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PAPER-1(B.E./B. TECH.)

JEE (Main) 2021

Questions & Solutions

(Reproduced from memory retention)

Date : 26 February, 2021 (SHIFT-1) Time ; (9.00 am to 12.00 pm)

Duration : 3 Hours | Max. Marks : 300

SUBJECT : PHYSICS

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PHYSICS

1. Work done by force is $W = \alpha^2\beta\ e^{-\frac{\beta x^2}{KT}}$, where x-distance, K = Boltzammn's constant and T is temperature. The dimension of α is

(1) $\alpha = M^1 L^2 T^{-1}$ (2) $M^0 L^1 T^0$ (3) $M^0 L^1 T^{-2}$ (4) $M^2 L^1 T^{-2}$

Ans. **(2)**

Sol. $\frac{\beta x^2}{KT}$ is dimension less so $KT = \beta x^2 \Rightarrow M^1L^2T^{-2} = \beta\ L^2$

$\beta = M^1\ T^{-2}$

$w = \alpha^2 \times \beta$

$M^1\ L^2\ T^{-2} = \alpha^2 \times M^1\ T^{-2}$

$\alpha = L$

2. **Statement-1** Resolving power of electron microscope is greater than optical microscope .

Statement-2 de-Broglie wave length of electron is very less than visible light.

(1) Statement (1) is correct, statement-(2) is correct but not correct explanation.

(2) Statement (1) is correct, statement (2) is correct and it is correct explanation.

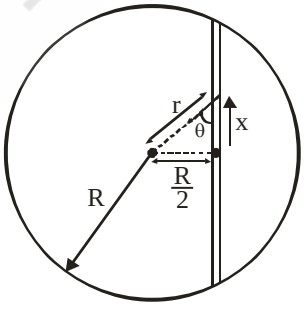
(3) Statement (1) is correct, statement (2) is wrong.

(4) Statement (1) is wrong and statement (2) is also wrong.

Ans. **(2)**

Sol. The wave length of wave associated with e^{-1} is less than that of visible light. Therefore the resolving power of an electron microscope is higher than that of an optical microscope.

3. A tunnel is dug along the chord at a distance $\frac{R}{2}$ from centre of earth as shown. If particle is released in tunnel, find its time period?



(1) $2\pi\sqrt{\frac{R}{2g}}$ (2) $2\pi\sqrt{\frac{R}{g}}$ (3) $\pi\sqrt{\frac{R}{2g}}$ (4) $4\pi\sqrt{\frac{R}{g}}$

Ans. **(2)**

Sol. If displaced from equilibrium position,

$$F_{\text{res towards equilibrium}} = \left(\frac{GMm\,r}{R^3}\right)\cos\theta$$

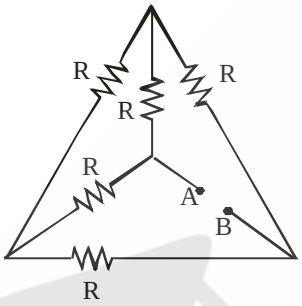
$$= \frac{GMm\,r}{R^3}\cdot\frac{x}{r}$$

$$= \left(\frac{GMm}{R^3}\right)x$$

$$= \left(\frac{gm}{R}\right)x$$

$$\therefore \quad T = 2\pi\sqrt{\frac{m}{\frac{mg}{R}}} = 2\pi\sqrt{\frac{R}{g}}$$

4. Find out equivalent resistance between AB.



(1) 3R (2) $\frac{R}{2}$ (3) 2R (4) R

Ans. **(4)**

Sol. It is balanced wheat stone bridge so

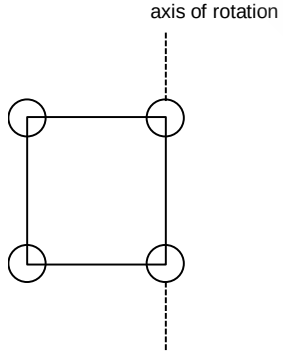
$R_{AB} = R$

5. Four identical solid spheres of mass m and radius a are placed on four corner of square of side b. Findout moment of inertia about any one side.

