Jee Advanced 2015 PHYSICS   Paper - 1

INTEGER ANSWER QUESTIONS :-

Q.1. Consider a concave mirror and a convex lens (refractive index = 1.5) of focal length 10 cm each, seperated by a distance of 50 cm in air (refractive index = 1) as shown in fgure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification M_1. When the set-up is kept in a meium of refractive index 7/6, the magnification becomes M_2 , the magnification becomes M_2.The magnitude IM_2/M_1I is

Q.2. A Young's double slit interference arrangement with slits S_1 and S_2 is immersed in water (refractive index = 4/3) as shown in figure. The positions of maxima on the surface of water are given by $x^2 = p^2m^2\lambda^2 - d^2$, where λ is the wavelength of light in air (refractive index = 1) , 2d is the seperation between the slits and *m* is an integer. The value of *p* is

Q.3. Two identical uniform discs roll without slipping on two surfaces AB and CD (see figure) starting at A and C with linear speed v_1 and v_2, respectively, and always remain in contact with the surfaces. If they reach B and D with same linear speed nd v_1 = 3 m/s, ten v_2 in m/s is (g = 10m/s^2)

Q.4. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches maximum height, its acceleration due to the planet's gravity is $1/4^{th}$ of its value at the surface of the planet. If the escape velocity from the planet is v_{esc} = v√N, the value of N is (ignore energy loss due to atmosphere)

Q.5. Two spheres starts A and B emit blackbody radiation. The radius of a is 400 times that of B and A emits 10^4 times the power emitted from B. The ratio (λ_A/λ_B) of their wavelengths λ_A and λ_B at which the peaks occour in their respetive radiation curves is

Q.6. A nuclear power plant supplying electrical power to a village uses a radioactive material of half life T years as fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of village for a maximum period of nT years, then the value of *n* is

Q.8. Consider a hydrogen atom with its electron in the n^{th} orbital. An electromagnetic radition of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electrons is 10.4 eV, then the value of *n* is (*hc* = 1242 eV nm)

MULTIPLE CHOICE QUESTIONS :-

Q.9. The figure below depicts two situations in which two infinitely long ststic line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charges *q* and -*q* are kept in equilibrium between them. The point charges are confined to move in the *x* direction only. If they are given small displacement about their equilibrium positions, then the correct stateent(s) is (are)

(A) Both charges execute simple harmonic motion.

(B) Both charges will continue moving in direction of their displacement.

(C) Charges +*q* executes simple harmonic motion while charge -*q* continues moving in the direction of its displacement.

(D) Charges -*q* executes simple harmonic motion while charge +*q* continues moving in the direction of its displacement.

Q.10. Two identical glss rods $S_1$and S_2 (refractive index = 1.5) have one convex and of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is

(A) 60 cm (B) 70 cm (C) 80 cm (D) 90 cm

Q.11. A conductor (shown in the figure) carriying constant current I is kept in the x-y plane in a uniform magnetic B. If F is the magnitude of the total magnetic force acting on the conductor, then the correct statement(s) is (are)

(A) If B is along z, $F \propto (L + R)$

(A) If B is along x, F = 0

(A) If B is along y, $F \propto (L + R)$

(A) If B is along z, F = 0

Q.13. In an Aluminium (Al) bar of square cross section, a square hole is drilled and a filled with iron (Fe) as shown in figure. The electrical resistivities of Al and Fe are 2.8×10^{-8} Ω m and 1.0×10^{-7} Ω m, respectively. The electrical resistance between the two faces P and Q of composite bar is

(A) 2475 μΩ, 64 μΩ (B) 1875 μΩ, 64 μΩ (C) 1875 μΩ, 49 μΩ (D) 2475 μΩ, 132 μΩ

Q.14. For photo-electric effect with incident photon wavelength λ, the stopping potential is V_0 . Identify the correct variation(s) of V_0 with λ and 1/λ .

Q.15. Consider a Vernier Callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier Callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then:

(A) If the pitch of the screw gauge is twice the least count of the Vernier Callipers, the least count of the screw gauge is 0.01 mm.

(B) If the pitch of the screw gauge is twice the least count of the Vernier Callipers, the least count of the screw gauge is 0.005 mm.

(C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier Callipers, the least count of the screw gauge is 0.01 mm.

(D) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier Callipers, the least count of the screw gauge is 0.005 mm.

