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IIT JEE PHYSICS PAPER SOLUTION 27 JUNE 2022 MORNING SHIFT

QUESTIONS BASED ON RAIN MAN PROBLEM,TWO BLOCK FRICTION,GAUSS LAW,BOHR MODEL & YDSE ARE TRICKY

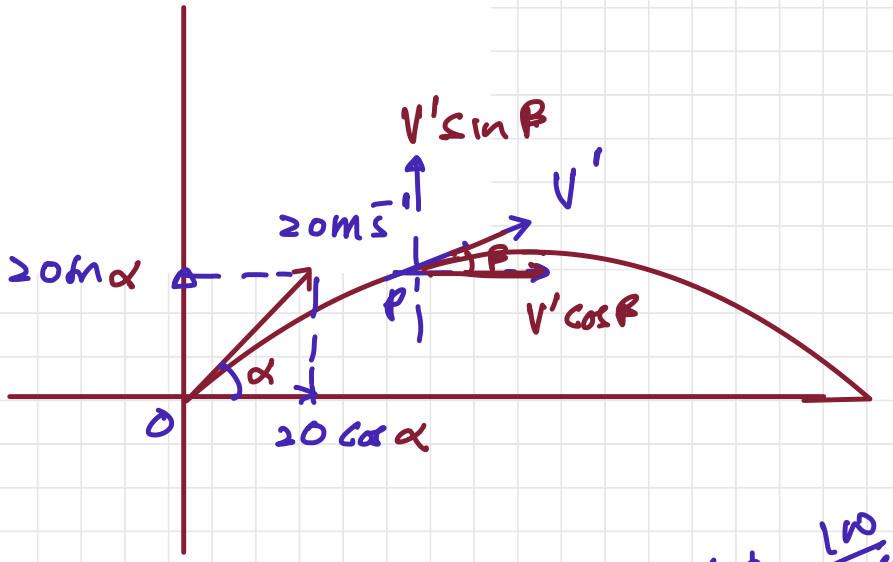
Q1: A projectile is launched at an angle $'\alpha'$ with the horizontal with a velocity 20 ms^{-1}. After 10s, its inclination with horizontal is $'\beta'$. The value of $\tan\beta$ will be: (g = 10 ms^{-2}).

(A) $\tan\alpha + 5\sec\alpha$

(B) $\tan\alpha - 5\sec\alpha$

(C) $2\tan\alpha - 5\sec\alpha$

(D) $2\tan\alpha + 5\sec\alpha$



Horizontal motion between O & P.

$V_x = u_x + a_x t$

$V'\cos\beta = 20\cos\alpha$ —①

Consider vertical motion between point O & P

$V_y = u_y + a_y t$

$V'\sin\beta = 20\sin\alpha - g(10)$ —②

EQUATION② / EQUATION① $\Rightarrow \frac{V'\sin\beta}{V'\cos\beta} = \frac{20\sin\alpha - g(10)}{20\cos\alpha}$