(1) $\frac{8}{5}ma^2 + 2mb^2$ (2) $\frac{8}{3}ma^2 + 2mb^2$ (3) $\frac{5}{3}ma^2 + mb^2$ (4) $\frac{8}{5}ma^2 + mb^2$

Ans. (1)

Sol.



$$I = 2\times\frac{2}{5}ma^2 + 2\left[\frac{2}{5}ma^2 + mb^2\right]$$

$$I = \frac{4}{5}\,ma^2 + \frac{4}{5}\,ma^2 + 2mb^2$$

$$= \frac{8}{5}\,ma^2 + 2mb^2$$

6. A sphere and ring are separated by $\sqrt{8}R$ distance. Find force between them?

(1) $\frac{GMm}{R^2}\left(\frac{2}{27}\right)$ (2) $\frac{GMm}{R^2}\left(\frac{\sqrt{8}}{3}\right)$ (3) $\frac{GMm}{R^2}\left(\frac{\sqrt{8}}{27}\right)$ (4) $\frac{GMm}{R^2}\left(\frac{\sqrt{6}}{27}\right)$

Ans. **(3)**

Sol. $F = \frac{GMm\sqrt{8}R}{(R^2+8R^2)^{3/2}}$

$$= \frac{GMm}{R^2}\times\frac{\sqrt{8}}{27}$$

7. In a spherical mirror height of an object is 100 cm and height of an image is 25 cm and their orientations are same then

(1) image real, convex mirror (2) image real, concave mirror

(3) image virtual, concave mirror (4) image virtual, convex mirror

Ans. **(4)**

Sol. Same orientation so image is virtual. It is combination or real object and virtual image using height it is possible only from convex mirror.

8. In YDSE experiment separation between plane of slits and screen is 1 m. Separation between slits is 2 mm. The wavelength of light is 500 nm. The fringe width is

(1) 0.25 mm (2) 0.2 mm (3) 0.30 mm (4) 0.40 mm

Ans. **(1)**

Sol. $\beta = \frac{\lambda D}{d} = \frac{500\times10^{-9}\times1}{2\times10^{-3}}$

$= 2.5\times10^{-4} = 0.25$ mm

9. In a gas LED separation between valance band and conduction band is 1.9 eV. Then the light emitted is:

(1) 1024 nm, Red (2) 1024 nm, Orange (3) 654 nm, Orange (4) 654 nm, Red

Ans. **(3)**

Sol. $\gamma = \frac{1242}{1.9}$ nm $= 654$ nm, Orange.

10. A particle is moving in circle with uniform speed under the action of central force F which is inversely proportional to radius as $F \propto \frac{1}{r^3}$. Period of revolution is proportional to.

(1) $T \propto \frac{1}{r^2}$ (2) $T \propto r^2$ (3) $T \propto r$ (4) $T \propto \frac{1}{r}$

Ans. (2)

Sol. $F = \frac{C}{r^3} = m\omega^2 r$

$\therefore \omega^2 \propto \frac{1}{r^4}$

$\therefore \omega \propto \frac{1}{r^2}$

$\therefore T \propto r^2$

11. Large numbers of small drops of radius r combine and form bigger drop of radius R. If mechanical equivalent of heat is J. Then heat released per unit volume. If surface tension is T.

(1) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (2) $\frac{3T}{J}\left(\frac{1}{r^2}-\frac{1}{R^2}\right)$ (3) $\frac{T}{J}\left(\frac{1}{r^2}-\frac{1}{R^2}\right)$ (4) $\frac{T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

Ans. (1)

Sol. $n\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\left(n^{1/3}\right)r = R$

Δu loss

= T (change in surface area)

= $T(n4\pi r^2 - 4\pi R^2)$

= $T4\pi (nr^2 - R^2)$.

$$\Delta U = 4\pi T\left[\left(\frac{R}{r}\right)^3 r^2 - R^2\right]$$

$$\Delta U = 4\pi T\frac{\left[\frac{R^3}{r} - R^2\right]}{J}$$

$$\frac{\Delta U}{V} = \frac{4\pi T\left[\frac{R^3}{r} - R^2\right]}{J \times \frac{4}{3}\pi R^3} = \frac{3T}{J}\left[\frac{1}{r} - \frac{1}{R}\right]$$

12. The current flowing in a wire is given as $I = I_1 \sin \omega t + I_2 \cos \omega t$. Find the rms value of current?