Q.16. Planck's constant *h*, speed of light *c* and gravitational constant *G* are used to form a unit of length *L* and a unit of mass *M*. Then the correct option(s) is (are)

(A) $M \propto vc$ (B) $M \propto vG$ (C) $L \propto vh$ (D) $L \propto vG$

Q.18. A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass (M/8) at rest at O. These masses can move radially outwards along two massless rods fixed on ring as shown in the figure. At some instant the angular speed of the system is (8/9) ω and one of the masses is at a distance of (3/5) R from O. At this instant the distance of the other mass from O is

(A) (2/3)R (B) (1/3)R (C) (3/5)R (D) (4/5)R

Jee Advanced Solutions Paper 1

1. Similar to Irodov Class Q. 30 Set-1 to find $m = m_1 m_2$.

Case - 1 :-

$$m_1 = \frac{f}{f-u} = \frac{-10}{-10-(-15)} = -2 \qquad \frac{1}{v_1} + \frac{1}{-15} = \frac{1}{-10}$$

$$\frac{1}{v_1} = \frac{2-3}{30} \Rightarrow v_1 = -30$$

$$u_2 = 50 - 30 = 20 \ (=2f) \qquad m_1 = \frac{f}{f-u} = \frac{-10}{-10-(-15)} = -2$$

$$\boxed{M_1 = m_1 m_2 = -2 \times -1 = 2}$$

Case - 2 :-

$v_1 = -30$, $\quad m_1 = -2$, same as before

$$\frac{f_1}{f_{air}} = \frac{\mu_y - 1}{\frac{\mu_y}{\mu_{air}} - 1} \Rightarrow \frac{f_1}{10} = \frac{1.5 - 1}{\frac{1.5 \times 6}{7} - 1} = \frac{0.5 \times 7}{2} = \frac{7}{4}$$

$$f_1 = \frac{70}{4} = \frac{35}{2}, \quad m_2 = \frac{35/2}{35/2 + (-20)} = \frac{35}{-5} = -7$$

$$\boxed{M_2 = m_1 m_2 = -2 \times -7 = 14} \Rightarrow \frac{M_2}{M_1} = \frac{14}{2} = 7$$

2. Similar as in Theory class of Optical Path in Interference.

$p = \mu\sqrt{(d^2 + x^2)} - \sqrt{(d^2 + x^2)} = (\mu - 1)\sqrt{(d^2 + x^2)} = 1/3\sqrt{(d^2 + x^2)} = m\lambda$ (maxima)

$d^2 + x^2 = gm^2\lambda^2 \qquad x^2 = gm^2\lambda^2 - d^2$

$\Rightarrow p^2 = 9 \qquad \Rightarrow p = 3$

3. Same as Q. 78 of rotational dynamics of H.C.V.

Case - 1 :-

$$\frac{1}{2} \times \frac{3}{2} MR^2 \left(\frac{3}{R}\right)^2 + Mg \cdot 30 = \frac{1}{2} \cdot \frac{3}{2} MR^2 \cdot \frac{V^2}{R^2}$$

Case - 2 :-

$$\frac{1}{2} \times \frac{3}{2} MR^2 \left(\frac{v_2}{R}\right)^2 + Mg \cdot 27 = \frac{1}{2} \cdot \frac{3}{2} MR^2 \cdot \frac{V^2}{R^2}$$

Solving, $v_2 = 7$ m/s

4. Same as Q. 37 of Gravitation of H.C.V.

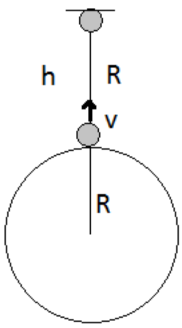
$$\frac{g/4}{g} = \frac{R^2}{(R+h)^2} \qquad 4R^2 = (R+h)^2$$

$$2R = R + h \Rightarrow \boxed{h = R}$$

$$\frac{1}{2} mv^2 - \frac{GMm}{R} = \frac{-GMm}{2R} + 0$$

$$v^2 = \frac{GM}{R} \qquad v_{ge} = \sqrt{\frac{2GM}{R}} = \sqrt{2v^2} = v\sqrt{N}$$

$$\boxed{N = 2}$$



5. Same as Theory class of Stefen's law and Wein's law.

$\frac{P_A}{P_B} = \frac{\sigma 4\pi R_A^2 T_A^4}{\sigma 4\pi R_B^2 T_B^4}$ ⇨ $10 = \left(\frac{4\pi R_B}{R_B}\right)^2 \left(\frac{T_A}{T_B}\right)^4$ ⇨ $\left(\frac{T_A}{T_B}\right)^4 = \left(\frac{1}{16}\right)^{\frac{1}{4}} = \frac{1}{2}$

Wein's Law,

$\frac{\lambda_A}{\lambda_B} = \left(\frac{T_A}{T_B}\right) = 2$

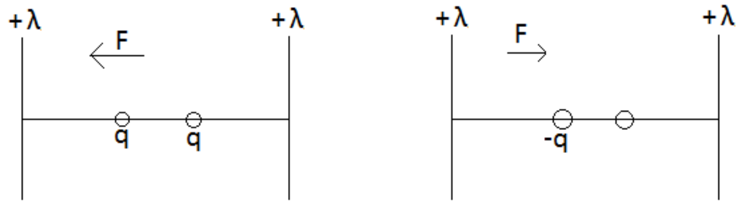
6. Taught directly in Theory class of Half Life in Nuclear Physics .

