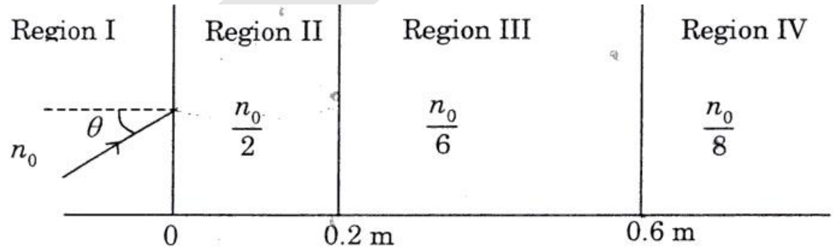
IITJEE-2008 Physics Paper - II

PART - II (PHYSICS)

SECTION - I

23. A light beam is traveling from Region *I* to Region *IV* (Refer Figure). The refractive index in Regions *I*, *II*, *III* and *IV* are n_0, $n_0 / 2$, $n_0 / 6$ and $n_0 / 8$, respectively. The angle of incidence θ for which the beam just misses entering Region *IV* is



(A) $\sin^{-1}(3/4)$ (B) $\sin^{-1}(1/8)$ (C) $\sin^{-1}(1/4)$ (D) $\sin^{-1}(1/3)$

23. **(B)** θ_1: angle of incidence at interface of II & III

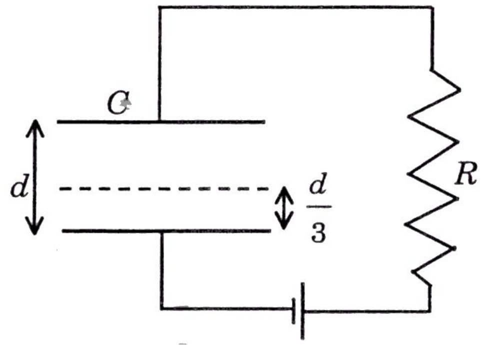
θ_2: angle of incidence at interface of III & IV. $(\sin\theta / \sin\theta_1) = (n_o / 2) / n_o$

$\Rightarrow \sin\theta_1 = 2\sin\theta$ and $(\sin\theta_1 / \sin\theta_2) = (n_o / 6) / (n_o / 2) = 3 \sin\theta_1 = 6 \sin\theta$

also θ_2: $C_{IV, III} \Rightarrow \sin\theta_2 = (n_o / 8) / (n_o / 6) = 3 / 4$ $\Rightarrow 3/4 = 6\sin\theta$

$\Rightarrow \theta = \sin^{-1}(1/8)$

24. A parallel plate capacitor *C* with plates of unit area and separation *d* is filled with a liquid of dielectric constant $K = 2$. The level of liquid is $d/3$ initially. Suppose the liquid level decreases at a constant speed *V*, the time constant as a function of time *t* is



(A) $6\varepsilon_0 R / 5d + 3Vt$ (B) $(15d + 9Vt)\varepsilon_0 R / 2d^2 - 3dVt - 9V^2t^2$

(C) $6\varepsilon_0 R / 5d - 3Vt$ *(D)* $(15d + 9Vt)\varepsilon_0 R / 2d^2 + 3dVt - 9V^2t^2$

24. (A) $C_1 = \varepsilon_0 / \{(2d/3) + Vt\} = 3\varepsilon_0 / (2d + 3Vt)$

and $C_2 = 2\varepsilon_0 / \{(d/3) - Vt\} = 6\varepsilon_0 / (d - 3Vt)$

$(1/C) = (1/C_1) + (1/C_2) \Rightarrow C = 6\varepsilon_0 / (5d + 3Vt)$

$\tau = RC =$ $\mathbf{6R\varepsilon_0 / (5d + 3Vt)}$

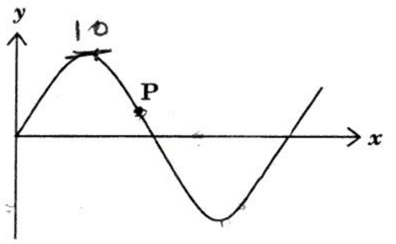
25. A vibrating string of certain length l under a tension T resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats per second when excited along with a tuning fork of frequency n. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity if sound in air to be 340 m/s, the frequency n of the tuning fork in Hz is