(1) $\frac{\left(I_1^2 + I_2^2\right)^{1/2}}{\sqrt{2}}$ (2) $\frac{\left(I_1^2 + I_2^2\right)^{1/2}}{2}$ (3) $\frac{\left(I_1^2 - I_2^2\right)^{1/2}}{\sqrt{2}}$ (4) $\frac{\left(I_1^2 - I_2^2\right)^{1/2}}{2}$

Ans. (1)

Sol. $I = \sqrt{I_1^2 + I_2^2 + 2I_1I_2\cos 90^o}$

$I_0 = \sqrt{I_1^2 + I^2}$

$I_{rms} = \frac{I_0}{\sqrt{2}}$

$= \sqrt{\frac{I_1^2 + I_2^2}{2}}$

13. A planet is revolving about sun in an elliptical orbit. Choose the correct option based on the statements given below.

(i) Areal velocity is constant.

(ii) Areal velocity is proportional to velocity.

(iii) When planet is nearest to sun it's speed is maximum.

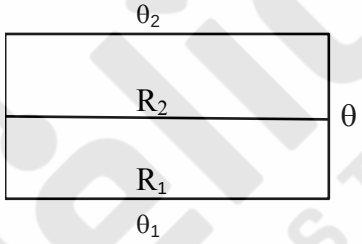
(iv) Planet will move with constant speed.

(v) Areal velocity is inversely proportional to velocity.

(1) (i) is correct (2) (ii) is correct (3) (iv) is correct (4) (v) is correct

Ans. (1)

14. Two rod of thermal resistance R_1 and R_2 are connected as shown. Temp θ_1 and θ_2 are given. Find common Temp θ of two connecting rod.



(1) $\frac{\theta_1R_2 - \theta_2R_1}{R_1 + R_2}$ (2) $\frac{R_1\theta_1 + R_2\theta_2}{R_1 + R_2}$ (3) $\frac{\theta_1R_2 - \theta_2R_1}{R_1 - R_1}$ (4) $\frac{\theta_1R_2 + \theta_2R_1}{R_1 + R_2}$

Ans. (4)

Sol. $\frac{\theta_2 - \theta}{R_2} = \frac{\theta - \theta_1}{R_1}$

$\theta_2R_1 - \theta R_1 = \theta R_2 - \theta_1R_2$

$\theta[R_1 + R_2] = \theta_1R_2 + \theta_2R_1$

$\theta = \frac{\theta_1R_2 + \theta_2R_1}{R_1 + R_2}$

15. If λ_1 represents wavelength of 3rd line of Lyman series and λ_2 represents, wave length of 1st line of paschen series in hydrogen spectrum. Find the ratio of $\frac{\lambda_1}{\lambda_2}$.

(1) $\frac{7}{135}$ (2) $\frac{5}{133}$ (3) $\frac{6}{135}$ (4) $\frac{9}{135}$

Ans. (1)

Sol. $\frac{1}{\lambda_1} = R\left[1 - \frac{1}{(4)^2}\right]$, Lyman,

$\frac{1}{\lambda_2} = R\left[\frac{1}{9} - \frac{1}{(4)^2}\right]$, Parchen

$\frac{\lambda_1}{\lambda_2} = \frac{\left(\frac{1}{9} - \frac{1}{16}\right)}{\left(1 - \frac{1}{16}\right)} = \frac{\frac{7}{9\times16}}{\frac{15}{16}}$

$\frac{\lambda_1}{\lambda_2} = \frac{7}{9\times15} = \frac{7}{135}$

16. Object of mass M (M >> m) moving with velocity u collides with the object of mass m, which is at rest Consider following statements.

Statement (1): After collision maximum velocity of object of mass m will be 2u.

Statement (2): In elastic collision kinetic energy and momentum both are conserved.

(1) Statement (1) is correct, statement-(2) is correct but not correct explanation.

(2) Statement (1) is correct, statement (2) is correct and it is correct explanation.

(3) Statement (1) is correct, statement (2) is wrong.

(4) Statement (1) is wrong and statement (2) is also wrong.

Ans. (2)

17. A uniform line charge of length ℓ and change Q is given as shown in figure. Find out electric field at point O (symmetrically arranged).