$\tan\beta = \frac{20\sin\alpha}{20\cos\alpha} - \frac{100}{20\cos\alpha}$

$= \tan\alpha - 5\sec\alpha$

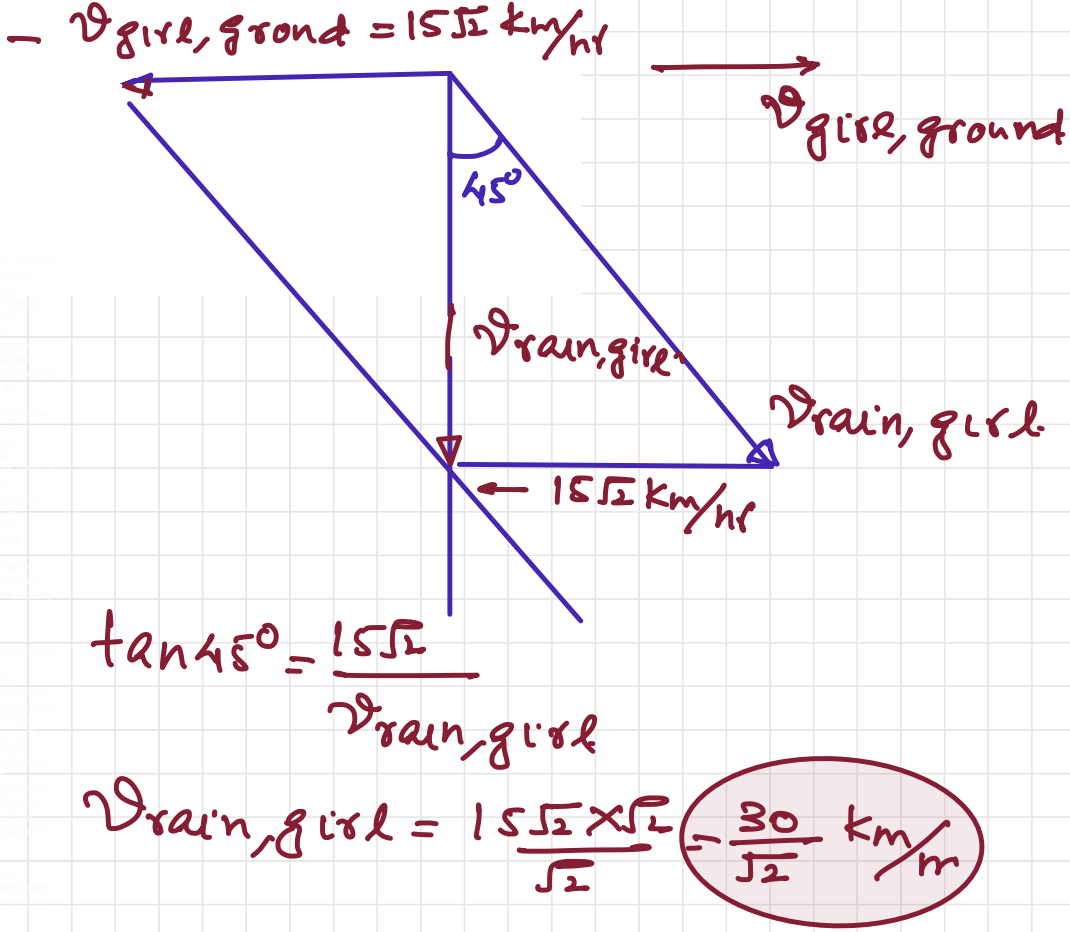
Q2: A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2}\,kmh^{-1}$,the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is:

(A) 30 kmh^{-1}

(B) $\frac{25}{\sqrt{2}}kmh^{-1}$

(C) ✓ $\frac{30}{\sqrt{2}}kmh^{-1}$

(D) $25\,kmh^{-1}$



Q3: A silver wire has a mass (0.6 ± 0.006)g, (0.5 ± 0.005)mm and length $(4 \pm 0.04)\,cm$. The maximum percentage error in the measurement of its density will be

(A) 4%

(B) 3%

(C) 6%

(D) 7%

ANS-3

$$M = \pi r^2 (l) \rho$$

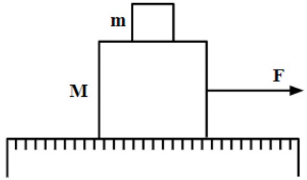
$$\rho = \frac{m}{\pi r^2 (l)}$$

$$\frac{\Delta \rho}{\rho} \times 100\% = \left(\frac{\Delta m}{m}\right) \times 100\% + 2\left(\frac{\Delta r}{r}\right) \times 100\% + \left(\frac{\Delta l}{l}\right) \times 100\%$$

$$= \frac{.006}{.6} \times 100 + 2\left(\frac{.005}{.05}\right) \times 100 + \left(\frac{.04}{4}\right) \times 100$$

$$= 1 + 2 + 1 = 4\%$$

Q4: A system of two blocks of masses in m = 2 kg and M = 8 kg is placed on a smooth table as shown in figure. The coefficient ident of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be:



(A) 9.8 N

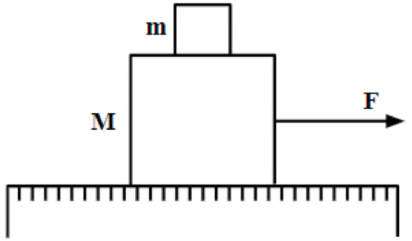
(B) 39.2 N

(C) 49 N ✓

(D) 78.4 N

Maximum acceleration of upper block = $\mu g = 0.5 \times 9.8 = 4.9$

$F_{max} = (2+8) \times 4.9 = 49N$



Let both the block move together

$a = \frac{F}{m+M}$

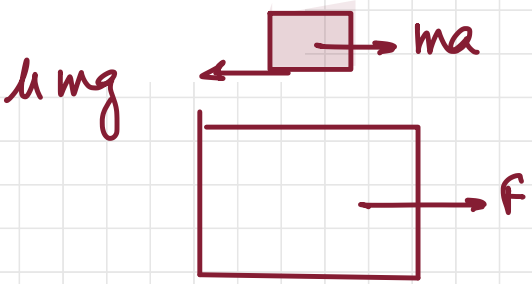
For both the block move together

$\mu mg > ma$

$(0.5)(9.8) \geq \frac{F}{(m+M)}$

$F \leq (0.5)(9.8)(10)$

$F \leq 49\,N$



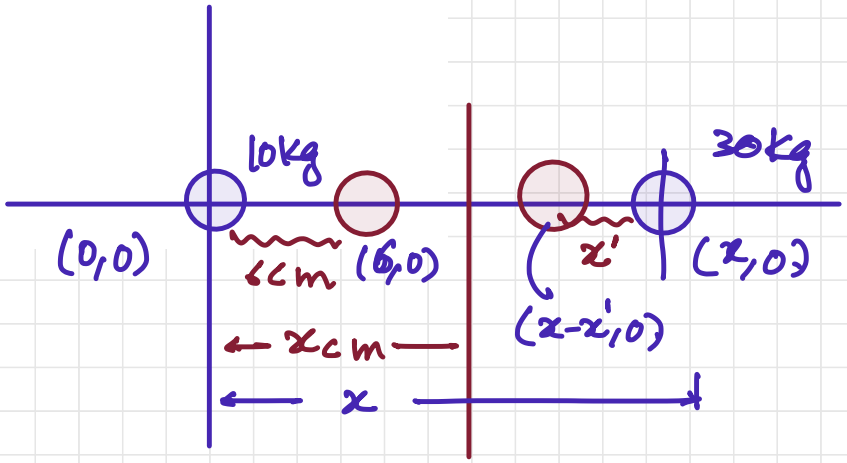
Q5: Two blocks of masses 10 kg and 30 kg are placed on the same straight line with coordinates (0, 0) on and (x, 0) cm respectively. The block of 10 kg is moved on the same line through as distance of 6 cm towards the other block. The distance through which Me block of 30 kg must be moved to keep the position of centre of mass of the system unchanged is :

(A) 4 cm towards the 10 kg block

(B) 2 cm away from the 10 kg block

(C) ✓ 2 cm towards the 10 kg block

(D) 4 cm away from the 10 kg block



CASE-I

$$x_{cm} = \frac{10(0)+30(x)}{30+10}$$

CASE-II

$$x'_{cm} = \frac{10(6)+30(x-x')}{(30+10)}$$

CASE-I = CASE II

$$\frac{30x}{40} = \frac{60+30(x-x')}{40}$$

$$30x = 60 + 30x - 30x'$$

$$60 = 30x' \Rightarrow x' = 2\,cm$$

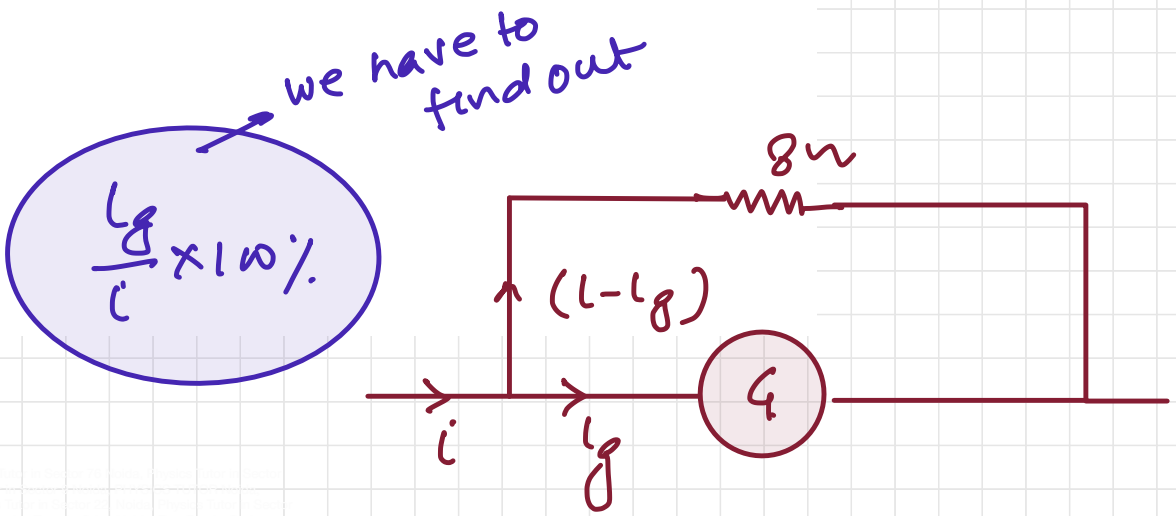
Q6: A 72Ω galvanometer is shunted by a resistance of 8 Ω. The percentage of the total current which passes through the galvanometer is:

(A) 0.1%

(B) 10%

(C) 25%

(D) 0.25%



$$f_g(G) = (i - I_g)\,8$$

$$f_g(72) = (i - I_g)\,8$$

$$I_g(72) = 8i - 8I_g$$

$$80 I_g = 8i \Rightarrow \frac{I_g}{i} = \frac{1}{10} \Rightarrow \frac{I_g}{i} \times 100\% = 10\%$$

Q7: Given below me two statements :

Statement I: The law of gravitation holds good for any pair of bodies in the universe.

Statement II: The weight of any person becomes zero when the person is at the centre of the earth. In the light of the above statements, choose the correct answer from the options given below.

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I true but Statement II is false

(D) Statement I false but Statement II is true

$F = \frac{GM_1M_2}{r^2}$ → holds gwd for any pair of bodies.

Yes $g=0$ at centre

hence $mg=0$

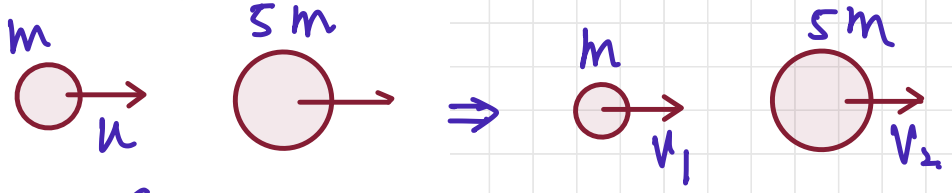
Q8: What percentage of kinetic energy of a moving particle is transferred to a stationary particle when it strikes the stationary particle of 5 times its mass? (Assume the collision to be head-on elastic collision)

(A) 50.0%

(B) 66.6%

(C) ✓ 55.6%

(D) 33.3%



$$m(u) + 0 = m v_1 + 5m v_2$$

$$v_1 + 5v_2 = u \quad \text{— (1)}$$

$$v_2 - v_1 = 1(u - 0) \quad \text{— (2)}$$

ADD

$$6v_2 = 2u \Rightarrow v_2 = u/3$$

$$\frac{\frac{1}{2}(5m)v_2^2}{\frac{1}{2}mu^2} \times 100$$

$$= \frac{5(u/3)^2}{u^2} \times 100 = \frac{5}{9} \times 100 = 55.6\%$$

Q9: The velocity of a small ball of mass 'm' and density d_1, when dropped in a container filled with glycerine, becomes constant after some time. If the density of glycerine is d_2, then the viscous form acting on the ball, will be:

(A) $mg\left(1-\frac{d_1}{d_2}\right)$

(B) ✓ $mg\left(1-\frac{d_2}{d_1}\right)$

(C) $mg\left(\frac{d_1}{d_2}-1\right)$

(D) $mg\left(\frac{d_2}{d_1}-1\right)$

$f_V = V d_2 g$

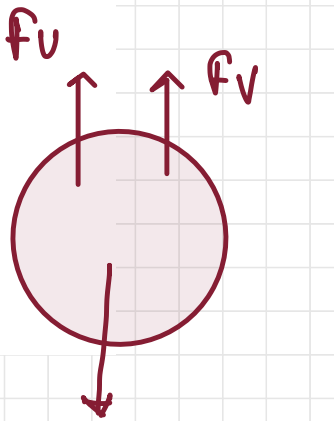
constant velocity
acceleration = 0

$V d_1 g - V d_2 g - f_V = 0$

$f_V = V g (d_1 - d_2)$

$= V g d_1 (1 - d_2/d_1)$

$\boxed{f_V = mg(1 - d_2/d_1)}$



Q10: The susceptibility of a paramagnetic material is 99. The permeability of the material in WB/A-m, is:

[Permeability of free space $\mu_0 = 4\pi \times 10^{-7} Wb/A-m$]

(A) $4\pi \times 10^{-7}$

(B) $4\pi \times 10^{-4}$

(C) $4\pi \times 10^{-5}$

(D) $4\pi \times 10^{-6}$

$$\mu_r = 1 + \chi$$

$$= 1 + 99 = 100$$

$$\mu = \mu_r \mu_0 = 100 \times 4\pi \times 10^{-7}$$

$$= 4\pi \times 10^{-5} \text{ wb/Amt}$$

Q11: The current flowing through can ac circuit is given by $I = 5\sin(120\pi t)A$ How long will the current take to reach the peak value starting from zero?

(A) $\frac{1}{60}s$

(B) 60 s

(C) $\frac{1}{120}s$

(D) $\frac{1}{240}s$

ANS = 11

but $I = I_0 = 5$

$I = I_0 \sin(120\pi t)$

$1 = \sin 120\pi t$

$\sin \pi/2 = \sin(120\pi t)$

$\pi/2 = 120\pi t$

$t = \frac{1}{240}$ sec

Q12: Match List – I with List – II

List – I	List – II		
(a)	Ultraviolet rays	(i)	Study crystal structure
(b)	Microwaves	(ii)	Greenhouse effect
(c)	Infrared waves	(iii)	Sterilizing surgical instrument
(d)	X-rays	(iv)	Radar system

Choose the correct answer from the options given below:

(A) (a)→(iii); (b)→(iv); (c)→(iii); (d)→(i)

(B) (a)→(iii); (b)→(i); (c)→(ii); (d)→(iv)

(C) (a)→(iv); (b)→(iii); (c)→(ii); (d)→(i)

(D) (a)→(iii); (b)→(iv); (c)→(i); (d)→(ii)

ANS - 12

(A)

Q13: An α particle and a carbon 12 atom has same kinetic energy K. The ratio of their de-Broglie wavelength $(\lambda_\alpha : \lambda_{C12})$ is:

(A) $1 : \sqrt{3}$

(B) $\sqrt{3} : 1$

(C) $3 : 1$

(D) $2 : \sqrt{3}$

ANC-13

$$K = \frac{1}{2} m v^2$$

$$v = \sqrt{\frac{2(K)}{m}}$$

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{\frac{2K}{m}}}$$

$$\lambda = \frac{h}{\sqrt{2mK}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{12}{4}} = \sqrt{\frac{3}{1}}$$

$$\lambda_1 : \lambda_2 :: \sqrt{3} : 1$$

Q14: A force of 10 N acts on a charged particle placed between two plates of a charged capacitor. If can plate of capacitor is removed, then the force acting on that particle will be

(A) 5 N

(B) 10 N

(C) 20 N

(D) Zero

ANS-14

SECOND LATE

+q

If one plate is removed.

$q' \rightarrow F' = q'E$

$F' = q'\left(\frac{q}{2A\epsilon_0}\right)$

$\frac{F}{F'} = \frac{qq'2A\epsilon_0}{\epsilon_0 qq'A} = 2$

$F' = F/2 = 10/2 = 5N$

FIRST CASE

+q

q

q' → F_1, F_2

$F = q(E_1 + E_2)$

$= q'\left(\frac{q}{2\epsilon_0 A} + \frac{q}{A2\epsilon_0}\right)$

$= \frac{qq'}{\epsilon_0 A}$

Q15: The displacement of simple harmonic oscillator after 3 seconds starting from its mean position is equal to half of its amplitude. The time period of harmonic motion is

(A) 6 s

(B) 8 s

(C) 12 s

(D) 36 s

Ans-15

$$y = a \sin \omega t$$

$$\frac{a}{2} = a \sin \frac{2\pi}{T} t$$

$$\sin \pi/6 = \sin \frac{2\pi}{T} t$$

$$\frac{\pi}{6} = \frac{2\pi}{T} (t)$$

$$t = \frac{T}{12} \Rightarrow T = 12 \times 3 = 36 \text{ sec}$$

Q16: An observer moves towards a stationary source of sound with a velocity equal to one-fifth of the velocity of sound. The percentage change in the frequency will be

