JEE–MAIN EXAMINATION – APRIL 2025

(HELD ON FRIDAY 04th APRIL 2025) **TIME : 9:00 AM TO 12:00 NOON**

PHYSICS | TEST PAPER WITH SOLUTION

SECTION-A

26. The mean free path and the average speed of oxygen molecules at 300 K and 1 atm are 3×10^{-7} m and 600 m/s, respectively. Find the frequency of its collisions.

(1) 2×10^{10}/s (2) 9×10^{5}/s

(3) 2×10^{9}/s (4) 5×10^{8}/s

Ans. **(3)**

Sol. $\text{Frequency} = \frac{1}{T} = \frac{V_{avg}}{\lambda}$

$$= \frac{600}{3 \times 157} = 2 \times 10^{9}\ \text{sec}^{-1}$$

27. A small mirror of mass m is suspended by a massless thread of length *l*. Then the small angle through which the thread will be deflected when a short pulse of laser of energy E falls normal on the mirror

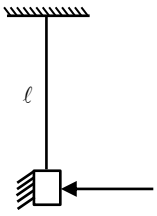
(c = speed of light in vacuum and g = acceleration due to gravity)

(1) $\theta = \frac{3E}{4mc\sqrt{gl}}$ (2) $\theta = \frac{E}{mc\sqrt{gl}}$

(3) $\theta = \frac{E}{2mc\sqrt{gl}}$ (4) $\theta = \frac{2E}{mc\sqrt{gl}}$

Ans. **(4)**

Sol.



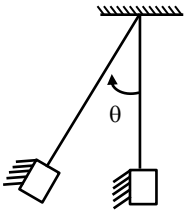
Force due to beam assuming complete reflection

$$F = \frac{2P}{C} = \frac{2}{C}\frac{dE}{dt}\ ;\ P \text{ is power}$$

So change in momentum of mirror.

$$m(V-0) = \int F dt = \frac{2}{C}\int dE = \frac{2E}{C}$$

Now using work energy theorem ….(1)



$W_g = \Delta k$

$$-mg\ell(1-\cos\theta) = 0 - \frac{1}{2}mv^2$$

$$g\ell\left(2\sin^2\frac{\theta}{2}\right) = \frac{v^2}{2}$$

as θ is small

$$g\ell 2\left(\frac{\theta}{2}\right)^2 = \frac{1}{2}\frac{4E^2}{m^2c^2} \quad \text{(from eq. (1))}$$

$$g\ell\theta^2 = \frac{4E^2}{m^2c^2}$$

$$\theta = \frac{2E}{mc\sqrt{g\ell}}$$

28. Two liquids A and B have θ_A and θ_B as contact angles in a capillary tube. If $K = \cos\theta_A/\cos\theta_B$. then identify the correct statement:

(1) K is negative, then liquid A and liquid B have convex meniscus.

(2) K is negative, then liquid A and liquid B have concave meniscus.

(3) K is negative, then liquid A has concave meniscus and liquid B has convex meniscus

(4) K is zero, then liquid A has convex meniscus and liquid B has concave meniscus.

Ans. **(3)**

Sol. $k = \frac{\cos\theta_A}{\cos\theta_B}$

It is negative when $\cos\theta_A$ & $\cos\theta_B$ are of opposite sign. so option (3)

29. Which of the following are correct expression for torque acting on a body?

A. $\vec{\tau}=\vec{r}\times\vec{L}$

B. $\vec{\tau}=\frac{d}{dt}(\vec{r}\times\vec{p})$

C. $\vec{\tau}=\vec{r}\times\frac{d\vec{p}}{dt}$

D. $\vec{\tau}=I\vec{\alpha}$

E. $\vec{\tau}=\vec{r}\times\vec{F}$

($\vec{r}$ = position vector; $\vec{p}$ = linear momentum; $\vec{L}$ = angular momentum; $\vec{\alpha}$ = angular acceleration; I = moment of inertia; $\vec{F}$ = force; t = time)

