. Assume a photon that is just able to dissociate an AgBr molecule.

Q 3. Find photon energy in e V.

(a)1.04 eV (b) 1.14 eV (c) 1.72eV (d) 1.28 eV

Q 4. Find the frequency of the photon

(a) 2.71×10^{14} Hz

(b) 2.01×10^{14} Hz

(c) 2.5×10^{14} Hz

(d) 20.1×10^{14} Hz

Q 5. Will the radiation from a 50 kW, 100 MHz FM station expose the film?

(a) no (b) yes

(c) cannot say (d) Incomplete data

Q 6. A photon strikes a free electron at rest and is scattered straight backward. If the speed of electron after collision is αc, where α << 1 then-

(a) electron's kinetic energy is a fraction a of photon's intial energy

(b) electron's kinetic energy is fraction $\frac{1}{\alpha}$ of photon's initial energy

(c) electron's kinetic energy is a fraction a^2 of photon's intial energy

(d) electron's kinetic energy is a fraction $\frac{1}{\alpha^2}$ of photon's initial energy

Q 7. Two sources A and B have same power. The wavelength of radiation of A is λ_a and that of B is λ_b. The number of photons emitted per second by A and B are n_a and n_b respectively, then -

(a) $\lambda a > \lambda_b$

(b) if $\lambda a > \lambda_b$, $n_a < n_b$

(c) if $\lambda a < \lambda_b$, $n_a < n_b$

(d) if $\lambda a > \lambda_b$, $n_a = n_b$

Q 8. A monochromatic beam of light (λ = 4900 Å) incident normally upon a surface produces a pressure of 5 x 10^{-7} N/m^2 on it. Assuming that 25% of the light incident is reflected and the rest absorbed, find the number of photons falling per second on a unit area of thin surface.

(a) $6 \times 10^{20} m^{-2} s^{-1}$

(b) $2 \times 10^{20} m^{-2} s^{-1}$

(c) $3 \times 10^{20} m^{-2} s^{-1}$

(d) $9 \times 10^{20} m^{-2} s^{-1}$

Q 9. If solar constant is S and average wavelength of sun radiation is λ, Total number of photons in a spherical volume of radius R near ground is

(a) $\frac{4\pi S\lambda R^3}{3hc^2}$

(b) $\frac{2\pi S\lambda R^3}{3hc^2}$

(c) $\frac{4\pi S\lambda R^3}{hc^2}$

(d) None of these

Q 10. Two black objects of same diameter, a sphere and a disc, are placed in front of a uniform beam of light. The plane of disc is perpendicular to the light rays. The radiation force on them is

