PHYSICS

BOOKS - JEE ADVANCED PREVIOUS YEAR

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PHYSICS

1. A current carrying wire heats a metal rod. The wire provides a constant power P to the rod. The metal rod is enclosed in an insulated container. It is observed that the temperature (T) in the metal rod change with the (t) as $T(t) = T_0\left(1 + \beta t^{1/4}\right)$ where β is a constant with appropriate dimension of temperature. the heat capacity of metal is :

A. $\dfrac{4P\left(T(t) - T_0\right)^3}{\beta^4 T_0^4}$

B. $\dfrac{4P\left(T(t) - T_0\right)^2}{\beta^4 T_0^3}$

C. $\dfrac{4P\left(T(t) - T_0\right)^4}{\beta^4 T_0^5}$

D. $\dfrac{4P\left(T(t) - T_0\right)}{\beta^4 T_0^2}$

Answer: A

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2. In a capillary tube of radius 0.2 mm the water rises up to height of 7.5 cm with angle of contact equal to zero. If another capillary with same radius but of different material dipped in the same liquid. The height of water raised in capillary will be, if angle of contact becomes 60°

A. 7.5 cm

B. 15 cm

C. 3.75 cm

D. 30 cm

Answer: C

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3. A sample of $._{19}K^{40}$ disintegrates into two nuclei Ca & Ar with decay constant $\lambda_{Ca} = 4.5 \times 10^{-10} S^{-1}$ and $\lambda_{Ar} = 0.5 \times 10^{-10} S^{-1}$ respectively. The time after which 99% of $._{19}K^{40}$ gets decayed is

A. $6.2 \times 10^{9}\text{sec}$

B. $9.2 \times 10^{9}\text{sec}$

C. $7.2 \times 10^{9}\text{sec}$

D. $4.2 \times 10^{9}\text{sec}$

Answer: B

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4. Consider a spherical gaseous cloud of mass density $\rho(r)$ in a free space where r is the radial distance from its centre. The gaseous cloud is made of particle of equal mass m moving in circular orbits about their common centre with the same kinetic energy K. The force acting on the particles is their mutual gravitational force. If $\rho(r)$ is constant with time. the particle number density n(r)=$\rho(r)$ /m is : (G=universal gravitational constant)

A. $\dfrac{3K}{\pi r^2 m^2 G}$

B. $\dfrac{K}{2\pi r^2 m^2 G}$

C. $\dfrac{K}{\pi^2 r^2 G}$

D. $\dfrac{K}{6\pi r^2 m^2 G}$

Answer: B

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5. A thin spherical insulating shell of radius R caries a uniformly distributed charge such that the potential act its surface is V_0. A hole with small area $\alpha 4\pi R^2 (\alpha < < 1)$ is made in the shell without effecting the rest of the shell. Which one of the following is correct.

A. The magnitude of $\vec{E}$ at a point located on a line passing through the hole and shell's centre on a distance 2R from the centre of spherical shell will be produced by $\frac{\alpha V_0}{2R}$

B. Potential at the centre of shell is reduced by $2\alpha v0$.

C. The magnitude of $\vec{E}$ at the centre of shell reduced by $\frac{\alpha V_0}{2R}$

D. The ratio of potential at the centre of the shell to that of the point at $\frac{1}{2}$ R from centre towards the hole will be $\frac{1 - \alpha}{1 - 2\alpha}$

Answer: D

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6. A charged shell of radius R carries a total charge Q. Given ϕ as the flux of electric field through a closed cylindrical surface of height h, radius r & with its centre same as that of the shell. Here centre of cylinder is a point on the axis of the cylinder which is equidistant from its top & bottom surfaces. which of the followintg are correct.

A. if hgt2R & rgtR then $\phi = \frac{Q}{\varepsilon_0}$

B. If $h < \frac{8R}{5}$ & $r = \frac{3R}{5}$ then $\phi = 0$

C. If h gt 2R & $r = \frac{4R}{5}$ then $\phi = \frac{Q}{5\varepsilon_0}$

D. If hgt2R & $r = \frac{3R}{5}$ then $\phi = \frac{Q}{5\varepsilon_0}$

Answer: A::B::D

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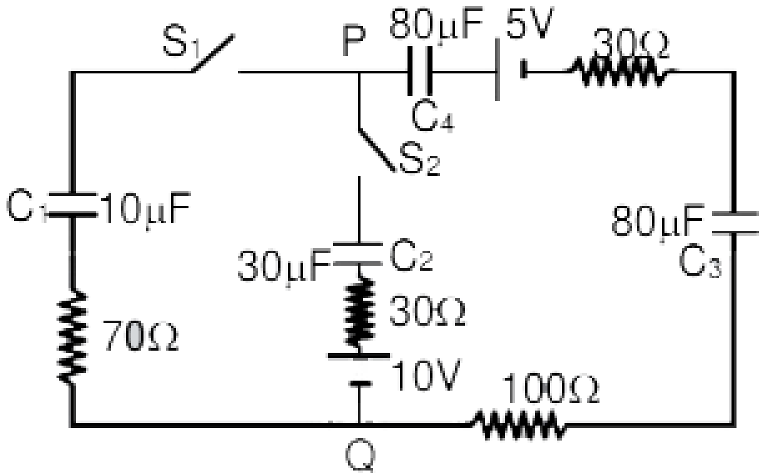
7. Which statements is/are correct



A. At time t=0, the S_1 is closedinstantaneous current in the closed circuit will 25 mA

B. The key S_1 is kept closed for long time such that capacitors are fully charged. Now key S_2 is closed at this time the instantaneous current across 30Ω resistor between P & Q will be 0.2 A

C. If key S_1 is kept closed for long time such that capacitors are fulley charged the voltage across C_1 will be 4V.

D. IF S_1 is kept closed for long time such that capacitors are fully charged the voltage difference between P & Q will be 10V.

Answer: A::C

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8. A galvanometer of resistance 10 ohm and maximum current of $2\mu A$ is converted into voltmeter of range 100mV and when converted into ammeter then range is 1mA. When these voltmeter and ammeter are connected by a (ideal) battery is series with a resistance of $R = 1000\Omega$, then

A. measure value of R is between 979Ω and 996Ω

B. resistance of voltmeter $10^5\Omega$

C. shunt resistance is $20m\Omega$

D. If the ideal battery is replaced by non ideal battery with internal resistance of 5Ω then R will be $gt1000\Omega$

Answer: A::C

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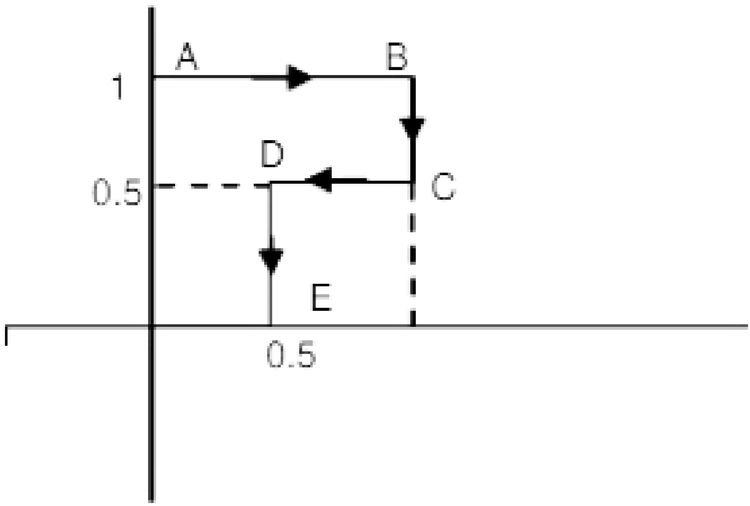
9. Conducting wire of parabolic shape, initially $y = x^2$ is moving with velocity $\vec{V} = v_0\hat{i}$ in a non-uniform magnetic field $\vec{B} = B_0\left(1 + \left(\frac{y}{L}\right)^\beta\right)\hat{k}$ as shown in figure. If V_0, B_0L and B are +ve constant $\Delta\phi$ is potential difference develop between the ends of wire, then correct statements (s) is/are



A. $|\Delta\phi| = \frac{1}{2}B_0V_0L$ for $\beta = 0$

B. $|\Delta\phi| = \frac{4}{3}B_0V_0L$ for $\beta = 2$

C. $|\Delta\phi|$ is proportional to the length of wire projected on y-axis

D. $|\Delta\phi|$ remains same if the parabolic wire is replaced by a straight wire, y=x, initially of length $\sqrt{2}l$

Answer: B::C::D

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10. If in a hypothetical system if the angular momentum and mass are dimensionless. Then which of the following is true.

A. The linear momentum varies as L^{-1}

B. The energy varies as L^{-2}

C. The power varies as L^{-4}

D. The force varies as L^{-5}

Answer: A::B::C

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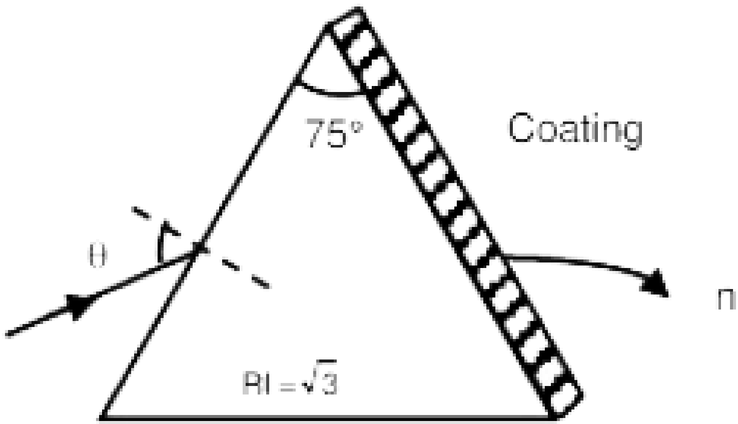
11. V-T diagram for n mol monoatomic gas is given below



Choose the correct statement"

A. $\left|\frac{\Delta Q_{1 \to 2}}{\Delta Q_{3 \to 4}}\right| = \frac{1}{2}$

B. $\left|\frac{\Delta Q_{1 \to 2}}{\Delta Q_{2 \to 3}}\right| = \frac{5}{3}$

C. Work done in cyclic process is $\Delta W = \frac{nRT_0}{2}$

D. There are only adiabatic and isochoric processes are involved

Answer: B::C

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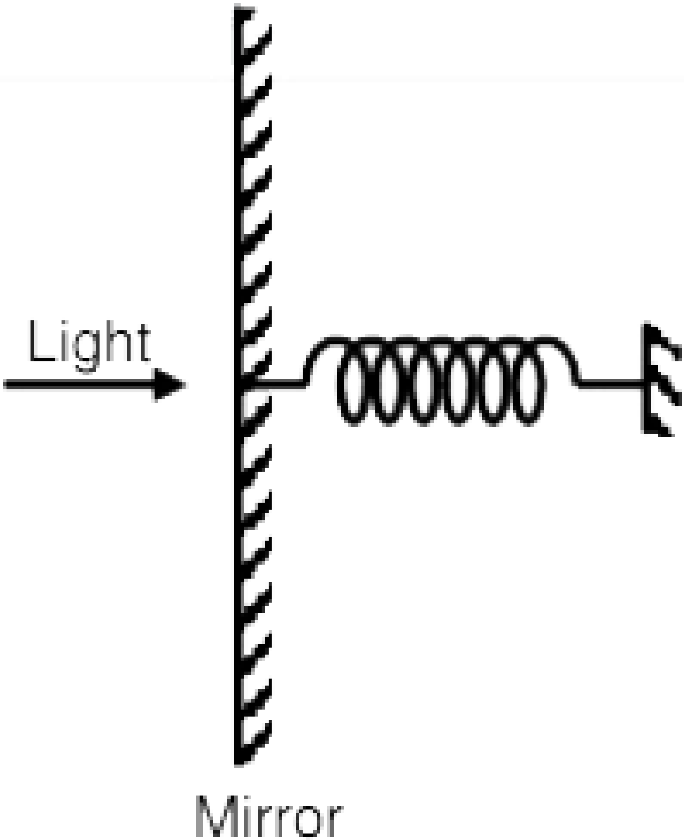

12.

Apparent depth for point object x in all three cases are $H_1, H_2 \& H_3$ respectively when seen from above given $H = 30cm, n = 1.5 \& R = 3m$, then

A. 0.8 lt H_2 - H_1lt0.9

B. $H_2 > H_1$

C. $H_2 > H_3$

D. $H_3 > H_1$

Answer: B::C

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13. Consider the following nuclear fission reaciton

$\cdot_{88}Ra^{226} \rightarrow \cdot_{86}Rn^{222} + \cdot_{2}He^{4} + Q$

In the fission reaction. Kinetic energy of α-particle is 4.44 MeV. Find the energy emitted as γ-radiation in keV in this reaction.

$m\left(\cdot_{88}Ra^{226}\right) = 226.005$ amu

$m\left(\cdot_{86}Rn^{222}\right) = 222.000$ amu

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14. N dielectics are introduced in series in a capacitor of thickness D. Each dielectric have width d=D/N & dielectric constant of m^{th} dielectric is given by $K_m = K(1 + m/N)$. [Ngtgt10^3, Area of plates =A] . Net capacitance is given by $\frac{K\varepsilon_0 A}{\alpha D \ln 2}$. find value of α

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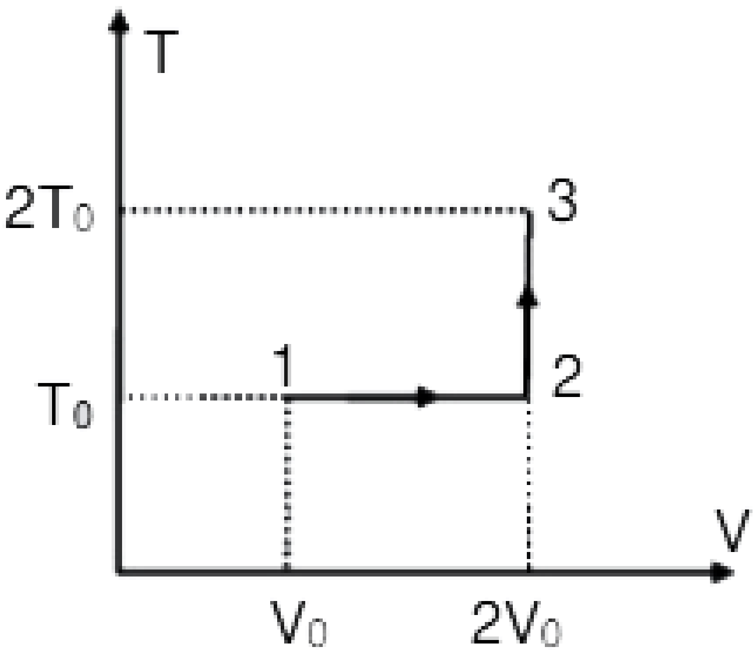
15. If at angle $\theta$the light takes maximum time to travel in optical fiber. Then the maximum time is $x \times 10^{-8}$, calculate x.



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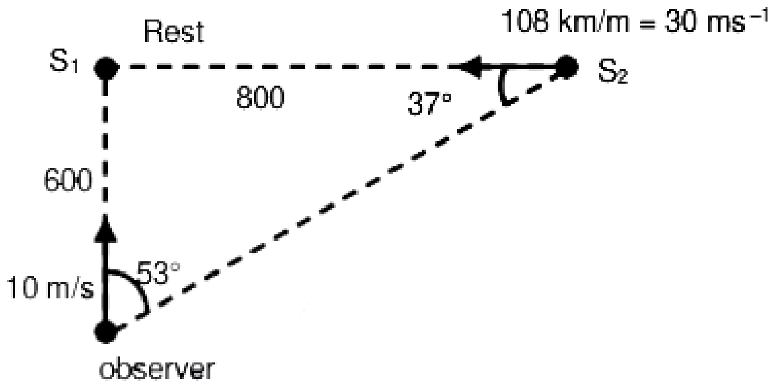
16. The sources S_1 is at rest. The observer and the source S_2 are moving towards S_1 as shown in figure. The roof beats observed by the observer if both sources have frequency 120 Hz and speed of sound 330m/s in is



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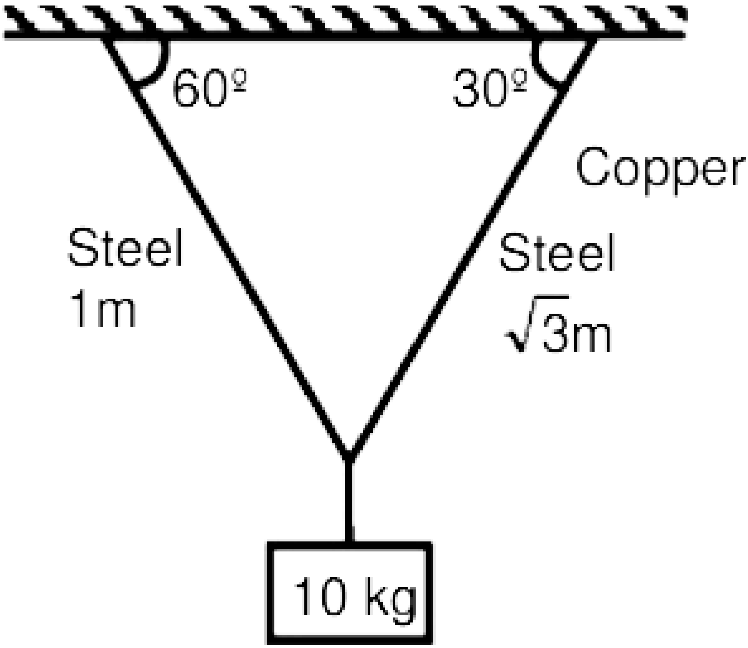
17. A weight of 100N is suspended by two wires made by steel and copper as shown in figure length of steel wire is 1m and copper wire is $\sqrt{3}m$. Find ratio of change in length of copper wire (Δl_c) to change in length of steel wire (Δl_s). given Young's modulus

$Y_{\text{Steel}} = 2 \times 10^{11} N/m^2, Y_{\text{Copper}} = 1 \times 10^{11} N/m^2$



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18. An optical bench, to measure the focal length of lens, is 1.5 m long and on the bench marks are with spacing $\frac{1}{4} cm$. Now a lens is placed at 75 cm and pin type object is placed at 45 cm marks on the bench. If its image is formed at 135 cm find maximum possible error in calculation of focal length.

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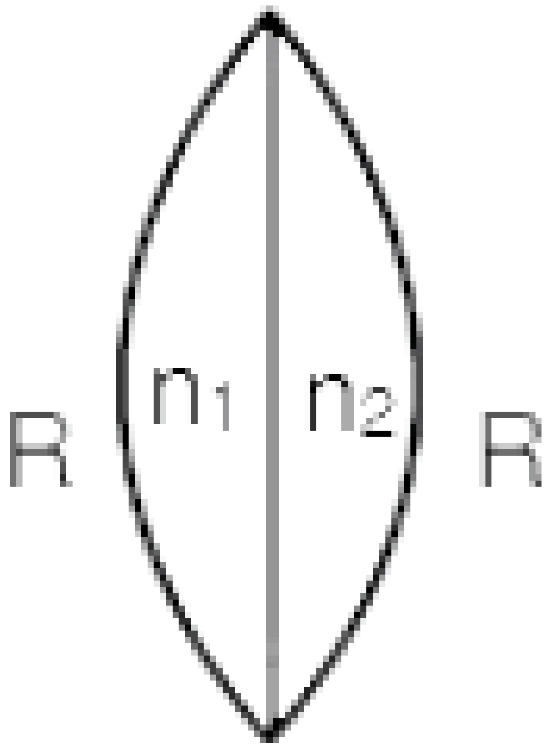
19. Consider two palne convex lanse of same radius of curvature and refrective index n_1 and n_2 respectively. Now consider two cases :



Case - I : When $n_1 = n_2 = n$, then equivalent focal length of length is f_0

Case - II : When $n_1 = n, n_2 = n + \Delta n$, then equilivant focal length of lens is $f = f_0 + \Delta f_0$

Then correct options are :

A. If $\Delta n / n > 0$, then $\Delta f_0 / f_0 < 0$

B. $\left|\Delta f_0 / f_0\right| < \left|\Delta n / n\right|$

C. If $n = 1.5$, $\Delta n = 10^{-3}$ and $f_0 = 20$ cm then $|\Delta f_0| = 0.02$ cm

D. If $\Delta n / n < 0$, then $\Delta f_0 / f_0 > 0$

Answer: A::C

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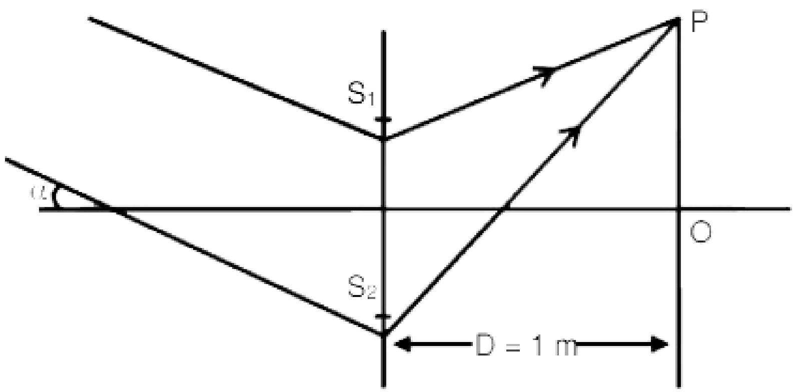
20. In YDSE monochromatic light of wavelength 600 nm incident of slits as shown in figure.



If $S_1S_2 = 3mm$, $OP = 11mm$ then

A. If $\alpha = \frac{0.36}{\pi}$ degree then destructive interface at point P

B. If $\alpha = \frac{0.36}{\pi}$ degree then constructive interfaces at point O

C. If $\alpha = 0$ then constructive interface at O

D. Fringe width depends an α

Answer: A::B::C

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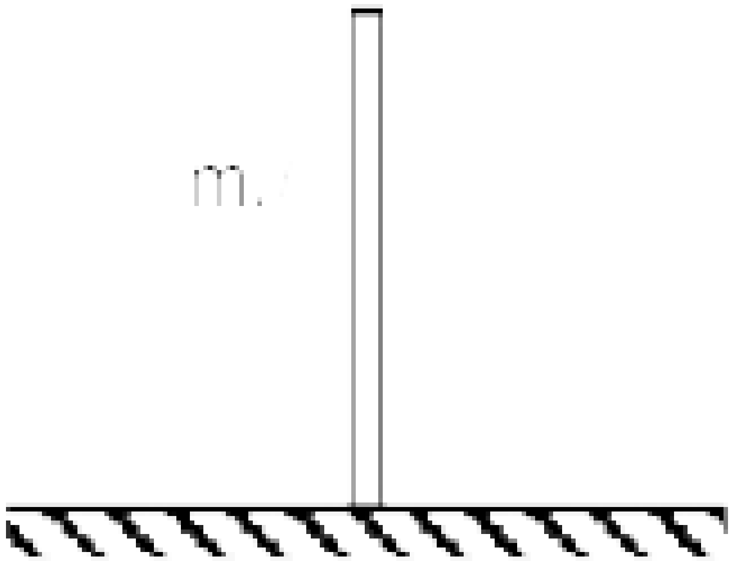
21. A uniform ridig rod of mass m & length l is released from vertical position on rough surface with sufficient friction for lower end not to slip as shown in figure. When rod makes angle 60° with vertical then find correct altrnatice/s



A. $\alpha = \frac{2g}{l}$

B. $\omega = \sqrt{\frac{3g}{2l}}$

C. $N = \frac{mg}{16}$

D. a_{radial} of centre $= \frac{3g}{4}$

Answer: B::C::D

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22. Monoatomic gas A having 5 mole is mixed with diatomic gas B having 1 mole in container of volume V_0. Now the volume of mixture is compressed to $\frac{V_0}{4}$ by adiabatic process. Initial pressure and temperature of ags mixture is P_0 and T_0. [given $2^{3.2} = 9.2$]

Choose correct option :

A. $._{\gamma mix} = 1.6$

B. Final pressure is between $9P_0$ and $10P_0$

C. $|W.D| = 13RT_0$

D. none of these

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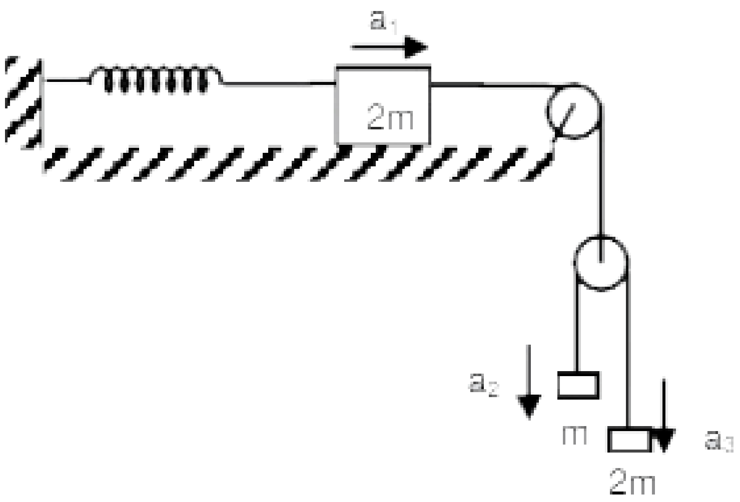
23. The given arrangement is released from rest when spring is in natural length. Maximum extension in spring during the motion is x_0. a_1, a_2 and

a_3 are accelerations of the blocks. Make the correct options



A. $a_2 - a_1 = a_1 - a_3$

B. $x_0 = \frac{4mg}{3k}$

C. Velocity of 2m connected to spring when elongation is $\frac{x_0}{2}$ is

$$v = \frac{x_0}{2}\sqrt{\frac{3k}{14m}}$$

D. acceleration a_1 at $\frac{x_0}{4}$ is $\frac{3kx_0}{42m}$

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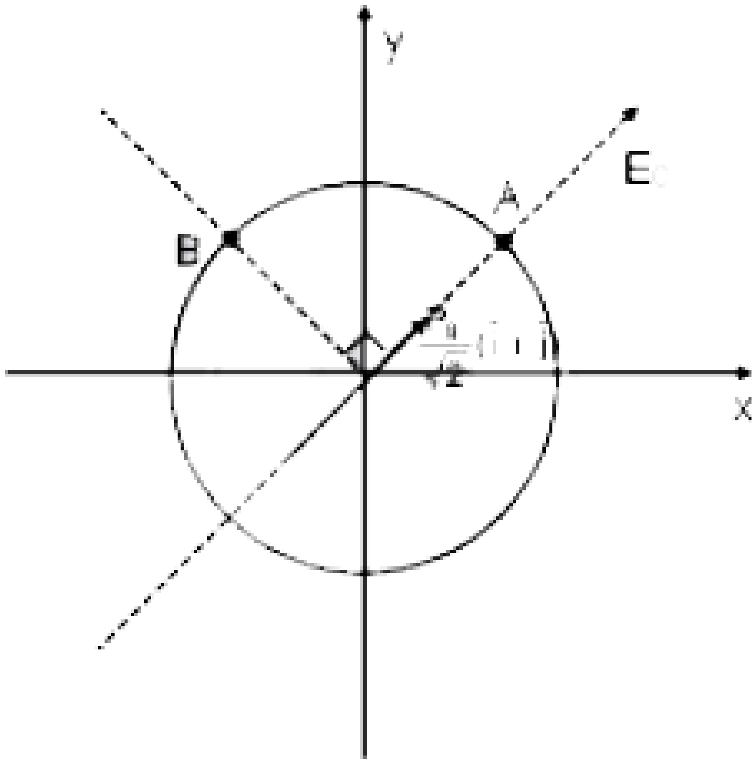
24. A dipole of Dipole moment $\vec{p} = \frac{p_0}{\sqrt{2}}(\hat{i} + \hat{j})$. Is placed at origin. Now a uniform external electrical filed at magnitude E_0 is applied along direction of dipole. Two points A and B are lying on a equipotential surface of radius R centered at origin. A is along axial position of dipole and B is along equatorial position. There correct option are :



A. Net electric field at point A is $3E_0$

B. Net electric field at point B is Zero

C. Radius of equatorial surface $R = \left(\frac{kp_0}{E_0}\right)^{1/3}$

D. Radius of equatorial surface $R = \left(\frac{\sqrt{2}kp_0}{E_0}\right)^{1/3}$

Answer: A::B::C

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25. A free hydrogen atom after absorbing a photon of wavelength λ_a gets excited from state n = 1 to n = 4. Immediately after electron jumps to n = m state by emitting a photon of wavelength λ_e. Let change in momentum of atom due to the absorption and the emission are ΔP_a and ΔP_e respectively. If $\lambda_a/\lambda_e = 1/5$. Which of the following is correct

A. m = 2

B. $\Delta P_a/\Delta P_e = 1/2$

C. $\lambda_e = 418nm$

D. Ratio of K.E. of electron in the state n = m to n= 1 is $1/4$

Answer: A::D

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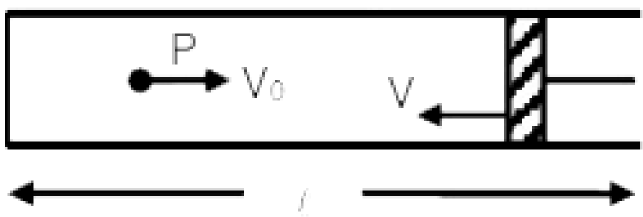
26. In a cyclinder a heavy piston is moving with speed v as shown diagram and gas is filled inside it. A gas molecule is moving with speed v_0 towards moving piston. Then which of the following is correct (Assume $v < < < < v_0 \frac{\Delta l}{l}$ and coillision is elastic)



A. change in speed after collision is 2V

B. change is speed after collision is $2v_0 \frac{\Delta l}{l}$

C. rate of collision is $\frac{V}{l}$

D. When piston is at $\frac{l}{2}$ its kinetic energy will be four times

Answer: A

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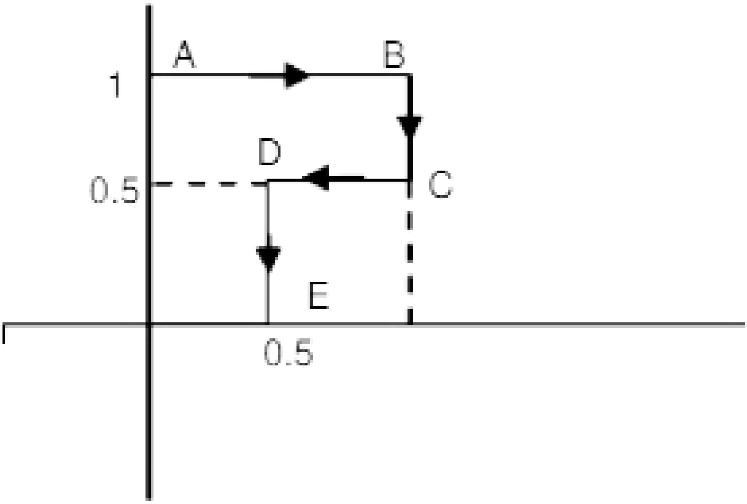
27. If $f = \alpha y\hat{i} + 2\alpha x\hat{j}$ calculate the work done if a particle moves along path as shown in (given $\alpha = 1$).



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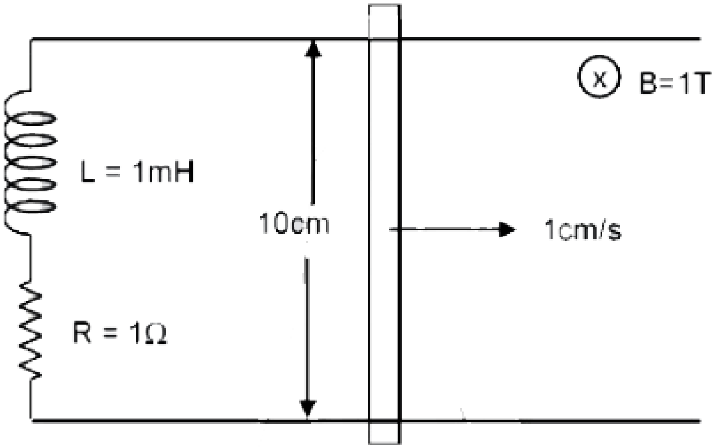
28. In a given circuit inductor of L = 1m H and resistance $R = 1\Omega$ are connected in series to ends of two parallel conducting rods as shown.

Now a rod of length 10 cm is moved with constant velocity of 1cm/s in magnetic field B=1T. If rod starts moving at t=0 then current in circuit after 1milisecond is $x = 10^{-3}A$. then value of x is : (given $e^{-1} = 0.37$)



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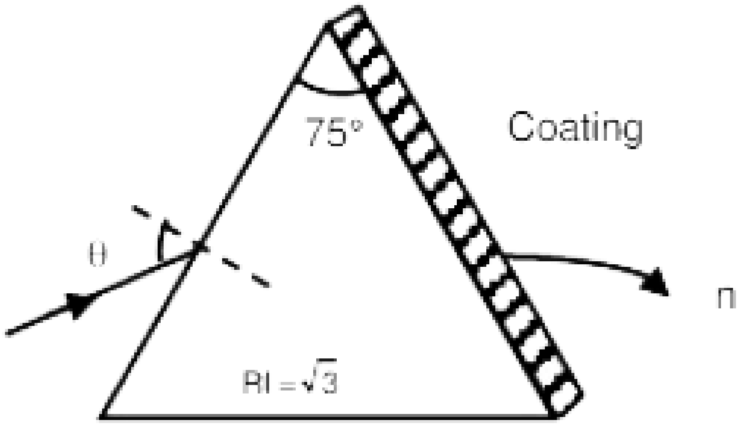
29. A prism is shown in the figure with prism angle 75° and refractive index $\sqrt{3}$. A light ray incidents on a surface at incident angle θ. Other face is coated with a medium of refractive index n. for $\theta \le 60^\circ$ ray suffers total internal reflection find value of n^2.



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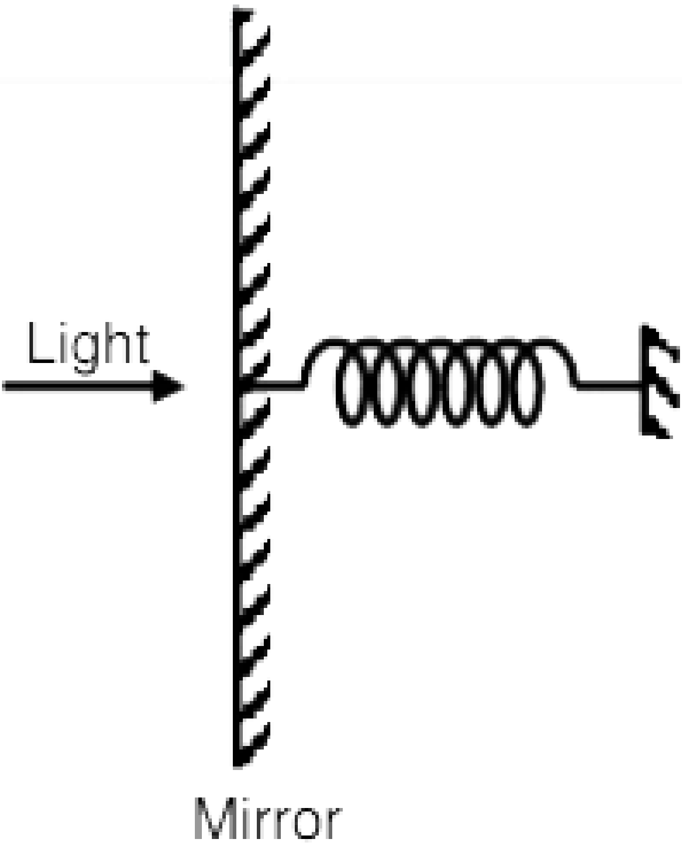
30. Perfectly reflecting mirror of mass M mounted on a spring consitute a spring mass system of angular frequency Ω such that $\frac{4\pi M\Omega}{h} = 10^{24}m^{-2}$ where h is plank constant. N photons of wavelength $\lambda = 8\pi \times 10^{-6}m$ strikes the mirror simultaneously at normal incidence such that the mirror gets displaced by 1 μm. if the value of N is $x \times 10^{12}$, then find value of x.