Choose the correct answer from the options given below :

(1) B, D and E Only (2) C and D Only

(3) B, C, D and E Only (4) A, B, D and E Only

Ans. **(3)**

Sol. Conceptual

30. In a Young's double slit experiment, the slits are separated by 0.2 mm. If the slits separation is increased to 0.4 mm, the percentage change of the fringe width is:

(1) 0% (2) 100%

(3) 50% (4) 25%

Ans. **(3)**

Sol. $\beta=\frac{D\lambda}{d}\propto\frac{1}{d}$

If d is doubled then β is half so 50% decrement.

31. An alternating current is represented by the equation,

$i=100\sqrt{2}\sin(100\pi t)$ ampere. The RMS value of current and the frequency of the given alternating current are

(1) $100\sqrt{2}$ A, 100 Hz (2) $\frac{100}{\sqrt{2}}$ A, 100 Hz

(3) 100 A, 50 Hz (4) $50\sqrt{2}$ A, 50 Hz

Ans. **(3)**

Sol. $i_r=\frac{i_0}{\sqrt{2}}=100\,A$

$f=\frac{w}{2\pi}=\frac{100\pi}{2\pi}=50\,Hz$

32. Consider the sound wave travelling in ideal gases of He, CH_4, and CO_2. All the gases have the same ratio $\frac{P}{\rho}$, where P is the pressure and ρ is the density. The ratio of the speed of sound through the gases $v_{He}:v_{CH_4}:v_{CO_2}$ is given by

(1) $\sqrt{\frac{7}{5}}:\sqrt{\frac{5}{3}}:\sqrt{\frac{4}{3}}$ (2) $\sqrt{\frac{5}{3}}:\sqrt{\frac{4}{3}}:\sqrt{\frac{7}{5}}$

(3) $\sqrt{\frac{5}{3}}:\sqrt{\frac{4}{3}}:\sqrt{\frac{4}{3}}$ (4) $\sqrt{\frac{4}{3}}:\sqrt{\frac{5}{3}}:\sqrt{\frac{7}{5}}$

Ans. **(3)**

Sol. $v_{sound}=\sqrt{\frac{\gamma p}{\rho}}\Rightarrow\gamma=1+\frac{2}{f}$

$\gamma_{He}=\frac{5}{3};\gamma_{CH_4}=\gamma_{CO_2}\approx1.33=\frac{4}{3}$ (Experimental data)

33. In an electromagnetic system, the quantity representing the ratio of electric flux and magnetic flux has dimension of $M^PL^QT^RA^S$, where value of 'Q' and 'R' are

(1) (3, –5) (2) (–2, 2)

(3) (–2, 1) (4) (1, –1)

Ans. **(4)**

Sol. $\frac{\phi_E}{\phi_M}=\frac{EA}{BA}=\frac{E}{B}$

$B=\frac{M\ell T^{-2}}{ATLT^{-1}}$

So $\left[\frac{E}{B}\right]=\frac{ML^{-3}A^{-1}}{MT^{-2}A^{-1}}=LT^{-1}$

Or

E = c.B (c = Speed of light) $\left[\frac{E}{B}\right]=LT^{-1}$

34. When an object is placed 40 cm away from a spherical mirror an image of magnification $\frac{1}{2}$ is produced. To obtain an image with magnification of $\frac{1}{3}$, the object is to be moved :

(1) 40 cm away from the mirror.

(2) 80 cm away from the mirror.

(3) 20 cm towards the mirror.

(4) 20 cm away from the mirror.

Ans. (1)

Sol. $m = \frac{1}{2} = \frac{f}{f-u}$

$\frac{1}{2} = \frac{f}{f-(-40)}$

$f + 40 = 2f \Rightarrow f = 40$ cm

now $m = \frac{1}{3} = \frac{40}{40-u}$

$40 - u = 120 \Rightarrow u = -80$

35. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**

Assertion A: In photoelectric effect, on increasing the intensity of incident light the stopping potential increases.