(a) Zero

(b) Bigger on disc

(c) Bigger on sphere

(d) Same on both

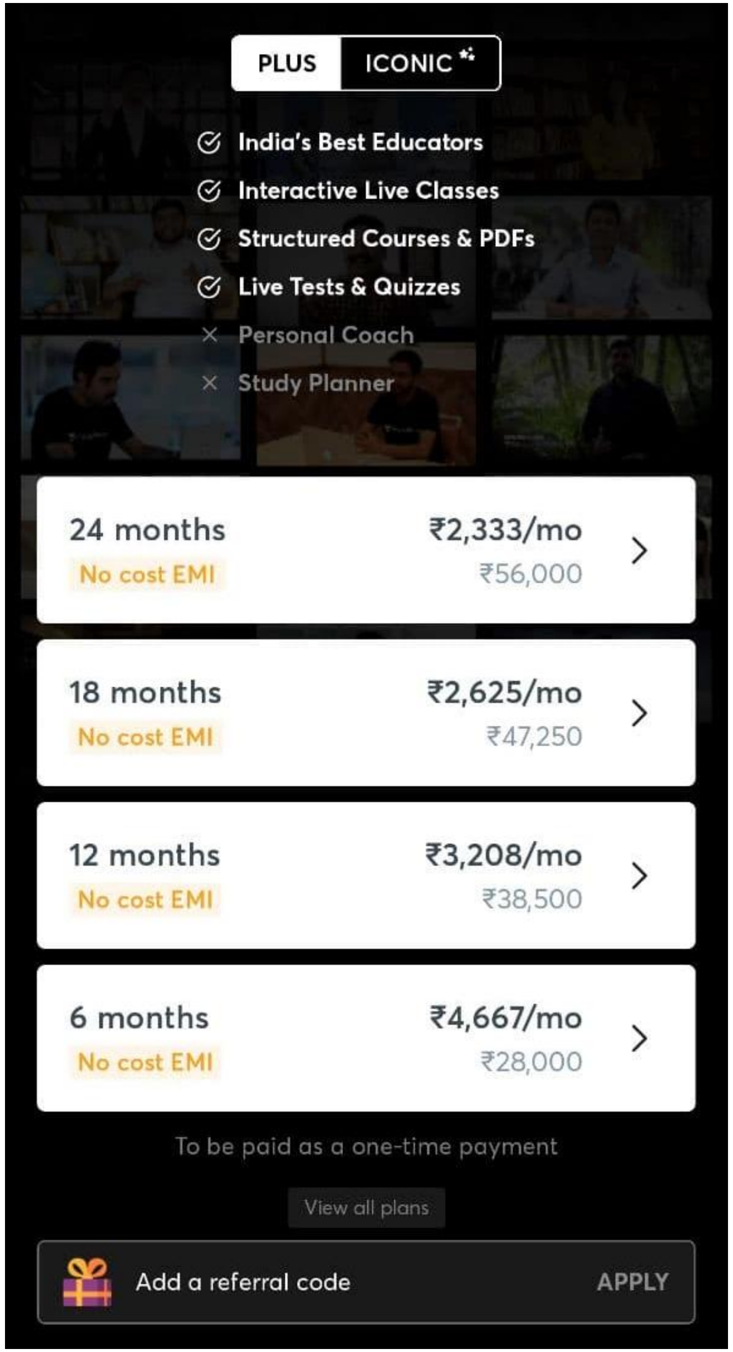
Q 11. A perfectly absorbing black solid sphere with constant density and radius R , hovers stationary above sun . This is because the gravitational attraction is balanced by radiation force due to sun light. Assume sun is far away that it is closely approximates a point source of light. The distance from the centre of sun at which sphere hovers is proportional to

(a) R (b) 1/R

(c) $\frac{1}{R^2}$ (d) R^0

Answer Key

Q.1 a	**Q.2 a**	**Q.3 a**	**Q.4 c**	**Q.5 a**
Q.6 a	**Q.7 c**	**Q.8 c**	**Q.9 a**	**Q.10 d**
Q.11 d				