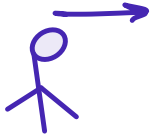
(A) 20%

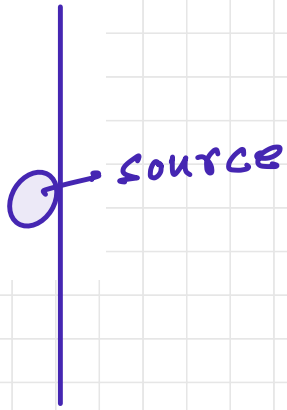
(B) 10%

(C) 5%

(D) 0%

$$f' = f\left(\frac{v + v_o}{v - v_s}\right)$$





$$f' = f\left(\frac{v + v/5}{v - 0}\right) = f\left(\frac{6}{5}\right)$$

$$\frac{f'}{f} = \frac{6}{5} \Rightarrow \frac{f'}{f} - 1 = \frac{6}{5} - 1 = \frac{1}{5}$$

$$\left(\frac{f' - f}{f}\right) \times 100\% = \frac{1}{5} \times 100\% = 20\%$$

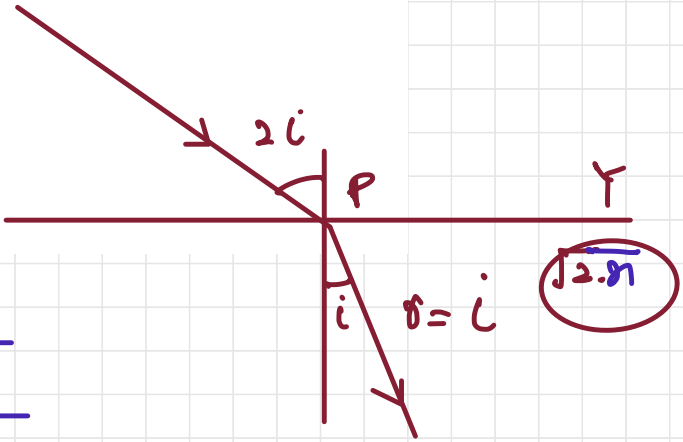
Q17: Consider a light ray travelling in air is incident into a medium of refractive index $\sqrt{2}n$. The incident angle is twice that of refracting angle. Then, the angle of incidence will be

(A) $\sin^{-1}(\sqrt{n})$

(B) $\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$

(C) $\sin^{-1}(\sqrt{2n})$

(D) $2\cos^{-1}\left(\sqrt{\frac{n}{2}}\right)$



for the surface XPY apply Snell's Law

$1 \sin 2i = \sqrt{2}\, n \sin i$

$2 \sin i \cos i = \sqrt{2}\, n \sin i$

$\cos i = \sqrt{n}/\sqrt{2}$ $\quad i = \cos^{-1}\frac{\sqrt{n}}{\sqrt{2}}$

Q18: A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of electron of the hydrogen atom will increase by the value of

(A) 2.10×10^{-34} Js

(B) 1.05×10^{-34} Js

(C) 3.15×10^{-34} Js

(D) 4.2×10^{-34} Js

$$-13.6 + 10.2 = -\frac{13.6}{n^2}$$

$$-3.4 = -\frac{13.6}{n^2}$$

$$n^2 = \frac{13.6}{3.4} = 4$$

$$n = 2$$

$$mvr = \frac{nh}{2\pi}$$

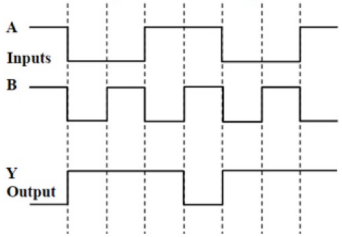
$$L_1 = \frac{h}{2\pi}$$

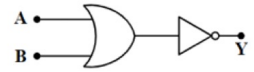
$$L_2 = \frac{2h}{2\pi}$$

$$L_2 - L_1 = \frac{2h}{2\pi} - \frac{h}{2\pi} = \frac{h}{2\pi}$$

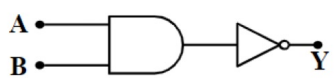
$$= \frac{6.6 \times 10^{-34}}{2 \times 3.14} = 1.05 \times 10^{-34} \text{ Js}$$

Q19: Identify the correct logic Gate for the following output (Y) of two inputs A and B