Reason R : Increase in intensity of light increases the rate of photoelectrons emitted, provided the frequency of incident light is greater than threshold frequency.

In the light of the above statements, choose the **correct** answer from the options given below

(1) Both **A** and **R** are true but **R** is **NOT** the correct explanation of **A**

(2) **A** is false but **R** is true

(3) **A** is true but **R** is false

(4) Both **A** and **R** are true and **R** is the correct explanation of **A**

Ans. (2)

Sol. $V_S = \frac{h\nu - \phi}{e}$

so stopping potential doesn't depend on Intensity

$I = \frac{\eta h\nu}{A}$

On increasing intensity no. of photons per sec. n increases so the no. of electrons.

36. If $\vec{L}$ and $\vec{P}$ represent the angular momentum and linear momentum respectively of a particle of mass 'm' having position vector $\vec{r} = a(\hat{i}\cos\omega t + \hat{j}\sin\omega t)$. The direction of force is

(1) Opposite to the direction of $\vec{r}$

(2) Opposite to the direction of $\vec{L}$

(3) Opposite to the direction of $\vec{P}$

(4) Opposite to the direction of $\vec{L} \times \vec{P}$

Ans. (1)

Sol. $\vec{a} = -\omega^2\vec{r}$

$\therefore \vec{F}$ opposite to $\vec{r}$ -

37. A body of mass m is suspended by two strings making angles θ_1 and θ_2 with the horizontal ceiling with tensions T_1 and T_2 simultaneously. T_1 and T_2 are related by $T_1 = \sqrt{3}T_2$. the angles θ_1 and θ_2 are

(1) $\theta_1 = 30°\ \theta_2 = 60°$ with $T_2 = \frac{3mg}{4}$

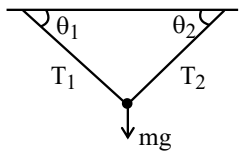
(2) $\theta_1 = 60°\ \theta_2 = 30°$ with $T_2 = \frac{mg}{2}$

(3) $\theta_1 = 45°\ \theta_2 = 45°$ with $T_2 = \frac{3mg}{4}$

(4) $\theta_1 = 30°\ \theta_2 = 60°$ with $T_2 = \frac{4mg}{5}$

Ans. (2)

Sol.



$T_1 \sin\theta_1 + T_2 \sin\theta_2 = mg$ & $T_1 = \sqrt{3}\, T_2$

$\Rightarrow T_2\left[\sqrt{3}\sin\theta_1 + \sin\theta_2\right] = mg$

for $\theta_1 = 60°$ & $\theta_2 = 30°$

$$T_2 = \frac{mg}{2}$$

38. Current passing through a wire as function of time is given as I(t) = 0.02 t + 0.01 A. The charge that will flow through the wire from t = 1s to t = 2s is :

(1) 0.06 C (2) 0.02 C

(3) 0.07 C (4) 0.04 C

Ans. (4)

Sol. $q = \int i\,dt$

$$\int_0^2 (0.02t + 0.01)dt$$

$$q = \left[0.02\frac{t^2}{2} + 0.01t\right]_1^2$$

= 0.01 (3) + 0.01 (1) = 0.04 C

39. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**

Assertion A : The kinetic energy needed to project a body of mass m from earth surface to infinity is $\frac{1}{2}$ mgR, where R is the radius of earth.

Reason R : The maximum potential energy of a body is zero when it is projected to infinity from earth surface.

In the light of the above statements, choose the **correct** answer from the option given below

(1) **A** False but **R** is true

(2) Both **A** and **R** are true and **R** is the correct explanation of **A**

(3) **A** is true but **R** is false

(4) Both **A** and **R** are true but **R** is **NOT** the correct explanation of **A**

Ans. (1)

Sol. $KE = \frac{1}{2}m\left(\frac{2Gm}{R}\right) = mgR$

Assertion wrong

at ∞ $U = 0$

$\therefore$ Reason correct.