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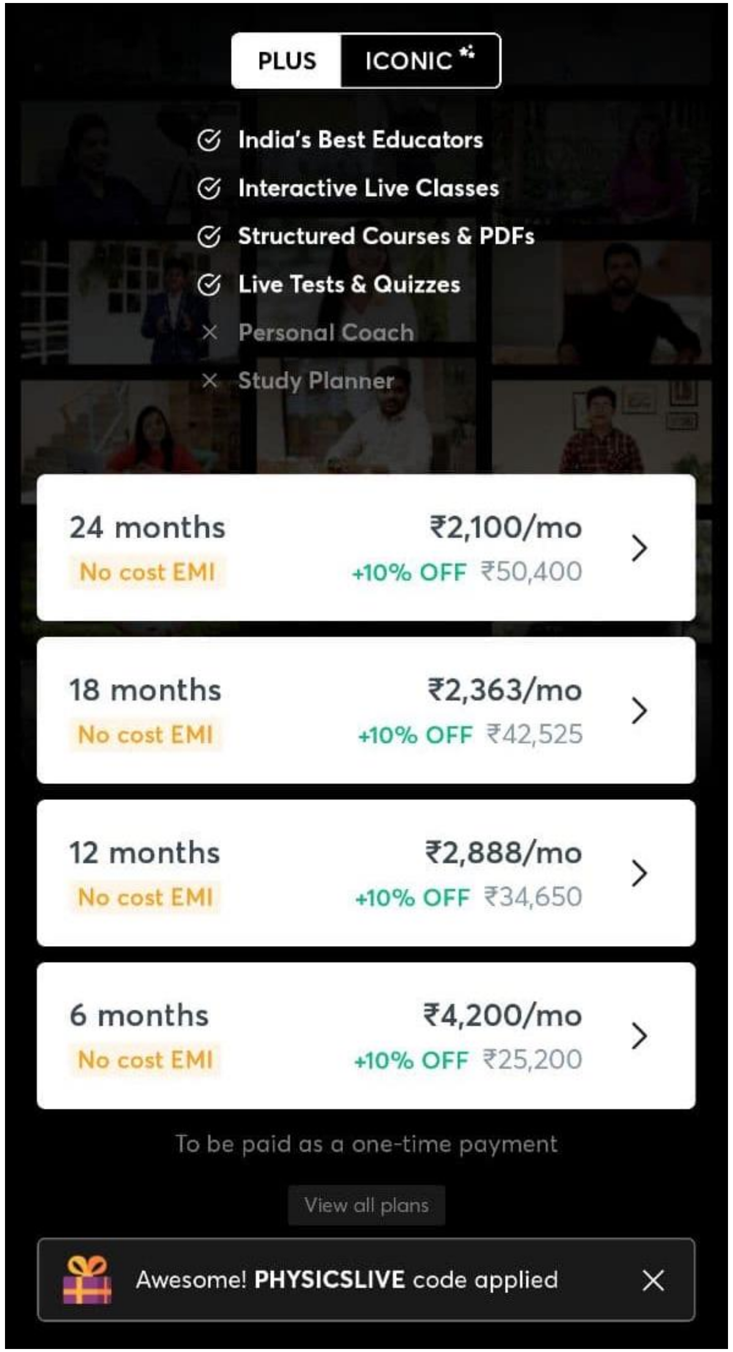

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Physics DPP - Solution

DPP- 1 Photon Theory & Radiation Pressure

By Physicsaholics Team

Q1) We wish to observe a particle which is 2.5 Å in size. The minimum energy photon that can be used (to observe a particle maximum required wavelength is equal to size of object) -

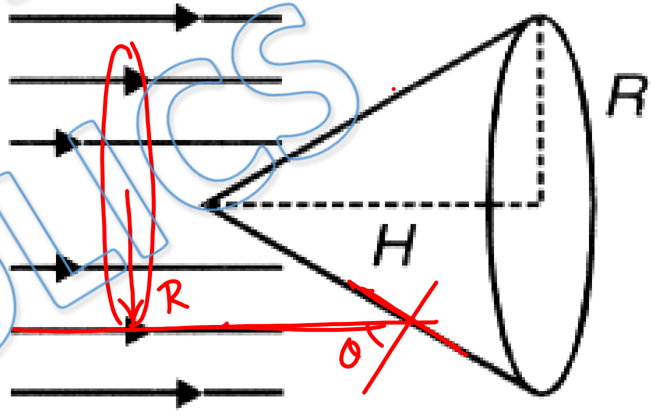
maximum

$$E = \frac{hc}{\lambda} = \frac{12400\ \text{Å eV}}{2.5\ \text{Å}}$$

$$= \frac{12.4}{2.5}\ \text{keV} \simeq 5\ \text{keV}$$

(a) 5 KeV (b) 8 KeV (c) 10 KeV (d) 12 KeV

Q2) The radiation force experienced by body exposed to radiation of intensity I assuming surface of body to be perfectly absorbing is