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31. A particle is projected with speed v_0 at an angle $\theta\left(\theta \neq 90^\circ\right)$ with horizontal and it bounce at same angle with horizontal. If average velocity of journey is $0.8v_0$ where v_0 is average velocity of first projectile then α is

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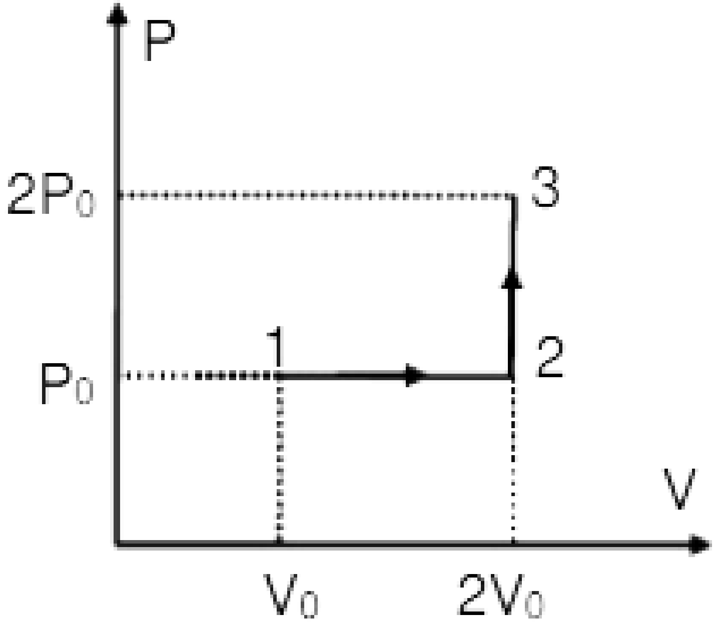
32. A sample of monoatomic gas undergoes different thermodynamic process. Q=Heat given to the gas, W=work done by the gas, U=Change in internal energy of the gas.

The sample of monoatomic gas undergoes a process as represented by P-V graph (if $P_0V_0 = 1/3RT_0$)



$(P) W_{1 \to 2} = 1/3 RT_0$ $(Q) Q_{1 \to 2 \to 3} = 11/6 RT_0$

$(R) U_{1 \to 2} = RT_0/2$ $(S) W_{1 \to 2 \to 3} = 1/3 RT_0$

Which of the following option are correct

A. P,Q,R,S are correct

B. Only P,Q are correct

C. Only R,S are correct

D. Only P,R,S correct

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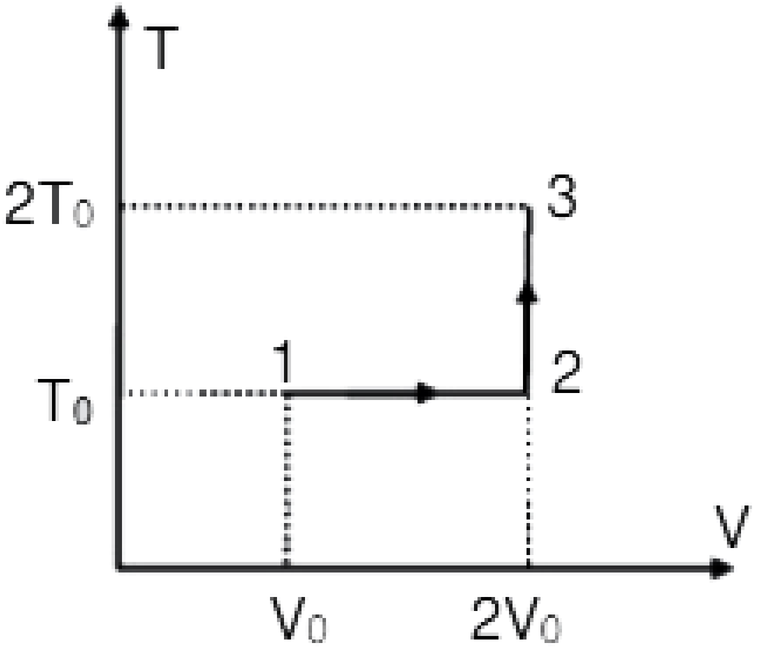
33. A sample of monoatomic gas undergoes a process as represented by T-V graph (if $P_0V_0 = 1/3RT_0$) then



$(P) W_{1 \to 2} = \frac{1}{3}RT_0 \ln 2 \quad (Q)_{1 \to 2 \to 3} = \frac{RT_0}{6}(2\ln(2) + 3)$

$(R) U_{1 \to 2} = 0 \quad (S) W_{1 \to 2 \to 3} = \frac{RT_0}{3}\ln 2$

Which of the following option are correct:

A. P,Q are incorrect

B. R,S are incorrect

C. P,Q,S are incorrect

D. none of these

Answer: D

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34. Length of string og musical instrument is varied from L_o to $2L_o$ in 4 different cases. Wire is made of different materials of mass per unit length $\mu, 2\mu, 3\mu, 4\mu$ respectively. For first case (string -1) length is L_o, Tension is T_o then fundamental frequency is f_o, for second case length of the string is $\frac{3L_o}{2}$ (3^{rd}Harmonic), for thid case length of the string is $\frac{5L_o}{4}$ (5^{th} Harmonic) and for the fouth case length of the string is $\frac{7L_o}{4}$ (14^{th} harmonic). if frequency of all is same then tension in string in terms of T_o

will be:

(A)	String-1	(P)	T_0
(B)	String-2	(Q)	$\frac{T_0}{\sqrt{2}}$
(C)	String-3	(R)	$\frac{T_o}{2}$
(D)	String-4	(S)	$\frac{T_o}{16}$
		(T)	$\frac{3T_o}{16}$

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35. The free length of all four string is varied from L_0 to $2L_0$. Find the maximum fundamental frequency of 1,2,3,4 in terms of f_0 (Tension is same in all strings)

(A)	String(μ) - 1	(P)	1
(B)	String(2μ) - 2	(Q)	$1/2$
(C)	String(3μ) - 3	(R)	$\frac{1}{\sqrt{2}}$
(D)	String(4μ) - 4	(S)	$\frac{1}{\sqrt{3}}$
		(T)	$1/16$
		(U)	$3/16$

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36. A resistance of 2Ω is connected across one gap of a metre-bridge(the length of the wire is 100 cm) and an unknown resistance, greater than 2Ω, is connected across the other gap. When these resistances are interchanged, the balance points shifts by 20 cm. Neglecting any corrections, the unknown resistance is

A. 3Ω

B. 4Ω

C. 5Ω

D. 6Ω

Answer: A

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37. In an experiment to determine the focal length (f) of a concave mirror by the u - v method, a student places the object pin A on the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then,

A. $x < f$

B. $f < x < 2f$

C. $x = 2f$

D. $x > 2f$

Answer: B

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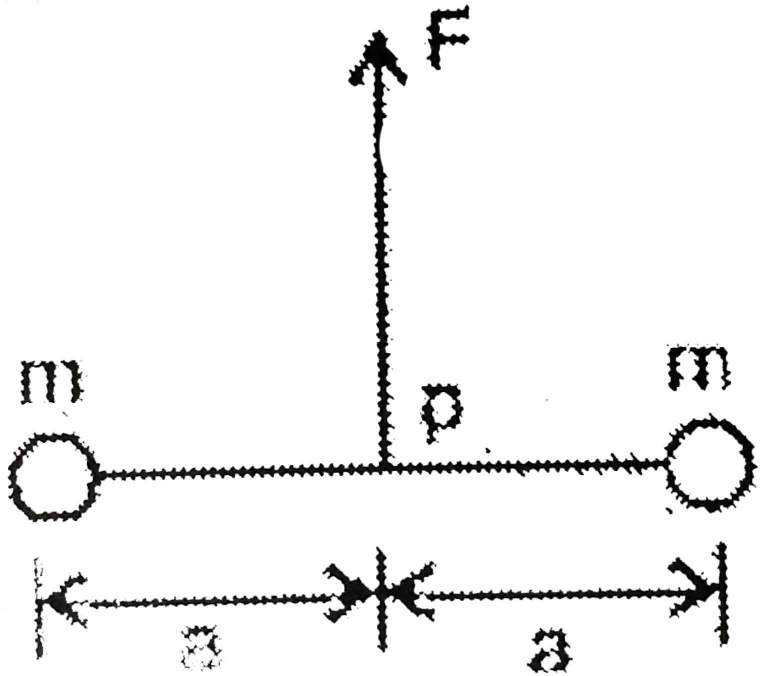
38. Two particles of mass m each are tied at the ends of a light string of length $2a$. The whole system is kept on a frictionless horizontal surface with the string held tight so that, each mass is at a distance 'a' from the center P (as shown in the figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes $2x$, is :



A. $\frac{F}{2m}\frac{a}{\sqrt{a^2 - x^2}}$

B. $\frac{F}{2m}\frac{x}{\sqrt{a^2 - x^2}}$

C. $\frac{f}{2m}\frac{x}{a}$

D. $\frac{F}{2m}\frac{\sqrt{a^2 - x^2}}{x}$

Answer: B

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39. A long, hollow conducting cylinder is kept coaxially inisde another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral.

A. A potenital difference appears between the two cylinders when a charge density is given to the inner cylinder.

B. A potential difference appears between the two cylinders when a charge density is given to the outer cylinder.

C. No potential difference appears between the two cylinders when a uniform lines charge is kept along the axis of the cylinders.

D. No potential difference appears between the two cylinders when same charge density is given to both the cylinders.

Answer: A

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40. Conisder a neutral conducting sphere. A poistive point charge is placed outisde the sphere. The net charge on the sphere is then

A. negative and distributed uniformly over the surface of the sphere

B. negative and appears only at the point on the sphere closest to the point charge

C. negative and distributed non-uniformly over the entire surface of the sphere

D. zero

Answer: D

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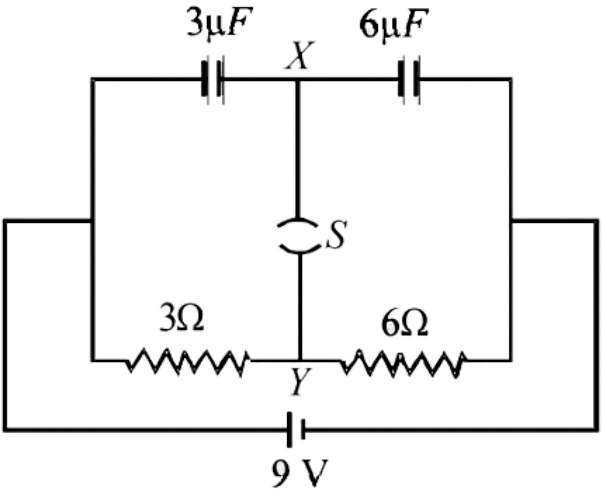
41. A circuit is connected as shown in the figure with the switch S open. When the switch is closed, the total amount of charge that flows from Y to X is



A. 0

B. 54 μC

C. $27 \mu C$

D. $81 \mu C$

Answer: C

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42. A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be

A. only a reflected ray and no refracted ray

B. only a refracted ray and no reflected ray

C. a reflected ray and a refracted ray and the angle between them would be less than $180^{\circ} - 2\theta$.

D. a reflected ray and a refracted ray and the angle between them would be greater than $180^{\circ} - 2\theta$

Answer: C

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43. In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is:

A. $E\left(^{236}U92\right) > E\left(^{137}I53\right) + E\left(^{97}Y39\right) + 2E(n)$

B. $E\left(^{236}U92\right) < E\left(^{137}I53\right) + E\left(^{97}Y39\right) + 2E(n)$

C. $E\left(^{236}U92\right) < E\left(^{140}B56\alpha\right) + E\left(^{94}K36r\right) + 2E(n)$

D. $E\left(^{236}U92\right) = E\left(^{140}B56\alpha\right) + E\left(^{94}K36r\right) + 2E(n)$

Answer: A

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44. The largest wavelength in the ultraviolet region of the hydrogen spectrum is $122nm$. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest interger) is (a) $802nm$ (b) $823nm$ (c) $1882nm$ (d) $1648nm$.

A. 802 nm

B. 823 nm

C. 1882 nm

D. 1648 nm

Answer: B

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45. Asseration : A block of mass m starts moving on a rough horizontal surface with a velocity v. It stops due to friction between the block and the surface after moving through a ceratin distance. The surface is now tilted to an angle of 30° with the horizontal and same block is made to go up on the surface with the same initial velocity v. The decrease in the mechanical energy in the second situation is small than the first situation.

Reason : The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

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

Answer: C

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46. STATEMENT-l : In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

STATEMENT-2 : In an elastic collision, the linear momentum of the system is conserved.

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 -2

C. Statement-1 is true, statement-2 is false

D. Statement-1 is false, statement-2 is true

Answer: B::D

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47. The formula connecting u,v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature. Because

Statement-2

Laws of reflection are strictly valid for plane surfaces, but nor for large spherical surfaces.s

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 -3

C. Statement-1 is true, statement-2 is false

D. Statement-1 is false, statement-2 is true

Answer: C

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48. Statement-1

If the accelerating potential in an X-ray tube is increased, the wavelength of the characterstic X-rays do not change.

because

Statement-2

When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

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 -4

C. Statement-1 is true, statement-2 is false

D. Statement-1 is false, statement-2 is true

Answer: B

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49. The ratio x_1/x_2 is

A. 2

B. $\frac{1}{2}$

C. $\sqrt{2}$

D. $\frac{1}{\sqrt{2}}$

Answer: C

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50. Two discs A and B are mounted coaxiallay on a vertical axle. The discs have moments of inertia I and 2 I respectively about the common axis. Disc A is imparted an initial angular velocity 2ω using the entire potential energy of a spring compressed by a distance x_1 Disc B is imparted an angular velocity ω by a spring having the same spring constant and compressed by a distance x_2 Both the discs rotate in the clockwise direction.

When disc B is brought in contact with disc A, they acquire a common angular velocity in time t. The average frictional torque on one disc by the other during this period is

A. $\frac{2I\omega}{3t}$

B. $\frac{9I\omega}{2t}$

C. $\frac{9I\omega}{4t}$

D. $\frac{3I\omega}{2t}$

Answer: A

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51. The loss of kinetic energy during the above proces is

A. $\frac{I\omega^2}{2}$

B. $\frac{I\omega^2}{3}$

C. $\frac{I\omega^2}{4}$

D. $\frac{I\omega^2}{6}$

Answer: B

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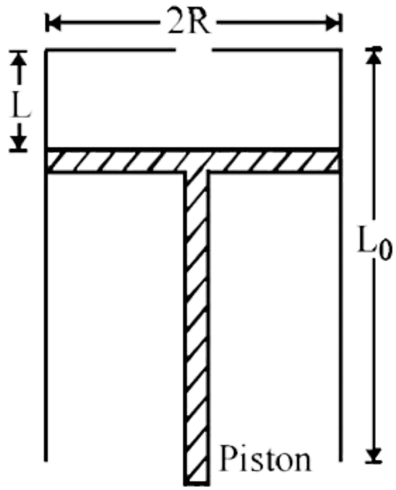
52. A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at the bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be

A. P_0

B. $\frac{P_0}{2}$

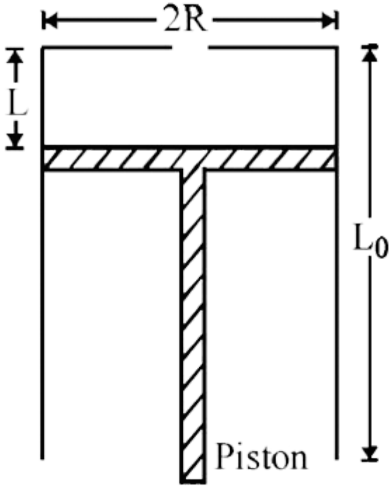
C. $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$

D. $\frac{P_0}{2} - \frac{Mg}{\pi R^2}$

Answer: A

Watch Video Solution

53. A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is

A. $\frac{2P_0\pi R^2}{\pi R^2 P_0 + Mg}(2L)$

B. $\frac{P_0\pi R^2 - Mg}{\pi R^2 P_0}(2L)$

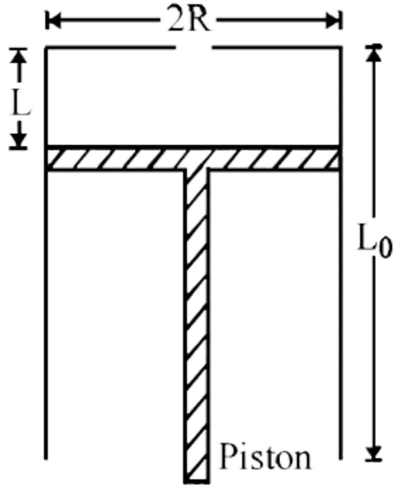
C. $\frac{P_0\pi R^2 + Mg}{\pi R^2 P_0}$

D. $\frac{P_0\pi R^2}{\pi R^2 P_0 - Mg}(2L)$

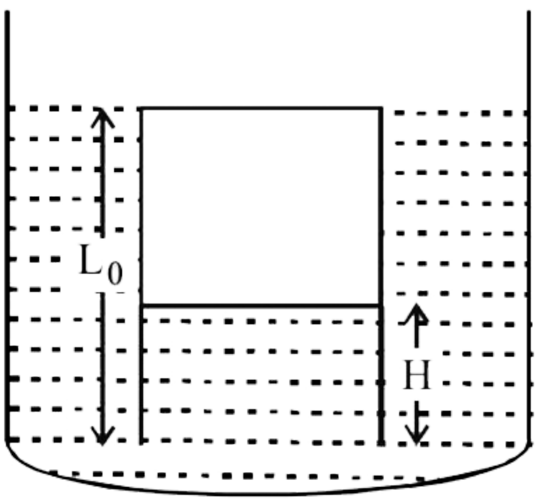
Answer: D

Watch Video Solution

54. A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water coulmn in the cylinder satisfies



A. $\rho g(L_0 - H)^2 + P_0(L_0 - H) + L_0P_0 = 0$

B. $\rho g(L_0 - H)^2 - P_0(L_0 - H) - L_0P_0 = 0$

C. $\rho g(L_0 - H)^2 + P_0(L_0 - H) - L_0P_0 = 0$

D. $\rho g(L_0 - H)^2 - P_0(L_0 - H) + L_0P_0 = 0$

Answer: C

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55. Some physical quantities are given in Column I and some possible SI units in which these quantities may be expressed are given in Column II. Match the physical quantities in Column I with the units in column II and indicate your answer by darkening appropriate bubbles in the 4×4

matrix given in the ORS.

	Column-I		Column-II
(A)	GM_eM_s G-universal gravitational Constant M_e - mass of the earth M_s - mass of the Sun	(P)	(volt)(coulomb)(meter)
(B)	$\frac{3RT}{3}$ R - universal gas constant T - absolute temperature M - molar mass	(Q)	(kilogram)(metre)^3
(C)	$\frac{F^2}{q^2B^2}$ F - force q - charge B - magnetic field	(R)	(metre)^2(second)$^{-2}$
(D)	$\frac{GM_e}{R_e}$ G - universal gravitational constant M_e - mass of the earth R_e - radius of the earth	(S)	(farad)(volt)^2(kg)$^{-1}$

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56. Column I gives certain situating in which a straight metallic wire of resitance R is used and Column II gives some resulting effects. Match the statements in Column I with the statements in Column II and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

Column I	Column II
(A) A charged capacitor is connected to the ends of the wire	(p) A constant current flows through the wire
(B) The wire is moved perpendicular to its length with a constant velocity in a uniform magnetic field perpendicular to the plane of motion	(q) Thermal energy is generated in the wire
(C) The wire is placed in a constant electric field that has a direction along the length of the wire	(r) A constant potential difference develops between the ends of the wire
(D) A battery of constant emf is connected to the ends of the wire	(s) Charges of constant magnitude appear at the ends of the wire

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57. Some lawa I processes are given in Column I. Match these with the physical phenomena given in Column II and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in the ORS.

Column I	Column II
(A) Transition between two atomic energy levels	(p) Characteristic X-rays
(B) Electron emission from a material	(q) Photoelectric effect
(C) Mosley's law	(r) Hydrogen spectrum
(D) Change of photon energy into kinetic energy of electrons	(s) β- decay

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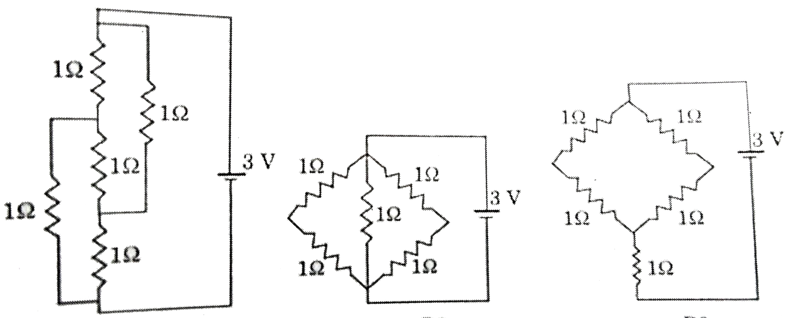
58. Figure shows three resistor configurations R1,R2 and R3 connected to 3V vattery If the prower dissipated by the configuration R1,R2 and R3 is P1 ,m P2 and P3 repecitively then

Figure



R1 R2 R3

A. $P1 > P2 > P3$

B. $P1 > P3 > P2$

C. $P2 > P1 > P3$

D. $P3 > P2 > P1$

Answer: C

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59. Which one of the following statement is $WRONG$ in the context of X-rays generated from X- rays tube ?

A. Wavelength of characteristic X rays decreases when the atomic number of the target increases

B. Cut off wavelength of the continuous X ray depenss on the atomic number of the target

C. Intensity of the characteristic X ray depends on the electrical power given to the x ray tube

D. cut off wavelength of the continous x rays depends on the energy of the electrons in the x ray tube

Answer: B

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60. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is $60 degree$). In the position of minimum deviation, the angle of refraction will be

A. 30° for both the colour

B. greater for the violet colour

C. greater for the red colour

D. equal but not 30° for both the colours

Answer: A

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61. An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of lthe gas is:

A. $\frac{1}{T}$

B. $\frac{2}{T}$

C. $\frac{3}{T}$

D. $\frac{4}{T}$

Answer: C

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62. A spherically symmetric gravitational system of particles has a mass

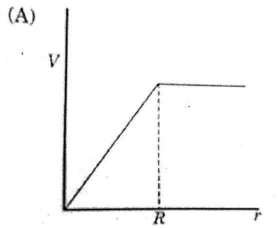
density $\rho = \begin{cases} \rho_0 & f \text{ or } \quad r < R \\ 0 & f \text{ or } \quad r > R \end{cases}$ where ρ_0 is a constant. A test mass can

undergo circular motion under the influence of the gravitational field of

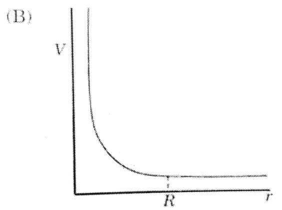
particles. Its speed v as a function of distahce $r(0 < r < OO)$ form the

centre of the system is represented by

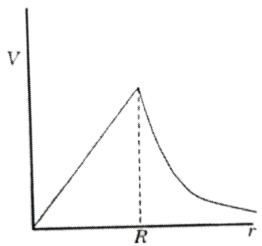
A.

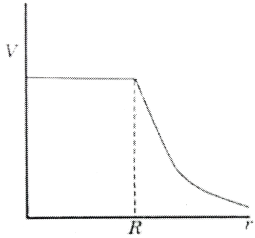


B.



C.



D. 

Answer: C

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63. Two balls having linear momenta $\vec{p}_1 = p\hat{i}$ and $\vec{p}_2 = -p\hat{i}$, undergo a collision in fre space. There is no external force acting on the ball. Let $\vec{p}_1^{\,'}$ and $\vec{p}_2^{\,'}$ be their final moment. Which of the following option(s) is (are) NOT ALLOWED for an non zero value of $p, a_1, a_2, b_1, b_2, c_1$ and c_2.

A. $\overset{\rightarrow}{p_1} = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$

$\vec{p}_2 = a_2\hat{i} + b_2\hat{j}$

B. $\vec{p}_1 = c_1\hat{k}$

$\overset{\wedge}{p_2} = c_2\hat{k}$

C. $\overrightarrow{p_1} = a_1\hat{i} + b_1\hat{j} + c_1\hat{k}$

$\hat{p_2} = a_2\hat{i} + b_2\hat{j} - c_1\hat{k}$

D. $\overrightarrow{p_1} = a_1 g\hat{i} + b_1\hat{j}$

$\hat{P}_2 = a_2\hat{i} + b_1\hat{j}$

Answer: A::D

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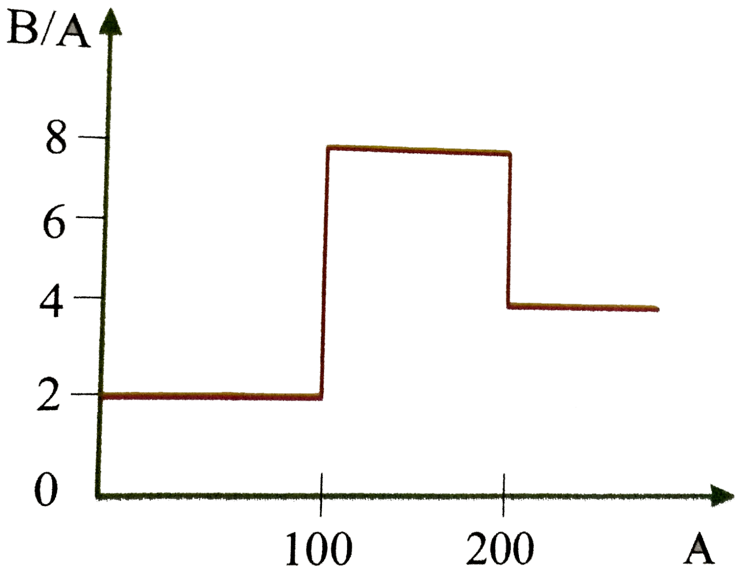
64. Assume that the nuclear binding energy per uncleon (B/A) versus mass number (A) is as shwon in Fig. Use this plot to choose the correct choice (s) given below:



A. fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy

B. fusion o ftwo nuclei with mass number lying in the range of 51 $< A < 100$will release energy

C. fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken in to two equal fragments

D. fission of a nucleus lying in the mass range of 200 < 260 will release energy when broken in to two equal fragment

Answer: B::D

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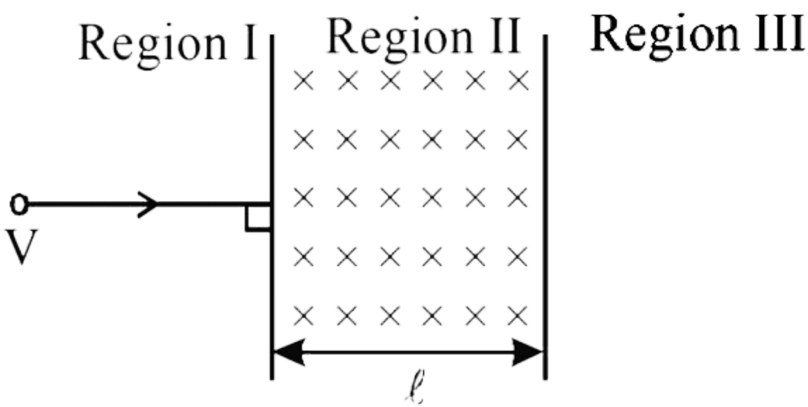
65. A particle of mass $m$and charge q, moving with velocity v enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper . The length of the region II is l. Choose the correct choice(s).



A. The particle enters Region III only if its velocity $V > \frac{qlB}{m}$

B. The particle enters Regions III only if its velocity $V < \frac{qlB}{m}$

C. Path length of the paritcle in Region II is maximum when velocity $V = \frac{qlB}{m}$

D. Time spent in Region II is same for any velocity v as long as the particle returns to Region 1

Answer: A::C::D

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66. In a Young's double slit experiment, the separation between the two slits is d and the wavelength of the light is λ. The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct choice (s).

A. If $d = \lambda$ the screen will contain onlly one maximum

B. if $\lambda < d < 2\lambda$ at least one more maximum (beside the central maximum) will be obseved on the screen

C. If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2 the intensities of the observed dark and bright fringes will increase

D. if the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit I the intensites of the observed dark and bright fringes will increase

Answer: A::B

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67. Statement-1 : In a Meter Bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.

Statement-2 : Resistance of metal increases with increase in temperature.

A. STATEMENT-1 is True STATEMENT -2 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

Answer: D

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68. Assertion : An astronaut in an orbiting space station above the earth experience weightlessness.

Reason : An object moving around the earth under the infuence of earth's gravitational force is in a state of 'free fall'

A. STATEMENT-1 is True STATEMENT -2 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

Answer: A

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69. Satement-1: two cylinder one hollow (metal) and the other side (wood) with the same mass and identical dimensions are simultaneously allowed to roll wihtout slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first.

Statement-2: By the principle of conservation of energy, the total kinetic energies of both the cylinder are identical when they reach the bottom of the incline.

A. STATEMENT-1 is True STATEMENT -2 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

Answer: D

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70. STATEMENT-1: The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.

STATEMENT-2: In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

A. STATEMENT-1 is True STATEMENT -2 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

Answer: A

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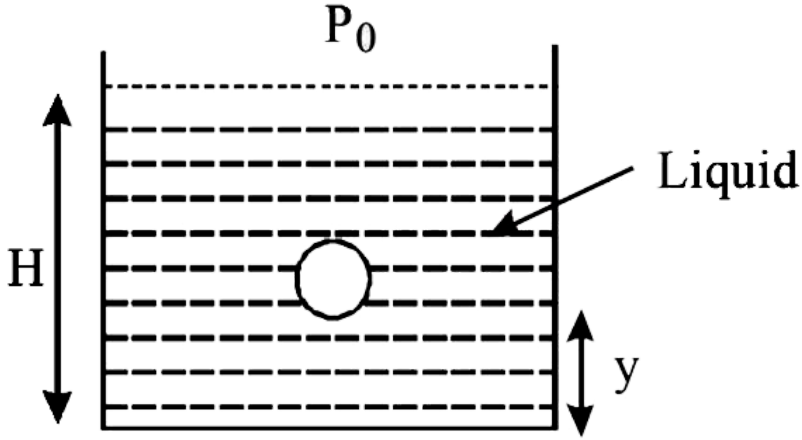
71. A small spherical monoatomic ideal gas bubble ($\gamma = 5/3$) is trapped inside a liquid of density ρ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure P_0 (Neglect surface tension).



As the bubble moves upwards, besides the buoyancy force the following forces are acting on it

A. only the force of gravity

B. The force due to gravity and the force due to the pressure f the liquied

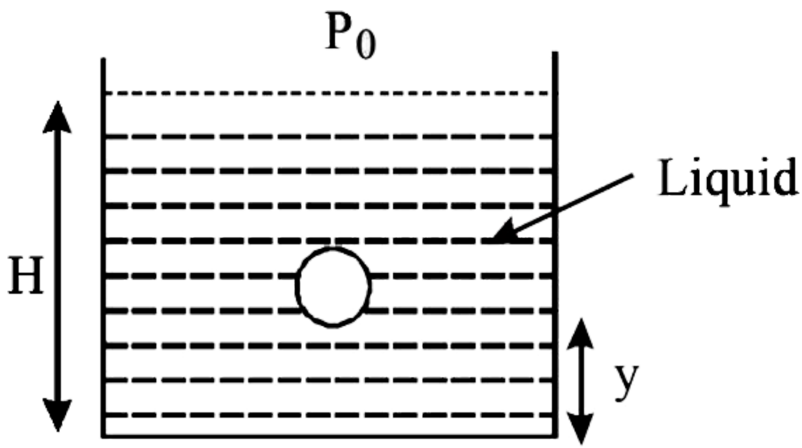
C. The force due to gravity the force due to the pressure of the liqueid and the force due to visocsity of the liquid

D. The force due to gravity and the force due to visosity of the liquid

Answer: D

Watch Video Solution

72. A small spherical monoatomic ideal gas bubble ($\gamma = 5/3$) is trapped inside a liquid of density ρ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure P_0 (Neglect surface tension).



When the gas bubble is at a height y from the bottom, its temperature is-

A. $T_0 \dfrac{\left(P_0 + \rho g H\right)}{\left(P_0 + \rho g y\right)^{2/5}}$

B. $T_0 \dfrac{\left(P_0 + \rho g(H - y)\right)}{\left(P_0 + \rho g H\right)^{2/5}}$

C. $T_0 \dfrac{\left(P_0 + \rho g H\right)}{\left(P_0 + \rho g y\right)^{3/5}}$

D. $T_0 \dfrac{\left(P_0 + \rho g(H - y)\right)}{\left(P_0 + \rho g H\right)^{\frac{3}{5}}}$

Answer: B

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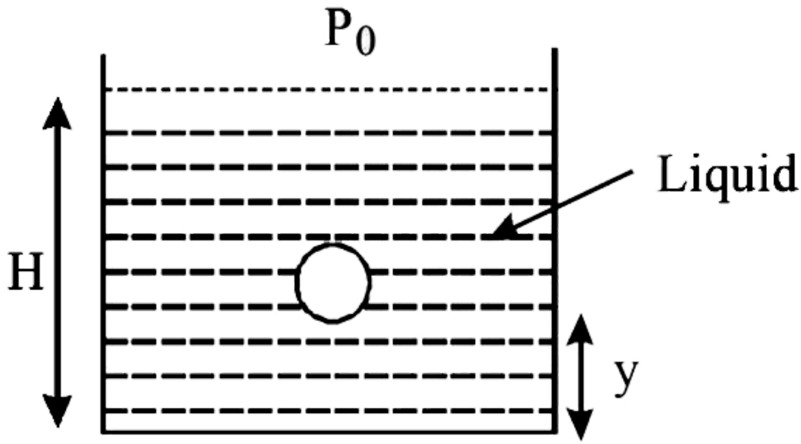
73. A small spherical monoatomic ideal gas bubble ($\gamma = 5/3$) is trapped inside a liquid of density ρ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure P_0 (Neglect surface tension).