40. The Boolean expression $Y = A\bar{B}C + \bar{A}\bar{C}$ can be realised with which of the following gate configurations.

A. One 3-input AND gate, 3 NOT gates and one 2-input OR gate, One 2-input AND gate,

B. One 3-input AND gate, 1 NOT gate, One 2-input NOR gate and one 2-input OR gate

C. 3-input OR gate, 3 NOT gates and one 2-input AND gate

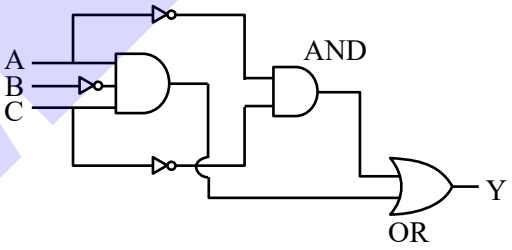
Choose the **correct** answer from the options given below

(1) B, C Only (2) A,B Only

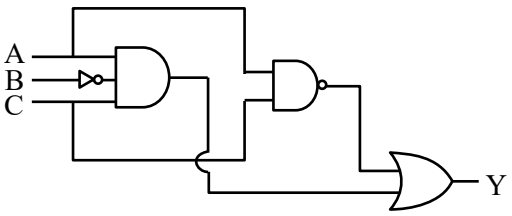
(3) A, B, C Only (4) A, C Only

Ans. (2)

Sol. (A)



(B)



$\because \quad \bar{A}\cdot\bar{C} + \overline{A + C} \equiv$ NOR gate

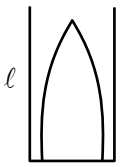
41. In an experiment with a closed organ pipe, it is filled with water by $\left(\frac{1}{5}\right)$th of its volume. The frequency of the fundamental note will change by

(1) 25% (2) 20%

(3) –20% (4) –25%

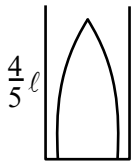
Ans. (1)

Sol.



$\lambda_1 = 4\ell$

$f_1 = \frac{v}{4\ell}$



$\lambda_2 = \frac{16\ell}{5}$

$f_2 = \frac{5V}{16\ell}$

$$\frac{\Delta f}{f} = \frac{\frac{V}{\ell}\left(\frac{1}{16}\right)}{\frac{V}{4\ell}} \times 100 = 25\%$$

42. Two simple pendulums having lengths l_1 and l_2 with negligible string mass undergo angular displacements θ_1 and θ_2, from their mean positions, respectively. If the angular accelerations of both pendulums are same, then which expression is correct ?

(1) $\theta_1 l_2^2 = \theta_2 l_1^2$ (2) $\theta_1 l_1 = \theta_2 l_2$

(3) $\theta_1 l_1^2 = \theta_2 l_2^2$ (4) $\theta_1 l_2 = \theta_2 l_1$

Ans. (4)

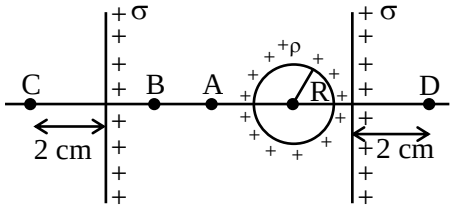
Sol. $\omega = \sqrt{\frac{g}{\ell}}$

$\alpha = -\omega^2\theta$

$\therefore \frac{g}{\ell_1}\theta_1 = \frac{g}{\ell_2}\theta_2$

$\Rightarrow \theta_1\ell_2 = \theta_2\ell_2$

43. Two infinite identical charged sheets and a charged spherical body of charge density 'ρ' are arranged as shown in figure. Then the correct relation between the electrical fields at A, B, C and D points is :