(A) 344 (B) 336 (C) 117.3 (D) 1109.3

25. **(A)** $f_s = f_{ac} = (3/4l_{ac})v = 340$ Hz , $f_s \sim n = 4$ and $f_s \propto \sqrt{T/\mu}$,

$\therefore f_s^1 > f_s,\ f_s^1 \sim n = 2 \Rightarrow n > f_s \Rightarrow n =$ **344 Hz**

26. A transverse sinusoidal wave moves along a string in the positive x–direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap–shot of the wave is shown in figure. The velocity of point P when its displacement is 5 cm is



(A) $\sqrt{3}\pi / 50\ \hat{j}$ m / s (B) $-\sqrt{3}\pi / 50\ \hat{j}$ m / s

(C) $\sqrt{3}\pi / 50\ \hat{j}$ m / s (D) $-\sqrt{3}\pi / 50\ \hat{j}$ m / s

26. **(A)** P executes SHM & $y_p = A/2 \Rightarrow A\sin(\omega t + (\phi/2)) = \pi/6$

$\therefore v = A\omega\cos(\omega t + \phi) = \sqrt{3}A\omega/2 =$ $\mathbf{(\sqrt{3}\pi/50)\ j\ ms^{-1}}$

shortcut : *P* has velocity along + *y* direction therefore only (A) is correct

27. A radioactive sample $S1$ having an activity of $5\mu Ci$ has twice the number of nuclei as another sample $S2$ which has an activity of $10\mu Ci$. The half lives of $S1$ and $S2$ can be

(A) 20 years and 5 years, respectively

(B) 20 years and 10 years, respectively

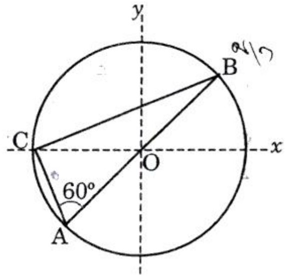
(C) 10 years each

(D) 5 years each

27. **(A)** $N_{S_1} = 2N_{S_2}$ and $A_{S_1} = \frac{1}{2} A_{S_2}$, also $N = N_o e^{-\lambda t} \Rightarrow A = dN/dt = -\lambda N_o$

$A_{S_1}/A_{S_2} = (\lambda_{S_1}/\lambda_{S_2}) \cdot (N_{S_1}/N_{S_2}) = (T_{S_2}/T_{S_1}) \cdot (N_{S_1}/N_{S_2})$, $\mathbf{(T_{S_1}/T_{S_2}) = 4}$

28. Consider a system of three charges $q / 3$, $q / 3$ and $-2q / 3$ placed at points A, B and C, respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle $CAB = 60°$



(A) The electric field at point O is $q / 8\pi\varepsilon_0 R^2$ directed along the negative x-axis

(B) The potential energy of the system is zero

(C) The magnitude of the force between the charges at C and B is $q^2 / 54\pi\varepsilon_0 R^2$

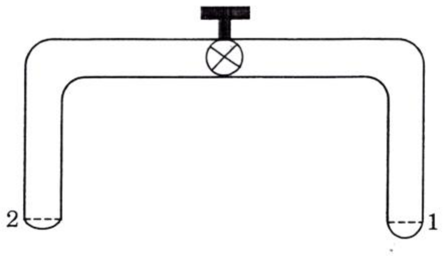
(D) The potential at point O is $q / 12\pi\varepsilon_0 R$

28. **(C)** $\vec{E}_O = \vec{E}_{OA} + \vec{E}_{OB} + \vec{E}_{OC} = \vec{E}_{OC}$ towards C

$\Rightarrow E_O = q / (6\pi\varepsilon_0 R^2)$ and $F_{BC} = K\{2(q / 3)^2\} / (BC)^2$

$= K (2q^2 / 9) / (\sqrt{3}R)^2 = \boldsymbol{q^2 / 54\pi\varepsilon_0 R^2}$

29. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closedposition. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve.



(A) air from end 1 flows towards end 2. No change in the volume of the soap bubbles

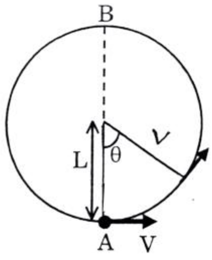
(B) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases

(C) no change occurs

(D) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases

29. **(B)** $R_2 > R_1 \Rightarrow P_2 < P_1$, $\therefore$ Air flows from 1 to 2 and pressure at 1 decreases hence its R incerases; $\therefore$ Volume of soap bubble at end 1 decreases.