(a) $\frac{\pi I R^2}{c}$

(b) $\frac{2\pi I R^2}{c}$

(c) $\frac{4\pi I R^2}{c}$

(d) *None of these*

momentum gain per second by Cone = $\frac{\text{Energy incident per Second}}{c}$

$= \frac{I \pi R^2}{c}$ = Radiation force

PASSAGE (Q.3 to Q.5)

The light sensitive compound on most photographic films is silver bromide {AgBr). A film is exposed when the light energy absorbed dissociates this molecule into its atoms, (the actual process is more complex, but the quantitative result does not differ with this assumption). The energy of dissociation of AgBr is 10^5 J/mol. Assume a photon that is just able to dissociate an AgBr molecule.

$1 J = 1.6 \times 10^{-19} eV$

Q 3. Find photon energy in e V.

Energy per molecule

$$= \frac{10^5}{6 \times 10^{23} \times 1.6 \times 10^{-19}} eV$$

(a)1.04 eV (b) 1.14 eV (c) 1.72eV (d) 1.28 eV

$$= \frac{10}{6 \times 16} = \frac{10}{96} eV$$

Q4) Find the frequency of the photon

(a) 2.71×10^{14} Hz

(b) 2.01×10^{14} Hz

(c) 2.5×10^{14} Hz

(d) 20.1×10^{14} Hz

$E = h\nu$

$\nu = \frac{E}{h} = \frac{104 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$

$= \frac{1.6}{6.6} \times 10^{15}$

$= \frac{16}{6.6} \times 10^{14}$ Hz

$= 2.5 \times 10^{14}$ Hz

Q5) Will the radiation from a 50 kW, 100 MHz FM station expose the film?

100×10^6 Hz

$= 10^8$ Hz

(a) no

(b) yes

(c) cannot say

(d) Incomplete data

Q6) A photon strikes a free electron at rest and is scattered straight backward. If the speed of electron after collision is αc, where $\alpha << 1$ then-

(a) electron's kinetic energy is a fraction α of photon's intial energy

(b) electron's kinetic energy is fraction $\frac{1}{\alpha}$ of photon's initial energy

(c) electron's kinetic energy is a fraction α^2 of photon's intial energy

(d) electron's kinetic energy is a fraction $\frac{1}{\alpha^2}$ of photon's initial energy

Ans. a

$$\underset{\lambda}{\leadsto} + e^{-} \longrightarrow \underset{\lambda'}{\leftsquigarrow} \quad \overset{m}{e^{-}} \rightarrow v = \alpha c$$

by Conservation of momentum →

$$\frac{h}{\lambda} = m\alpha c - \frac{h}{\lambda'}$$

$$\frac{1}{\lambda} + \frac{1}{\lambda'} = \frac{m\alpha c}{h} \quad \text{---(i)}$$

by Conservation of energy

$$\frac{hc}{\lambda} = \frac{1}{2} m\alpha^2 c^2 + \frac{hc}{\lambda'}$$

$$\frac{1}{\lambda} - \frac{1}{\lambda'} = \frac{m\alpha^2 c}{2h} \quad \text{---(ii)}$$

$$\frac{2}{\lambda} = \frac{m\alpha c}{h}\left(1 + \frac{\alpha}{2}\right) = \frac{m\alpha c}{h} \quad \text{Since } \alpha << 1 \quad \text{---(iii)}$$

$$\frac{\text{KE of electron}}{\text{energy of incident photon}} = \frac{\frac{1}{2} m\alpha^2 c^2 \lambda}{hc} = \left(\frac{m\alpha c\lambda}{2h}\right)\alpha = \alpha$$

Q7) Two sources A and B have same power. The wavelength of radiation of A is λ_a and that of B is λ_b. The number of photons emitted per second by A and B are n_a and n_b respectively, then -