The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)

A. $\rho nRgT_0 \dfrac{\left(P_0 + \rho_t gH\right)^{2/5}}{\left(P_0 + \rho gy\right)^{7/5}}$

B. $\dfrac{\rho nRgT_0}{\left(p_0 + \rho gH\right)^{2/5}}\left[P_0 + \rho g(H - y)\right]^{3/5}$

C. $\rho nRgT_0 \dfrac{\left(P_0 + \rho gH\right)^{3/5}}{\left(P_0 + \rho gy\right)^{8/5}}$

D. $\rho nRgT_0 \dfrac{P_0 + \rho gH}{\left(P_0 + \rho gy\right)^{8/5}}$

Answer: B

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74. In a mixture of H - He^{+} gas (He + is singly ionized He atom), H atom and He + ions are excited to their respective first excited state. Subsequently H atoms transfer their total excitation energy to He + ions (by collisions) Assume that the bohr model of atom is exactly valid.

The quantum number n of the state finally populated in He^{+} inos is -

A. 2

B. 3

C. 4

D. 5

Answer: C

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75. In a mixture of H - He^{+} gas (He + is singly ionized He atom), H atom and He + ions are excited to their respective first excited state.

Subsequently H atoms transfer their total excitation energy to $He+$ ions (by collisions) Assume that the bohr model of atom is exactly valid.

The wavelength of light emitted in the visible region by $He+$ Ions after collisions with H atoms is -

A. 6.5×10^{-7} m

B. 5.6×10^{-7} m

C. 4.8×10^{-7} m

D. 4.0×10^{-7} m

Answer: C

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76. In a mixture of $H - He^{+}$ gas (He^{+} is singly ionized He atom), H atoms and He^{+} ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He^{+} ions (by collisions). Assume that the Bohr model of atom is exctly valid.

The ratio of the kinetic energy of the $n = 2$ electron for the H atom to that of He^+ ion is:

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 1

D. 2

Answer: A

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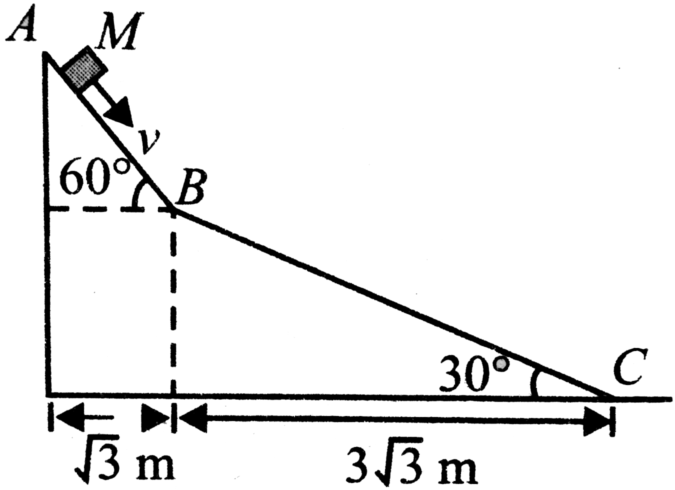
77. A small block of mass M moves on a frictionless surface of an inclined plane, as shown in the figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is many at rest at A. Assume that collisions between the block id the incline are totally inelastic.

The speed of the block at point B immediately after it strikes the second incline is



A. $\sqrt{60}m/s$

B. $\sqrt{45}m/s$

C. $\sqrt{30}m/s$

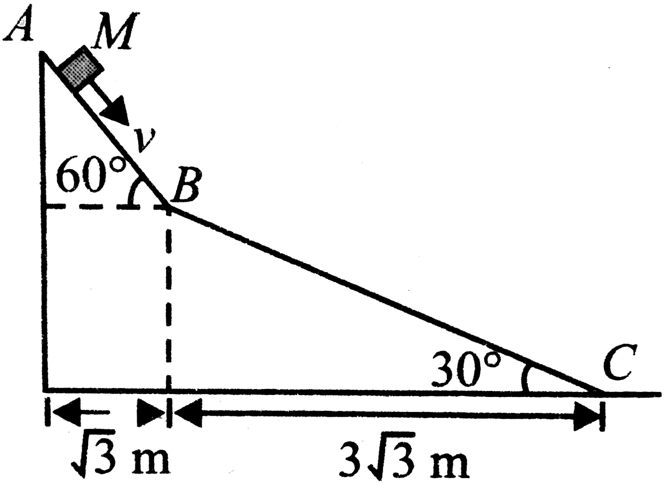
D. $\sqrt{15}m/s$

Answer: B

Watch Video Solution

78. A small block of mass M moves on a frictionless surface of an inclined plane, as shown in the figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is many at rest at A. Assume that collisions between the block id the incline are totally inelastic.

The speed of the block at point C, immediately before it leaves the second incline



A. $\sqrt{120} m/s$

B. $\sqrt{105} m/s$

C. $\sqrt{90} m/s$

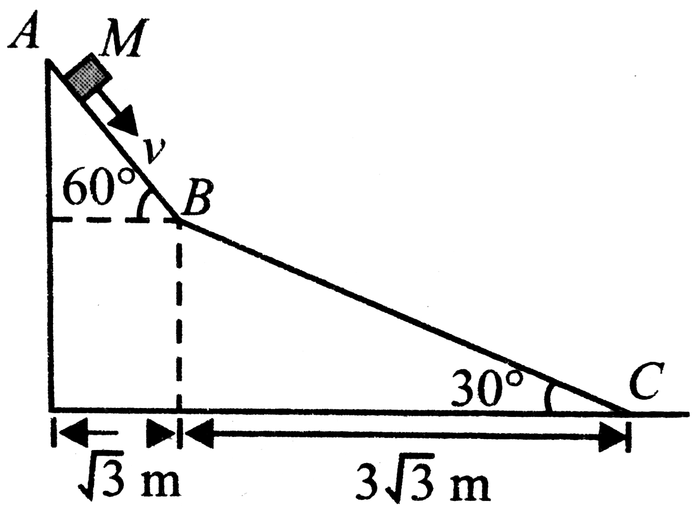
D. $\sqrt{75} m/s$

Answer: B

Watch Video Solution

79. A small block of mass M moves on a frictionless surface of an inclined plane, as shown in the figure. The angle of the incline suddenly changes from 60° to 30° at point B. The block is many at rest at A. Assume that collisions between the block id the incline are totally inelastic.

If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the blocks at point B, immediately after it strikes the second incline is



A. $\sqrt{30}m/s$

B. $\sqrt{15}m/s$

C. 0

D. -$\sqrt{15}m/s$

Answer: C

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80. A radioactive sample S_1 having an activity of $5\mu Ci$ has twice the number of nuclei as another sample S_2 which has an activity of $10\mu Ci$. The half-lives of S_1 and S_2 can be

A. 20 years and 5 years, respectively

B. 20 years and 10 years, respectively

C. 10 years each

D. 5 years each

Answer: A

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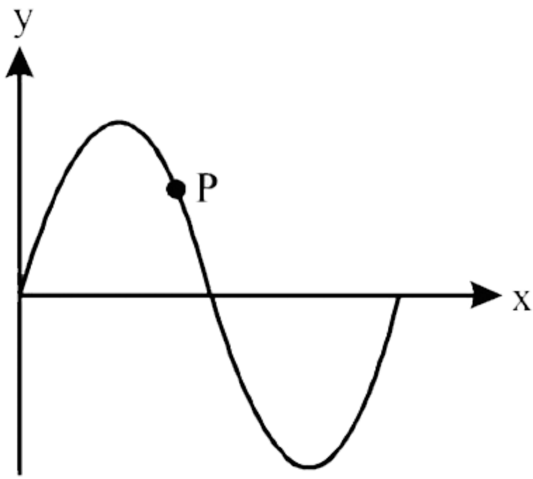
81. A transverse sinusoidal wave moves along a string in the positive x-direction at a speed of $10m/s$. The wavelength of the wave is $0.5m$ and its amplitude is $10cm$. At a particular time t, the snap-shot of the wave is shown in figure. The velocity of point P when its displacement is $5cm$ is -



A. $\frac{\sqrt{3}\pi}{50}\hat{j}m/s$

B. $-\frac{\sqrt{3}\pi}{50}\hat{j}m/s$

C. $\frac{\sqrt{3}\pi}{50}\hat{i}m/s$

D. - $\frac{\sqrt{3}\pi}{50}\hat{i}m/s$

Answer: A

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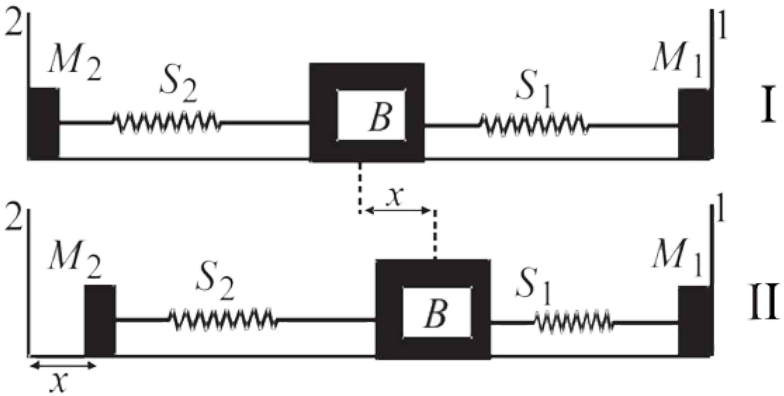
82. A block (B) is attached to two unstriched sprig S_1 and S_(2) with spring constant K and $4K$, respectively (see fig 1) The other ends are atteched in identical support M_1 and M_2 not attached in the walls . The springs and supports have negligible mass . There is no friction anywhere . The block B is displaced toword wall 1 by a small distance z (figure (ii)) and released . THe block return and moves a maximum displacements x and y are musured with reoact to the equalibrum of the block B and the ratio y/x is



A. 4

B. 2

C. $\frac{1}{2}$

D. $\frac{1}{4}$

Answer: C

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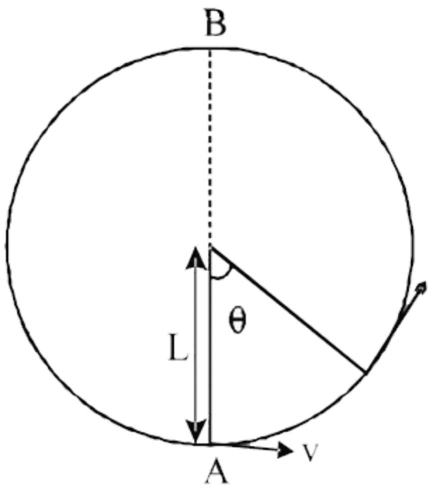
83. A bob of mass M is suspended by a massless string of length L. The horizonta velocity v at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies



A. $\theta = \frac{\pi}{4}$

B. $\frac{\pi}{4} < \theta < \frac{\pi}{2}$

C. $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$

D. $\frac{3\pi}{4} < \theta < \pi$

Answer: D

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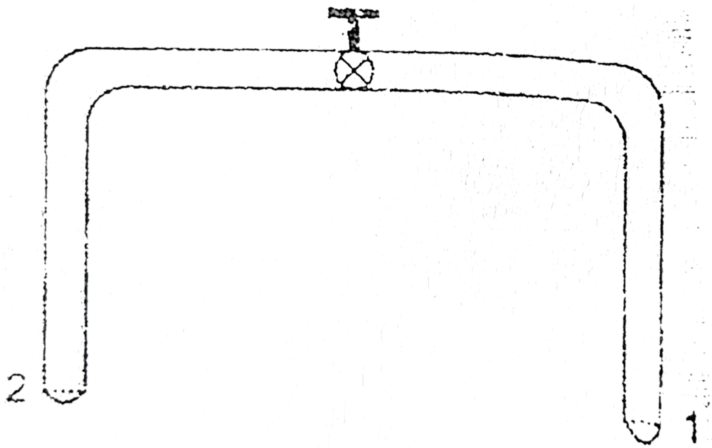
84. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve.



A. air from ene 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.

Answer: B

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85. 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 $75cm$ 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 2 per second. Assuming the velocity of sound in air to be $340m/s$, the frequency n of the tuning fork in Hz is

A. 344

B. 336

C. 117.3

D. 109.3

Answer: A

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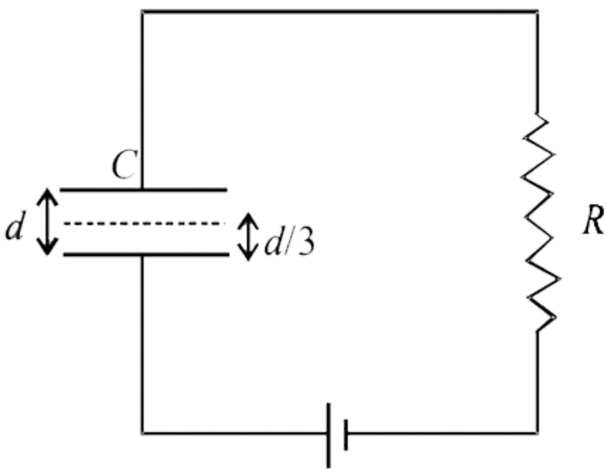
86. A parallel plate capacitor C with plates of unit area and separation d is filled with a liquid of dielectric constant $K = 2$. The level of liquid is $d/3$ initially. Suppose the liquid level decreases at a constant speed v, the time constant as a function of time t is-



A. $\frac{6\varepsilon_0 R}{5d + 3Vt}$

B. $(15d + 9Vt)\frac{\varepsilon R}{2d^2 - 3dVt - 9V^2t^2}$

C. $\frac{6\varepsilon_0 R}{5d - 3Vt}$

D. $(15d - 9Vt)\frac{\varepsilon_0 R}{2d^2 + 3dVt - 9V^2t^2}$

Answer: A

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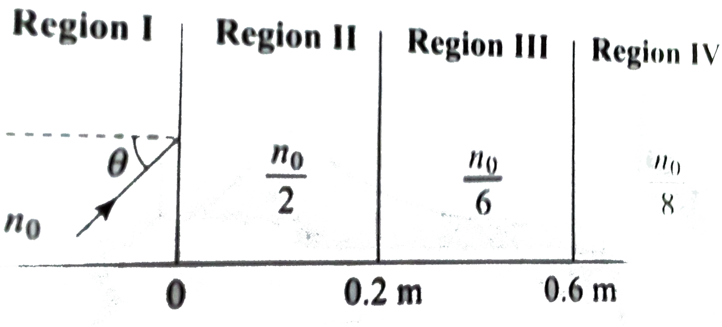
87. A light beam is traveling from Region I to region IV (refer figure). The refractive indices in Region I, II, III, and IV are $n_0, n_0/2, n_0/6$ and $n_0/8$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is



A. $\sin^{-1}\left(\frac{3}{4}\right)$

B. $\sin^{-1}\left(\frac{1}{8}\right)$

C. $\sin^{-1}\left(\frac{1}{4}\right)$

D. $\sin^{-1}\left(\frac{1}{3}\right)$

Answer: B

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88. 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 .

STATEMENT - 2 : If the observer and the object are moving at velocities $\vec{v}_1$ and $\vec{v}_2$ respecttively with refrence to a laboratory frame , the velocity of the object with respect to a laboratory frame , the velocity of the object with respect to the observer is $\vec{v}_2$ - $\vec{v}(1)$.

(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

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.

Answer: B

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89. STATEMENT-1: It is easier to pull a heavy object than to push it on a level ground and

STATEMENT-2: The magnitude fo 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 correct explanation for statement-2

C. statement-1 is true, statement -2 is false.

D. statement-1 is false, statement-2 is true.

Answer: B

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90. STATEMENT-1: For practical purposes, the earth is used as a reference at zero potencial in electrical circuits. and

STATEMENT-2: The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi\varepsilon_0 R}$.

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-3

C. statement-1 is true, statement -2 is false.

D. statement-1 is false, statement-2 is true.

Answer: A

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91. STATEMENT-1: For practical purposes, the earth is used as a reference at zero potencial in electrical circuits. and

STATEMENT-2: The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi\varepsilon_0 R}$.

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-4

C. statement-1 is true, statement -2 is false.

D. statement-1 is false, statement-2 is true.

Answer: C

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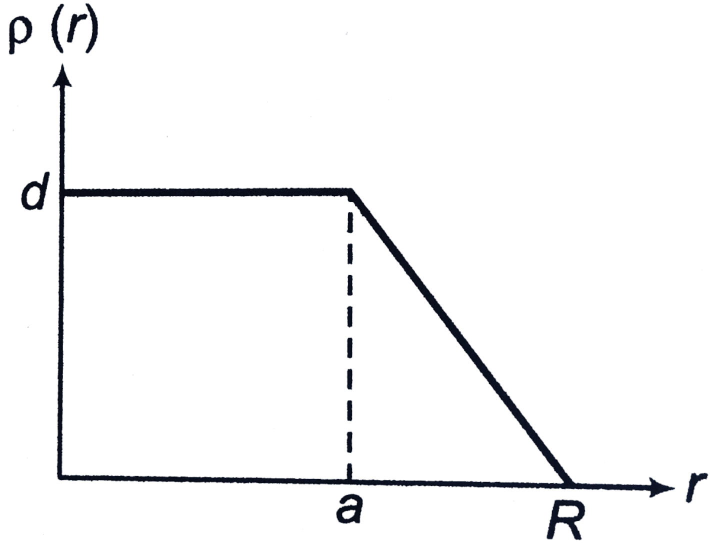
92. The nuclear charge (Ze) is non uniformlly distribute with in a nucleus of radius r. The charge density $\rho(r)$ (charge per unit volume) is dependent only on the radial distance r form the centre of the nucleus s shown in figure. The electric field is only along the radial direction.



The electric field at $r = R$ is

A. independent of a

B. directly proportional to a

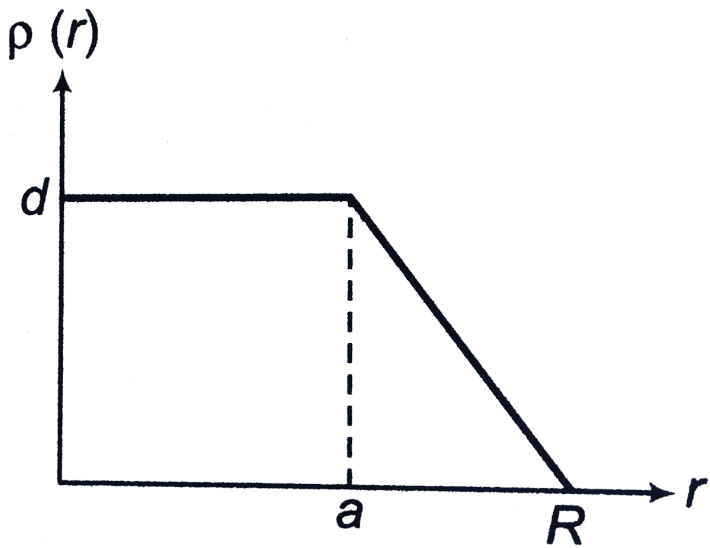
C. directly proportional to a^2

D. inversely proportional to a

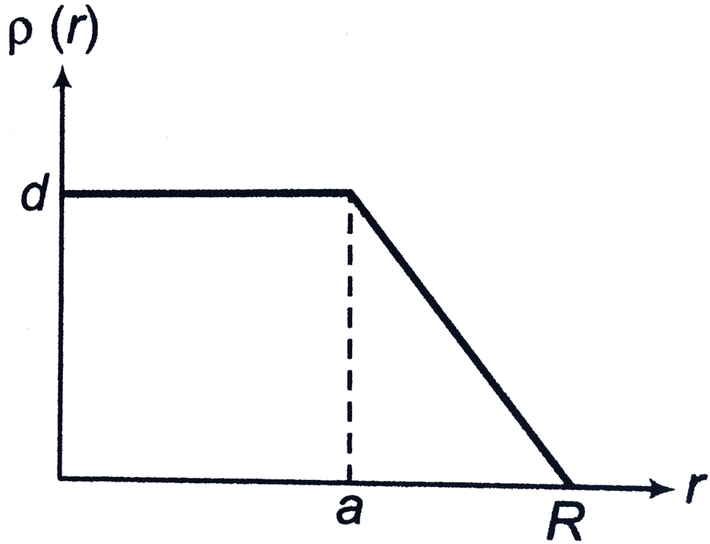
Answer: A

Watch Video Solution

93. The nuclear charge (Ze) is non uniformlly distribute with in a nucleus of radius r. The charge density $\rho(r)$ (charge per unit volume) is dependent only on the radial distance r form the centre of the nucleus s shown in figure. The electric field is only along the radial direction.



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



A. $\frac{3Ze}{4\pi R^3}$

B. $\frac{3Ze}{\pi R^3}$

C. $\frac{4Ze}{3\pi R^3}$

D. $\frac{Ze}{3\pi R^3}$

Answer: B

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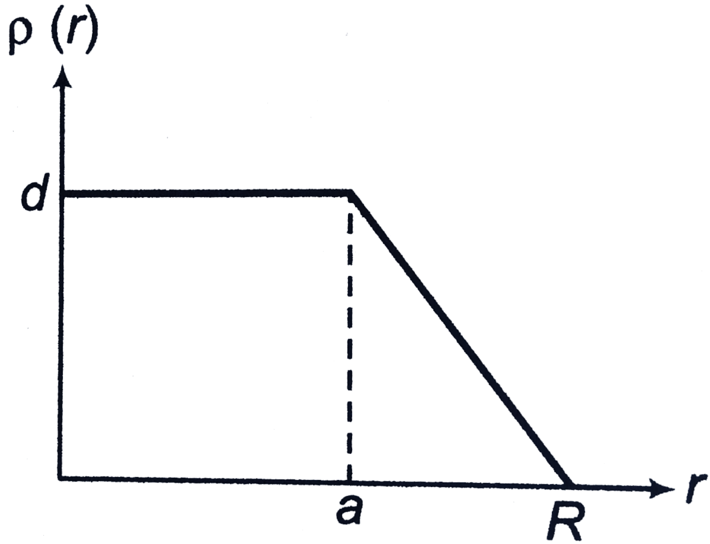
94. The nuclear charge (Ze) is non uniformlly distribute with in a nucleus of radius r. The charge densilty $\rho(r)$ (charge per unit volume) is dependent only on the radial distance r form the centre of the nucleus s shown in figure. The electric field is only along the radial direction.



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

A. $a = 0$

B. $a = \frac{R}{2}$

C. $a = R$

D. $a = \frac{2R}{3}$

Answer: C

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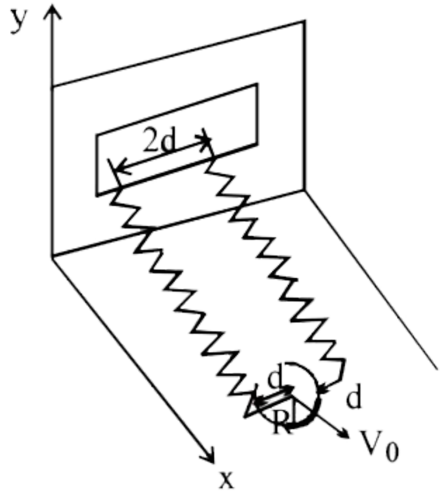
95. A uniform thin cylindrical disk of mass M and radius R is attaached to two identical massless springs of spring constatn k which are fixed to the wall as shown in the figure. The springs are attached to the axle of the disk symmetrically on either side at a distance d from its centre. The axle is massless and both the springs and the axle are in 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 $\vec{V}_0 = vacV_0\hat{i}$. The coefficinet of friction is μ.



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. $-2kx$

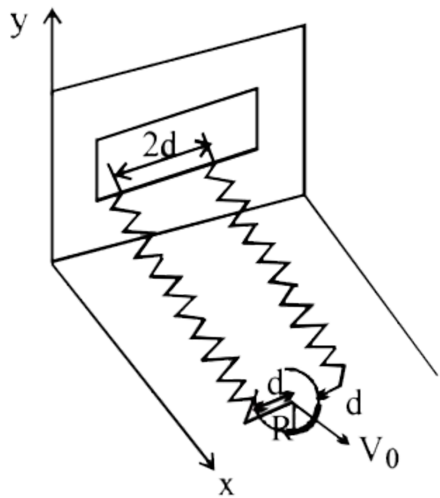
C. $-\frac{2kx}{3}$

D. $-\frac{4kx}{3}$

Answer: D

Watch Video Solution

96. A uniform thin cylindrical disk of mass M and radius R is attaached to two identical massless springs of spring constatn 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 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 $\vec{V}_0 = vacV_0\hat{i}$. The coefficinet of friction is μ.



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

A. $\sqrt{\frac{k}{M}}$

B. $\frac{\sqrt{2k}}{M}$

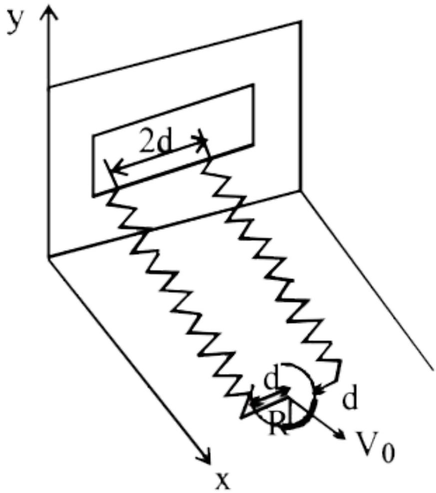
C. $\frac{\sqrt{2k}}{3M}$

D. $\frac{\sqrt{4k}}{3M}$

Answer: D

Watch Video Solution

97. A uniform thin cylindrical disk of mass M and radius R is attaached to two identical massless springs of spring constatn 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 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 $\vec{V}_0 = vacV_0\hat{i}$. The coefficinet of friction is μ.



The maximum value of V_0 for whic the disk will roll without slipping is-

A. $\mu g\sqrt{\frac{M}{k}}$

B. $\mu g\sqrt{\frac{M}{2k}}$

C. $\mu g\frac{\sqrt{3M}}{k}$

D. $\mu g\frac{\sqrt{5M}}{2k}$

Answer: C

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98. Column I gives a listof 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 even in Column II. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS.

Column I

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

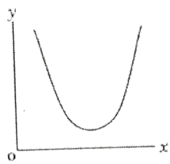
(B) Displacement (y axis) as a function of time (x axis) for a one dimensional motion at zero or constant acceleration when the body is moving along the positive x-direction

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

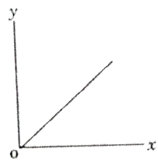
(D) The square of the time period (y axis) of a simple pendulum as a function of its length (x axis)

Column II

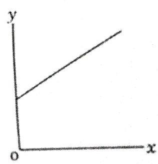
(p)



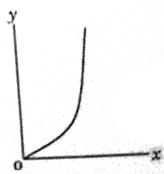
(q)



(r)



(s)



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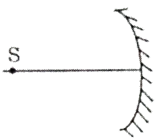
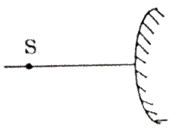
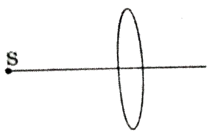
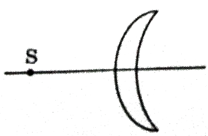
99. An optical component and an object S placed along its optic axis are given in Column I. The distance between the object and the components can be varied. The properties of images are given in Column II. Match all the properties of images from Column II with the appropriate components given in Column 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

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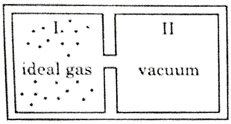
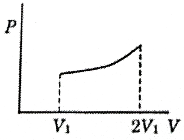
100. Column I contains a list of processes involving expansion of an ideal gas. Match this with Column II describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4 × 4 matrix given in the ORS.

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



Column I	Column II
(B) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, 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 $P \propto \frac{1}{V^{4/3}}$, 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



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101. A particle of mass m is initially at rest at the origin. It is subjected to a force and starts moving along the x-axis. It kinetic energy K changes with time as $dK/dt = \gamma t$, where γ is a positive constant of appropriate dimensions. Which of the following statement is (are) true?

A. The force applied on the particle is constant

B. The speed of the particle is proportional to time

C. The distacne of the particle from the roigin increases linerarly with time

D. The force is conservative

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102. Consider a thin square plate floating on a viscolas liquid in a large tank. The heighth of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true?

A. The resistive force of liquid on the plate is inversely proportional to h

B. The resistive forec of liquid on the plate is independent of the area of the plate

C. The tangential (shear) stress on the floor of the tank increases with u_0

D. The tangential (shear) streass on the plate varies linearly with the viscosity η of the liquid

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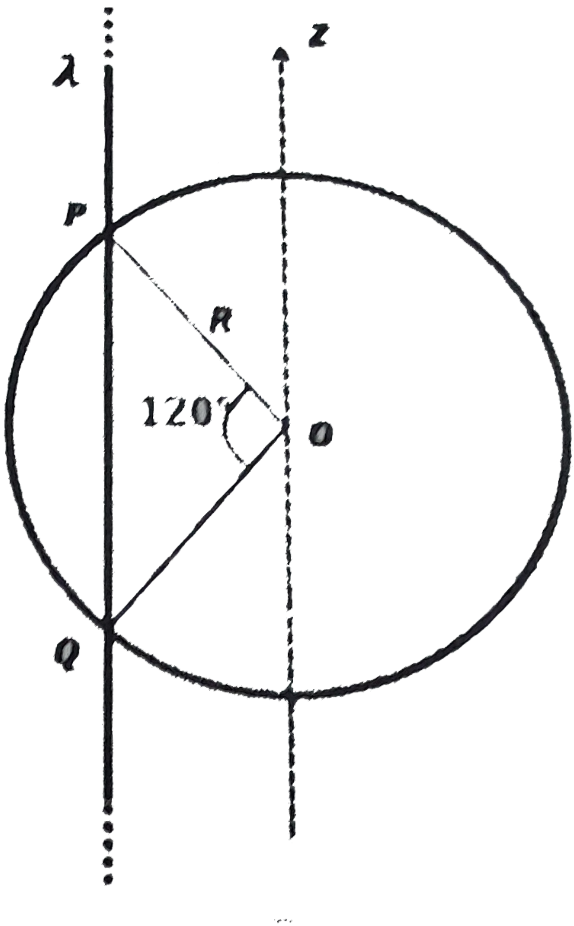
103. An infinitely long thin non-conduction wire is parallel to the z-axis and carries a uniform line charge density λ. It pierces a thin non-conducting spherical shell of radius r in such a way that that the are PQ subtends an angle 120° at the centre O of the spherical shell, as shown in the figure. The permittivity of free space is ε_0. which of the following statements is (are) true ?



A. The electric flux through the shell is $\sqrt{3}R\lambda/\varepsilon lion_0$

B. The z component of the electric field is zero at all the points on the surface of the shel

C. The electric flux through the shell is $\sqrt{2}R\lambda/\varepsilon$

D. The electric field is normal to the surface of the shell at all points

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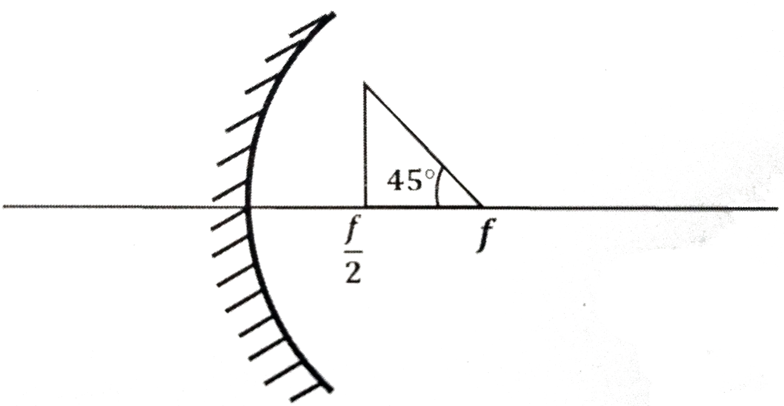
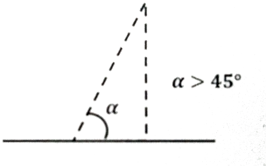
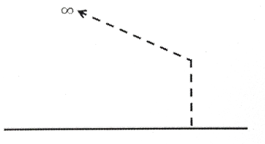
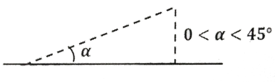
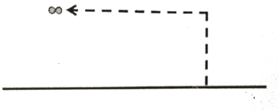
104. A wire is bent in the shape of a right angled triangle and is placed in front of a concave mirror of focal length f,as shown in the figure which of the figures shown in the four options qualitatively represents (s) the shape of the image of the bent wire ? (These figures are not to scale)



A. 

B. 

C. 

D. 

Answer: D

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105. In a radioactive decay chain $^{232}_{90}Th$ nucleus decays to $^{212}_{82}Pb$ nucleus .Let N_α and N_β be the number of α and β particles respectively emitted in this decay process which of the following statement is (are) true ?

A. $N_\alpha = 5$

B. $N_{\alpha} = 6$

C. $N_{\beta} = 2$

D. $N_{\beta} = 4$

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106. In an experiment to measure the speed of sound by a resonating air column, a tuning fork of frequency 500 Hz is used. The length of the air column is varied by changing the leavel of water in the resonance tube. Two successive resonances are heard at air columns of length 50.7 cm and 83.9 cm. Which of the following statements is (are) true?

A. The speed of sound determined form this experimnet is 332 m s^{-1}

B. The end correction in this experiment is 0.9 cm

C. The wavelength of the sound wave is 66.4 cm

D. The resonance at 50.7 cm corresponds to the fundamental harmonic

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107. A solid horizontal surface is coovered with a thin layer of oil.A rectangular block of mass m = 0.4 kg is at rest on this surface. An impulse of 1.0 N s is applied to the block at time to t = 0 so that it starts moving along the x-axis with a velocity $v(t) = v_0 e^{=t/\tau}$, where v_0 is a contant and $\tau = 4s$.The displacement of the block, in metres, at $t = \tau$ is .... Take $e^{-1} = 0.37$?

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108. A ball is projected form the ground at an angle of 45° with the horizonatl surface .It reaches a maximum height of 120 m and return to fthe ground .upon hitting the ground for the first time it loses half of its kinetic energy immediately after the bounce the velocity of the ball makes an angle of 30° with the horizontal surface .The maximum height it reaches after the bounce in metres is ______

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109. A particle of mass 10^{-3} kg and charge 1.0 c is initially at rest At time t=0 the particle comes under the influence of an electric field $\hat{E}(t) = E_0 \sin\omega t \hat{i}$ where $E_0 = 1.0 NC^{-1}$ and $\omega = 10^3 rads^{-1}$ consider the effect of only the electrical force on the particle .Then the maximum speed in m s^{-1} attained by the particle at subsequent times is ____________

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110. A moving coil galvanometer has 50 turns and each turn has an area 210 . The magnetic field produced by the magnet inside the galvanometer is 0.02 . The torsional constant of the suspension wire is 10 . When a current flows through the galvanometer, a full scale deflection occurs if the coil rotates by 0.2 . The resistance of the coil of the galvanometer is 50 . This galvanometer is to be converted into an ammeter capable of measuring current in the range 01.0 . For this purpose, a shunt resistance is to be added in parallel to the galvanometer. The value of this shunt resistance, in , is ________.