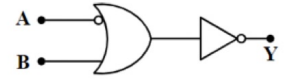


(A) 

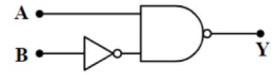
$\Rightarrow \overline{A+B}$ ✗

(B) 

$\overline{A}\,\overline{B}$ ✓ → TRUTH TABLE IS VALID

(C) 

$\overline{A+B}$

(D) 

$\overline{A}\,\overline{B}$

A	B	Y
1	1	0
0	0	1
0	1	1
1	0	1
1	1	0
0	0	1

Q20: A mature of hydrogen and oxygen has volume 2000 cm^3 temperature 300 K, pressure 100 kPa and mass 0.76 g. The ratio of number of moles of hydrogen to number of moles of oxygen in the mixture will be :
[Take gas constant R = 8.3 JK^{-1} mol^{-1}]

(A) $\frac{1}{3}$

(B) $\frac{3}{1}$ ✓

(C) $\frac{1}{16}$

(D) $\frac{16}{1}$

n_1 ↓ mole of O_2

n_2 ↓ mole of H_2

Mass of gas mixture = 0.76 gm ($O_2 + H_2$)

$V = 2000\ cm^3$

$P = 100 \times 10^3\ Pa$

$T = 300\ K$

$$n = \frac{PV}{RT} = \frac{100 \times 10^3 \times 2000 \times 10^{-6} \times 3}{25 \times 300}$$

$$n = \frac{2}{25} = .08 = n_1 + n_2$$

$$\Rightarrow n_2 = .08 - n_1$$

$$n_1 \times 32 + n_2(2) = 0.76$$

$$n_2 + 16 n_1 = 0.38$$

$$.08 - n_1 + 16 n_1 = 0.38$$

$$15 n_1 = 0.38 - .08 = 0.30$$

$$n_1 = \frac{0.30}{15} = .02$$

$$n_2 = .08 - .02 = .06$$

$$\frac{n_2}{n_1} = \frac{.06}{.02} = 3.$$

Q21: In a carnot engine, the temperature of reservoir is 527°C and that of sink 200 K. If the work done by the engine when it transfers heat from reservior to sink is 12000 kJ, the quantity of heat absorbed by the engine from reservoir is _____x 10^6 J.

16000 kJ

ANS-21

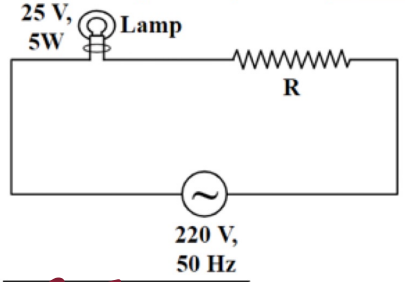
$$\frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\frac{12000}{Q_1} = 1 - \frac{200}{800}$$

$$\frac{12000}{Q_1} = \frac{600}{800}$$

$$Q_1 = \frac{12000 \times 8}{6} = 16000\ kJ$$

Q22: A 220 V, 50 Hz AC source is connected to a 25 V, 5 W lamp and an additional resistance R in series (as shown in figure) to run the lamp at its peak brightness, then the value of R (in ohm) will be 975-ohm



975-ohm

25 Volt, 5 watt

$P = VI \Rightarrow I = P/V = 5/25 = 1/5$ Amp

$5 = \frac{V^2}{R'} \Rightarrow R' = \frac{V^2}{5} = \frac{25 \times 25}{5} = 125$ ohm.

$220 = \frac{1}{5}(125 + R)$

$220 \times 5 = 125 + R$

$1100 - 125 = R$

$R = 975\ \Omega$

Q23: In Young's double slit experiment the two slits are 0.6 mm distance apart. Interference pattern is observed on a screen at a distance 80 cm from the slits. The first dark fringe is observed on the screen directly opposite to one of the slits. the wavelength of light will be 450 nm.