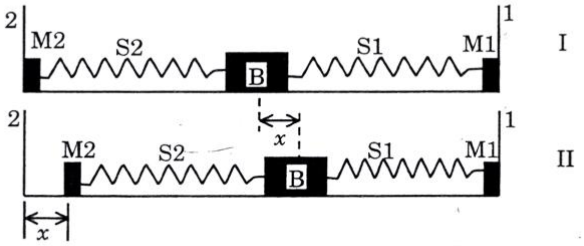
30. A bob of mass M is suspended by a massless string of length L. The horizontal velocity V at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies



(A) $\theta = \pi / 4$ (B) $\pi / 4 < \theta < \pi / 2$
(C) $\pi / 2 < \theta < 3\pi / 4$ (D) $3\pi / 4 < \theta < \pi$

30. (D) $V = \sqrt{(5gL)}$ and $\frac{1}{2} mv^2 = \frac{1}{2} m(v^2 / 4) + mgL(1 - \cos\theta)$ $\Rightarrow$ **$\cos\theta = -7/8$**

31. A block (B) is attached to two unstretched springs $S1$ and $S2$ with spring constants k and $4k$, respectively (see figure I). The other ends are attached to identical supports $M1$ and $M2$ not attached to the walls. The springs and supports have negligible mass. There is no friction anywhere. The block B is displaced towards wall 1 by a small distance x (figure II) and released. The block returns and moves a maximum distance y towards wall 2. Displacement x and y are measured with respect to the equilibrium position of the block B. The ratio y / x is



(A) 4 (B) 2 (C) 1 / 2 (D) 1 / 4

31. (**C**) At both positions there are only potential energy & energy conservations is applicable.
$U_i = U_1 = \frac{1}{2}(kx^2)$ and $U_f = U_2 = \frac{1}{2}(4k)x^2$ and $U_i = U_f$, $\therefore (y / x) =$ **1 / 2**

SECTION – II
Reasoning Type

32. STATEMENT – 1
It is easier to pull a heavy object than to push it on a level ground.
and
STATEMENT – 2
The magnetude of frictional force depends on the nature of the two surfaces in contact.
(A) STATEMENT – 1 is True, STATEMENT– 2 is True; STATEMENT–2 is a correct explanation for STATEMENT - 1.
(B) STATEMENT - 1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a cor rect explanation for STATEMENT-1
(C) STATEMENT - 1 is True, STATEMENT-2 is False
(D) STATEMENT-1is False, STATEMENT-2 is True

32. (**B**) During pulling normal reaction (*N*) and hence friction (*f*) decreases whereas during pushing *N* and hence *f* increases.

33. STATEMENT – 1

For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary.

and

STATEMENT – 2

If the observer and the object are moving at velocities $\vec{V}_1$ and $\vec{V}_2$ respectively with reference to a laboratory frame, the velocity of the object with respect to the observeris $\vec{V}_2 - \vec{V}_1$.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1.

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT–1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

33. (**B**) $\vec{V}_{2,1} = \vec{V}_2 - \vec{V}_1$

34. STATEMENT – 1

The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as a core inside the coil.

and

STATEMENT – 2

Soft iron has a high magnetic permeability and cannot be easily magnetized or demagnetized.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1.

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT–1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

34. (**C**) Sensitivity = $\theta / i = nAB / K$

$\therefore$ $(\theta / 2) \propto B$ and soft iron core can be easily magnetised or demagnetised on applying or removing magnetic field.

35. STATEMENT – 1

For practical purposes, the earth is used as a reference at zero potential in electrical circuits.

and

STATEMENT – 2

The electrical potential of a sphere of radius *R* with charge *Q* uniformaly distributed on the surface is given by $Q / 4\pi\varepsilon_0 R$.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1.

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is NOT a correct explanation for STATEMENT–1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

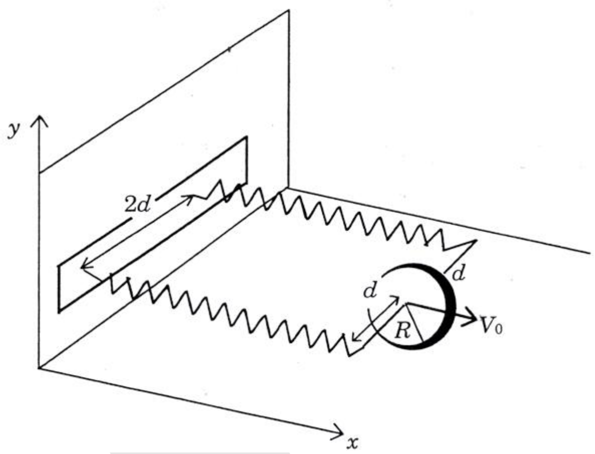
35. (B) $V_{\mathbf{earth}} = (Q / 4\pi\varepsilon_0 R_{\mathbf{earth}})$ is never zero.