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111. A steel wire of diameter 0.5 and Young's modulus 210 carries a load of mass . The length of the wire with the load is 1.0. A vernier scale with 10 divisions is attached to the end of this wire. Next to the steel wire is a reference wire to which a main scale, of least count 1.0 , is attached. The 10 divisions of the vernier scale correspond to 9 divisions of the main scale. Initially, the zero of vernier scale coincides with the zero of main scale. If the load on the steel wire is increased by 1.2 kg, the vernier scale division which coincides with a main scale division is ________. Take g = $10ms^{-2}$ and $\pi = 3.2$.

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112. One mole of a monatomic ideal gas undergoes an adiabatic expansion in which its volume becomes eight times its initial value. If the initial temperature of the gas is 100 universal gas constant 8.0, the decrease in its internal energy, in , is________.

A. and the universal gas constant 8.0, the decrease in its internal energy, in , is________.

B.

C.

D.

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113. In a photoelectric experiment a parallel beam of monochromatic light with power of 200 is incident on a perfectly absorbing cathode of work function 6.25. The frequency of light is just above the threshold frequency so that the photoelectrons are emitted with negligible kinetic energy. Assume that the photoelectron emission efficiency is 100%. A potential difference of 500 is applied between the cathode and the anode. All the emitted electrons are incident normally on the anode and are absorbed. The anode experiences a force 10 due to the impact of the electrons. The value of is ________. Mass of the electron 910 and 1.01.610.

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114. Consider a hydrogen-like ionized atom with atomic number with a single electron. In the emission spectrum of this atom, the photon emitted in the 2 to 1 transition has energy 74.8 higher than the photon emitted in the 3 to 2 transition. The ionization energy of the hydrogen atom is 13.6. The value of is ________.

A. higher than the photon emitted in the 3 to 2 transition. The ionization energy of the hydrogen atom is 13.6. The value of is ________.

B.

C.

D.

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115. The electric field is measured at a point 0,0, generated due to various charge distributions and the dependence of on is found to be different for different charge distributions. List-I contains different relations between E and . List-II describes different electric charge distributions, along with their locations. Match the functions in List-I with the related charge distributions in List-II.

LIST–I	LIST–II
P. E is independent of d	1. A point charge Q at the origin
Q. $E \propto \frac{1}{d}$	2. A small dipole with point charges Q at $(0,0,l)$ and $-Q$ at $(0,0,-l)$. Take $2l \ll d$
R. $E \propto \frac{1}{d^2}$	3. An infinite line charge coincident with the x-axis, with uniform linear charge density λ
S. $E \propto \frac{1}{d^3}$	4. Two infinite wires carrying uniform linear charge density parallel to the x- axis. The one along $(y=0,\ z=l)$ has a charge density $+\lambda$ and the one along $(y=0,\ z=-l)$ has a charge density $-\lambda$. Take $2l \ll d$
	5. Infinite plane charge coincident with the xy-plane with uniform surface charge density

A. $P \rightarrow 5, Q \rightarrow 3, 4, R \rightarrow 1, S \rightarrow 2$

B. $P \rightarrow 5, Q \rightarrow 3, R \rightarrow 1, 4, S \rightarrow 2$

C. $P \rightarrow 5, Q \rightarrow 3, R \rightarrow 1, 2, S \rightarrow 4$

D. $P \rightarrow 4, Q \rightarrow 2, 3, R \rightarrow 1, S \rightarrow 5$

116. A planet of mass , has two natural satellites with masses and . The radii of their circular orbits are and respectively. Ignore the gravitational force between the satellites. Define , and to be, respectively, the orbital speed, angular momentum, kinetic energy and time period of revolution of satellite 1, and , , and to be the corresponding quantities of satellite 2. *Given*/2 and /1/4, match the ratios in List-I to the numbers in List-II.

LIST–I	LIST–II
P. $\frac{v_1}{v_2}$	1. $\frac{1}{8}$
Q. $\frac{L_1}{L_2}$	2. 1
R. $\frac{K_1}{K_2}$	3. 2
S. $\frac{T_1}{T_2}$	4. 8

A. $P \rightarrow 4, Q \rightarrow 2, R \rightarrow 1, S \rightarrow 3$

B. $P \rightarrow 3, Q \rightarrow 2, R \rightarrow 4, S \rightarrow 1$

C. $P \rightarrow 2, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 4$

D. $P \rightarrow 2, Q \rightarrow 3, R \rightarrow 4, S \rightarrow 1$

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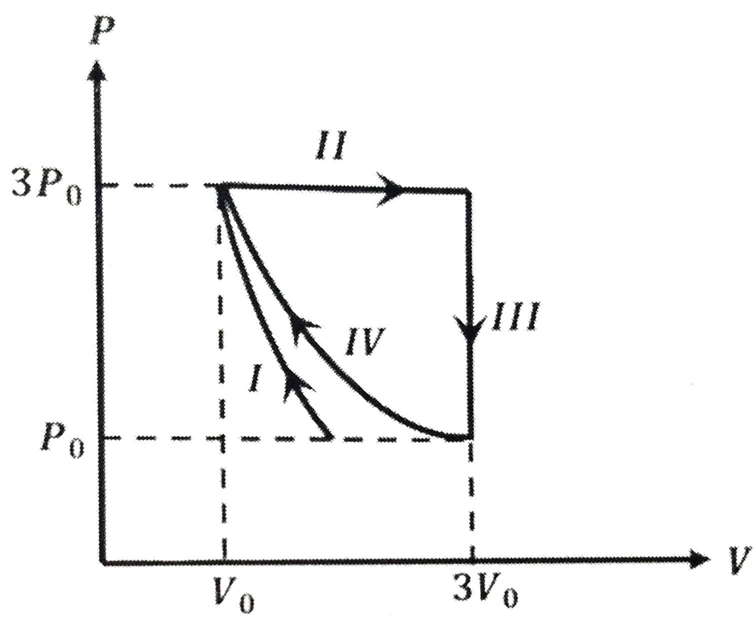
117. One mole of a monatomic ideal gas undergoes four thermodynamic processes as shown schematically in the -diagram below. Among these four processes, one is isobaric, one is isochoric, one is isothermal and one is adiabatic. Match the processes mentioned in List-1 with the corresponding statements in List-II.



A. $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 2$

B. $P \rightarrow 1, Q \rightarrow 3, R \rightarrow 2, S \rightarrow 4$

C. $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 1, S \rightarrow 2$

D. $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 2, S \rightarrow 1$

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118. In the List-I below, four different paths of a particle are given as functions of time. In these functions, and are positive constants of appropriate dimensions and . In each case, the force acting on the particle is either zero or conservative. In List-II, five physical quantities of the particle are mentioned: is the linear momentum, is the angular momentum about the origin, is the kinetic energy, is the potential energy and is the total energy. Match each path in List-I with those quantities in List-II, which are conserved for that path.

LIST–I	LIST–II
P. $\vec{r}(t) = \alpha t\,\hat{i} + \beta t\,\hat{j}$	1. $\vec{p}$
Q. $\vec{r}(t) = \alpha \cos \omega t\ \hat{i} + \beta \sin \omega t\ \hat{j}$	2. $\vec{L}$
R. $\vec{r}(t) = \alpha\,(\cos \omega t\ \hat{i} + \sin \omega t\ \hat{j})$	3. K
S. $\vec{r}(t) = \alpha t\,\hat{i} + \frac{\beta}{2} t^2\,\hat{j}$	4. U
	5. E

A. $P \rightarrow 1, 2, 3, 4, 5, Q \rightarrow 2, 5, R \rightarrow 2, 3, 4, 5, S \rightarrow 5$

B. $P \rightarrow 1, 2, 3, 4, 5, Q \rightarrow 3, 5, R \rightarrow 2, 3, 4, 5, S \rightarrow 2, 5$

C. $P \rightarrow 1, 2, 3, 4, Q \rightarrow 5, R \rightarrow 2, 3, 4, 5, S \rightarrow 2, 5$

D. $P \rightarrow 1, 2, 3, 4, 5, Q \rightarrow 2, 5, R \rightarrow 2, 3, 4, 5, S \rightarrow 2, 5$

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MULTIPLE CHOICE QUESTIONS

1. In the experiment to determine the speed of sound using a resonance column,

A. prongs of the tuning fork are kept in vertical plane

B. prongs of the tuning fork are kept in a horizontal plane

C. in one of the two resonance observed, the length of the resonating air column is close to the wavelength of sound in air

D. in one of the two resonance observed, the length of the resonating air column is close to half of the wavelength of sound in air.

Answer: A

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2. A student performs an experiment to determine the Young's modulus of a wire, exactly $2m$ long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8mm with an uncertainty of $\pm 0.05mm$ at a load of exactly $1.0kg$, the student also measures the diameter of the wire to be $04mm$ with an uncertainty of $\pm 0.01mm$. Take $g = 9.8m/s^2$ (exact). the Young's modulus obtained from the reading is

A. $(2.\,0 \pm 0.3) \times 10^{11} N/m^2$

B. $(2.0 \pm 0.2) \times 10^{11} N/m^2$

C. $(2.0 \pm 0.1) \times 10^{11} N/m^2$

D. $(2.0 \pm 0.05) \times 10^{11} N/m^2$

Answer: A::B

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3. A particle moves in the xy plane under the influence of a force such that its linear momentum is $\vec{P}(t) = A\left[\hat{i}\cos(kt) - \hat{j}\sin(kt)\right]$, where A and k are constants. The angle between the force and momentum is

A. 0°

B. 30°

C. 45°

D. 90°

Answer: D

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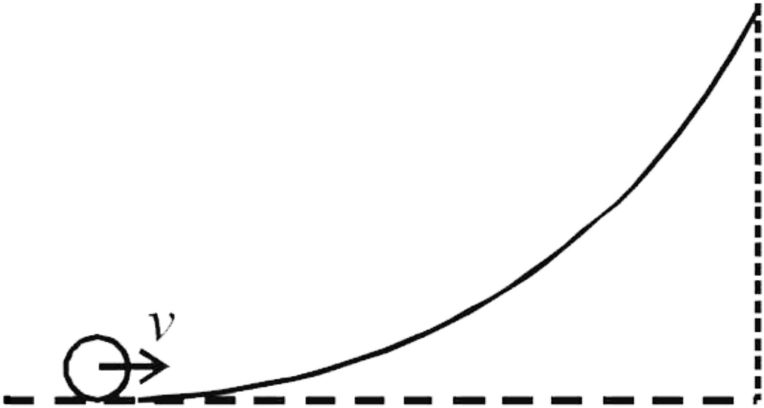
4. A small object of uniform density rolls up a curved surface with an initial velocity v. it reaches up to a maximum height of `(3v^2)/(4g)



with respect to the initial position. The object is

A. ring

B. solid sphere

C. hollow sphere

D. disc

Answer: D

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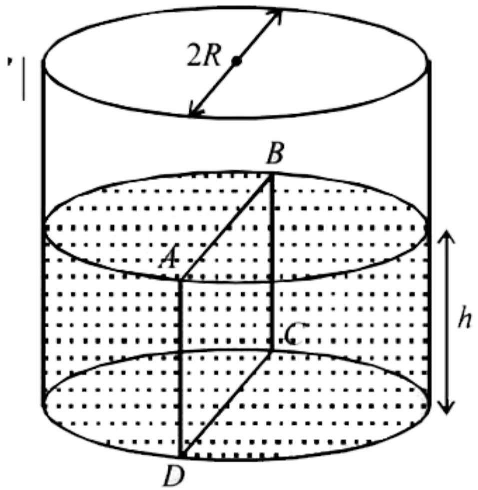
5. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude



A. $\left|2P_0Rh + \pi R^2\rho gh - 2RT\right|$

B. $\left|2P_0Rh + R\rho gh^2 - 2RT\right|$

C. $\left|P_0\pi R^2 + R\rho gh^2 - 2RT\right|$

D. $\left|P_0\pi R^2 + R\rho gh^2 + 2RT\right|$

Answer: B

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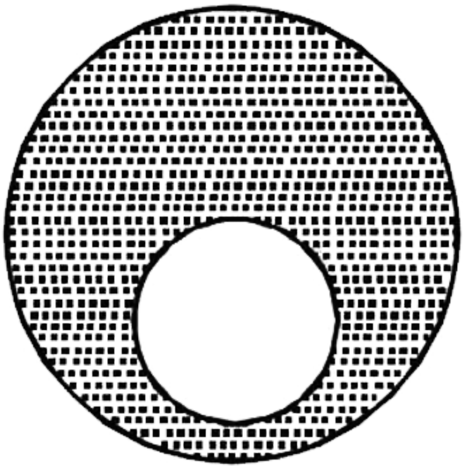
6. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume as shown in the figure. The electric field inisde the emptied space is



A. zero everywhere

B. non-zero and uniform

C. non-uniform

D. zero only at its center.

Answer: B

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7. Poistive and negative point charges of equal magnitude are kept at $\left(0, 0, \frac{a}{2}\right)$ and $\left(0, 0, \frac{-a}{2}\right)$ respectively. The work done by the electric field when another poistive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is

A. positive

B. negative

C. zero

D. depends on the path connecting the initial and final positions

Answer: C

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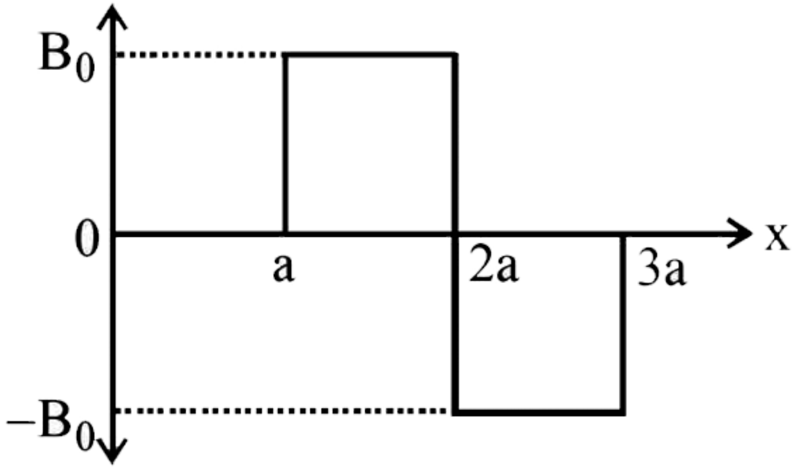
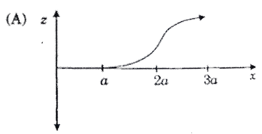
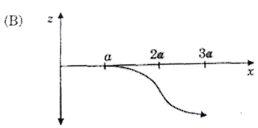
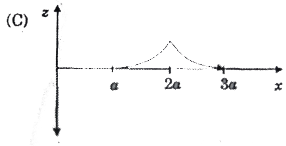
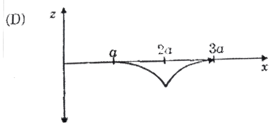
8. A magnetic field $\vec{B} = B_0\hat{j}$, exists in the region $a < x < 2a$, and $\vec{B} = -B_0\hat{j}$, in the region $2a < x < 3a$, where B_0 is a positive constant . A positive point charge moving with a velocity $\vec{v} = v_0\hat{i}$, where v_0 is a positive constant , enters the magnetic field at $x = a$. The trajectory of the charge in this region can be like



A. 

B. 

C. 

D. 

Answer: A

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9. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-ray is

A. $\lambda_0 = \frac{2mc\lambda^2}{h}$

B. $\lambda_0 = \frac{2h}{mc}$

C. $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$

D. $\lambda_0 = \lambda$

Answer: A

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10. Satement-1: if there is no external torque on a body about its centre of mass, then the velocity of the center of mass remains constant.

Statement-2: The linear momentum of an isolated system remains constant.

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 .

Answer: D

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11. STATEMENT-1: A cloth covers a table. Some dishes are kept on it. The cloth can be pulled out without dislodging the dishes from the table.

STATEMENT-2: For every action there is an equal and opposite reaction.

A. Statement - 1 is True, Statement - 2 is Ture, 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.

Answer: B

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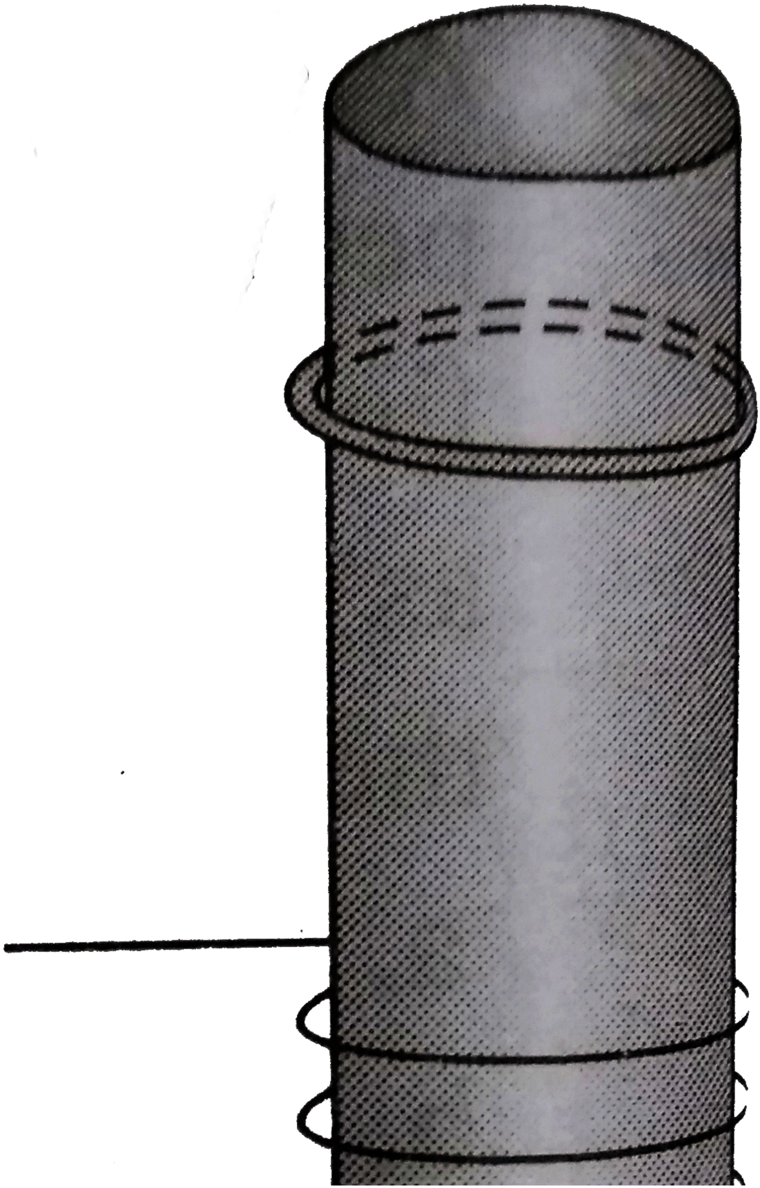
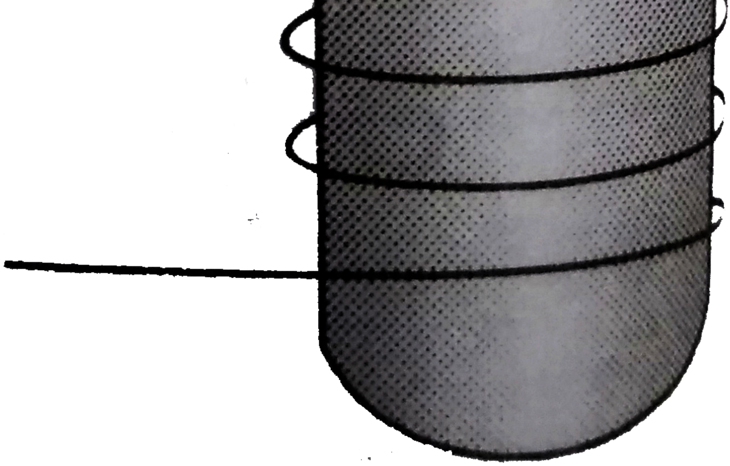
12. Statement I: A vertical iron rod has coil of wire wound over it at the bottom end. An alternating current flows in the coil. The rod goes through a conducting ring as shown in the figure. The ring can float at a certain height above the coil.

Statement II: In teh above situation, a current is induced in he ring which interacts with the horizontal component of teh magnetic field to produce an average force in the upward direction.





A. Statement-1 is True, Statement -2 is True,, Statement -2 is a correct explanations 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

Answer: A

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13. Statement-1: The total translational kinetic energy of fall the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume because.

Statement-2: The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

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

Answer: B

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14. Two trains A and B moving with speeds $20m/s$ and $30m/s$ respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle. Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800Hz$ to $f_2 = 1120Hz$, as shown in the figure. The spread in the frequency (highest frequency - lowest frequency) is thus $320Hz$. The speed of sound in still air is $340m/s$.

(4) The speed of sound of the whistle is

A. 340m/s for passengers in A and 310 m/s for passengers in B

B. 360 m/s for passengers in A and 310 m/s for passengers in B

C. 310 m/s for passengers in A and 360 m/s for passengers in B

D. 340 m/s for passengers in both the trains

Answer: B

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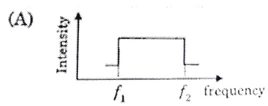
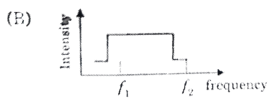
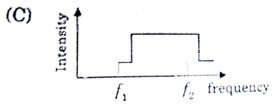
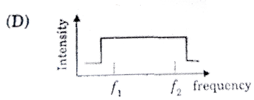
15. Two trains A and B moving with speeds $20m/s$ and $30m/s$ respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle. Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800Hz$ to $f_2 = 1120Hz$, as shown in the figure. the spread in the frequency (highest frequency - lowest frequency) is thus $320Hz$. the speed of sound in still air is $340m/s$.

(5) The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by

A. 

B. 

C. 

D. 

Answer: A

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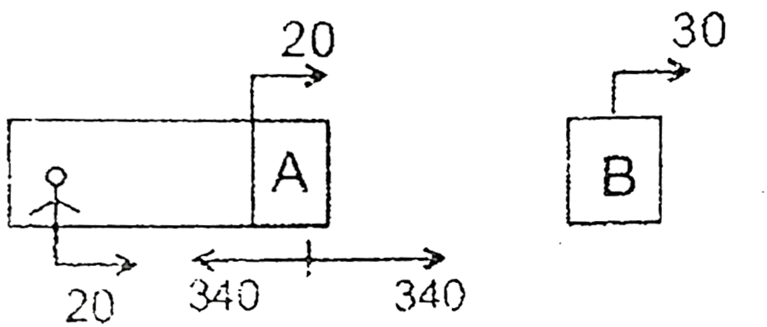
16. Two trains A and B are moving with speeds $20m/s$ respectively in the same direction on the same stright track, with B ahead of A. The engines are at the front ends. The engines of train A blows a long whistle.

Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800Hz$ to $f_2 = 1120Hz$, asz shown in figure. The spread in the frequency (highest frequency - lowest frequency) is thus $320Hz$. The speed of sound in still air is $340m/s$.



The spred of frequency as observed by the passengers in train B is

A. 310 Hz

B. 330 Hz

C. 350 Hz

D. 290 Hz

Answer: A

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17. Light travels as a

A. parallel beam in each medium

B. convergent beam in each medium

C. divergent beam in each medium

D. divergent beam in one medium and convergent beam in the other medium

Answer: A

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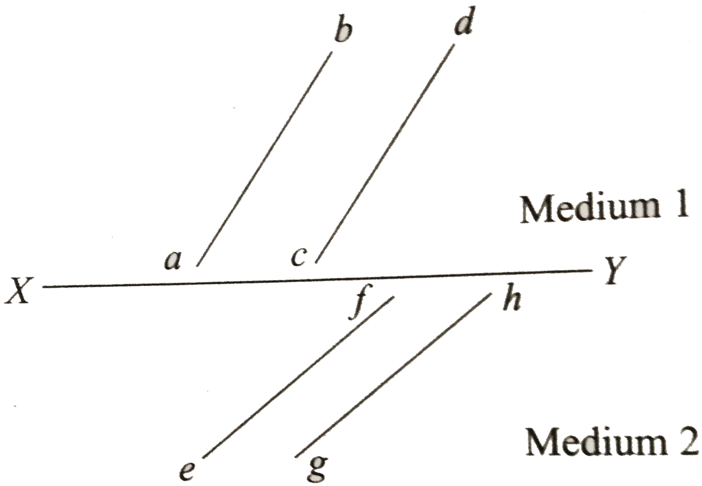
18. Fig. shows a surface XY separating two transparent media, medium 1 and medium 2. Lines ab and cd represent wavefronts of a light wave travelling in medium 1 and incident on XY. Line ef and gh represent wavefront of the light wave in medium 2 after rafraciton.



The phase of the ligth wave at c, d, e, and f are ϕ_c, phi_(d), ϕ_e and ϕ_f, respectively. It is given that $\phi_c \neq \phi_f$. Then

A. ϕ_c cannot be equal to ϕ_d

B. ϕ_d can be equal to ϕ_e

C. $\left(\phi_d - \phi_f\right)$ is equal to $\left(\phi_c - \phi_e\right)$

D. $\left(\phi_d - \phi_c\right)$ is not equal to $\left(\phi_f - \phi_e\right)$

Answer: C

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19. Speed of light is

A. the same in medium - 1 and medium - 2

B. larger in medium - 1 than in medium - 2

C. larger in medium - 2 than in medium -1

D. different at b and d

Answer: B

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20. Column I describes some situations in which a small object moves. Column II describes some characteristics of these motion. Match the situtions in column I with the characteristics in column II.

	Column - I		Column - II
(a)	The object moves on the x-axis under a conservative force in such a way that its speed and position satisfy $v = c_1\sqrt{c_2 - x^2}$, where c_1 and c_2 are positive constants.	(p)	The object executes a simple harmonic motion.
(b)	The object moves on the x-axis in such a way that its velocity and its displacement from the origin satisfy $v = -kx$, where k is a positive constant.	(q)	The object does not change its direction.

(c)	The object is attached to one end of a massless spring of a given spring constant. The other end of the spring is attached to the ceiling of an elevator. Initially everything is at rest. The elevator starts going upwards with a constant acceleration a. The motion of the object is observed from the elevator during the period it maintains this acceleration.	(r)	The kinetic energy of the objects keeps on decreasing.
(d)	The object is projected from the earth's surface vertically upwards with a speed $2\sqrt{GM_e / R_e}$, where M_e is the mass of the earth and R_e is the radius of the earth. Neglect forces from objects other than the earth.	(s)	The object can change its direction only once.

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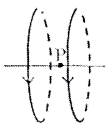
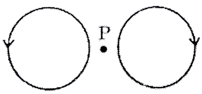
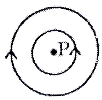
21. Two wires each carrying a steady current I are shown in four configurations in Column I. Some of the resulting effects are described in

Column II. Match the statements in Column I with the statements in Column II and the indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in the ORS.

Column I		Column II
(A) Point P is situated midway between the wires.		(p) The magnetic fields (B) at P due to the currents in the wires are in the same direction.
(B) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii.		(q) The magnetic fields (B) at P due to the currents in the wires are in opposite directions.
(C) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii.		(r) There is no magnetic field at P.
(D) Point P is situated at the common center of the wires.		(s) The wires repel each other.

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22. Column I gives some devices and Column II gives some processes on which the functioning of these devices depend. Match the devices in Column I with the processes in Column II and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in the ORS.

Column I	Column II
(A) Bimetallic strip	(p) Radiation from a hot body
(B) Steam engine	(q) Energy conversion
(C) Incandescent lamp	(r) Melting
(D) Electric fuse	(s) Thermal expansion of solids

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SECTION-III (Comprehension Type)

1. Three concentric metallic spherical shells of radii R, 2R, 3R are given charges $Q_1 Q_2 Q_3$, respectively. It is found that the surface charge densities on the outer surface of the shells are equal. Then, the ratio of the charges given to the shells $Q_1 : Q_2 : Q_3$ is

A. $1:2:3$

B. $1:3:5$

C. $1:4:5$

D. $1:8:18$

Answer: B

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2. A block of base $10cm \times 10cm$ and height $15cm$ is kept on an inclined plane. The corfficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased frm 0°. Then

A. at $\theta = 30^{\circ}$, the block will start sliding down the plane

B. the block will remain at rest on the plane up to certain θ and then it will topple

C. at $\theta = 60^{\circ}$, the block will start sliding down the plane and continue to do so at higher angles

D. at $\theta = 60^{\circ}$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ

Answer: B

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3. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4.3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of the ball as

$$\left[Take_g = 10\frac{m}{s^2}.\right]$$

A. 9m/s

B. 12m/s

C. 16m/s

D. 21.33m/s

Answer: C

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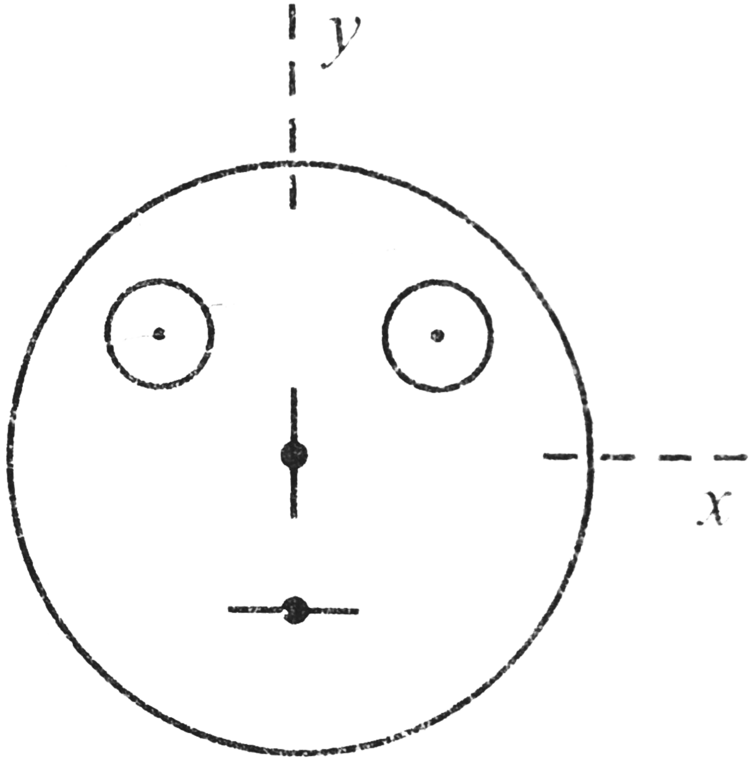
SECTION-I(Single Correct Choice Type)

1. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is $6m$.

The coordinates of the centres of the different parts are: outer circle $(0, 0)$, left inner circle $(-a, a)$, right inner circle (a, a), vertical line $(0, 0)$ and horizontal line $(0, -a)$. The y-coordinate of the centre of mass of the ink in this drawing is



A. $\frac{a}{10}$

B. $\frac{a}{8}$

C. $\frac{a}{12}$

D. $\frac{a}{3}$

Answer: A

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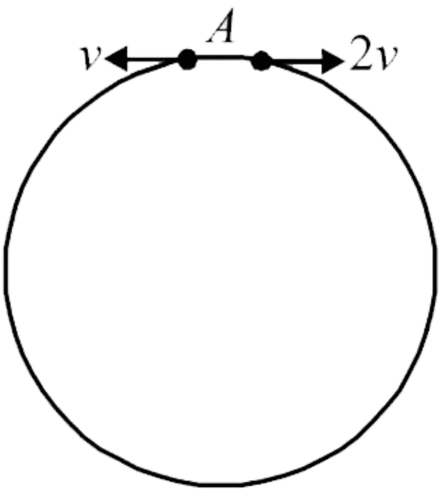
2. Two small particles of equal masses stant moving in opposite direction from a point A in a burtizonetal circule orbic their tangention velocity are V and $2V$, respectively as shown in the figure between collsions , the particals move with constant speed After making how many elastic collition , other the then that at A these two partical will again reach the point A ?