450-nm

$d = 0.6 \times 10^{-3}$ mt

$D = 80 \times 10^{-2}$ mt

For dark fringe

$$\frac{x_n d}{D} = (2n-1)\frac{\lambda}{2}$$

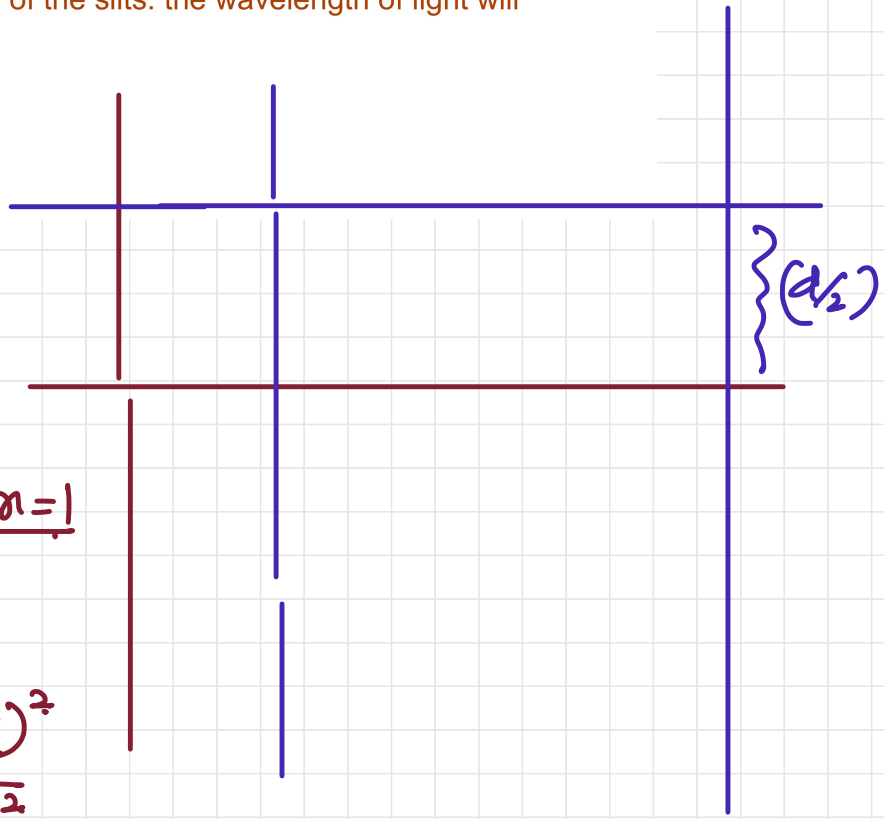
$$x_n = \frac{(2n-1)\lambda D}{2d}$$

$n=1$

$$\frac{d}{2} = \frac{\lambda D}{2d}$$

$$\lambda = \frac{d^2}{D} = \frac{(0.6\times10^{-3})^2}{80\times10^{-2}}$$

$$= \frac{0.6\times0.6\times10^{-6}}{80\times10^{-2}\times100} = \frac{36}{80}\times10^{-6} = 450\text{nm}$$



Q24: A beam of monochrome light is used to excite the electron in Li^{++} from the first orbit to the third orbit. The wavelength of monochrome light is found to be $x \times 10^{-10} m$. The value of *x* is _____ [Given hc =1242 eV nm]

114 × 10⁻¹⁰ mt

$$\frac{hc}{\lambda} = 13.6 Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1242 \times 10^{-9}}{\lambda} = 13.6 (9) \left(\frac{1}{1^2} - \frac{1}{3^2}\right)$$

$$\lambda = 114 \times 10^{-10} \text{ mt}$$

Q25: A cell, shunted by a 8 Ω resistance, is balanced across a potentiometer wire of length 3m. The balancing length is 2 m when the cell is shunted by 4Ω resistance. The value of internal resistance of the cell will be 8 Ω.

8-ohm

$$r = R\left(\frac{l_1}{l_2} - 1\right)$$

$$r = 8\left(\frac{l_1}{3} - 1\right) \quad \text{—— (1)}$$

$$r = 4\left(\frac{l_1}{2} - 1\right) \quad \text{— (2)}$$

$$2 \cancel{8}\left(\frac{l_1}{3} - 1\right) = \cancel{4}\left(\frac{l_1}{2} - 1\right)$$

$$\frac{2l_1}{3} - 2 = \frac{l_1}{2} - 1$$

$$l_1\left(\frac{2}{3} - \frac{1}{2}\right) = 2 - 1 = 1$$

$$l_1\left(\frac{4-3}{6}\right) = 1 \Rightarrow l_1 = 6 \text{ mt}$$

but in (1)

$$r = 8\left(\frac{6}{3} - 1\right)$$

$$= 8\text{-ohm}$$