(1) $\vec{E}_A = \vec{E}_B; \vec{E}_C = \vec{E}_D$ (2) $\vec{E}_A > \vec{E}_B; \vec{E}_C = \vec{E}_D$

(3) $\vec{E}_C \neq \vec{E}_D; \vec{E}_A > \vec{E}_B$ (4) $|\vec{E}_A| = |\vec{E}_B|; \vec{E}_C > \vec{E}_D$

Ans. (3)

Sol. Conceptual

$E_C \neq E_D$

$E_A > E_B$

44. Two small spherical balls of mass 10g each with charges –2μC and 2μC, are attached to two ends of very light rigid rod of length 20 cm. The arrangement is now placed near an infinite non-conducting charge sheet with uniform charge density of 100μC/m^2 such that length of rod makes an angle of 30° with electric field generated by charge sheet. Net torque acting on the rod is:

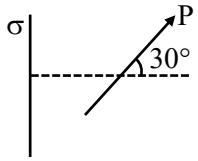
(Take ε_o : 8.85 × 10^{-12} C^2/Nm^2)

(1) 112 Nm (2) 1.12 Nm

(3) 2.24 Nm (4) 11.2 Nm

Ans. (2)

Sol.



$E = \frac{\sigma}{2\varepsilon_0}$

$\tau = PE\sin\theta$

$$= \left[\left(2\times10^{-6}\right)\left(\frac{2}{10}\right)\right]\left[\frac{100\times10^{-6}}{2\times8.85\times10^{-12}}\right]\left(\frac{1}{2}\right)$$

$$= \frac{10}{8.85} = 1.12\,\text{Nm}$$

45. Considering the Bohr model of hydrogen like atoms, the ratio of the ratio of the radius 5th orbit of the electron in Li^{2+} and He^{+} is

(1) $\frac{3}{2}$ (2) $\frac{4}{9}$

(3) $\frac{9}{4}$ (4) $\frac{2}{3}$

Ans. **(4)**

Sol. $r = r \cdot \frac{n^2}{2}$

for Li^{2+}

$r_5 = r \cdot \frac{25}{3}$

for He^{+}

$r_5 = r \cdot \frac{25}{2}$

$\therefore \frac{r_{Li^{2+}}}{r_{He^{+}}} = \frac{2}{3}$

SECTION-B

46. A circular ring and a solid sphere having same radius roll down on an inclined plane from rest without slipping. The ratio of their velocities when reached at the bottom of the plane is $\sqrt{\frac{x}{5}}$ where x = _____.

Ans. **(4)**

Sol. Applying Mechanical Energy conservation :

$k_i + U_i = k_f + U_f$

$\Rightarrow 0 + Mgh = \frac{1}{2}mv^2\left(1+\frac{k^2}{R^2}\right)+0$

$\Rightarrow V = \sqrt{\frac{2gh}{1+\frac{k^2}{R^2}}}$

So Ratio of velocities

$\frac{V_{Ring}}{V_{solids\ sphere}} = \sqrt{\frac{1+\frac{2}{5}}{1+1}} = \sqrt{\frac{7}{10}}$

x = 3.5 Rounding off x = 4

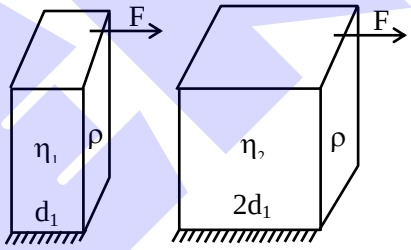
47. Two slabs with square cross section of different materials (1, 2) with equal sides (l) and thickness d_1 and d_2 such that $d_2 = 2d_1$ and $l > d_2$. Considering lower edges of these slabs are fixed to the floor, we apply equal shearing force on the narrow faces. The angle of deformation is $\theta_2 = 2\theta_1$. If the shear moduli of material 1 is 4×10^9 N/m^2, then shear moduli of material 2 is $x \times 10^9$ N/m^2, where value of x is ____.