A. 4

B. 3

C. 2

D. 1

Answer: C

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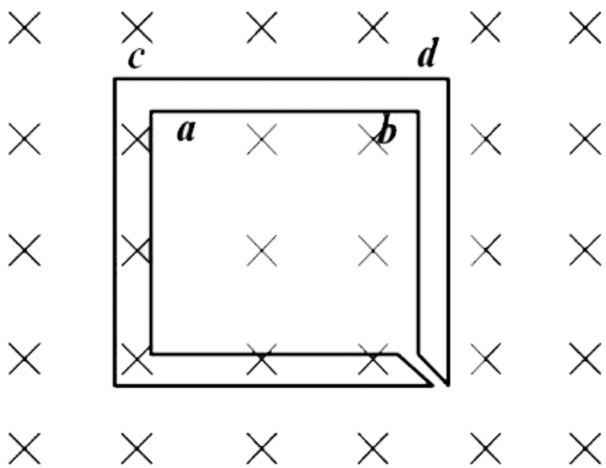
3. The figure shows certain wire segments joined together to form a coplaner loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time I_1 and I_2 are the currents in the segments ab and cd. Then,



A. $I_1 > I_2$

B. $I_1 < I_2$

C. I_1 is in the direction ba and I_2 is in the direction cd

D. I_1 is in the direction ab and I_2 is in the direction dc.

Answer: D

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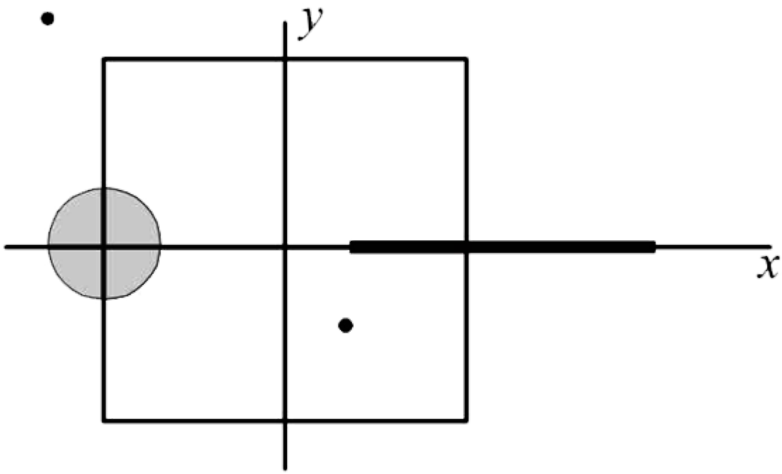
4. A disc of radius $a/4$ having a uniformly distributed charge $6C$ is placed in the x-y plane with its centre at $(-a/2, 0, 0)$. A rod of length a carrying a uniformly distributed charge 8C is placed on the x-axis from $x = a/4$ to $x = 5a/4$. Two point charges $-7C$ and $3C$ are placed at $(a/4, -a/4, 0)$ and $(-3a/4, 3a/4, 0)$, respectively. Conisder a cubical surface formed by isx surfaces $x = \pm a/2$, $y = \pm a/2$, $z = \pm a/2$. The electric flux through this cubical surface is



A. $\frac{-2C}{\varepsilon_0}$

B. $\frac{2C}{\varepsilon_0}$

C. $\frac{10C}{\varepsilon_0}$

D. $\frac{12C}{\varepsilon_0}$

Answer: A

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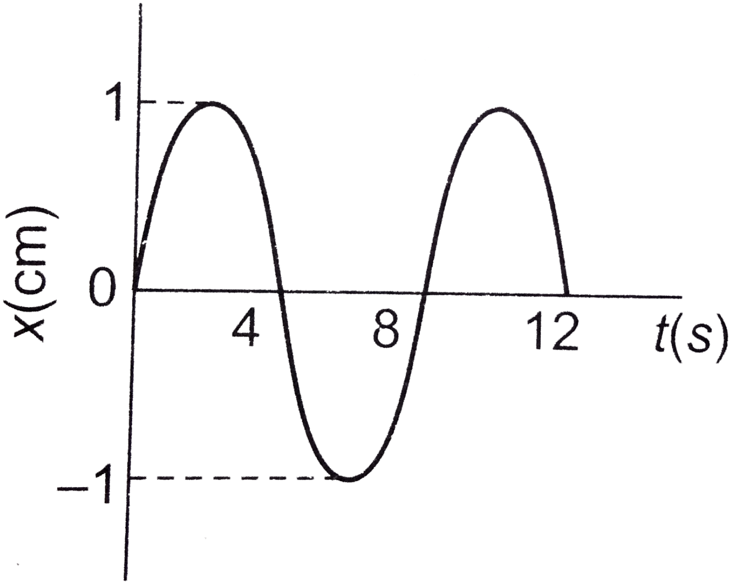
5. The x-t graph of a particle undergoing simple harmonic motion is shown below. The acceleration of the particle of $t = 4/3s$ is



A. $\frac{\sqrt{3}}{32}\pi^2 cm/s^2$

B. $\frac{-\pi^2}{32} cm/s^2$

C. $\frac{\pi^2}{32} cm/s^2$

D. $-\frac{\sqrt{3}}{32}\pi^2 cm/s^2$

Answer: D

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SECTION-II (Multiple Correct Choice Type)

1. If the resultant of all the external forces acting on a system of particles is zero. Then from an inertial frame, one can surely say that

A. linear momentum of the system does not change in time

B. kinetic energy of the system does not change in time

C. angular momentum of the system does not change in time

D. potential energy of the system does not change in time

Answer: A

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2. A student performed the experiment of determination of focal length of a concave mirror by u - v method using an optical bench of length 1.5

meter. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are: $(42, 56), (48, 48), (60, 40), (66, 33), (78, 39)$. The data set (s) that cannot come from experiment and is (are) incorrectly recorded, is (are)

A. (42,56)

B. (48,48)

C. (66,33)

D. (78,39)

Answer: C::D

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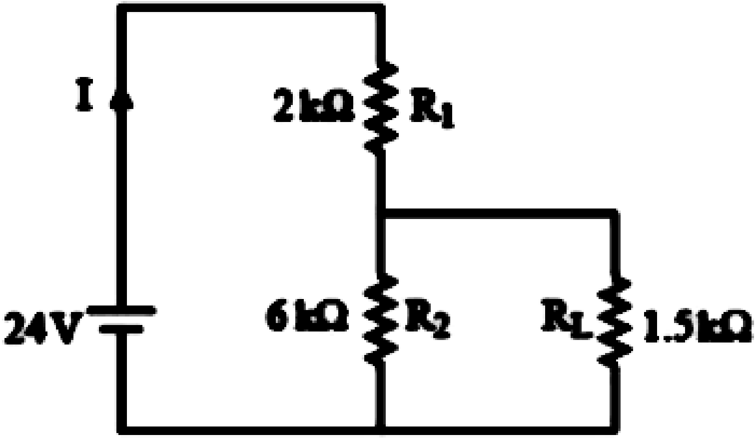
3. For the circuit shown in the figure



A. the current I through the battery is 7.5 mA

B. the potential difference across R_1 is $18V$

C. ratio of powers dissipated in R_1 and R_2 is 3

D. if R_1 and R_2 are interchanged , magnitude of the power dissipated in R_1, will decreased by a factor of 9

Answer: A::D

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4. C_p and C_v denote the molar specific heat capacities of a gas at constant pressure and volume respectively. Then :

A. $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatimic ideal gas

B. $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatimic ideal gas

C. C_p / C_v is larger for a diatomic ideal gas than for a monoatimic ideal gas

D. $C_p \cdot C_v$ is larger for a diatomic ideal gas than for a monoatimic ideal gas

Answer: B::C

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SECTION-III (Comprehension Type)

1. Scientists are working hard to develop nuclear fusion reactor Nuclei of heavy hydrogen, $\_ (1)^2H$, known as deuteron and denoted by D, can be thought of as a candidate for fusion rector . The $D - D$ reaction is $\_ (1)^2H + {}_1^2H \rightarrow {}_2^1He + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen of $\_ (1)^2H$ is fully ionized into deuteron nuclei and electrons. This collection of $\_ 1^2H$ nuclei and electrons is known as plasma . The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually , the temperature in the reactor core are too high and no material will can be used to confine the to plasma for a time t_0 before the particles fly away from the core. If n is the density (number volume) of deuterons , the product$nt_0$is called Lawson number. In one of the criteria , a reactor is termed successful if Lawson number is greater then $5 \times 10^{14} s/cm^2$

it may be helpfull to use the following boltzmann constant

$$\lambda = 8.6 \times 10^{-5} eV/k, \frac{e^2}{4\pi s_0} = 1.44 \times 10^{-9} eVm$$

Assume that two deuteron nuclei in the core of fusion reactor at temperature energy T are moving toward each other, each with kinectic energy $1.5kT$, when the seperation between them is large enough to neglect coulomb potential energy . Also neglate any interaction from other particle in the core . The minimum temperature T required for them to reach a separation of $4 \times 10^{-15} m$ is in the range

A. strong nuclear force acting between the deuterons

B. Coulomb force acting between the deuterons.

C. Coulomb force acting between deuteron-electron pairs

D. the high temperature maintained inside the reactor core

Answer: D

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2. Scientists are working hard to develop nuclear fusion reactor Nuclei of heavy hydrogen, $\_(1)^2H$, known as deuteron and denoted by D, can be thought of as a candidate for fusion rector . The $D - D$ reaction is $\_(1)^2H +_1^2H \rightarrow _2^1He + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen of $\_(1)^2H$ is fully ionized into deuteron nuclei and electrons. This collection of $\_1^2H$ nuclei and electrons is known as plasma . The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually , the temperature in the reactor core are too high and no material will can be used to confine the to plasma for a time t_0 before the particles fly away from the core. If n is the density (number volume) of deuterons , the product$nt_0$is called Lawson number. In one of the criteria , a reactor is termed successful if Lawson number is greater then $5 \times 10^{14} s/cm^2$

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A. $1.0 \times 10^9 K < T < 2.0 \times 10^9 K$

B. $2.0 \times 10^9 K < T < 3.0 \times 10^9 K$

C. $3.0 \times 10^9 K < T < 4.0 \times 10^9 K$

D. $4.0 \times 10^9 K < Y < 5.0 \times 10^9 K$

Answer: A

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3. Scientists are working hard to develop nuclear fusion reactor Nuclei of heavy hydrogen, $_(1)^2H$, known as deuteron and denoted by D, can be thought of as a candidate for fusion rector . The D-D reaction is $_(1)^2H +_1^2H \rightarrow_2^1He + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen of $_(1)^2H$ is fully ionized into deuteron nuclei and electrons. This collection of $_1^2H$ nuclei and electrons is known as plasma . The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually , the temperature in the reactor core are too high and no material will can be used to confine the to plasma for a time t_0 before the particles fly away from the core. If n is the density (number volume) of deuterons , the product$nt_0$is called Lawson number. In one of the criteria , a reactor is termed successful if Lawson number is greater then $5 \times 10^{14} s/cm^2$

it may be helpfull to use the following boltzmann constant

$\lambda = 8.6 \times 10^{-5} eV/k, \dfrac{e^2}{4\pi s_0} = 1.44 \times 10^{-9} eVm$

Result of calculations for four different design of a fusion reactor using D - D reaction are given below. which of these is most promising based on Lawson criterion ?

A. deuteron density $= 2.0 \times 10^{12} cm^{-3}$, confinement time $= 5.0 \times 10^{-3} s$

B. deuteron density $= 8.0 \times 10^{14} cm^{-3}$, confinement time $= 9.0 \times 10^{-1} s$

C. deuteron density $= 4.0 \times 10^{23} cm^{-3}$, confinement time $= 1.0 \times 10^{-11} s$

D. deuteron density $= 1.0 \times 10^{24} cm^{-3}$, confinement time $= 4.0 \times 10^{-12} s$

Answer: B

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4. When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where α if of nenometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de Broglie relation. The energy of the particle of mass m is related to its linear momentum as $E = \frac{p^2}{2m}$. Thus the energy of the particle can be denoted by a quantum number n taking values 1,2,3, ...($n = 1$, called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particle moving along the line from $x = 0$ to $x = \alpha$. Take $h = 6.6 \times 10^{-34} Js$ and $e = 1.6 \times 10^{-19}$ C.

Q. The allowed energy for the particle for a particular value of n is proportional to

A. a^{-2}

B. $a^{-3/2}$

C. a^{-1}

D. a^2

Answer: A

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5. When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where α if of nenometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de Broglie relation. The energy of the particle of mass m is related to its linear momentum as $E = \frac{p^2}{2m}$. Thus the energy of the particle can be denoted by a quantum number n taking values 1,2,3, ...($n = 1$, called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particle moving along the line from $x = 0$ to $x = \alpha$. Take $h = 6.6 \times 10^{-34} Js$ and $e = 1.6 \times 10^{-19}$ C.

Q. If the mass of the particle is $m = 1.0 \times 10^{-30}$kg and $\alpha = 6.6nm$, the energy of the particle in its ground state is closest to

A. 0.8 meV

B. 8meV

C. 80meV

D. 800 meV

Answer: B

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6. When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where α if of nenometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de Broglie relation. The energy of the particle of mass m is related to its linear momentum as $E = \frac{p^2}{2m}$. Thus the energy of the particle can be denoted by a quantum number n taking values 1,2,3, ...($n = 1$, called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particle moving along the line from $x = 0$ to $x = \alpha$. Take $h = 6.6 \times 10^{-34} Js$ and $e = 1.6 \times 10^{-19}$C

Q. The speed of the particle that can take discrete values is proportional to

A. $n^{-3/2}$

B. n^{-1}

C. $n^{1/2}$

D. n

Answer: D

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SECTION-IV(Matrix-Match Type)

1. Six point charges , each of the same magnitude q, are arranged in different manners as shown in Column II . In each case, a point M and a line PQ passing through M are shown . Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest . Now, the whole system is set into rotation with a constant angular velocity about the line PQ . Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition . Assume each rotating charge to be equivalent to a steady current .

Column I

(A) $E = 0$

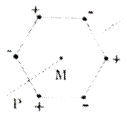
(B) $V \neq 0$

(C) $B = 0$

(D) $\mu \neq 0$

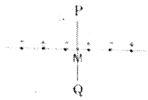
Column II

(p)



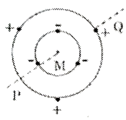
Charges are at the corners of a regular hexagon. M is at the centre of the hexagon. PQ is perpendicular to the plane of the hexagon.

(q)



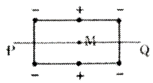
Charges are on a line perpendicular to PQ at equal intervals. M is the mid-point between the two innermost charges.

(r)



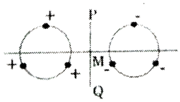
Charges are placed on two coplanar insulating rings at equal intervals. M is the common centre of the rings. PQ is perpendicular to the plane of the rings.

(s)



Charges are placed at the corners of a rectangle of sides a and $2a$ and at the mid points of the longer sides. M is at the centre of the rectangle. PQ is parallel to the longer sides.

(t)



Charges are placed on two coplanar, identical insulating rings at equal intervals. M is the mid-point between the centres of the rings. PQ is perpendicular to the line joining the centres and coplanar to the rings.

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2. Column II show five systems in which two objects are labelled as X and Y. also in such case a point P is shown . Column I gives some statements about X and/or Y . Match these statements to the appropriate system(s) from Column.II

Column I

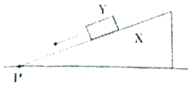
(A) The force exerted by X on Y has a magnitude Mg.

(B) The gravitational potential energy of X is continuously increasing.

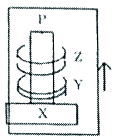
(C) Mechanical energy of the system X + Y is continuously decreasing.

(D) The torque of the weight of Y about point P is zero.

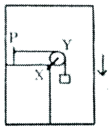
Column II

(p) 

Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity.

(q) 

Two ring magnets Y and Z, each of mass M, are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant velocity.

(r) 

A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at point P of the table. The whole system is kept in a lift that is going down with a constant velocity.

(s) 

A sphere Y of mass M is put in a nonviscous liquid X kept in a container at rest. The sphere is released and it moves down in the liquid.

(t) 

A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container.

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SECTION-I (Single correct Choice Type)

1. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is:

A. $\frac{a}{gk}$

B. $\frac{a}{2gk}$

C. $\frac{2a}{gk}$

D. $\frac{a}{4gk}$

Answer: B

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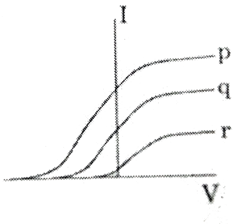
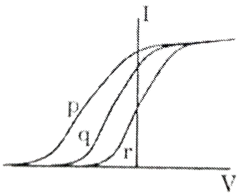
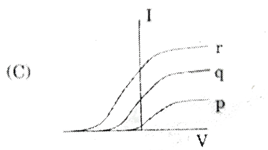
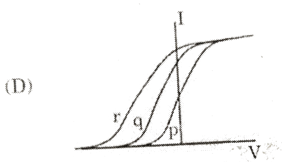
2. Photoelectric effect experiments are performed using three different metal plates p, q and$r$ having work function $\phi_p = 2.0eV, \phi_e = 2.5eV$ and $\phi_r = 3.0eV$ respectively A light beam containing wavelength of $550nm$, $450nm$ and $350nm$ with equal intensities illuminates each of the plates . The correct I - V graph for the experiment is [Take hc = 1240 eV nm]

A. 

B. 

C. 

D. 

Answer: A

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3. A uniform rod of length (L) and mass (M) is pivoted at the centre. Its two ends are attached to two springs of equal spring constants (k). The springs are fixed to rigid supports as shown in the figure, and the rod is free to oscillate in the horizontal plane. The rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle (theta) in one direction and released. The frequency of oscillation is. ?

(##JMA_CHMO_C10_009_Q01##).

A. $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$

B. $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$

C. $\frac{1}{2\pi}\sqrt{\frac{6k}{M}}$

D. $\frac{1}{2\pi}\sqrt{\frac{24k}{M}}$

Answer: C

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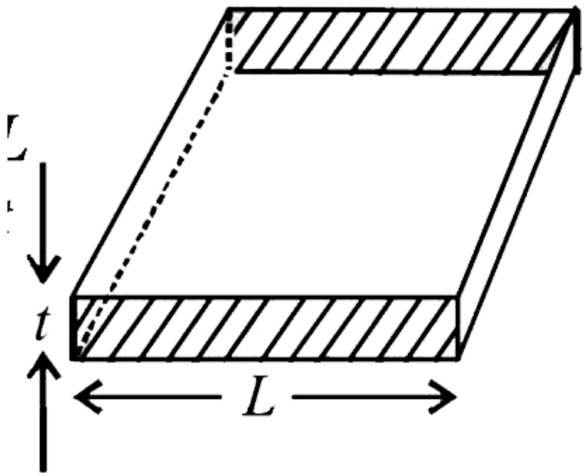
4. Consider a thin square sheet of side L and thickness t, made of a material of resistivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is



A. directly proportional to L

B. directly proportional to t

C. independent of L

D. independent of t

Answer: C

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5. A real gas behaves like an ideal gas if its

A. pressure and temperature are both high

B. pressure and temperature are both low

C. pressure is high and temperature is low

D. pressure is low and temperature is high

Answer: D

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6. Incandescent bulbs are designed by keeping in mind that the resistance of their filament increases with the increase in temperature. If at room temperature, $100W, 60W$ and $40W$ bulbs have filament resistances R_{100}, R_{60} and R_{40}, respectively, the relation between these resistances is

A. $\frac{1}{R_{100}} = \frac{1}{R_{40}} + \frac{1}{R_{60}}$

B. $R_{100} = R_{40} + R_{60}$

C. $R_{100} > R_{60} > R_{40}$

D. $\dfrac{1}{R_{100}} > \dfrac{1}{R_{60}} > \dfrac{1}{R_{40}}$

Answer: D

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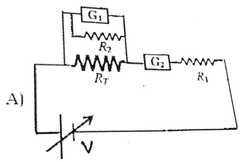
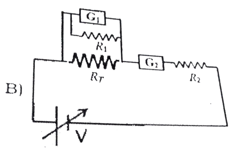
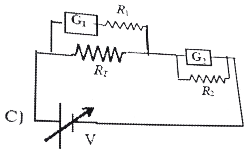
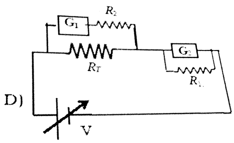
7. To verify Ohm's law, a student is provided with a test resistor R_T, a high resistance R_1, a small resistance R_2, two identical galvanometer G_1 and G_2, and a variable voltage source V. The correct circuit to carry out the experiment is

A. 

B. 

C. 

D. 

Answer: C

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8. An AC voltage source of variable angular frequency ω and fixed amplitude V_0 is connected in series with a capacitance C and an electric bulb of resistance R (inductance Zero). When ω is increase.

A. the bulb glows dimmer

B. the bulb glows brighter

C. total impedance of the circuit is unchanged

D. total impedance of the circuit is increases

Answer: B

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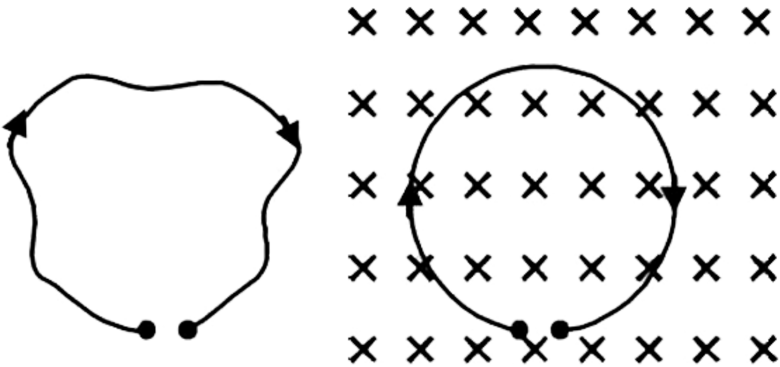
9. A thin wire of length L is connected to two adjacent fixed points and carries a current I in the clockwise direction , as shown in the figure. When the system is put in a uniform magnetic field of strength B going into the plane of the paper , the wire takes the shape of a circle . The tension in the wire is



A. IBL

B. $\frac{IBL}{\pi}$

C. $\frac{IBL}{2\pi}$

D. $\frac{IBL}{4\pi}$

Answer: C

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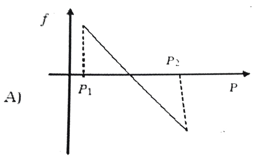
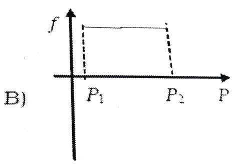
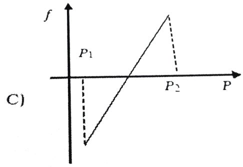
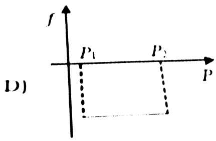
10. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and $\tan\theta > \mu$. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like

A. 

B. 

C. 

D. 

Answer: A

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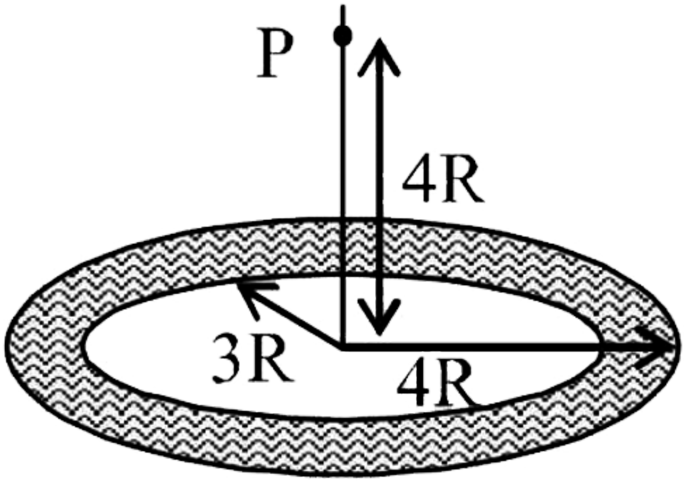
11. A thin uniform disc (see figure) of mass M has outer radius 4R and inner radius 3R. The work required to take a unit mass for point P on its axis to infinity is



A. $\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$

B. $-\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$

C. $\frac{GM}{4R}$

D. $\frac{2GM}{5R}\left(\sqrt{2}-1\right)$

Answer: A

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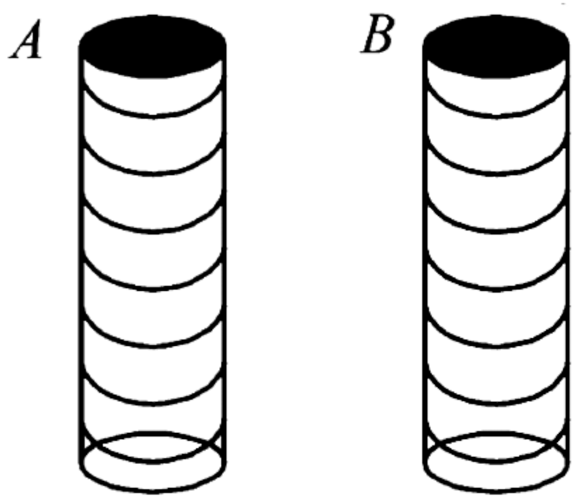
SECTION-II (Multiple correct Choice Type)

1. Two metallic rings A and B, identical in shape and size but having different reistivities ρA and ρB, are kept on top of two identical solenoids as shown in the figure . When current I is switched on in both the solenoids in identical manner, the rings A and B jump to heights h_A and h_B, repectively , with $h_A > h_B$. The possible relation(s) between their resistivities and their masses m_A and m_B is(are)



A. $\rho_A > \rho_B$ and $m_A = m_B$

B. $\rho_A < \rho_B$ and $m_A = m_B$

C. $\rho_A > \rho_B$ and $m_A > m_B$

D. $\rho_A < \rho_B$ and $m_A < m_B$

Answer: B::C

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2. A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air-column is the second resonance. Then,

A. the intensity of the sound heard at the first resonance was more than that at the second resonance

B. the prongs of the tuning fork wer kept in a horizontal plane above the resonance tube

C. the amplitude of vibration of the ends of the prongs is typically around 1 cm

D. the length of the air-column at the first resonance was somewhat shorter than 1/4th of the wavelength of the sound in air

Answer: A::D

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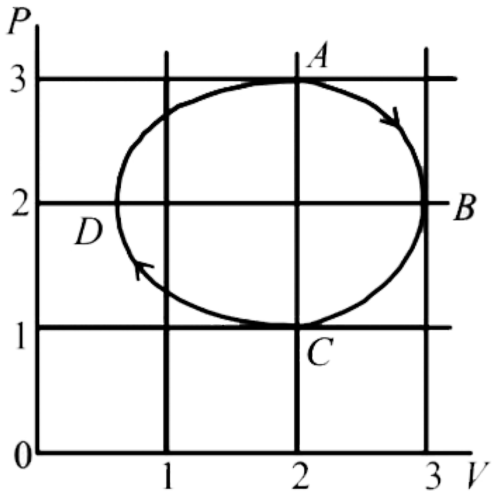
3. The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then,



A. the process during the path $A \rightarrow B$ is isothermal

B. heat flows out of the gas during the path $B \rightarrow C \rightarrow D$

C. work done during the path $A \rightarrow B \rightarrow C$ is zero

D. positive work is done by the gas in the cycle ABCDA

Answer: B::D

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4. Under the influence of the Coulomb field of charge $+Q$, a charge $-q$ is moving around it in an elliptical orbit. Find out the correct statement(s).

A. The angular momentum of the charge -q is constant

B. The linear momentum of the charge -q is constant

C. The angular velocity of the charge -q is constant

D. The linear speed of the charge -q is constant

Answer: A

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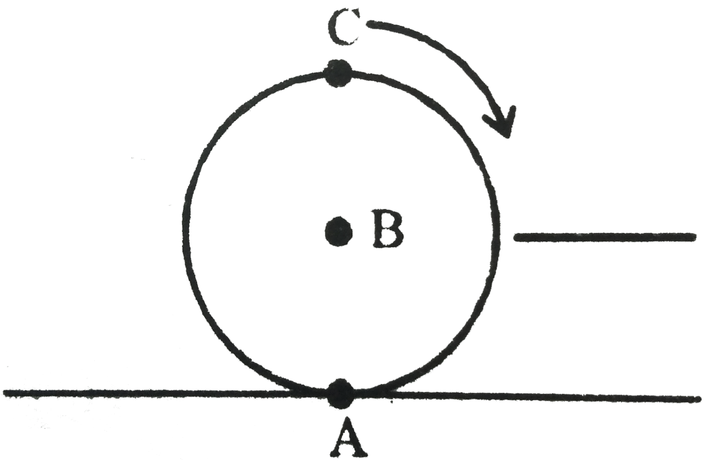
5. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact. B is the centre of the sphere and C is its topmost point. Then



A. $\vec{V}_c - \vec{V}_A = 2\left(\vec{V}_B - \vec{V}_C\right)$

B. $\vec{V}_C - \vec{V}_B = \vec{V}_B - \vec{V}_A$

C. $\left|\vec{V}_c - \vec{V}_A\right| = 2\left|\vec{V}_B - \vec{V}_C\right|$

D. $\left|\vec{V}_c - \vec{V}_A\right| = 4\left|\vec{V}_B\right|$

Answer: B::C

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SECTION-IV (Integer Answer Type)

1. A metal rod AB of length 10x has its one end A in ice at $0^\circ C$, and the other end B in water at $100^\circ C$. If a point P one the rod is maintained at $400^\circ C$, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is $540 cal/g$ and latent heat of melting of ice is $80 cal/g$. If the point P is at a distance of λx from the ice end A, find the value λ. [Neglect any heat loss to the surrounding.]

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2. A cylindrical vessel of height 500mm has an orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it up to height H. Now the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with height of water column being 200mm. Find the fall in height(in mm) of water level due to opening of the orifice.

[Take atmospheric pressure $= 1.0 \times 10^5 N/m^2$, density of water=1000kg//m^3 and g=10m//s^2`. Neglect any effect of surface tension.]

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3. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure $8N/m^2$. The radii of bubbles A and B are $2cm$ and $4cm$, respectively. Surface tension of the soap. Water used to make bubbles is $0.04N/m$. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B respectively. [Neglect the effect of gravity.]

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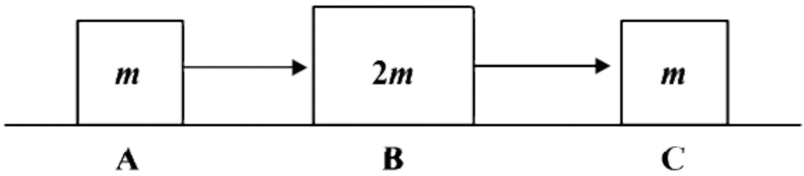
4. There object A, B and C are kept is a straing line a fritionlas horizental surface . These have masses have increase on $2m$ and m repectively . The object A move toward B with a speed 9 m//s and makes as electic collision with a there after B makes complately inclesis with C . All motion over on the same strength line . Find the first speed of the object C



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5. A steady current I goes through a wire loop PQR having shape of a right angle triangle with $PQ = 3x$, $PR = 4x$ and $QR = 5x$. If the magnitude of the magnetic field at P due to this loop is $k\left(\frac{\mu_0 I}{48\pi x}\right)$, find the value of K.

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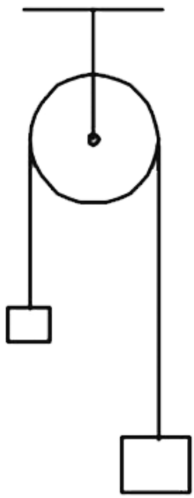
6. A light inextensible string that gas over a smoth fixed polley as shown in the figure connect two blocks of mases it 0.36 kg and 0.72 kg Taking $g = 10ms^{-2}$, find the work done by the string on the block of mass 0.36 kg doring the first second after the system is refosed from rest ,



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7. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = kr^{a}$, where k and a are constants and r is the distance from its centre. If the electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times that $r = R$, find the value of a.

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8. A $20cm$ long string, having a mass of $1.0g$, is fixed at both the ends. The tension in the string is $0.5N$. The string is into vibrations using an external vibrator of frequency $100Hz$. Find the separation (in cm) between the successive nodes on the string.

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Section-II (Multiple correct choice type)

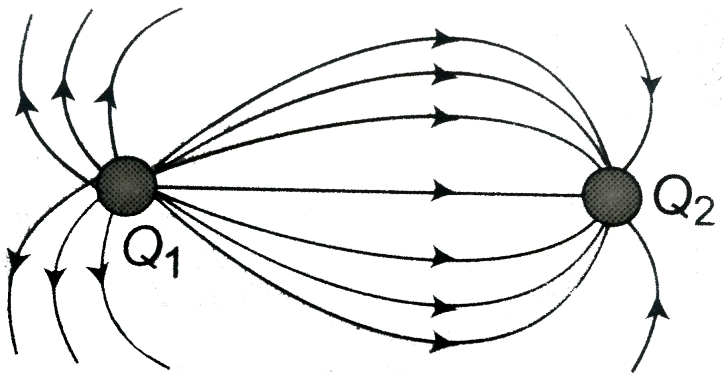
1. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis are shown in the figure. These lines suggest that

(i) $|Q_1| > |Q_2|$

(ii) $|Q_1| < |Q_2|$

(iii) At a finite distance to the left of Q_1 the electric field is zero

(iv) At a finite distance to the right of Q_2 the electric field is zero



A. $|Q_1| > |Q_2|$

B. $|Q_1| < |Q_2|$

C. at a finite distance to the left of Q_1 the electric field is zero

D. at a finite distance to the right of Q_2 the electric field is zero

Answer: A::D

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2. A student uses a simple pendulum of exactly $1m$ length to determine g, the acceleration due ti gravity. He uses a stop watch with the least count of $1\sec$ for this and record $40\text{sec}onds$ for 20 oscillations for this observation, which of the following statement $(s)is(are)$ true?

A. Errot ΔT in measuring T, the time period, is 0.05 s

B. Error ΔT in measuring T, the time period , is 1 s

C. percentage error in the determination of g is 5%

D. percentage error in the determination of g is 2.5 %

Answer: A::C::D

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3. A point mass of $1kg$ collides elastically with a stationary point mass of $5kg$. After their collision, the $1kg$, mass reverses its direction and moves with a speed of $2ms^{-1}$. Which of the following statement(s) is (are) correct for the system of these two masses?

A. total momentum of the sytem is 3 kg ms^{-1}

B. momentum of 5 kg mass after collision is 4 kg ms^{-1}

C. KE of the centre of mass is 0.75 J

D. totak KE of the system is 4J

Answer: A::C::D

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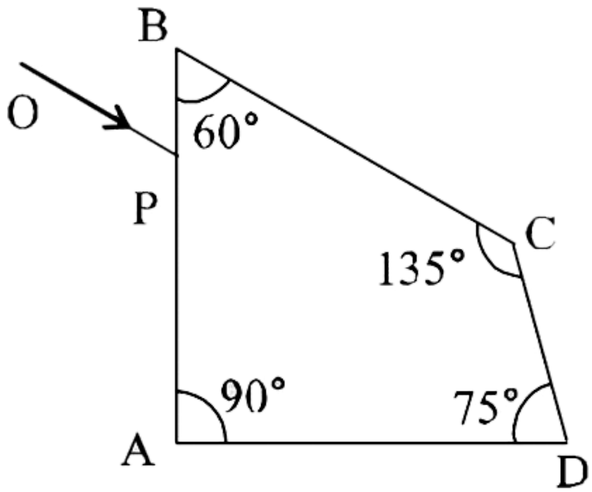
4. A ray OP of monochromatic light is incident on the face AB of prism ABCD mear vertex B at an incident angle of $60 degree$ (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) are correct? `



A. The ray gets totally internally reflected at face CD

B. The ray comes out through face AD

C. The angle between the incident ray and the emergent ray is $90\,^{\circ}$

D. The angle between the incident ray and the emergent ray is $120\,^{\circ}$

Answer: A::B::C

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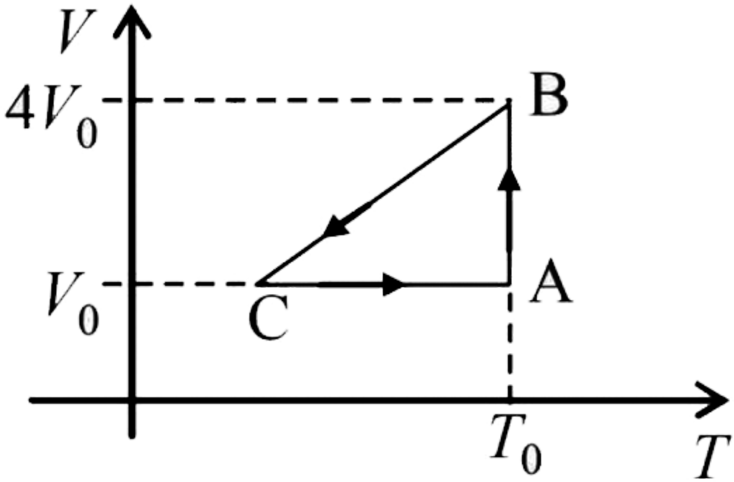
5. One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, as shown in the figure. Its pressure at A is P_0. Choose the correct option (s) from the following



A. Internal energies at A and B are the same

B. work done by the gas in process AB is $P_0V_0\ln 4$

C. pressure at C is $\frac{P_O}{4}$

D. Temperature at C is $\frac{T_O}{4}$

Answer: A::B::C::D

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Section-III (Paragraph)

1. When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$ it performs simple harmonic motion. The correspondubing time period is proprtional to $\frac{\sqrt{m}}{h}$, as can be seen easily using dimensional analusis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape toin finity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = ax^4 (a > 0)$ for |x| neat the origin and becomes a constant equal to V_0 for |x|impliesX_(0)` (see figure).

(##JMA_CHMO_C10_031_Q01##)

If total energy of the particle is E, it will perform perildic motion only if.