(1) $\frac{Q}{2\sqrt{3}\,\varepsilon_0\pi\ell^2}$ (2) $\frac{Q}{\sqrt{3}\,\pi\varepsilon_0\ell^2}$ (3) $\frac{Q}{2\sqrt{2}\,\pi\varepsilon_0\ell^2}$ (4) $\frac{Q}{2\,\pi\varepsilon_0\ell^2}$

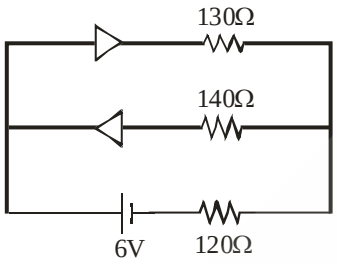
Ans. **(1)**

Sol. $E = \frac{K\lambda}{r}(\sin\theta_1 + \sin\theta_2)$

$\theta_1 = \theta_2 = 30°,\ r = \frac{\sqrt{3}\,\ell}{2},\ \lambda = \frac{Q}{\ell}$

$E = \frac{1}{4\pi\varepsilon_0}\frac{\frac{Q}{\ell}\left(\frac{1}{2}+\frac{1}{2}\right)}{\frac{\sqrt{3}\,\ell}{2}} = \frac{Q}{2\sqrt{3}\,\pi\varepsilon_0\ell^2}$

18. Two diodes are shown in figure. in forward biasing resistance of diodes is 50Ω and in reverse biasing it is infinite. Find the current flowing through 120Ω?



(1) 20 mA (2) 25 mA (3) 32 mA (4) 16 mA

Ans. (1)

Sol. $i = \frac{6}{300} = \frac{1}{50} A$

$= \frac{1000}{50} mA$

= 20 mA

19. A 2 kg object is placed on a frictionless surface (In x-y plane). If force acting on the object is $\vec{F} = 20\hat{i} + 10\hat{j}$ N. Find out displacement along x-axis in first 10 sec.

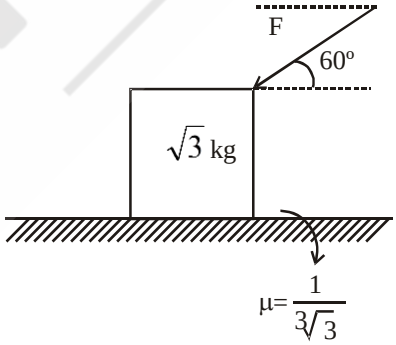
(1) 500 m (2) 300 m (3) 400 m (4) 200 m

Ans. (1)

Sol. $a_x = \frac{20}{2} = 10 \text{ m/s}^2$

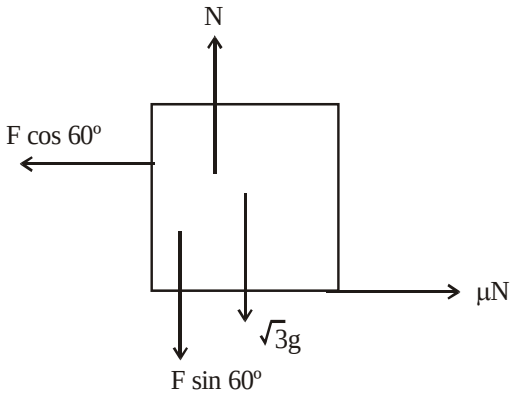
$x = 0 + \frac{1}{2} \times 10 \times 10^2 = 500 \text{ m.}$

20. If limiting value of force for block just to slide is 3x then write the value of x.



Ans. 3

Sol.



$$F\cos 60^\circ = \mu\left(\sqrt{3}g + F\sin 60^\circ\right)$$

$$\therefore \frac{F}{2} = \mu\left(\sqrt{3}g + \frac{\sqrt{3}F}{2}\right)$$

$$\therefore \frac{F}{2} = \frac{\sqrt{3}g}{3\sqrt{3}} + \frac{F}{6}$$

$$\therefore \frac{F}{3} = \frac{\sqrt{3}g}{3\sqrt{3}}$$

$$\therefore F = g = 10$$

$$3x = 10$$

$$x = \frac{10}{3} = 3.33$$

21. In a series L-C-R circuit, At resonance quality factor is 100. Now value of self inductance L is doubled and resistance is decreased two fold then find new value of quality factor.