SECTION – III

Linked Comprehension Type

Paragraph for Question Nos. 36 to 38

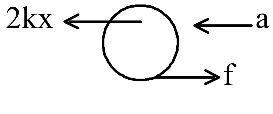
A uniform thin cylindrical disk of mass M and radius R is attached to two identical massless springs of spring constant k which are fixed to the wall as shown in the figure. The springs are attached to the axle of the disk symmetrically on either side at a distance d from its centre. The axle is massless and both the springs and the axle are in a horizontal plane. The unstretched length of each spring is L. The disk is initially at its equilibrium position with its centre of mass (CM) at a distance L from the wall. The disk rolls without slipping with velocity $\vec{V}_0 = V_0\hat{i}$. The coefficient of friction is μ.



36. The net external force acting on the disk when its centre of mass is at displacement x with respect to its equilibrium position is

(A) $-kx$ (B) $-2kx$ (C) $-2kx / 3$ (D) $-4kx / 3$

36. (**D**)



$2kx\ R = (3 / 2)\ MR^2 a / R$

$a = -4kx / 3M \Rightarrow F_{ext} = Ma = \mathbf{-4kx / 3}$

37. The centre of mass of the disk undergoes simple harmonic motion with angular frequency ω equal to

(A) $\sqrt{k / M}$ (B) $\sqrt{2k / M}$ (C) $\sqrt{2k / 3M}$ (D) $\sqrt{4k / 3M}$

37. **(D)** $\omega^2 = 4K / 3M$

38. The maximum value of V0 for which the disk will roll without slipping is

(A) $\mu g\sqrt{M / k}$ (B) $\mu g\sqrt{M / 2k}$ (C) $\mu g\sqrt{3M / k}$ (D) $\mu g\sqrt{5M / 2k}$

38. **(C)** $2Kx - f = Ma$

$f = Ma / 2 \leq \mu Mg$

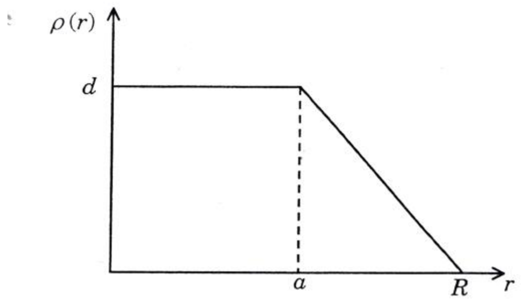
$\omega^2 A \leq 2\mu g$

$\omega^2(V_0 / \omega) \leq 2\mu g$

$V_0 \leq \mathbf{\mu g\sqrt{(3M / K)}}$

Paragraph for Question Nos. 39 to 41

The nuclear charge (Ze) is non-uniformaly distributed within a nucleus of radius R. The charge density ρ (r) [charge per unit volume] is dependent only on the radial distance r from the centre of the nucleus as shown in figure. The electric field is only along the radial direction.



39. The electric field at $r = R$ is

(A) independent of a (B) directly proportional to a

(C) directly proportional to a^2 (D) inversely proportional to a

39. **(A)** $E.4\pi R^2 = Ze / \varepsilon_0$

40. For $a = 0$, the value of d (maximum value of ρ as shown in the figure) is

(A) $3Ze / 4\pi R^3$ (B) $3Ze / \pi R^3$ (C) $4Ze / 3\pi R^3$ (D) $Ze / 3\pi R^3$

40. (**B**) Ze = $\int_O^R \frac{d(R-r)}{R} 4\pi r^2 dr$

$\Rightarrow$ d = **3Ze / πR³**

41. The electric field within the nucleus is generally observed to be linearly dependent on r. This implies

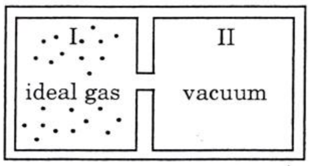
(A) $a = 0$ (B) $a = R / 2$ (C) $a = R$ (D) $a = 2R / 3$

41. (**C**) For a uniformly charged solid sphere, $E \propto r$, $O \le r \le R$

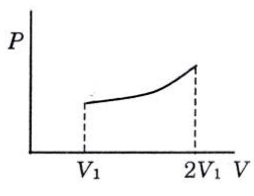
SECTION – IV

42. Column I contains a list of processes involving expansion of an ideal gas. Match this with Column Ii describing the thermodynamic change during this process. In dicate your answer by darkening the appropriaste bubbles of the 4 × 4 matrix given in the ORS.