A. Elt 0

B. Egt0

C. $V_0 > E > O$

D. $E > V_0$

Answer: A::B::C::D

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2. When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$ it performs simple harmonic motion. The correspondubing time period is proprtional to $\frac{\sqrt{m}}{h}$, as can be seen easily using dimensional analusis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape toin finity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = ax^4 (a > 0)$ for |x| neat the origin and becomes a constant equal to V_0 for |x|impliesX_(0)` (see figure).

(##JMA_CHMO_C10_032_Q01##).

For periodic motion of small amplitude A,the time period (T) of thes particle is proportional to.

A. $A\sqrt{\frac{m}{\alpha}}$

B. $\frac{1}{A}\sqrt{\frac{m}{\alpha}}$

C. $A\sqrt{\frac{\alpha}{m}}$

D. $\frac{1}{A}\sqrt{\frac{\alpha}{m}}$

Answer: B

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3. When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$ it performs simple harmonic motion. The correspondubing time period is proprtional to $\frac{\sqrt{m}}{h}$, as can be seen easily using dimensional analusis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape toin finity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = ax^4 (a > 0)$ for |x| neat the origin and becomes a constant equal to V_0 for |x|impliesX_(0) (seefigure). $\left(##JMA_CHMO_C10_{033}-Q01##\right)$. $Theae \leq rationofthisparti \leq f$ or |x|gtX_(0)$is(a) \propto rtional \rightarrow$ V_(0)`

(b) proportional to.

A. proportional to $\frac{V_0}{mX_0}$

B. Proportional to V_0

C. proportional to $\sqrt{\frac{V_0}{mX_0}}$

D. zero

Answer: D

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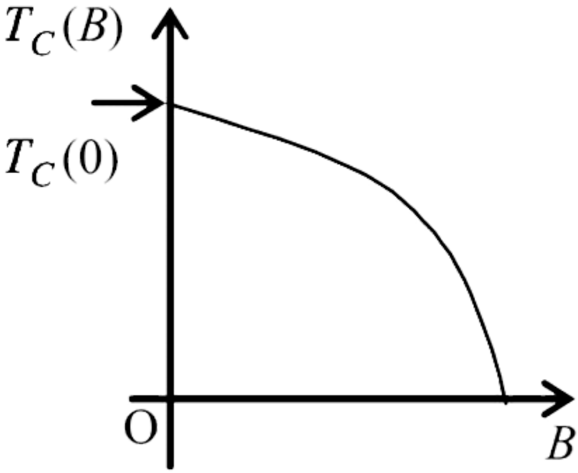
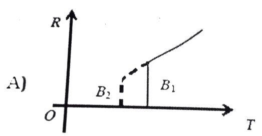
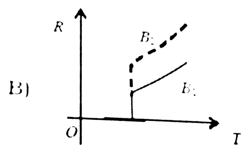
4. Electrical resistance of certain materials, known as superconductors, changes abruptly from a nonzero value of zero as their temperature is lowered below a critical temperature $T_C(0)$. An interesting property of super conductors is that their critical temperature becomes smaller than

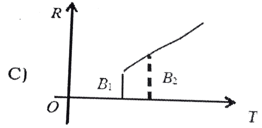
$T_C(0)$ if they are placed in a magnetic field, i.e., the critical temperature $T_C(B)$ is a function of the magnetic field strength B. The dependence of $T_C(B)$ on B is shown in the figure.

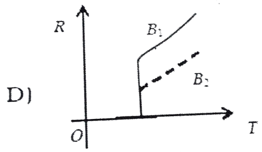


In the graphs below, the resistance R of a superconductor is shown as a function of its temperature T for two different magnetic fields B_1(solid line) and B_2 (dashed line). If B_2 is larget than B_1 which of the following graphs shows the correct variation of R with T in these fields?

A. 

B. 

C. 

D. 

Answer: A

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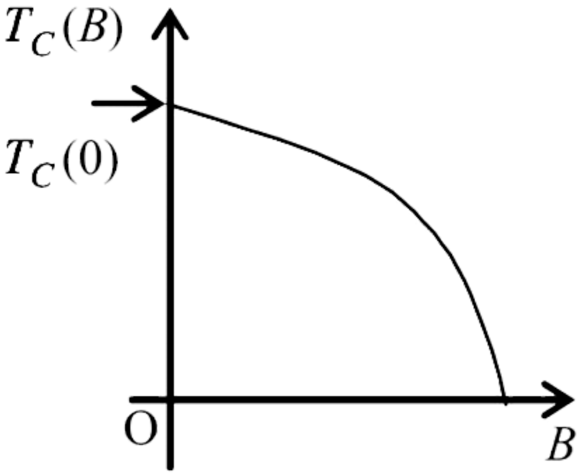
5. Electrical resistance of certain materials, known as superconductors, changes abruptly from a nonzero value of zero as their temperature is lowered below a critical temperature $T_C(0)$. An interesting property of super conductors is that their critical temperature becomes smaller than $T_C(0)$ if they are placed in a magnetic field, i.e., the critical temperature $T_C(B)$ is a function of the magnetic field strength B. The dependence of $T_C(B)$ on B is shown in the figure.



A superconductor has $T_C(0) = 100K$. When a magnetic field of 7.5 Tesla is applied , its T_C decreases to 75 K. For this material one can difinitely say that when

A. B=5 Tesla, $T_c(B)$ =80 K

B. B=5 Tesla, 75 K ltT_c (B) lt 100 K

C. B=10 Tesla, 75 K lt $T_c(B)$lt100 K

D. B=10 Tesla, $T_c(B)$ =70 K

Answer: B

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Section -IV (Integer type)

1. The focal length of a thin biconvex lens is $20cm$. When an object is moved from a distance of $25cm$ in front of it to $50cm$, the magni-fication of its image changes from $m_{25} \rightarrow m_{50}$. The ratio $\frac{m_{25}}{m_{50}}$ is.

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2. An α- particle and a proton are accelerated from rest by a potential difference of $100V$ After this their de Broglie wavelength are λ_a and λ_p respectively The ratio $\frac{\lambda_p}{\lambda_p}$, to the nearest integer is

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3. When two identical batteries of internal resistance 1Ω each are connected in series across a resistor R, the rate of heat produced in R is

J_1. When the same batteries are connected in parallel across R, the rate is

J_2 = 2.25 J_2$thenthevalueofR \in$ Omega` is

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4. Two spherical bodies A (radius 6cm) and B (radius 18cm) are at temperature T_1 and T_2 respectively The maximum intensity in the emission spectrum of A is at $500nm$ and in that of B is at $1500nm$ considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B . ?

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5. When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin\left(2x - 6t - \frac{\pi}{2}\right)$ are superimposed, the amplitude of the resultant wave is

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6. A $0.1kg$ mass is suspended from a wire of negligible mass. The length of the wire is 1m and its crosssectional are is $4.9 \times 10^{-7}m^2$. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency $140rads^{-1}$. If the Young's modulus of the material of the wire is $n \times 10^9 Nm^{-2}$, the value of n is

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7. A binary star consists of two stars $A\left(mass 2.2M_s\right)$ and B $\left(mass 11M_s\right)$ where M_s is the mass of the sun, they are separted by distane d and are rotating about their center of mass, which is stationary. The ratio of the total angular momentum of the binary to the angular momentum of star B about the centre of mass is

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8. Graviational acceleration on the surface of plane fo $\frac{\sqrt{6}}{11}g$. where g is the gracitational acceleration on the surface of the earth. The average mass density of the planet is $\frac{2}{3}$ times that of the earth. If the escape speed on the surface of the earht is taken to be $11kms^{-1}$ the escape speed on teh surface of the planet in kms^{-1} will be

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9. A piece of ice (heat capacity $= 2100Jkg^{-1}.^{\circ}C^{-1}$ and latent heat $= 3.36 \times 10^5 Jkg^{-1}$) of mass m grams is at $-5.^{\circ}C$ at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice . Water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m in gram is

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10. A stationary source is emitting sound at a fixed frequency f_0, which is reflected by two cars approaching the source. The difference between the frequencies of sound reflected from the cars is 1.2% of f_0. What is the difference in the speeds of the cars (in km per hour) to the nearest integer ? The cars are moving at constant speeds much smaller than the speed of sound which is $330 ms^{-1}$.

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Section-I (single correct choice type)

1. A vernier calipers has $1mm$marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier calipers, the least count is

A. 0.02 mm

B. 0.05 mm

C. 0.1 mm

D. 0.2 mm

Answer: D

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2. A hollow pipe of length $0.8m$ is closed at one end. At its open end a $0.5m$ long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is $50N$ and the speed of sound is $320ms^{-1}$, the mass of the string is

A. 5 grams

B. 10 gm

C. 20 gm

D. 40 gm

Answer: B

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3. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

A. virtual and at a distance of 16 cm from the mirror

B. real and at a distance of 16 cm from the mirror

C. virtual and at a distance of 20 cm from the mirror

D. real and at a distance of 20 cm from the mirror

Answer: B

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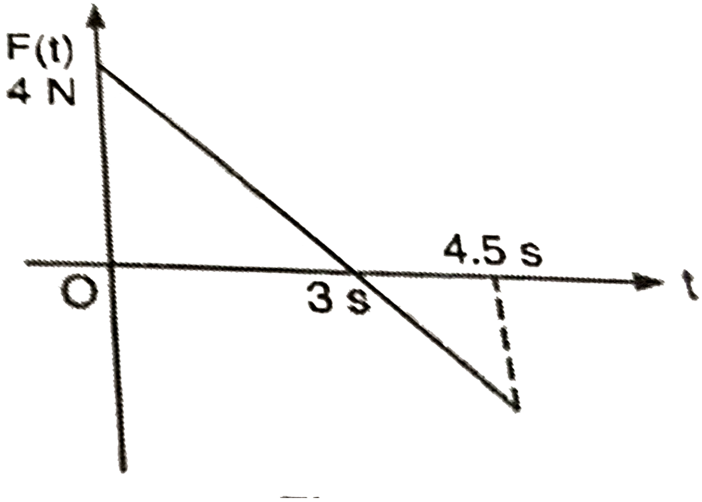
4. A block of mass 2 kg is free to move along the x-axis it is at rset and from t=0 onwards it is subjected to a time dependent force F(t) in the x-direction The force F(t) varies with t as shown in the figure The kinetic energy of the block after 4.5 seconds, is:



A. 4.50 J

B. 7.50 J

C. 5.06 J

D. 14.06 J

Answer: C

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5. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5 Vm^{-1}$. When the field is switched off, the drop is observed to fall with terminal velocity $2 \times 10^{-3} ms^{-1}$. Given $g = 9.8 ms^{-2}$, viscoisty of the air $= 1.8 \times 10^{-5} Nsm^{-2}$ and the denisty of oil $= 900 kgm^{-3}$, the magnitude of q is

A. $1.6 \times 10^{-19} C$

B. $3.2 \times 10^{-19} C$

C. $4.8 \times 10^{-19} C$

D. $8.0 \times 10^{-19} C$

Answer: D

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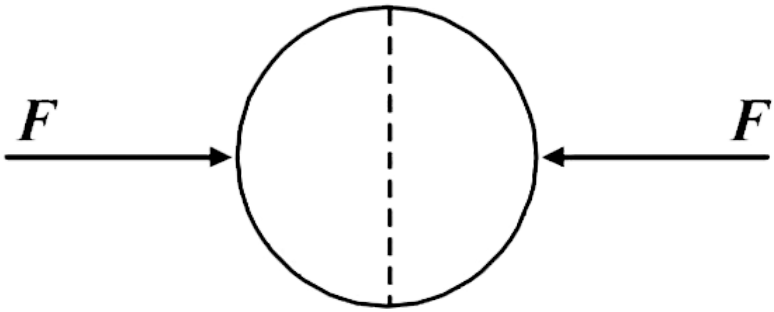
6. A uniformly charged thin spherical shell of radius R carries uniform surface charge denisty of *isgma* per unit area. It is made of two hemispherical shells, held together by presisng them with force F(see figure). F is proportional to



A. $\frac{1}{\varepsilon_0}\sigma^2 R^2$

B. $\frac{1}{\sigma_0}\sigma^2 R$

C. $\frac{1}{\varepsilon_0}\frac{\sigma^2}{R}$

D. $\frac{1}{\varepsilon_0}\frac{\sigma^2}{R^2}$

Answer: A

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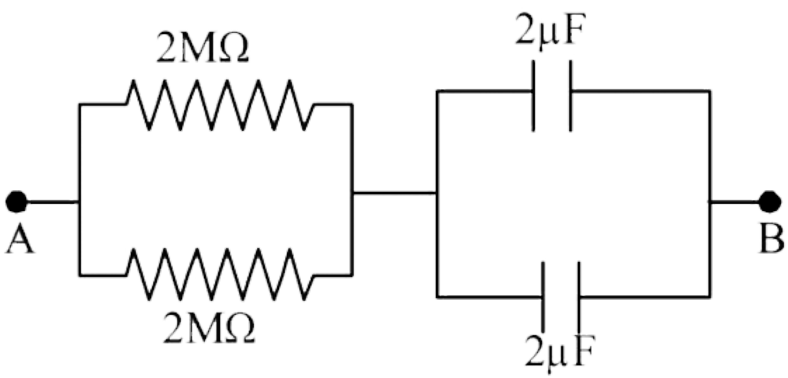
Section-II (Integer type)

1. A diatomic ideal gas is compressed adiabatically to 1/32 of its initial volume. If the initial temperature of the gas is T_i (in Kelvin) and the final temperature is a T_i, the value of a is

Watch Video Solution

2. At time t=0, a battery of 10 V is connected across points A and B in the given circuit. If the capacitors have no charge initially, at what time (in seconds) does the voltage across them beocme 4V? $[Take: In5 = 1.6, In3 = 1.1]$.



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3. Image of an object approaching a convex mirror of radius of curvature 20m slong its optical axis is observed to move from $\frac{25}{3}$m to $\frac{50}{7}$m in 30 seconds. What is the speed of the object in km per hour?

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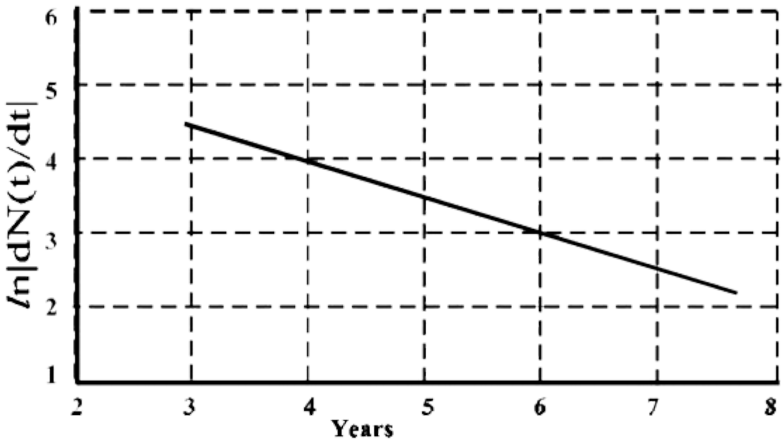
4. A large glass slabe $(\mu = 5/3)$ of thickness 8cm is placed over a point source of light on a plane surface. It is seen that light emerges out of th etop surface fo the slab from a circular area of radius R cm. What is the value of R?

Watch Video Solution

5. To determine the half life of a radioactive element , a student plote a graph of in $\left|\frac{dN(t)}{dt}\right| versus t, Here \left|\frac{dN(t)}{dt}\right|$ is the rate of radioatuion decay at time t , if the number of radoactive nuclei of this element decreases by a factor of p after 4.16 year the value of p is



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Section -(III) (Paragraph type)

1. When liquid medicine of density ρ is to put in the eye, it is done with the help of a dropper. As the bulp on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (assuming r ltltR) is

A. $2\pi rT$

B. $2\pi RT$

C. $\frac{2\pi r^2 T}{R}$

D. $\frac{2\pi R^2 T}{r}$

Answer: C

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2. When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of te drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy.

To determine the size, we calculate the net vertical force due to the surfacetension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

If $r = 5 \times 10^{-4}$m $\tilde{n} = 10^3 kgm^{-3}$, $g = 10ms^{-2}$, $T = 0.11Nm^{-1}$ the radius of the drop when it detaches from the dropper is approximately

A. $1.4 \times 10^{-3} m$

B. $3.3 \times 10^{-3} m$

C. $2.0 \times 10^{-3} m$

D. $4.1 \times 10^{-3} m$

Answer: A

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3. When liquid medicine of density ρ is to put in the eye, it is done with the help of a dropper. As the bulp on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (assuming r ltltR) is

A. $1.4 \times 10^{-6} J$

B. $2.7 \times 10^{-6} J$

C. $5.4 \times 10^{-6} J$

D. $8.1 \times 10^{-6} J$

Answer: B

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4. The key feature of Bohr's spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid.The rule to be applied is Bohr's quantization condition.

A diatomic molecule has moment of inertia I. By Bohr's quantization condition its rotational energy in the n^{th} level ($n = 0$ is not allowed) is

A. $\frac{1}{n^2}\left(\frac{h^2}{8\pi^2 I}\right)$

B. $n\left(\frac{h^2}{8\pi^2 I}\right)$

C. $n^2\left(\frac{h^2}{8\pi^2 I}\right)$

D.

Answer: D

Watch Video Solution

5. The key feature of Bohr's spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid.The rule to be applied is Bohr's quantization condition.

it is found that the excitation from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi} \times 10^{11} Hz$ then the moment of inertia of CO molecule about its center of mass is close to

$\left(Take h = 2\pi \times 10^{-34} Js\right)$

A. $2.76 \times 10^{-46} kgm^2$

B. $1.87 \times 10^{-46} kgm^2$

C. $4.67 \times 10^{-47} kgm^2$

D. $1.17 \times 10^{-47} kgm^2$

Answer: B

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6. The key feature of Bohr's spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid.The rule to be applied is Bohr's quantization condition.

In a CO molecule, the distance between $C(mass = 12a.m.u)$ and $O(mass = 16a.m.u)$ where $1a.m.u = \frac{5}{3} \times 10^{-27}kg$, is close to

A. $2.4 \times 10^{-10}m$

B. $1.9 \times 10^{-10}m$

C. $1.3 \times 10^{-10}m$

D. $4.4 \times 10^{-11}m$

Answer: C

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Section -IV (matrix type)

1. Two transparent media of refractive indicies μ_1 and μ_3 have a solid lens shaped transpar material of refractive index μ_2 between them as shown in figure in column II. A traversing these media is also shown in the figures . In column I different relationsh between μ_1, μ_2 and μ_3 are given. match them to the ray diagrams shown in column

Column I

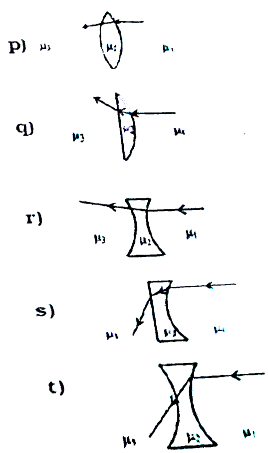
A) $\mu_1 < \mu_2$

B) $\mu_1 > \mu_2$

C) $\mu_2 = \mu_3$

D) $\mu_2 > \mu_3$

Column II



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2. You are given many resistance, capacitors and inductors. These are connected to variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequency (the next three circuits) in different ways as shown in column II. When a current (steady state for DC or rms for AC) flows through the circuit , the corrresponding voltage V_1 and V_2 . (indicated in circuit) are related as shown in column I . match the two

Column I

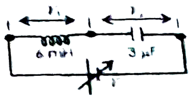
A) $I \neq 0, V_1$ is proportional to I

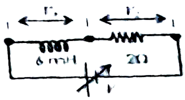
B) $I \neq 0, V_2 > V_1$

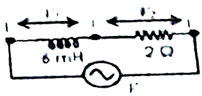
C) $V_1 = 0, V_2 = V$

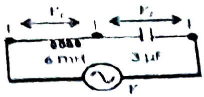
D) $I \neq 0, V_2$ is proportional to I

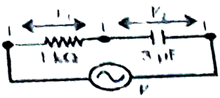
Column II

p) 

q) 

r) 

s) 

t) 

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Section - I Single correct Answer Type

1. A police car with a siren of frequency $8 KHz$ is moving with uniform velocity $36 Km/hr$ towards a ball building which reflects the sound waves.

The speed of sound in air is $320 m/s$. The frequency of the siren heard by the car driver is

A. 8.50 kHz

B. 8.25 kHz

C. 7.75 kHz

D. 7.50 kHz

Answer: A

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2. 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be T_1, the work done in the process is

A. $\frac{9}{8}RT_1$

B. $\frac{3}{2}RT_1$

C. $\frac{15}{8}RT_1$

D. $\frac{9}{2}RT_1$

Answer: A

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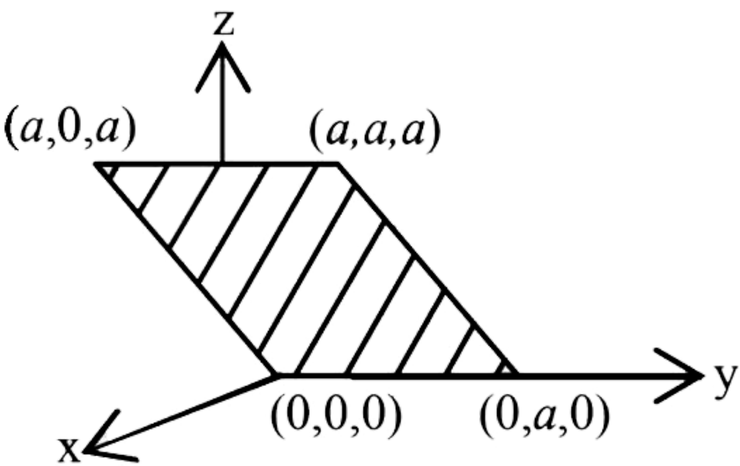
3. Conisder an electric field $\vec{E} = E_0\hat{x}$ where E_0 is a constant .

The flux through the shaded area (as shown in the figure) due to this field is



A. $2E_0a^2$

B. $\sqrt{2}E_0a^2$

C. $E_0 a^2$

D. $\frac{E_0 a^2}{\sqrt{2}}$

Answer: C

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4. The wavelength of the first spectral line in the Balmer series of hydrogen atom is $6561 A^{\circ}$. The wavelength of the second spectral line in the Balmer series of singly - ionized helium atom is

A. 1215Å

B. 1640 Å

C. 2430 Å

D. 4687 Å

Answer: A

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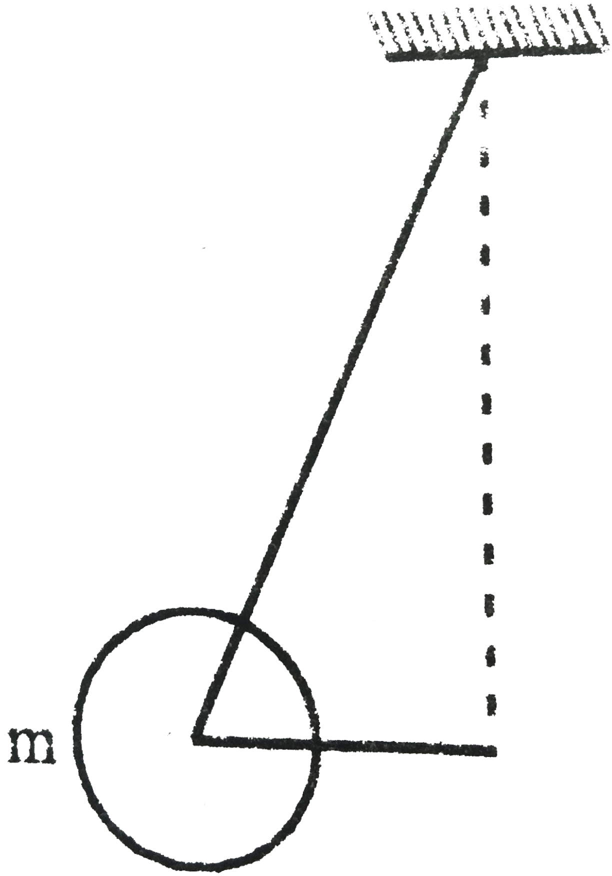
5. A ball of mass $(m)0.5kg$ is attached to the end of a string having length $(L)0.5m$. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is $324N$. The maximum possible value of angular velocity of ball (in radian//s) is -



A. 9

B. 18

C. 27

D. 36

Answer: D

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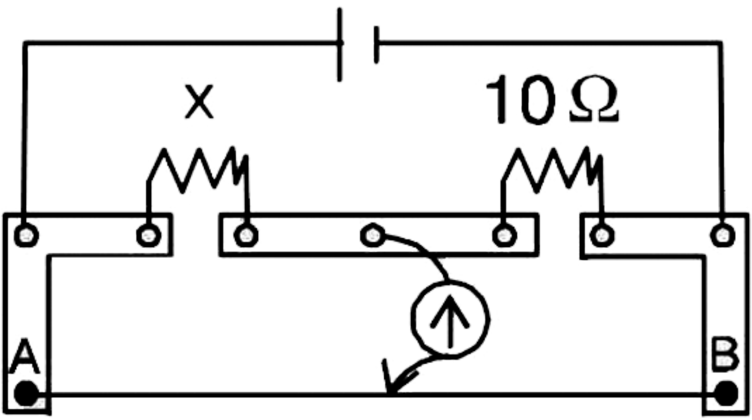
6. A meter bridge is set up as shown, to determine an unknown resistance X using a standard 10 ohm resistor. The galvanometer shows null point when tapping -key is at 52 cm mark. The end-corrections are 1 cm and 2 cm respectively for the ends A and B. The determine value of X is



A. 10.2 ohm

B. 10.6 ohm

C. 10.8 ohm

D. 11.1 ohm

Answer: B

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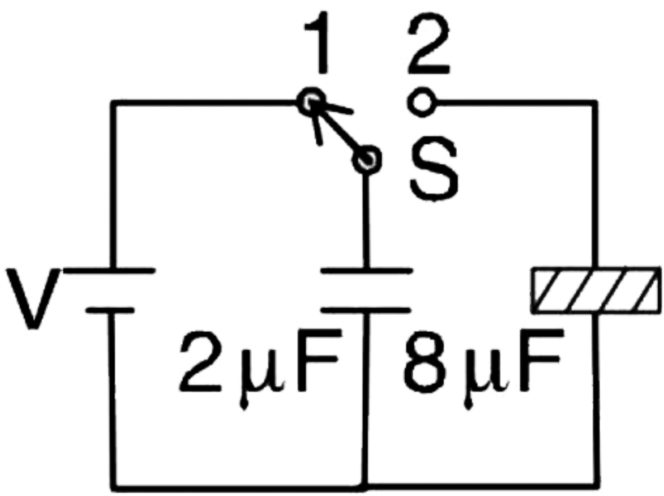
7. A $2\mu F$ capacitor is charged as shown in the figure. The percentage of its stored energy disisapted after the switch S is turned to poistion 2 is



A. 0 %

B. 20 %

C. 75 %

D. 80 %

Answer: D

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Section - II (Multiple correct Answer Type)

1. A spherical metal shell A of radius R_A and a solid metal sphere B of radius $R_B\left(< R_A\right)$ are kept far apart and each is given charge $' + Q'$. Now they are connected by a thin metal wire. Then

A. $E_A^{\text{inside}} = 0$

B. $Q_A > Q_B$

C. $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$

D. $E_A^{\text{no surface}} < E_B^{\text{on surface}}$

Answer: A::B::C::D

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2. An electron and a proton are moving on straight parallel paths with same velocity. They enter a semi infinite region of uniform magnetic field perpendicular to the velocity.

Which of the following statement(s) is /are true?

A. They will never come out of the magnetic field region.

B. They will come out travelling along parallel paths

C. They will come cout at the same time.

D. They will come out at different times.

Answer: B::C::D

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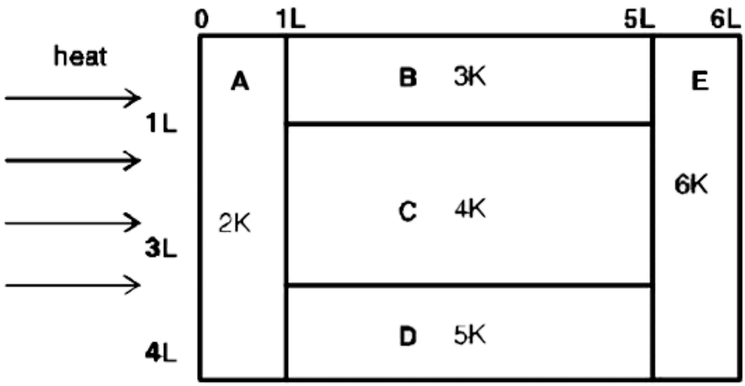
3. A composite block is made of slabs A,B,C,D and E of different thermal conductivities (given in terms of a constant K and sizes (given in terms of length, L) as shown in the figure. All slabs are of same width. Heat 'Q' flows only from left to right through the blocks. Then in steady state



A. heat flow through A and E slabs are same

B. heat flow through slab E is maximum

C. temperature difference across slab E is smallest

D. heat flow through C = heat flow through B +heat flow through D.

Answer: A::C::D

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4. A metal rod of length 'L' and mass 'm' is pivoted at one end. A thin disc of mass 'M' and radius 'R' (ltL) is attached at its center to the free end of the rod. Consider two ways the disc is attached : (case A). The dise is not free to rotate about its centre and (case B) the disc is free to rotate about its centre. The rod disc system perfoms (SHM) in vertical plane after being released from the same displacement position. Which of the following statement (s) is (are) true ?

(##JMA_CHMO_C10_021_Q01##).

A. Restoring torque in case A = Restoring torque in case B

B. Restoring torque in case A $<$ Restoring torque in case B

C. Angular frequency for case A $>$ Angular frequency for case B.

D. Angular frequency for case A $<$ Angular frequency for case B.

Answer: A::B

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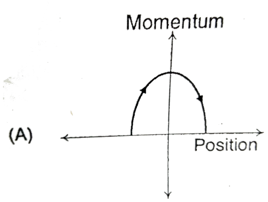
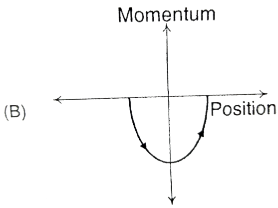
Section - III (Paragraph Type)

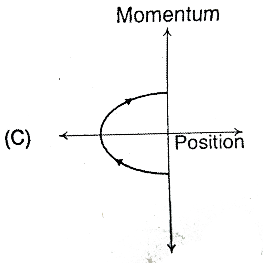
1. Phase space deagrams are useful tools (##JMA_CHMO_C10_034_Q01##). in analyzing all kinds of dynamical problems. They are especially usrful in studying the changes in motion as initial position and momenum are changed. Here we conseder some simple dynamical systems in one dimension. For such systems, phase space is a plane in which position is plotted along horizontal axis and momentum is plotted along vertical axis. The phase space diagram is `x(t) vs. p(t) curve in this plane. The arrow on the curve indicates the time flow. For example, the phase space diagram for a particle moving with constant velocity is a straight line as shown in the figure. We use the sign convention in which positon or momentum upwards (or to right) is poitive and downwards (or to left) is negative.

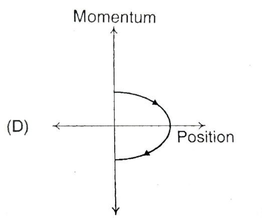
The phace diagram for a ball thrown vertically up from ground is.



A.

B. 

C. 

D. 

Answer: D

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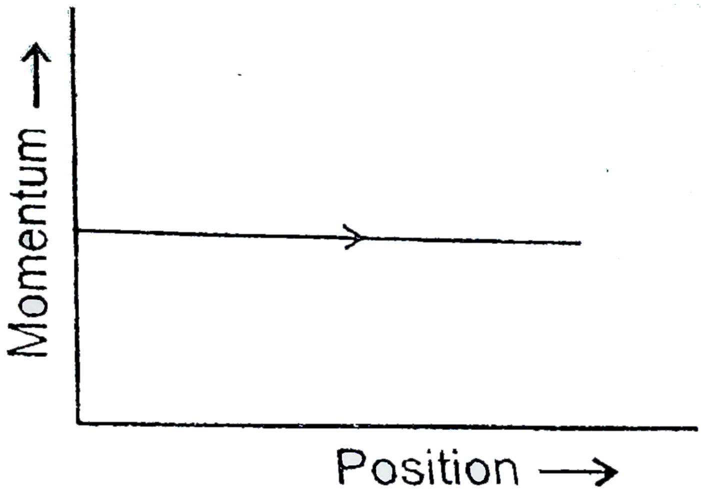
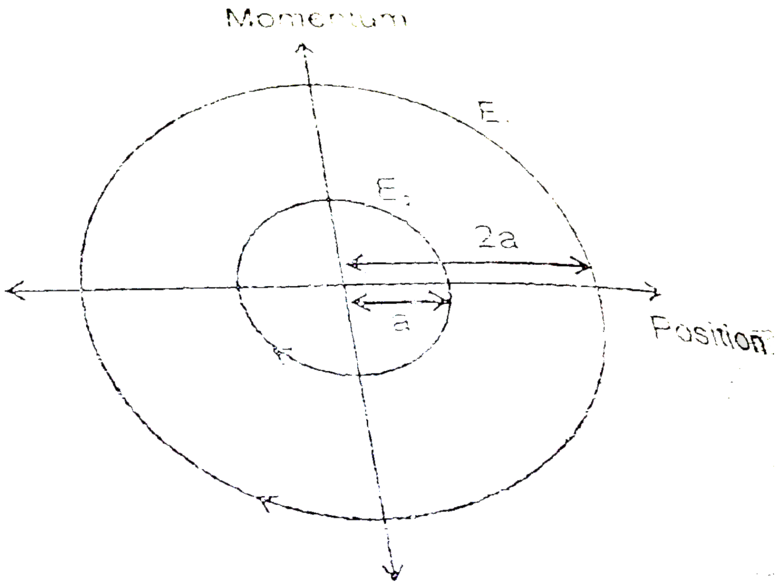
2. Phase space diagrams are useful tools in analysing all kond of dynamical problems. Theya re especially useful in studying the changes in motion as initial position and momentum are changed. Here we consider some simple dynamical system in one-dimelnsion. for such systeam, phase space is a plane in which position is plotted along horizontal axis and momentum is plotted along vertical axis. The phase space diagram is $x(t)$ vs. $p(t)$ curve in this plane. The arrow on the curve indicates the time flow. for example, the phase space diagram for a particle moving with constant velocity is a straight line as shown in the figure. We use the sign convention in which position or momentum. upwards (or to right) is positive and downwards (or to left) is negative.