Ans. **(1)**

Sol. Deformation angle

$2\theta_1 = \theta_2$

$\Rightarrow 2\frac{\sigma_1}{\eta_1} = \frac{\sigma_2}{\eta_2}$



$\Rightarrow 2\left(\frac{F}{\ell d_1 \eta_1}\right) = \frac{F}{\ell d_2 \eta_2}$

$\Rightarrow \eta_2 = \frac{\eta_1}{4} = 1\times10^9 \Rightarrow x = 1$

48. Distance between object and its image (magnified by $-\frac{1}{3}$) is 30 cm. The focal length of the mirror used is $\left(\frac{x}{4}\right)$ cm,

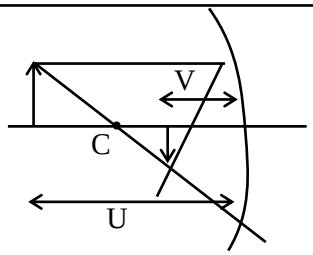
where magnitude of value of x is _____.

Ans. **(45)**

Sol. $M = -\frac{1}{3}$

$-\frac{-V}{-U} = \frac{-1}{3} \Rightarrow V = \frac{U}{3}$

Distance b/w object and image :



$U - V = 30$

$U - \frac{\mu}{3} = 30$

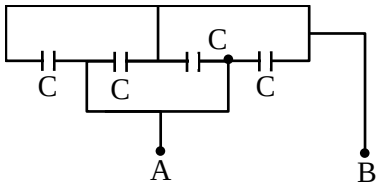
$\Rightarrow U = 45 \quad V = 15$

$\frac{1}{f} = \frac{1}{V} + \frac{1}{U} = -\frac{1}{15} - \frac{1}{45}$

$\Rightarrow F = \frac{45}{4}$

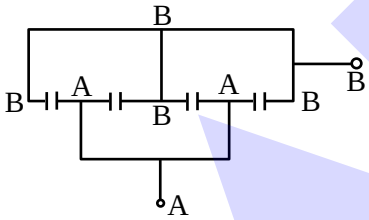
$x = 45$

49. Four capacitor each of capacitance 16μF are connected as shown in the figure. The capacitance between points A and B is : _____ (in μF).



Ans. (64)

Sol.



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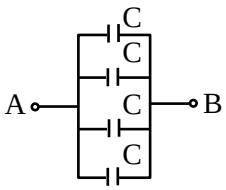
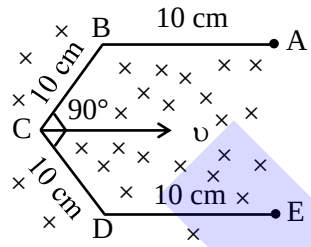


$C_{eq} = 4C = 64$

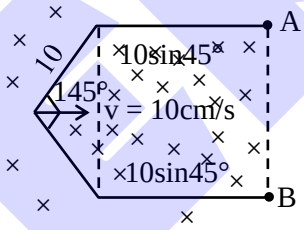
50. Conductor wire ABCDE with each arm 10 cm in length is placed in magnetic field of $\frac{1}{\sqrt{2}}$ Tesla, perpendicular to its plane. When conductor is pulled towards right with constant velocity of 10 cm/s, induced emf between points A and E is _____ mV.



$B = \frac{1}{\sqrt{2}}$ Tesla

Ans. (10)

Sol.



As field is uniform we can replace the bent wire with straight wire from A to B.

So EMF :

$\varepsilon = Bv\ell_{AB}$

$= \frac{1}{\sqrt{2}} \times \frac{10\text{cm}}{5} \times 2(10\sin 45°)\text{cm}$

$\varepsilon = 10$ mV

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