Ans. 283

Sol. $Q = \frac{X_L}{R} = \frac{wL}{R} = \frac{1}{\sqrt{LC}} \times \frac{L}{R} = \frac{\sqrt{L}}{R\sqrt{C}}$

$$Q^1 = \frac{\sqrt{2L}.2}{\sqrt{C}\,R} = 2\sqrt{2}Q$$

$$Q^1 = 2\sqrt{2}(100) = 282.8 = 283$$

22. There are two capacitor C_1 and C_2 if $C_2 > C_1$ when they are connected in parallel the equivalent capacitance is $\frac{15}{4}$ times the equivalent capacitance when connected in series. Find C_2/C_1?

Ans. **Bonus**

Sol. $C_1 + C_2 = \frac{15}{4}\left(\frac{C_1C_2}{C_1 + C_2}\right)$

$4(C_1 + C_2)^2 = 15C_1C_2$

$4C_1^2 + 4C_2^2 - 7C_1C_2 = 0$

$4 + 4\left(\frac{C_2}{C_1}\right)^2 - 7\frac{C_2}{C_1} = 0$

$4\left(\frac{C_2}{C_1}\right)^2 - 7\frac{C_2}{C_1} + 4 = 0$

$\frac{C_2}{C_1}$ has not real value.

$\frac{C_2}{C_1}$ = Imaginary.

23. The maximum and minimum amplitude of modulated wave is 16 V and 8 V respectively. The modulation index is $x \times 10^{-2}$. Find value of x.

Ans. **33**

Sol. $u = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$

$= \frac{16-8}{16+8} = \frac{8}{24} = \frac{1}{3}$

$= 0.33 = 33 \times 10^{-2}$

$x = 33$

24. A 1000 W bulb has optical efficiency 1.2%. Find the amplitude (V/m) of electric field at distance 2 m from bulb?

Ans. **13**

Sol. $I = \frac{1}{2}(\varepsilon_0 c)E_0^2 = \frac{\text{Power}}{4\pi(2)^2}$

$\therefore \frac{1}{2} \times (4\pi\varepsilon_0)(c)E_0^2 = \frac{1000 \times 1.2}{4} \times \frac{1}{100}$

$\therefore \frac{1}{2} \times \frac{3 \times 10^8}{9 \times 10^9} \times E_0^2 = 3$

$\therefore E_0^2 = 180$

$\therefore E_0 = 13.41$ V/m

≈ 13 V/m

25. Displacement equation of string wave is given by y = A sin (x + 30t). Mass per unit length of wire is 0.325 gm/cm. Find tension (in N) in string.

Ans. **29 N**

Sol. $v = \frac{\omega}{K} = 30 \text{ m/s}$

$v = \sqrt{\frac{T}{\mu}}$

$T = v^2 \times u = \frac{(30)^2 \times (0.325) \times 10^{-3}}{10^{-2}}$

$= 900 \times 3.25 \times 10^{-2}$

$T = 29.25 \text{ N}$

26. 20 coulomb charge flows through 15 volt battery in a certain interval. Find work done (in J) by the battery?

Ans. 300

Sol. $\omega = QV$

$= 15 \times 20 = 300$ Joules

27. A non-conducting container is divided into two parts of volume 4.5 Litre and 5.5 Litre, pressure 2 atmosphere and 3 atmosphere, number of moles 3 and 4. If partition valve is opened then find out common pressure (in atmosphere). (In both parts ideal gases are identical)

Ans. 2.55

Sol. using energy conservation

$\frac{f}{2} \times 2 \times 4.5 + \frac{f}{2} \times 3 \times 5.5 = \frac{f}{2} \times P \times 10$

$2 \times \frac{9}{2} + 3 \times \frac{11}{2} = P \times 10$

$\frac{18}{2} + \frac{33}{2} = P \times 10$

$P = \frac{51}{20}$

$P = 2.55$ atmosphere

28. When a man holding spring balance in stationary lift then it's reading is 60 kg. Now if lift starts descends with constant acceleration 1.8 m/s^2 then what is the new reading of spring balance in newton. (take g = 10 m/s^2)

Ans. 492

Sol. $mg - T = ma$

$T = m(g-a)$

$= 60 [10 - 1.8]$

$= 60 \times 8.2$

$= 492 \text{ N}$

29. Coming soon.

Ans.

Sol.

30. Coming soon.

Ans.

Sol.