The phase space diagram for simple harmonic motion is a circle cen-tered at the origin.In the figure, the two circles represent the same oscillator but for different initial conditions, and E_1 for E_2 are the total mechanical energies respectively. Then



A. $E_1 = \sqrt{2}E_2$

B. $E_1 = 2E_2$

C. $E_1 = 4E_2$

D. $E_1 = 16E_2$

Answer: C

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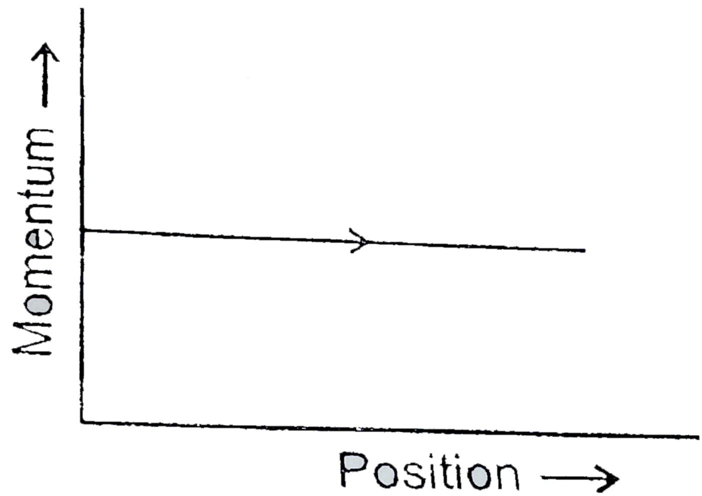
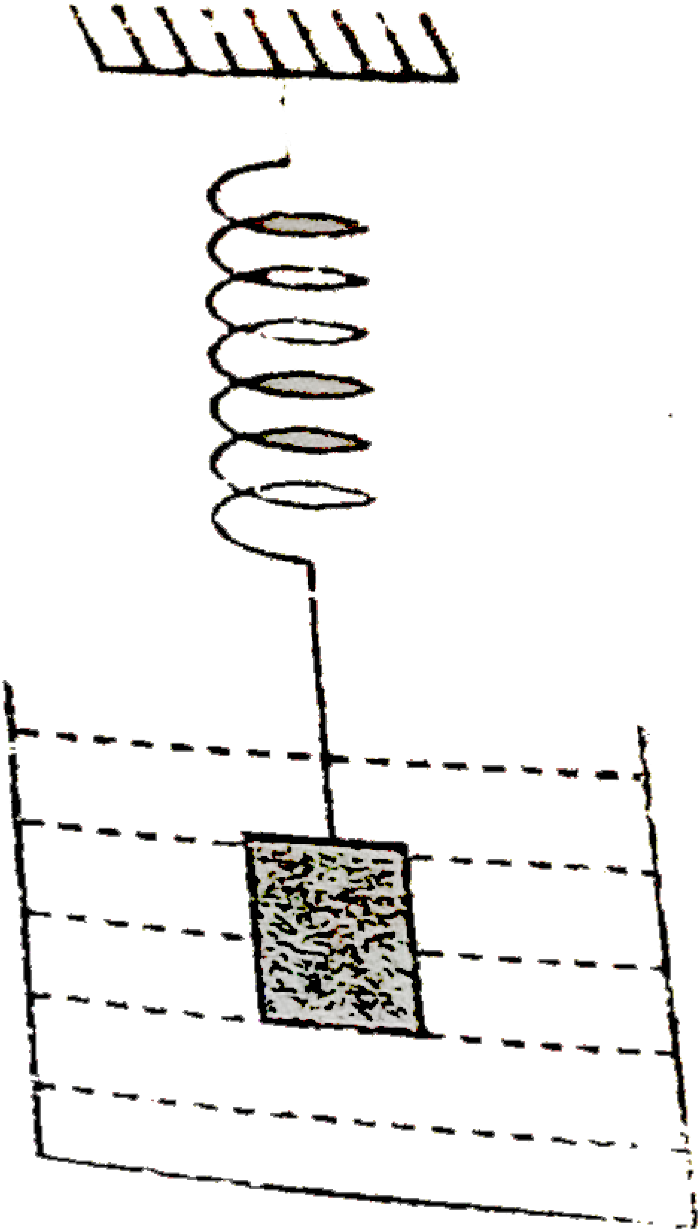
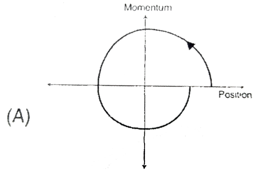
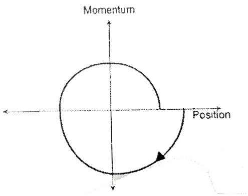
3. Phase space diagrams are useful tools in analysing all kond of dynamical problems. Theya re especially useful in studying the changes in motion as initial position and momentum are changed. Here we consider some simple dynamical system in one-dimelnsion. for such systeam, phase space is a plane in which position is plotted along horizontal axis and momentum is plotted along vertical axis. The phase space diagram is $x(t)$ vs. $p(t)$ curve in this plane. The arrow on the curve indicates the time flow. for example, the phase space diagram for a particle moving with constant velocity is a straight line as shown in the figure. We use the sign convention in which position or momentum. upwards (or to right) is positive and downwards (or to left) is negative.

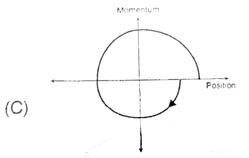


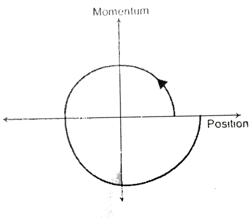
Consider the spring-mass system, with mass submerged in water, as shown in the figur, the phase diagram for one cycle of this system is :



A. 

B. 

C. 

D. 

Answer: B

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4. A dence collection of equal number of electrona and positive ions is called netural plasma. Certain solids contianing fixed positive ions surroundedby free electrons can be treated as neytral plasma. Let 'N' be the numbrer density of free electrons, each of mass 'm'. When the elctrons are subjected to an eletric field, they are displaced relatively away from the heavy positive ions. if the electric field becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency 'ω_P' which is called the plasma frequency. to sustain the oscillations, a time varying electric field needs to be applied that has an angular frequrncy ω, where a part of the energy is absorbed and a part of it is reflected. As ω approaches ω_p all the free electrons are set to resonance together and all the energy is reflected. this is the explaination of high reflectivity of metals.

(1) Taking the electronic charge as 'e' and the permittivity as 'ε_0'. use dimensional analysis to determine the correct expression for ω_p.

A. $\sqrt{\frac{Ne}{m\varepsilon_0}}$

B. $\sqrt{\frac{m\varepsilon_0}{Ne}}$

C. $\sqrt{\frac{Ne^2}{m\varepsilon_0}}$

D. $\sqrt{\frac{m\varepsilon_0}{Ne^2}}$

Answer: C

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5. A dence collection of equal number of electrona and positive ions is called netural plasma. Certain solids contianing fixed positive ions surroundedby free electrons can be treated as neytral plasma. Let 'N' be the numbrer density of free electrons, each of mass 'm'. When the elctrons are subjected to an eletric field, they are displaced relatively away from the heavy positive ions. if the electric field becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency 'ω_P' which is called the plasma frequency. to sustain the oscillations, a time varying electric field needs to be applied that has an angular frequrncy ω, where a part of the energy is absorbed and a part of it is reflected. As ω approaches ω_p all the free electrons are set to resonance together and all the energy is reflected. this is the explaination of high reflectivity of metals.

(2) Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons $N \approx 4 \times 10^{27} m^{-3}$. Taking $\varepsilon_0 = 10^{11}$ and mass $m \approx 10^{-30}$, where these quantities are in proper SI units.

A. 800 nm

B. 600 nm

C. 300 nm

D. 200 nm

Answer: B

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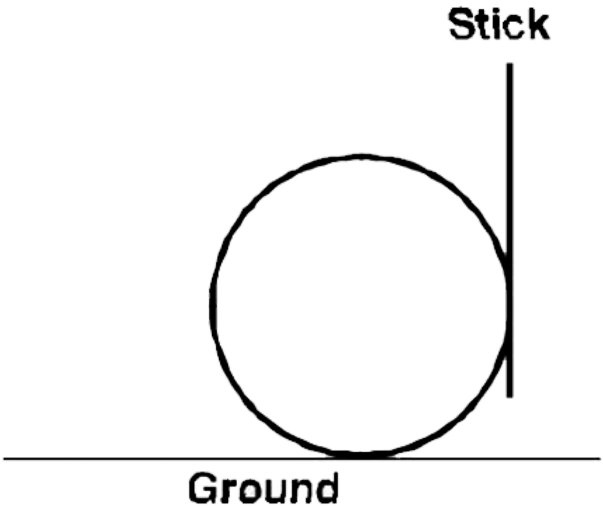
Section - IV (Integer Answer Type)

1. A boy is pushng a ring of mass 2kg and radius 0.5 m with a stick as shwon in figure. The stick applies a force of 2N on the ring and rolls it without slipping with an accelertaion of $0.3\frac{m}{s^2}$. The coefficinet of friction between the ground and the ring is large enough that rolling always occurs and the coefficient of friction between the stick and the ring of (P/10). The value of P is



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2. A block is moving on an inclined plane making an angle 45° with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define $N = 10\mu$, then N is

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3. Four point charges, each of $+q$, are rigidly fixed at the four corners of a square planar soap film of side 'a'. The surface tension of the soap film is γ. The system of charges and planar film are in equilibrium, and $a = k\left[\frac{q^2}{\gamma}\right]^{1/N}$, where 'K' is a constant. Then N is

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4. Steel wire of length 'L' at $40^\circ C$ is suspended from the ceiling and then a mass 'm' is hung from its free end. The wire is cooled down from $40^\circ C \rightarrow 30^\circ C$ to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is $10^{-5}/^\circ C$, Young's modulus of steel is $10^{11} N/m^2$ and radius of the wire is 1mm. Assume that $L > > $ diameter of the wire. Then the value of 'm' in kg is nearly

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5. The activity of a freshly prepared radioactive sample is 10^{10} disintergrations per second, whose mean life is $10^9 s$. The mass of an atom of this radioisotope is $10^{-25} kg$. The mass (in mg) of the radioactive samples is

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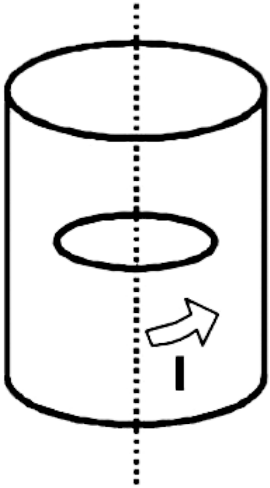
6. A long circular tube of length $10m$ and radius $0.3m$ carries a current I along its curved surface as shown . A wire - loop of resistance $0.005 ohm$ and of radius $0.1m$ is placed inside the tube its axis coinciding with the axis of the tube . The current varies as $I = I_0 \cos(300t)$ where I_0 is constant. If the magnetic moment of the loop is $N\mu_0 I_0 \sin(300t)$, then 'N' is



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7. Four solid sphereas each of diameter $\sqrt{5}cm$ and mass $0.5kg$ are placed with their centres at the corners of a square of side $4cm$. The moment of inertia of the system about the diagonal of the square is $N \times 10^{-4}kg - m^2$, the N is -

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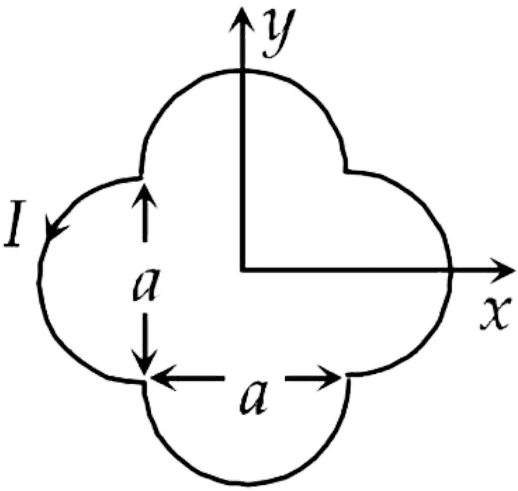
Section I : Single Correct Answer Type

1. A loop carrying current I lies in the x - y plane as shown in the figure . The unit vector $\hat{k}$ is coming out of the plane of the paper . The magnetic moment of the current loop is



A. $a^2 I\hat{k}$

B. $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$

C. - $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$

D. $(2\pi+1)a^2 I\hat{k}$

Answer: B

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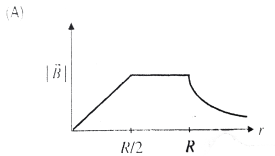
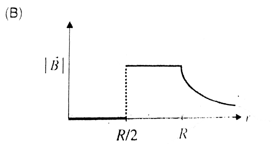
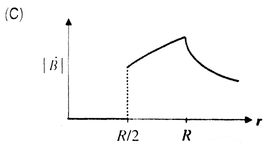
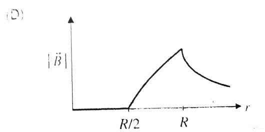
2. An infinitely long hollow conducting cylinder with inner radius $\frac{r}{2}$ and outer radius R carries a uniform current ra density along its length . The magnitude of the magnetic field , $|\vec{B}|$ as a function of the radial distance r from the axis is best represented by

A. 

B. 

C. 

D. 

Answer: D

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3. A thin uniform cylindrical shell, closed at both ends, is partially filled with water. It is floating vertically in water in half-submerged state. If ρ_c is the relative density of the material of the shell with respect to water, then the correct statement is that the shell is

A. more than half-filled if ρ_c is less than 0.5.

B. more than half-filled if ρ_c is more than 1.0.

C. half-filled if ρ_c is more than 0.5.

D. less than half-filled if ρ_c is less than 0.5.

Answer: A

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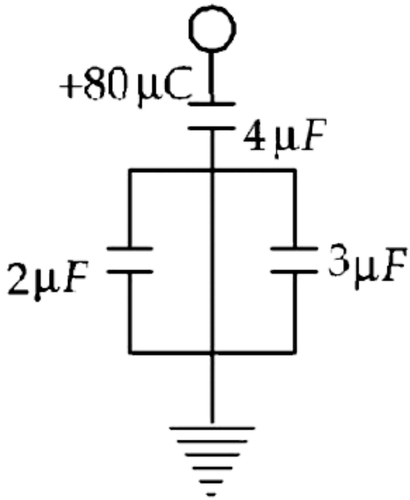
4. In the given circuit, a charge of $+80\mu C$ is given to the upper plate of the $4\mu F$ capacitor. Then in the steady state, the charge on the upper plate of the $3\mu F$ capacitor is



A. $+32\mu C$

B. $+40\mu C$

C. $+48\mu C$

D. $+80\mu C$

Answer: C

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5. Two moles of ideal helium gas are in a rubber balloon at $30^{\circ} C$. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to $35^{\circ} C$. The amount of heat required in raising the temperature is nearly (take R

$= 8.31 J/mol. K$)

A. 62 J

B. 104 J

C. 124 J

D. 208 J

Answer: D

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6. A student is performing the experiment of Resonance Column. The diameter of the column tube is $4 cm$. The diameter of the column tube is

$4cm$. The frequency of the tuning fork is $512Hz$. The air temperature is $38\,^{\circ}C$ in which the speed of sound is $336m/s$. The zero of the meter scale coincides with the top end of the Resonance column tube. When the first resonance occurs, the reading of the water level in the column is

A. 14.0 cm

B. 15.2 cm

C. 16.4 cm

D. 17.6 cm

Answer: B

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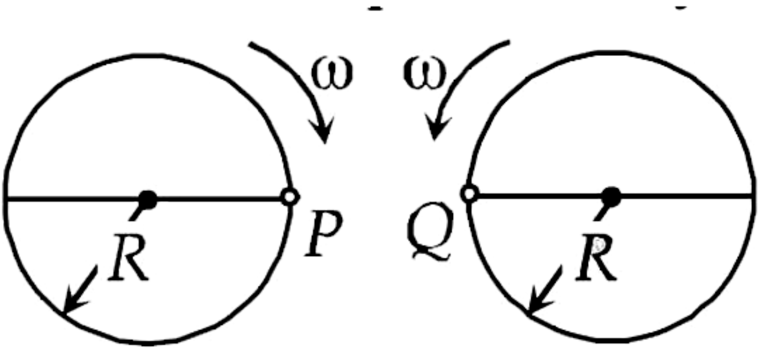
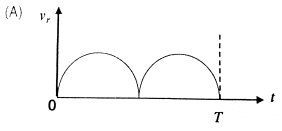
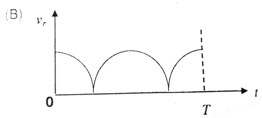
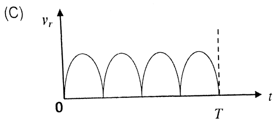
7. Two identical discs of same radius R are rotating about their axes in opposite directions with the same constant angular speed ω . The discs are in the same horizontal plane. At time $t = 0$, the points P and Q are facing each other as shown in the figure. The relative speed between the two points P and Q is v_r. In one time period (T) of rotation of the discs ,

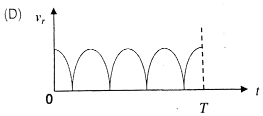
v_r as a function of time is best represented by



A. 

B. 

C. 

D. 

Answer: A

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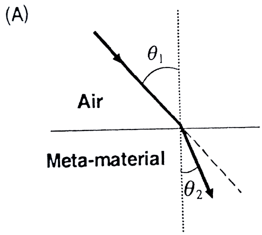
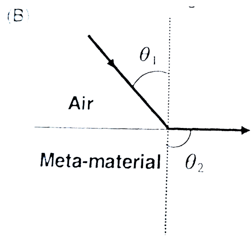
Section II : Paragraph Type

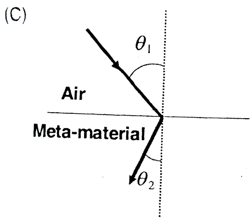
1. Most materials have the refractive index, $n > 1$. So, when a light ray from air enters a naturally occuring material, then by Snell's law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_1}{n_2}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = (c/v) = \pm\sqrt{\varepsilon_r, \mu_r}$, where c is the speed of the electromagnetic waves in vacuum, v its speed in the medium, ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artifically prepared and are called meta-materials. They exhibit significantly different optical behaviour, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials.

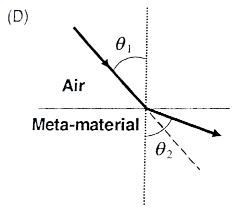
Answer the following questions :

For light incident from air on a meta-material, the appropriate ray diagram is

A. 

B. 

C. 

D. 

Answer: C

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2. Most materials have the refractive index, $n > 1$. So, when a light ray from air enters a naturally occuring material, then by Snell's law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_1}{n_2}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = (c/v) = \pm\sqrt{\varepsilon_r, \mu_r}$, where c is the speed of the electromagnetic waves in vacuum, v its speed in the medium, ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artifically prepared and are called meta-materials. They exhibit significantly different optical behaviour, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials.

Answer the following questions :

Choose the correct statement.

A. The speed of light in the meta-material is $v = c|n|$

B. The speed of light in the meta-material is $v = \frac{c}{|n|}$

C. The speed of light in the meta-material is v=c.

D. The wavelength of the light in the meta-material (λ_m) is given by

$\lambda_m = \lambda_{air}|n|$, where λ_{air} is the wavelength of the light in air.

Answer: B

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3. The β-decay process, discovered around 1900, is basically the decay of a neutron (n), In the laboratory, a proton (p) and an electron (e^-) are observed as the decay products of the neutron. Therefore, considering the decay of a neutron as a tro-body dcay process, it was observed that the electron kinetic energy has a continuous spectrum. Considering a three-body decay process i.e., $n \rightarrow p + e^- + \bar{v}_e$, around 1930, Pauli explained the observed electron energy spectrum. Assuming the anti-neutrino $\left(\bar{V}_e\right)$ to be massless and possessing negligible energy, and neutron to be at rest, momentum and energy conservation principles are applied. From this calculation, the maximum kinetic energy of the electron is $0.8 \times 10^6 eV$. The kinetic energy carried by the proton is only the recoil energy.

What is the maximum energy of the anti-neutrino?

A. Zero

B. Much less than $0.8 \times 10^6 eV$.

C. Nearly $0.8 \times 10^6 eV$.

D. Much larger than $0.8 \times 10^6 eV$.

Answer: C

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4. The β-decay process, discovered around 1900, is basically the decay of a neutron (n), In the laboratory, a proton (p) and an electron $\left(e^-\right)$ are observed as the decay products of the neutron. Therefore, considering the decay of a neutron as a tro-body dcay process, it was observed that the electron kinetic energy has a continuous spectrum. Considering a three-body decay process i.e., $n \to p + e^- + \bar{v}_e$, around 1930, Pauli explained the observed electron energy spectrum. Assuming the anti-neutrino $\left(\bar{V}_e\right)$ to be massless and possessing negligible energy, and neutron to be at rest, momentum and energy conservation principles are applied. From this calculation, the maximum kinetic energy of the electron is $0.8 \times 10^6 eV$. The kinetic energy carried by the proton is only the recoil energy.

What is the maximum energy of the anti-neutrino?

A. $0 \leq K \leq 0.8 \times 10^6 eV$

B. $3.0eV \leq K \leq 0.8 \times 10^6 eV$

C. $3.0eV \leq K \leq 0.8 \times 10^6 eV$

D. $0 \leq K < 0.8 \times 10^6 eV$

Answer: D

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5. The general motion of a rigid body can be considered to be a combination of (i) a motion of its centre of mass about an axis, and (ii) its motion about an instantaneous exis passing through the centre of mass. These axes need not be stationary. Consider, for example, a thin uniform disc welded (rigidly fixed) horizontally at its rim to a massless, stick as shown in the figure. When the disc-stick system is rotated about the origin on a horizontal frictionless plane with angular speed ω the motion at any instant can be taken as a combination of (i) a rotation of the disc through an instantaneous vertical axis passing through its centre of mass (as is seen from the changed orientation of points P and Q). Both these motions have the same angular speed ω in this case

Now consider two similar system as shown in the figure: Case (a) the disc with its face vertical and parallel to x-z plane, Case (b) the disc with its face making an angle of 45° with x-y plane and its horizontal diameter parallel to x-axis. In both the cases, the disc is welded at point P, and the systems are rotated with constant angular speed ω about the z-axis.

- It is vertical for both the cases (a) and (b).

- It is vertical for case (a), and is at 45° to the x-z plane and lies in the plane of the disc for case (b).
- It is horizontal for case (a), and is at 45° to the x-z plane and is normal to the plane of the disce for case (b).
- It is vertical for case (a), and is at 45° to the x-z plane and is normal to the plane of the disc for case (b).

Answer: A

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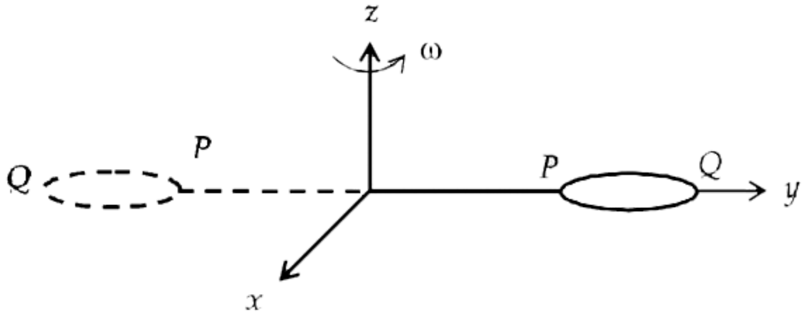
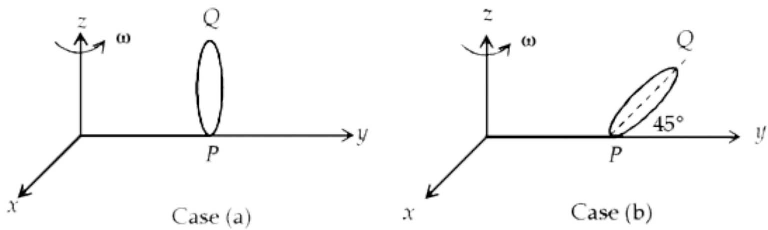
6. The general motion of a rigid body can be considered to be a combination of (i) a motion of its centre of mass about an axis, and (ii) its motion about an instantaneous exis passing through the centre of mass. These axes need not be stationary. Consider, for example, a thin uniform disc welded (rigidly fixed) horizontally at its rim to a massless, stick as shown in the figure. When the disc-stick system is rotated about the origin on a horizontal frictionless plane with angular speed ω the motion at any instant can be taken as a combination of (i) a rotation of the disc through an instantaneous vertical axis passing through its centre of mass (as is seen from the changed orientation of points P and Q). Both these motions have the same angular speed ω in this case



Now consider two similar system as shown in the figure: Case (a) the disc with its face vertical and parallel to x-z plane, Case (b) the disc with its face making an angle of $45°$ with x-y plane and its horizontal diameter parallel to x-axis. In both the cases, the disc is welded at point P, and the systems are rotated with constant angular speed ω about the z-axis.



Which of the following statements regarding the angular speed about the instantaneous axis (passing through the centre of mass) is correct?

A. It is $\sqrt{2\omega}$ for both the cases.

B. It is ω for case (a) , and $\frac{\omega}{\sqrt{2}}$ for case (b).

C. It is ω for case (a), and $\sqrt{2}\omega$ for case (b).

D. It is ω for both the cases.

Answer: D

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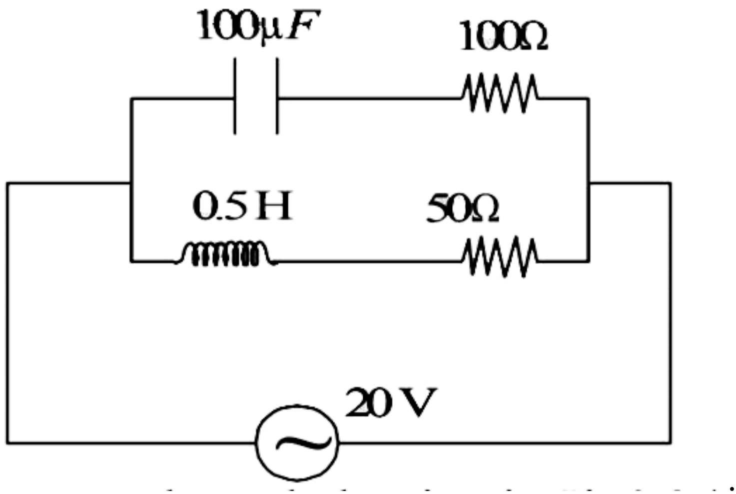
Section III : Multiple Correct Answer(s) Type

1. In the given circuit, the AC source has $(\omega) = 100 rad/s$. Considering the inductor and capacitor to be ideal, the correct choice(s) is (are)



A. The current through the circuit, I is 0.3 A.

B. The current through the circuit, I is $0.3\sqrt{2}A$.

C. The voltage across 100Ω resistor $= 10\sqrt{2}V$.

D. The voltage across 50Ω resistor = 10 V.

Answer: A::C

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2. A current carrying infinitely long wire is kept along the diameter of a circular wire loop, without touching it, the correct statements(s) is(are)

A. The emf induced in the loop is zero if the current is constant.

B. The emf induced in the loop is finite if the current is constnat.

C. The emf induced in the loop is zero if the current decreases at a steady rate.

D. The emf induced in the loop is finite if the current decreases at a steady rate.

Answer: A::C

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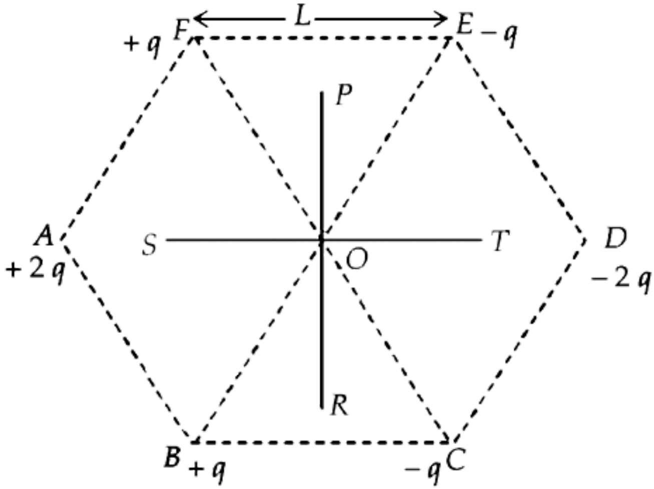
3. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\varepsilon_0}\frac{q}{L^2}$, which of the following statements(s) is (are) correct?



A. The electric field at O is 6K along OD.

B. The potential at O is zero.

C. The potential at all points on the line PR is same.

D. The potential at all points on the line ST is same.

Answer: A::B::C

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4. Two solid cylinders P and Q of same mass and same radius start rolling down a fixed inclined plane from the same height at the same time. Cylinder P has most of its mass concentrated near its surface, while Q has most its mass concentrated near the axis. Which statement(s) is (are) correct?

A. Both cylinders P and Q reach the ground at the same time.

B. Cylinder P has larger acceleration than cylinder Q.

C. Both cylinders reach the ground with same translational kinetic energy.

D. Cylinder Q reaches the ground with larger angular speed.

Answer: D

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5. Two spherical planets P and Q have the same uniform density ρ, masses M_p and M_Q and surface areas A and 4A respectively. A spherical planet R also has uniform density ρ and its mass is $\left(M_P + M_Q\right)$. The escape velocities from the plantes P,Q and R are $V_P V_Q$ and V_R respectively. Then

A. $V_Q > V_R > V_P$

B. $V_R > V_Q > V_P$

C. $V_R / V_P = 3$

D. $V_P / V_Q = \frac{1}{2}$

Answer: B::D

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6. The figure shows a system consisting of (i) a ring the outer radius 3R rolling clockwise without slipping on a horizontal surface with angular speed ω and (ii) an inner disc of radius 2R rotating anti clockwise with angular speed $\omega/2$. The ring and disc are separted. The point P on the inner disc is at a distance R from the origin, where OP makes an angle of 30° with the horizontal. Then with respect to the horizontal surface,

A. the point O has a linear velocity $3R\omega\hat{i}$.

B. the point P has a linear velocity $\frac{11}{4}R\omega\hat{i} + \frac{\sqrt{3}}{4}R\omega\hat{k}$.

C. the point P has a linear velocity $\frac{13}{4}R\omega\hat{i} - \frac{\sqrt{3}}{4}R\omega\hat{k}$.

D. the point P has a linear velocity $\left(3 - \frac{\sqrt{3}}{4}\right)R\omega\hat{i} + \frac{1}{4}R\omega\hat{k}$.

Answer: A::B

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PART I : PHYSICS (SECTION -1)

1. The diameter of a cylinder is measured using a vernier callipers with no zero error . It is found that the zero of the vernier scale lies between 5.10 and $5.15cm$ of the main scale . The $24th$ division of the vernier scale exactly coincides with one of the main scale divisions . The diameter of the cylinder is

A. 5.112 cm

B. 5.124 cm

C. 5.136 cm

D. 5.148 cm

Answer: B

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2. A ray of light travelling in the direction $\frac{1}{2}\left(\hat{i}, + \sqrt{3}\hat{j}\right)$ is incident on a plane mirror. After reflection, it travels along the direction $\frac{1}{2}\left(\hat{i} - \sqrt{3}\hat{j}\right)$. The angle of incidence is

A. 30°

B. 45°

C. 60°

D. 75°

Answer: A

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3. In the Young's double slit experiment using a monochromatic light of wavelength λ, the path difference (in terms of an integer n) corresponding to any point having half the peak

A. $(2n+1)\frac{\lambda}{2}$

B. $(2n+1)\frac{\lambda}{4}$

C. $(2n+1)\frac{\lambda}{8}$

D. $(2n+1)\frac{\lambda}{16}$

Answer: B

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4. Two non-reactive monoatomic ideal gases have their atomic masses in the ratio $2:3$. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is $4:3$. The ratio of their densities is

A. $1:4$

B. $1:2$

C. $6:9$

D. $8:9$

Answer: D

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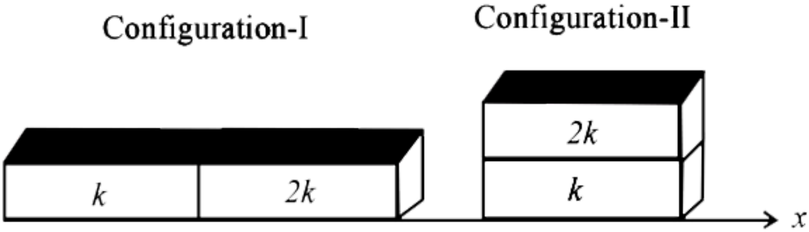
5. Two rectangular blocks, having identical dimensions, an be arranged either in configuration-I or in configuration-II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration-I. The time to transport the same amount of heat in the configuration-II is



A. $2.0s$

B. $3.0s$

C. $4.5s$

D. $6.0s$

Answer: A

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6. A pulse of light of duration $100ns$ is absorbed completely by a small object initially at rest power of the pulse is $30mW$ and the speed of light is $3 \times 10^8 ms^{-1}$ The final momentum of the object is

A. $0.3 \times 10^{-17} kgms^{-1}$

B. $1.0 \times 10^{-17} kgms^{-1}$

C. $3.0 \times 10^{-17} kgms^{-1}$

D. $9.0 \times 10^{-17} kgms^{-1}$

Answer: B

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7. A particle of mass m is projected from the ground with an initial speed u_0 at an angle α with the horizontal. At the highest point of its trajectory, it makes a completely inelastic collision with another identical particle, which was thrown vertically upward from the ground with the same initial speed u_0. The angle that the composite system makes with the horizontal immediately after the collision is

A. $\frac{\pi}{4}$

B. $\frac{\pi}{4} + \alpha$

C. $\frac{\pi}{2}$ - α

D. $\frac{\pi}{2}$

Answer: A

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8. The work done an a particle of mass m by a force

$$K\left[\frac{x}{\left(x^2+y^2\right)^{3/2}}\hat{i}+\frac{y}{\left(x^2+y^{2^{3/2}}\right)\hat{j}}\right](Kbe \in gaconstantofap \propto riate \dim ensions),$$

(a,0) $\rightarrow thep\oint$ (0,a)` along a circular path of radius a about the origin in x - y plane is

A. $\frac{2K\pi}{a}$

B. $\frac{K\pi}{a}$

C. $\frac{K\pi}{2a}$

D. 0

Answer: D

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9. One end of a horizontal thick copper wire of length 2L and radius 2R is welded to an end fo another horizontal thin copper wire of lenth L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is

A. 0.25

B. 0.50

C. 2.00

D. 4.00

Answer: C

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10. The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real is one-third the size of the object. The wavelength of light inside the lens is 2/3 times the wavelength in free space. The radius of the curved surface of the lens is

A. 1 m

B. 2 m

C. 3 m

D. 6 m

Answer: C

Watch Video Solution

PART I : PHYSICS (SECTION -2)

1. A horizontal stretched string, fixed at two ends, is vibrating in its fifth harmonic according to the equation, $y(x, t) = (0.01m)\sin\left[\left(62.8m^{-1}x\right]\cos\left[\left(628s^{-1}\right)t\right]$. Assuming $p = 3.14$, the correct statement(s) is (are)

A. The number of nodes is 5.

B. The length of the string is 0.25 m.

C. The maximum displacement of the midpoint of the string, from its equilibrium position is 0.01 m.

D. The fundamental frequency is 100 Hz.

Answer: B::C

Watch Video Solution

2. A solid sphere of radius R and density ρ is attached to one end of a mass-less spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statements(s) is (are)

A. the net elongation of the spring is $\dfrac{4\pi R^3 \rho g}{3k}$

B. the net elongation of the spring is $\dfrac{8\pi R^3 \rho g}{3k}$

C. the light sphere is partially submerged.

D. the light sphere is completely submerged.

Answer: A::D

Watch Video Solution

3. A particle of mass M and positive charge Q, moving with a constant velocity $\vec{u}_1 = 4\hat{i}ms^{-1}$, enters a region of uniform static magnetic field , normal to the $x - y$ plane. The region of the magnetic field extends from

$x = 0$ to $x = L$ for all values of y. After passing through this region, the particle emerges on the other side after $10 milliseconds$ with a velocity $\vec{u}_2 = 2\left(\sqrt{3}\hat{i} + \hat{j}\right)ms^{-1}$. The correct statement(s) is (are)

A. The direction of the magnetic field is -z direction.

B. The diretion fo the magnetic field is +z direction.

C. The magnitude of the magnetic field $\frac{50\pi M}{3Q}$ units.

D. The magnitude of the magnetic field is $\frac{100\pi M}{3Q}$ units.

Answer: A::C

Watch Video Solution

4. Two non-conducting solid spheres of radii R and 2R, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance 2R from the centre of the smaller sphere, along the line joining the centres of the spheres, is zero. The ratio $\frac{\rho_1}{\rho_2}$ can be

A. -4

B. - $\frac{32}{25}$

C. $\frac{32}{25}$

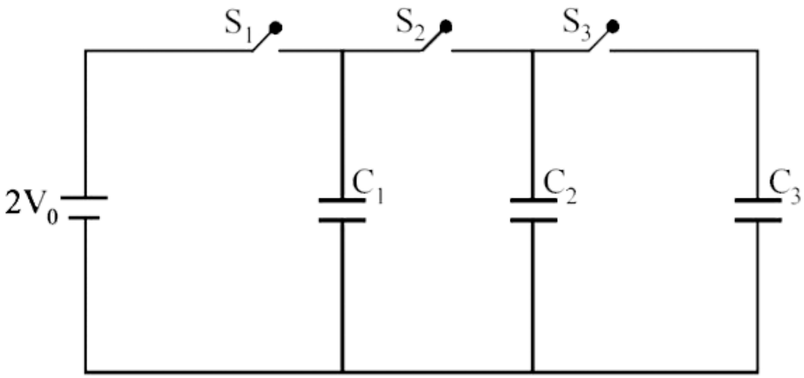
D. 4

Answer: B::D

Watch Video Solution

5. In the circuit shown in the figure, there are two parallel plate capacitors each of capacitance C. The switch S_1 is pressed first to fully charge the capacitor C_1 and then released. The switch S_2 is then pressed to charge the capacitor C_2. After some time, S_2 is released and then S_3 is pressed.