(a) $\lambda a > \lambda_b$

(b) if $\lambda a > \lambda_b$, $n_a < n_b$

(c) if $\lambda a < \lambda_b$, $n_a < n_b$

(d) if $\lambda a > \lambda_b$, $n_a = n_b$

$P = n\left(\frac{hc}{\lambda}\right)$ → no of photons emitted per second

$P = \frac{n_a hc}{\lambda_a} = n_b\left(\frac{hc}{\lambda_b}\right)$

$\frac{n_a}{\lambda_a} = \frac{n_b}{\lambda_b}$

$\Rightarrow \frac{n}{\lambda} = \text{Const}$

$\Rightarrow n \propto \lambda$

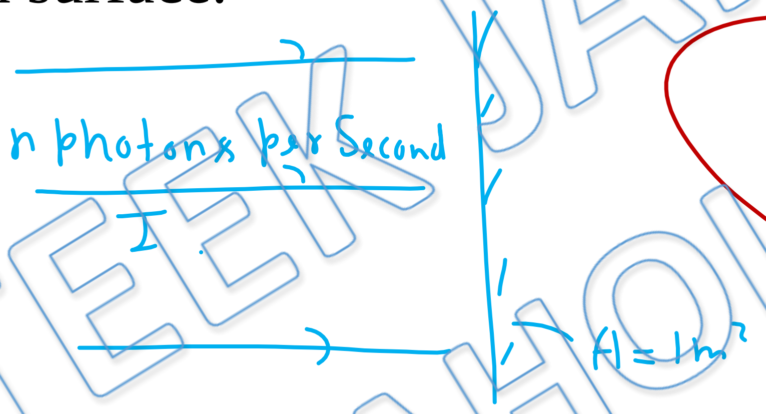
Q8) A monochromatic beam of light (λ = 4900 Å) incident normally upon a surface produces a pressure of 5 x 10^{-7} N/m^2 on it. Assuming that 25% of the light incident is reflected and the rest absorbed, find the number of photons falling per second on a unit area of thin surface.

(a) $6 \times 10^{20} m^{-2} s^{-1}$

(b) $2 \times 10^{20} m^{-2} s^{-1}$

~~(c)~~ $3 \times 10^{20} m^{-2} s^{-1}$

(d) $9 \times 10^{20} m^{-2} s^{-1}$



$n\left(\frac{h}{\lambda}\right) \to$ momentum incident/Sec

Momentum reflected/Sec $= -\frac{nh}{4\lambda}$

$F = |\text{change in momentum/Sec}| = \left|\left(\frac{-nh}{4\lambda}\right) - \left(\frac{nh}{\lambda}\right)\right| = \frac{5}{4}\frac{nh}{\lambda}$

$\frac{5}{4}\frac{nh}{\lambda} = P$

$n = \frac{4\lambda P}{5h}$

$= \frac{4 \times 4900 \times 10^{-10} \times 5 \times 10^{-7}}{5 \times 6.6 \times 10^{-34}}$

$= \frac{49000}{165} \times 10^{17}$

$= \frac{49}{165} \times 10^{20}$

$\simeq 3 \times 10^{20}$

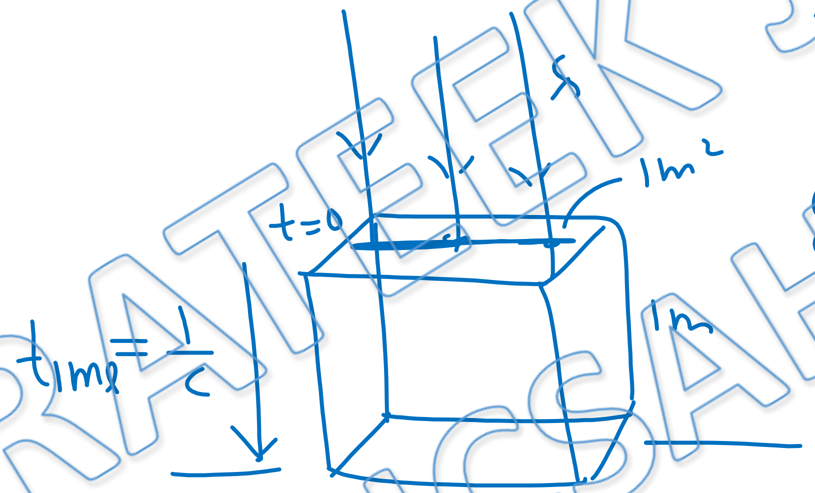
Q9) If solar constant is S and average wavelength of sun radiation is λ , Total number of photons in a spherical volume of radius R near ground is