$P = \frac{P_0}{8} = \frac{P_0}{2^{xT/T}}$ ⇨ $x = 3$

8. Directly taught as Basic concepts of Atomic Models and Hydrogen Spectra.

$\frac{1242}{90} = \frac{13.6}{n^2} + 10.4\ e$ ⇨ $3.4 = \frac{13.6}{n^2}$ ⇨ $n = \sqrt{4} = 2$

9. Directly taught in Applications of Gauss' Law with Electric Field (**E**)



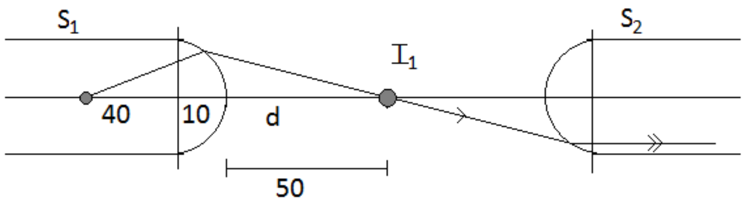
Ans., (c) + q will execute S.H.M. , -q will continue to move toward right.

10. This Numerical was taught directly during Theory class of Refraction by Curved Surfaces.

S_1 :- $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

⇨ $\frac{1}{v_1} - \frac{1.5}{-50} = \frac{1 - 1.5}{-10}$

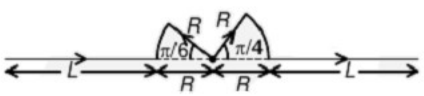
$v_1 = +50$



S_2 :- Ray will move to ∞ ∴ $v = \infty$ ⇨ $\frac{1.5}{\infty} - \frac{1}{-(d-50)} = \frac{1.5 - 1}{+10}$ ⇨ $d = 70$ cm Ans. (c)

11. Taught directly in numerical no. 18 of H.C.V., Ch - 34 as a shortcut.

Join initial (i) and final (f) points to find **l** , $\mathbf{F_m} = i\,\mathbf{l} \times \mathbf{B}$



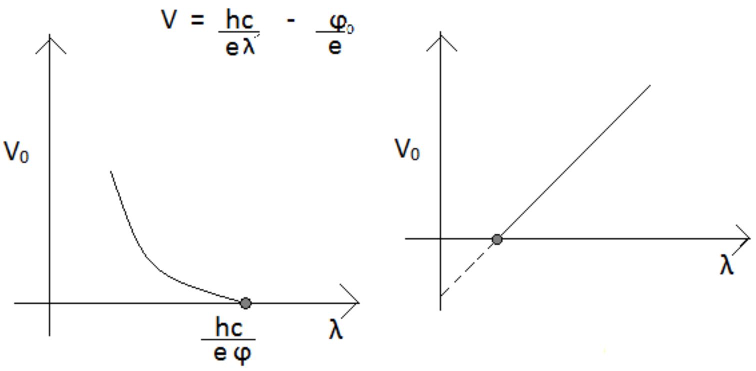
F_m is independent of the slope of wire in A, B, C.

13. Taught directly as Parallel Combination of Resistors.

$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$ and $R = \rho \frac{l}{A}$

14. Taught directly in Graph of Photoelectron speed V_0 v/s λ and V_0 v/s 1/λ .

The graph of will be parabola like Boyle's Law with zero value of v at $\lambda = hc/e\phi$

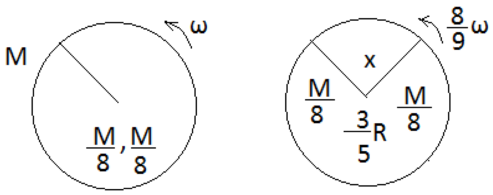


15. Taught directly in Theory class on Slide Callipers and Screw Gauge. Comparing the L. C. of both correct option in B , C

16. Taught directly in Units and Dimension .

$M \propto h^l G^m c^n$ --> $M \propto h^{1/2} G^{1/2} c^{1/2}$ Also, $L \propto h^l G^m c^n$

18. Taught directly in Theory class of Angular Momentum Conservation.



By Conservation of Angular Momentum ,

$$MR^2\omega = \left[MR^2 + \frac{M}{8}\left(\frac{3}{5}R\right)^2 + \frac{Mx^2}{8}\right]\frac{8}{9}\omega \Rightarrow \boxed{x = \frac{4}{5}R}$$