Column I	**Column II**
(A) An insulted container has two chambers sepasrated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The V\valve is opened.	(p) The temperature of the gas decreases



(B) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto 1 / V_2$, where V is the volume of the gas	(q) The temperature of the gas increases or remains constant
(C) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto 1 / V^{4/3}$, where V is its volume	(r) The gas loses heat
(D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph	(s) The gas gains heat



42. A [q] $\Delta Q = \Delta W = \Delta V = 0$

B [p,r] $(P_0, V_0, T_0) \rightarrow (P_0 / 4, 2V_0, T_0 / 2)$
$\Delta V < 0$
$\Delta W > 0$
$\therefore |\Delta W| < |\Delta V|$
Hence $\Delta Q < 0$

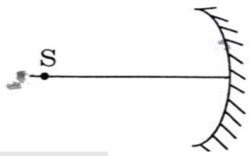
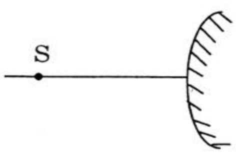
C [p, s] $(P_0, V_0, T_0) \rightarrow (P_0 / 2^{4/3}, 2V_0, T_0 / 2^{1/3})$
$\Delta V < 0$

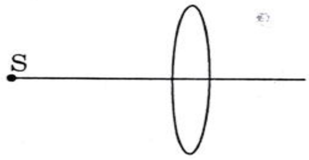
$$\Delta W = \int_{vi}^{vf} pdV > 0$$

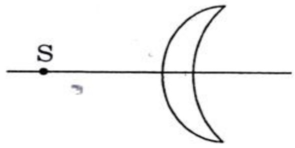
$|\Delta W| > |\Delta U|$
$\therefore \Delta Q > 0$

D [q,s] $P(\uparrow) \quad V(\uparrow) \Rightarrow T(\uparrow)$
$\therefore \Delta W > 0$
also $\Delta U > 0$
$\therefore \Delta Q > 0$

43. An optical component and an object S placed along its optic axis are given in **Column I**. The distance between the object and the component can be varied. The properties of images are given in **Column II**. Match all the properties of images from **Column II** with the appropriate components given in **Column I**. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS.

Column I	**Column II**
(A) 	(p) Real image
(B) 	(q) Virtual image

(C)  (r) Magnified image

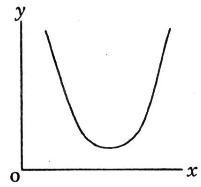
(D)  (s) Image at infinity

43. A [p, q, r, s]
    B [q]
    C [p, q, r, s]
    D [p, q, r, s]

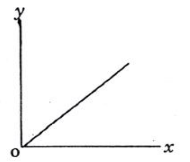
44. **Column I** gives a list of possible set of parameters measured in some experiments. The variations of the parameters in the form of graphs are shown in **Column II**. Match the set of parameters given in **Column I** with the graphs given in **Column II**. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS.

Column I **Column II**

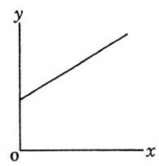
(A) Potential energy of a simple pendulum (y axis) as a function of displacement (x axis)

(p) 

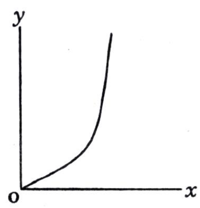
(B) Displacement (y axis) as a function of time (x axis) for a one dimensional motion at zero or constant acceleration when the body is moving along the positive x - direction

(q) 

(C) Range of a projectile (y axis) as a function of its velocity (x axis) when projected at a fixed angle

(r) 

(D) The square of the time period (y axis) of a sikmple pendulum as a function of its length (x axis)

(s) 

44.	A	[p, s]	P. E $\propto x^2$
	B	[q, r, s]	$S = vt \quad (a = 0)$
			$S = vt + 1/2\ at^2\ (a \neq 0)$
	C	[s]	$R \propto u^2$
	D	[q]	$T^2 \propto L$