(a) $\dfrac{4\pi S\lambda R^3}{3hc^2}$

(b) $\dfrac{2\pi S\lambda R^3}{3hc^2}$

(c) $\dfrac{4\pi S\lambda R^3}{hc^2}$

(d) None of these



time taken by light to fill the ~~table~~ Cube $= 1/c$

Energy stored in cube

$= I \times 1\,m^2 \times \frac{1}{c}$

no of photons in Cube

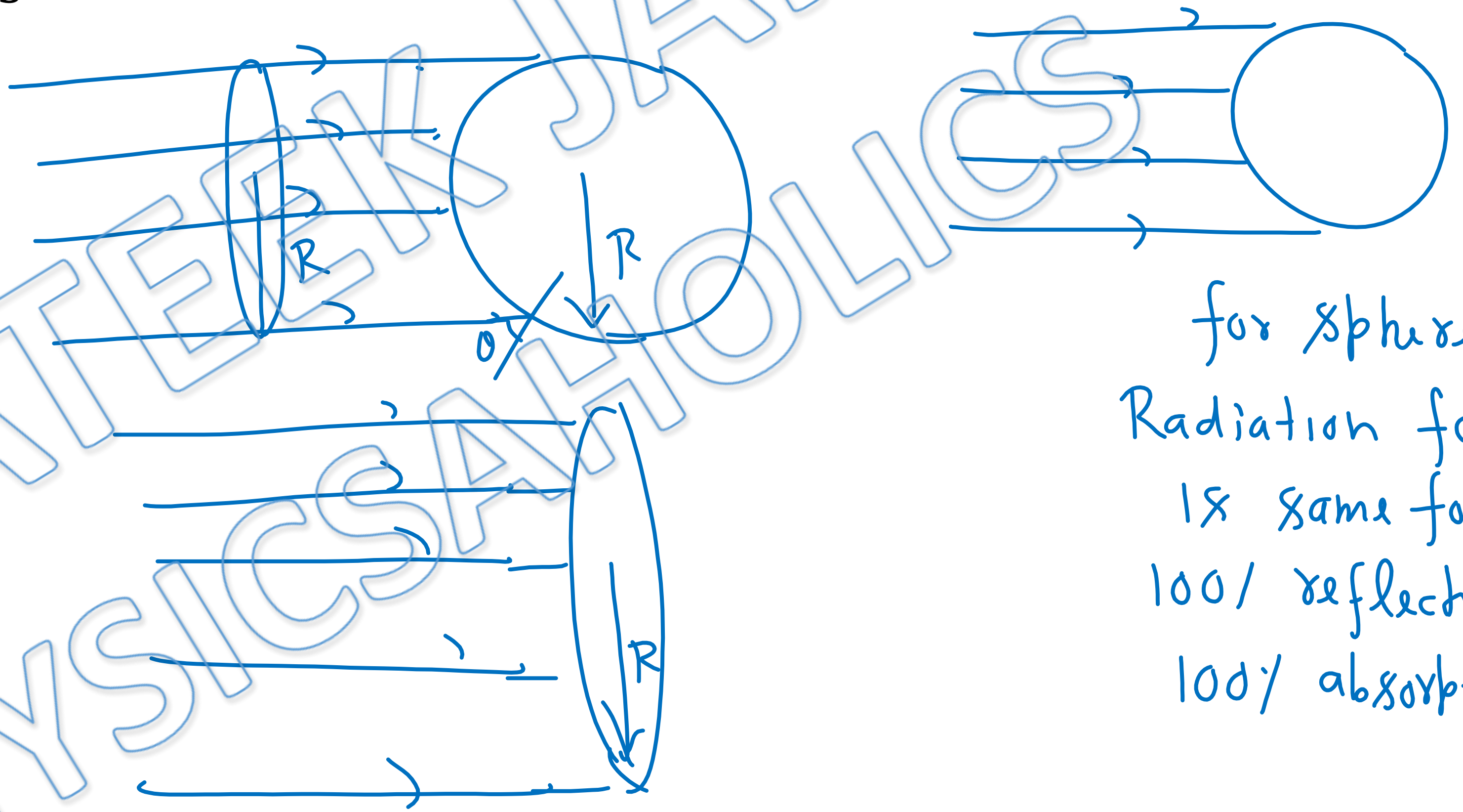
$=$ " " " per m^3

$= \dfrac{I}{c\,(hc/\lambda)} = \dfrac{I\lambda}{hc^2} = \dfrac{S\lambda}{hc^2}.$

no of photons in sphere

$= \frac{4}{3}\pi R^3 \times \dfrac{S\lambda}{hc^2}$

Q10) Two black objects of same diameter, a sphere and a disc, are placed in front of a uniform beam of light. The plane of disc is perpendicular to the light rays. The radiation force on them is



(a) Zero

(b) Bigger on disc

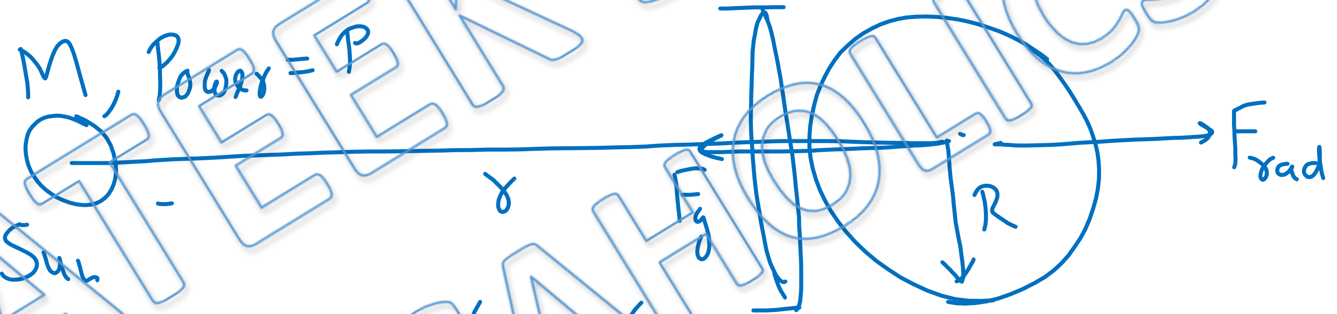
(c) Bigger on sphere

(d) Same on both ✓

for sphere
Radiation force
is same for
100% reflection &
100% absorption

Q11) A perfectly absorbing black solid sphere with constant density and radius R , hovers stationary above sun . This is because the gravitational attraction is balanced by radiation force due to sun light. Assume sun is far away that it is closely approximates a point source of light. The distance from the centre of sun at which sphere hovers is proportional to

Intensity on body $= \frac{P}{4\pi r^2}$



(a) R

(b) 1/R

(c) $\frac{1}{R^2}$

(d) R^0 ✓

$$\frac{GM\rho\frac{4}{3}\pi R^3}{r^2} = \left(\frac{P}{4\pi r^2}\right)\frac{\pi R^2}{c}$$

R = Constant

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Chalo Niklo