After some time



A. the charge on the upper plate of C_1 is $2CV_0$.

B. the charge on the upper plate of C_1 is CV_0

C. the charge on the upper plate of C_2 is 0.

D. the charge on the upper plate of C_2 is $-CV_0$

Answer: B::D

Watch Video Solution

PART I : PHYSICS (SECTION -3)

1. The work function of Silver and sodium are 4.6 and $2.3eV$, respectively . The ratio of the slope of the stopping potential versus frequency plot for silver to that of sodium is

Watch Video Solution

2. A freshly prepared sample of a radioisotope of half - life $1386s$ has activity 10^3 disintegrations per second Given that $\ln 2 = 0.693$ the fraction of the initial number of nuclei (expressed in nearest integer percentage) that will decay in the first $80s$ after preparation of the sample is

Watch Video Solution

3. A particle of mass 0.2 kg is moving is one dimension under a force that delever is a constant preses $0.5W$ in the particle . If the detail speed $\left(nms^{-1}\right)$ of the particle is zero , the speed $\left(mms^{-1}\right)$ after $5 \times$ is

Watch Video Solution

4. A uniform circular disc of mass 50kg and radius 0.4 m is rotating with an angular velocity of $10 rads^{-1}$ about its own axis, which is vertical. Two uniform circular rings, each of mass 6.25 kg and radius 0.2 m, are gently placed symmetrically on the disc in such a manner that they are touching each other along the axis of the disc and are horizontal. Assume that the friction is large enough such that the rings are at rest relative to the disc and the system rotates about the original axis. The new angular velocity $\left(\in reds^{-1}\right)$ of the system is

Watch Video Solution

5. A bob of mass m, suspended by a string of length l_1 is given a minimum velocity required to complete a full circle in the vertical plane. At the highest point, it collides elastically with another bob of mass m suspended by a string of length l_2, which is initially at rest. Both the strings are mass-less and inextensible. If the second bob, after collision acquires the minimum speed required to complete a full circle in the vertical plane, the ratio $\frac{l_1}{l_2}$ is

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PART I: PHYSICS (SECTION-1) (One or more options correct Type)

1. Using the expression $2d\sin\theta = \lambda$, one calculates the values of d by measuring the corresponding angles θ in the range $0 \rightarrow 90^\circ$. The wavelength λ is exactly known and error in θ is constant for all values of θ. As θ increases from 0°

A. the absolute error in d remains constant

B. the absolute error in d increase

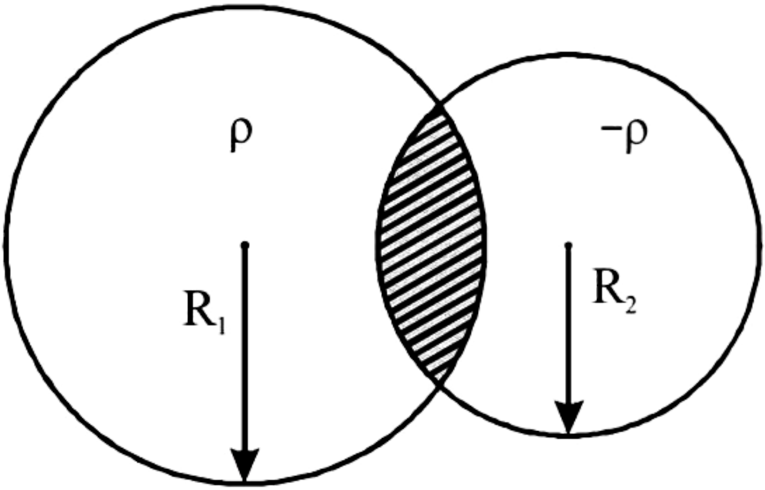
C. the fractional error in d remains constant

D. the fractional error in d decreases.

Answer: D

Watch Video Solution

2. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region



A. the electrostatic field is zero.

B. the electrostatic potential is constant.

C. the electrostatic field is constant in magnitude

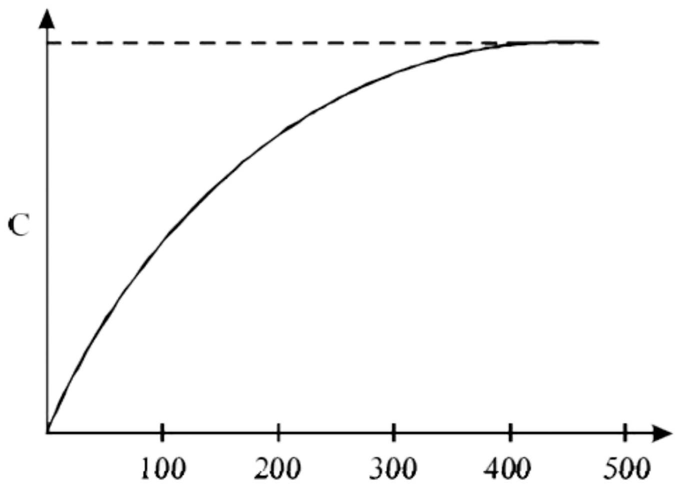
D. the electrostatic field has same direction.

Answer: D

Watch Video Solution

Watch Video Solution

3. The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously form 0 to 500K at a constant rate. Ignoring any volume change, the following statement (s) is (are) correct to a reasonable approximation.



A. the rate at which heat is absorbed in the range 0-100 K varies linearly with temperature T.

B. heat absorbed in increasing the temperature from 0-100 K is less than the heat required for increasing the termperature from 400-

500 K.

C. there is no change in the rate of heat absorption in the range 400-

500 K.

D. the rate of heat absorption increases in the range 200-300 K.

Answer: A::B::C::D

Watch Video Solution

4. The radius of the orbit of an electron in a Hydrogen-like atom is $4.5a_0$, where a_0 is the Bohr radius. Its orbital angular momemtum is $\frac{3h}{2\pi}$. It is given that h is Plank constant and R si Rydberg constant. The possible wavelength (s), when the atom-de-excites. is (are):

A. $\frac{9}{32R}$

B. $\frac{9}{16R}$

C. $\frac{9}{5R}$

D. $\frac{4}{3R}$

Answer: A::C

Watch Video Solution

5. Two bodies, each of mass M, are kept fixed with a separation 2L. A particle of mass m is projected from the midpoint of the line joining their cehntres, perpendicualr to the line. The gravitational constant is G. The correct statement (s) is (are)

A. The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $4\sqrt{\frac{GM}{L}}$

B. The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $2\sqrt{\frac{GM}{L}}$

C. The minimum initial velocity of the mass m to escape the gravitational field of the two bodies is $\sqrt{\frac{GM}{L}}$

D. The energy of the mass m remains constant.

Answer: B::D

Watch Video Solution

6. A particle of mass m is attached to one end of a mass-less spring of force constant k, lying on a frictionless horizontal plane. The other end of the spring is fixed. The particle starts moving horizontally from its equilibrium position at time $t = 0$ with an initial velocity u_0. when the speed of the particle is $0.5u_0$, it collides elastically with a rigid wall. After this collision

A. the speed of the particle when it returns to its equilibrium position is u_0.

B. the time at which the particle passes through the equilibrium position for the first time is $t = \pi\sqrt{\frac{m}{k}}$.

C. the time at which the maximum compression of the spring occurs is $t = \frac{4\pi}{3}\sqrt{\frac{m}{k}}$.

D. the time at which the particle passes through the equilibrium position for the second time is $t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$

Answer: A::D

Watch Video Solution

7. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. This cylinder is placed coaxially inside an infinite solenoid of radius $2R$. The solenoid has a n turns per unit length and carries a steady current I. Consider a point p at a distance r from the common axis . The correct statement(s) is (are)

A. In the region $0 < r < R$, the magnetic field in non-zero.

B. In the region $R < r < 2R$, the magnetic field is along the common axis.

C. In the region $R < r < 2R$, the magnetic field is tangential to the circle of radius r, centered on the axis.

D. In the region $r > 2R$, the magnetic field is zero.

Answer: A

Watch Video Solution

8. Two vehicles, each moving with speed u on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity w. One of these vehicles blows a whistle of frequency f_1. An observer in the other vehicle hears the frequency of the whistle to be f_2. the speed of sound in still air is V_C. The correct statement (s) is (are)

A. If the wind blows from the observer ot the source $f_2 > f_1$

B. If the wind blows from the source to the observe , $f_2 > f_1$

C. If the wind blows from observer to the source $f_2 < f_1$

D. If the wind blows from the soruces to the observer, $f_2 < f_1$

Answer: A::B

Watch Video Solution

9. A point charges Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. S uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of hte orbit remains constant. The application of hte magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It si known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a porportionality constant λ.

The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the mangnetic field change is

A. $\frac{BR}{4}$

B. $\frac{BR}{2}$

C. BR

D. 2BR

Answer: B

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PART I: PHYSICS SECTION-3: (Paragraph Type)

1. A point charges Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. S uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of hte orbit remains constant. The application of hte magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It si known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a porportionality constant λ.

The charge in the magnetic dipole moment associated with the orbit. at the end of the time interval of hte magnetic field charge, is

A. $-\gamma BQR^2$

B. $\gamma \frac{BQR^{\circ}}{2}$

C. $\gamma \frac{BQR^2}{2}$

D. γBQR^2

Answer: B

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PART I: PHYSICS SECTION-2: (Paragraph Type)

1. The mass of nucleus $._{Z}X^{A}$ is less than the sum of the masses of $(A - Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of mass m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of massws m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M "only if $(m_3 + m_4) > M$". The masses of some neutral atoms are given in the table below.

$_{1}^{1}H$	$1.007825u$	$_{1}^{2}H$	$2.014102u$
$_{1}^{3}H$	$3.016050u$	$_{2}^{4}H$	$4.002603u$
$_{3}^{6}Li$	$6.015123u$	$_{3}^{7}Li$	$7.016004u$
$_{30}^{70}Zn$	$69.925325u$	$_{34}^{82}Se$	$81.916709u$
$_{64}^{152}Gd$	$151.91980u$	$_{82}^{206}Pb$	$205.97445u$
$_{83}^{209}Bi$	$208.980388u$	$_{84}^{210}Po$	$209.982876u$

The correct statement is

A. The nucleus $_{3}^{6}Li$ can emit an alpha particle.

B. The nucleus $_{84}^{210}Po$can emit a proton

C. Deuteron and alpha particle can undergo complete fusion.

D. The nuclei $_{30}^{70}Zn$ and $_{34}^{82}Se$ can undergo complete fusion.

Answer: C

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2. The mass of nucleus $._{Z}X^{A}$ is less than the sum of the masses of $(A - Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of mass m_1 and m_2 only if $\left(m_1 + m_2\right) < M$. Also two light nuclei of massws m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M "only if $\left(m_3 + m_4\right) > M$". The masses of some neutral atoms are given in the table below.

$._{1}^{1}H$	$1.007825u$	$._{1}^{2}H$	$2.014102u$
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$._{64}^{152}Gd$	$151.91980u$	$._{82}^{206}Pb$	$205.97445u$
$._{83}^{209}Bi$	$208.980388u$	$._{84}^{210}Po$	$209.982876u$

The kinetic energy (in KeV) of the alpha particle, when the nucleus at rest undergo alpha decay, is

A. 5319

B. 5422

C. 5707

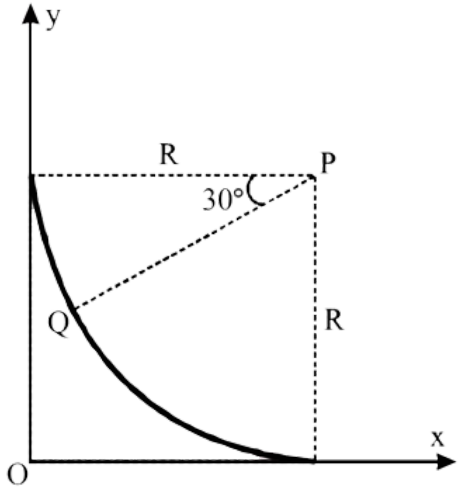
D. 5818

Answer: A

Watch Video Solution

3. A small block of mass 1 kg is a circular are of ratius 40 m . The block sides along the track without topping and a frictionnal force acts on it in the direction opposite in the instrmens velocity . The work done in evercoming the friction up to the point Q as shown is the figure below is $150J$

(Take the acceleration due to gravity $g = 10ms^{-2}$)



The speed of the block when it reaches the point Q is

A. $5ms^{-1}$

B. $10ms^{-1}$

C. $10\sqrt{3}ms^{-1}$

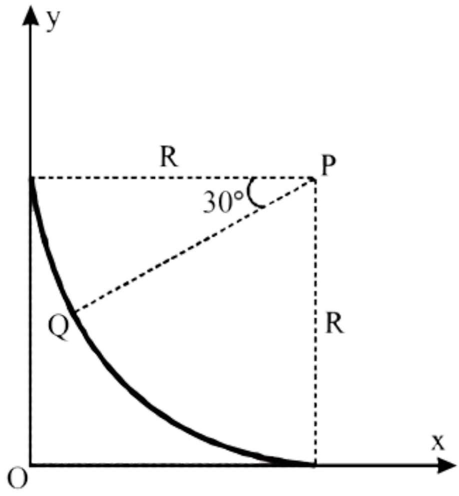
D. $20ms^{-1}$

Answer: B

Watch Video Solution

4. A small block of mass 1 kg is a circular are of ratius 40 m . The block sides along the track without topping and a frictionnal force acts on it in the direction opposite in the instrmens velocity . The work done in evercoming the friction up to the point Q as shown is the figure below is $150J$

(Take the acceleration due to gravity $g = 10ms^{-2}$)



The magnitude of the normal reaction that acts on the block at the point Q is

A. 7.5 N

B. 8.6 N

C. 11.5 N

D. 22.5 N

Answer: A

Watch Video Solution

5. A thermal power plant produed electric power of 600kW at 4000V, which is to be transported to a place 20 km away form the power plant for consumer's usage. It can be transported either directly with a cable of large current carrying capacity or by sing a combination of step-up and step-down transfprmers at the two ends. THe drawback of the direct transmission is the large energy dissipation. In the method wsing transformers, the dissipatiion is much smaller. In this method a step-up transformers is used at the plant side so that the current is reduced to a smaller value. At the consumers'end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resostive and the transformers are ideal with power factor unity. All the currents and voltagementioned are values.

If hte direct transmission method with a cable of resistance $0.4(\omega)km^{-1}$ is used, the power dissipation (in %) during transmission is

A. 20

B. 30

C. 40

D. 50

Answer: B

Watch Video Solution

6. A thermal power plant produed electric power of 600kW at 4000V, which is to be transported to a place 20 km away form the power plant for consumer's usage. It can be transported either directly with a cable of large current carrying capacity or by sing a combination of step-up and step-down transfprmers at the two ends. THe drawback of the direct transmission is the large energy dissipation. In the method wsing transformers, the dissipatiion is much smaller. In this method a step-up transformers is used at the plant side so that the current is reduced to a smaller value. At the consumers'end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resostive and the transformers are ideal with power factor unity. All the currents and voltagementioned are values.

In the method using the transformers assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is 1:10 if the power to the consumers has to be supplied at 200V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is

A. $200:1$

B. $150:1$

C. $100:1$

D. $50:1$

Answer: A

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PART I: PHYSICS Section-3:(Matching List Type)

1. Match List I of the nuclear processes with List II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists :

List I / सूची I		List II / सूची II	
P.	Alpha decay ऐल्फा-क्षय	1.	${}^{15}_{8}O \rightarrow {}^{15}_{7}N + \ldots..$
Q.	β^+ decay β^+ क्षय	2.	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + \ldots..$
R.	Fission विखंडन	3.	${}^{185}_{83}Bi \rightarrow {}^{184}_{82}Pb + \ldots..$
S.	Proton emission	4.	${}^{239}_{94}Pu \rightarrow {}^{140}_{57}La + \ldots..$

A.

P	Q	R	S
4	2	1	3

B.

P	Q	R	S
1	3	2	4

C.

P	Q	R	S
2	1	4	3

D.

P	Q	R	S
4	3	2	1

Answer: C

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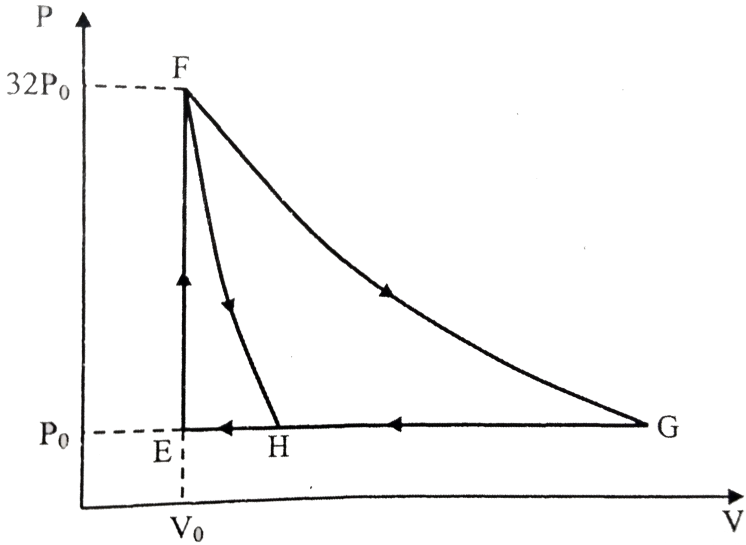
2. One mole of a monatomic ideal gas is taken along two cyclic processes $E \rightarrow F \rightarrow G \rightarrow E$ and $E \rightarrow F \rightarrow H \rightarrow E$ as shown in the PV diagram. The processes involved are purely isochoric , isobaric , isothermal or adiabatic

.



Match the paths in List I with the magnitudes of the work done in List II and select the correct answer using the codes given below the lists.

List I / सूची I		List II / सूची II	
P.	$G \rightarrow E$	1.	$160 P_0 V_0 \ln 2$
Q.	$G \rightarrow H$	2.	$36 P_0 V_0$
R.	$F \rightarrow H$	3.	$24 P_0 V_0$
S.	$F \rightarrow G$	4.	$31 P_0 V_0$

A.

P	Q	R	S
4	2	3	1

B.

P	Q	R	S
4	3	1	2

C.

P	Q	R	S
3	1	2	4

D.

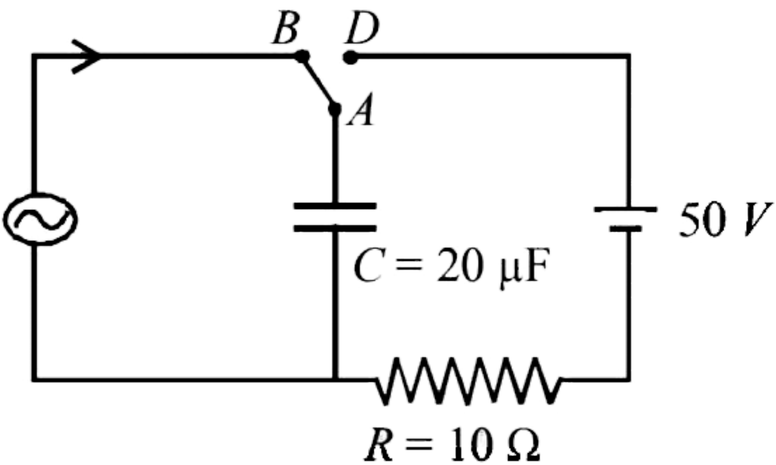
P	Q	R	S
1	3	2	4

Answer: A

Watch Video Solution

SECTION - 1 (ONE OR MORE THAN ONE OPTIONS CORRECT TYPE)

1. At time $t = 0$, terminal A in the circuit shown in the figure is connected to B by a key and an alternating current $I(t) = I_0\cos(\omega t)$, with $I_0 = 1A$ and $(\omega) = 500 rads^{-1}$ starts flowing in it with the initial direction shown in the figure. At $t = (7\pi/6\omega)$, the key is switched from B to D. Now onwards only A and D are connected. A total charge Q flows from the battery to charge the capacitor fully. If `C=20(mu)F, R = 10(Omega) and the battery is ideal with emf of 50 V, identify the correct statement(s).



A. Magnitude of the maximum charge on the capacitor before $t = \frac{7\pi}{6\omega}$ is $1x10^{-3}C$.

B. The current in the left part of the circuit just before $t = \frac{7\pi}{6\omega}$ is clockwise.

C. Immediately after A is connected to D, the current in R is 10A.

D. $Q = 2 \times 10^{-3}C$.

Answer: A::C::D

Watch Video Solution

2. A light source, which emits two wavelength $\lambda_1 = 400nm$ and $\lambda_2 = 600nm$, is used in a Young's double slit experiment. If recorded fringe width for λ_1 and λ_2 are β_1 and β_2 and the number of fringes for them within a distance y on one side of the central maximum are m_1 and m_2 respectively, then

A. $\beta_2 > \beta_1$

B. $m_1 > m_2$

C. From the central maximum 3^{rd} maximum of λ_2 overlaps with 5^{th} minimun of λ_1

D. The angular separation of fringes for λ_1 is greater than λ_2.

Answer: A::B::C::D

Watch Video Solution

3. One end of a taut string of length $3m$ along the x-axis is fixed at $x = 0$. The speed of the waves in the string is $100ms^{-1}$. The other end of the string is vibrating in the y-direction so that stationary waves are set up in the string. The possible wavelength(s) of these sationary waves is (are)

A. $y(t) = A\frac{\sin(\pi x)}{6}\cos.\ \frac{50\pi t}{3}$

B. $y(t) = A\frac{\sin(\pi x)}{3}\cos.\ \frac{100\pi t}{3}$

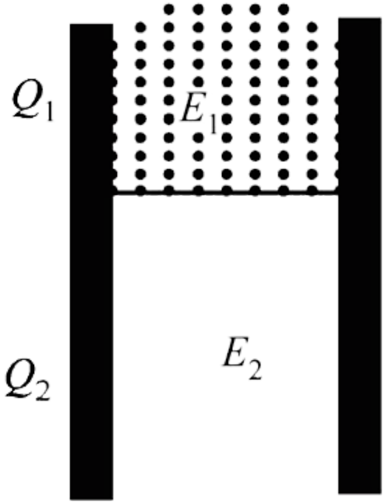
C. $y(t) = A\frac{\sin(5\pi x)}{6}\cos.\ \frac{250\pi t}{3}$

D. $y(t) = A\frac{\sin(5\pi x)}{2}\cos 250\pi t$

Answer: A::C::D

Watch Video Solution

4. A parallel plate capacitor has a dielectric slab of dielectric constant K between its plates that covers $1/3$ of the area of its plates, as shown in the figure. The total capacitance of the capacitor is C while that of the portion with dielectric in between is C_1. When the capacitor is charged, the plate area covered by the dielectric gets charge Q_1 and the rest of the area gets charge Q_2. The electric field in the dielectric is E_1 and that in the other portion is E_2. Choose the correct option/options, ignoring edge effects.



A. $\frac{E_1}{E_2} = 1$

B. $\frac{E_1}{E_2} = \frac{1}{K}$

C. $\frac{Q_1}{Q_2} = \frac{3}{K}$

D. $\frac{C}{C_1} = \frac{2+k}{k}$

Answer: A::D

Watch Video Solution

5. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respectively electric field at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. If $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then

A. $Q = 4\sigma\pi r_0^2$

B. $r_0 = \frac{\lambda}{2\pi\sigma}$

C. $E_1(r_0/2) = 2E_2(r_0/2)$

D. $E_2(r_0/2) = 4E_3(r_0/r)$

Answer: C

Watch Video Solution

6. A student is performing an experiment using a resonance column and a tuning fork of frequency $244s^{-1}$. He is told that the air in the tube has been replaced by another gas (assuming that the air column remains filled with the gas). If the minimum height at which resonance occurs is

$(0.350 \pm 0.005)m$, the gas in the tube is (Useful information : $\sqrt{167RT} = 640J^{1/2}mol^{-1/2}$,

$\sqrt{140RT} = 590J^{1/2}mol^{-1/2}$. The molar masses M in grams are given in the options. take the values of $\sqrt{\frac{10}{M}}$ for each gas as given there.)

A. Neon $\left(M = 20, \sqrt{\frac{10}{20}} = \frac{7}{10}\right)$

B. Nitrogen $\left(M = 28\sqrt{\frac{10}{28}} = \frac{3}{5}\right)$

C. Oxygen $\left(M = 28, \sqrt{\frac{10}{10}} = \frac{9}{16}\right)$

D. Argon $\left(M = 36, \sqrt{\frac{10}{36}} = \frac{17}{32}\right)$

Answer: D

Watch Video Solution

7. Heater of an electric kettle is made of a wire of length L and diameter d. It takes 4 minutes to raise the temperature of 0.5 kg water by 40K. This heater is replaced by a new heater having two wires of the same material, each of length L and diameter 2d. The way these wires are connected is given in the options. How much time in minutes will it take to raise the temperature of the same amount of water by 40 K?

A. 4 if wires are in parallel

B. 2 if wires are in series

C. 1 if wires are in series

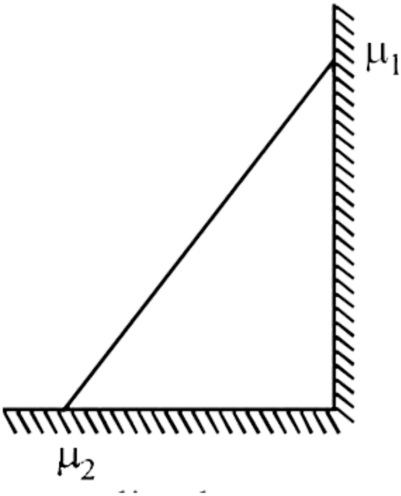
D. 0.5 if wires are in parallel

Answer: A::B::D

Watch Video Solution

8. In the figure, a ladder of mass m is shown leaning against a wall. It is in static equilibrium making an angle θ with the horizontal floor. The coefficient of friction between the wall and the ladder is μ_1 and that between the floor and the ladder is μ_2. the normal reaction of the wall on the ladder is N_1 and that of the floor is N_2. if the ladder is about to slip.

than



A. $\mu_1 = 0 \mu_2 \neq 0$ and $N_2 \tan\theta = \frac{mg}{2}$

B. $\mu_1 \neq 0 \mu_2 = 0$ and $N_1 \tan\theta = \frac{mg}{2}$

C. $\mu_1 \neq 0 \quad \mu_2 \neq 0$ and $N_2 = \frac{mg}{1 + \mu_1 \mu_2}$

D. $\mu_1 \neq 0 \quad \mu_2 \neq 0$ and $N_1 = \frac{mg}{1 + \mu_1 \mu_2}$

Answer: A::C::D

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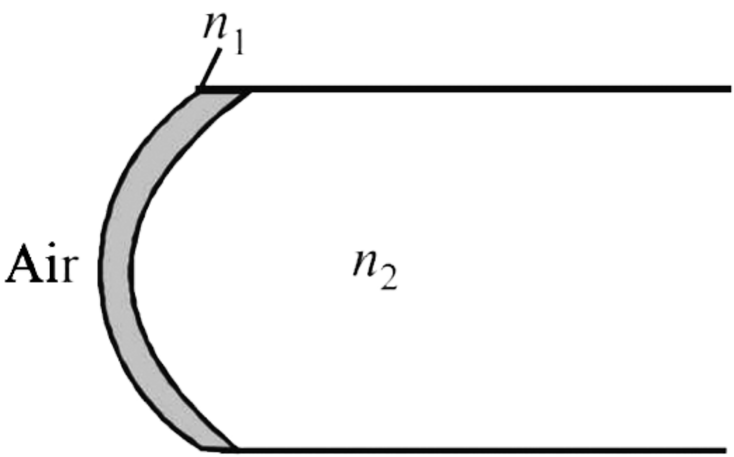
9. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film, Then `



A. $|f_1| = 3R$

B. $|f_1| = 2.8R$

C. $|f_2| = 2R$

D. $|f_2| = 1.4R$

Answer: A::C

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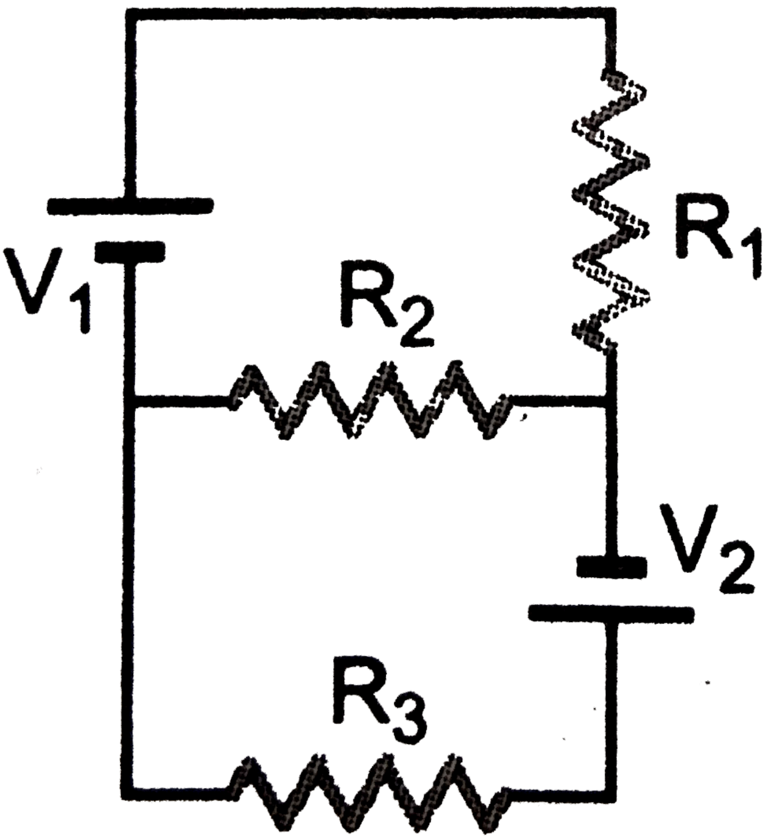
10. Two ideal batteries of $emfV_1$ and V_2 and three resistance R_1R_2 and R_3 are connected The current in resistance R_2 would be zero if



A. $V_1 = V_2$ and $R_1 = R_2 = R_3$

B. $V_1 = V_2$ and $R_1 = 2R_2 = R_3$

C. $V_1 = 2V_2$ and $2R_1 = 2R_1 = 2R_2 = R_3$

D. $2V_1 = V_2$ and $2R_1 = R_2 = R_3$

Answer: A::B::D

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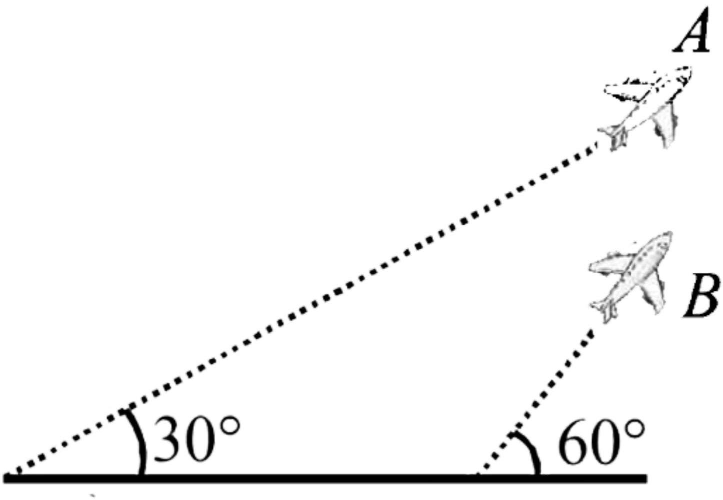
SECTION -2 (ONE INTEGER VALUES CORRECT TYPE)

1. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in figure . The speed of A is $100\sqrt{3}m/s$. At time $t = 0s$, an observer in A finds B at a distance of $500m$. The observer sees B moving with a constant velocity perpendicular to the line of motion of A . If at $t = t_0$, A just escapes being hit by B, t_0 , A just escapes being hit by B, t_0 in seconds is



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2. During Searle's experiment, zero of the Vernier sacle lies between 3.20×10^{-2}, and $3.25 \times 10^{-2} m$ of the main scale. The 20^{th} division of the Vernier scale exactly coincides with one of the main scale divisions. When an additional load of $2kg$ is applied to the wire, the zero of the vernier scale still lies between 3.20×10^{-2}, and $3.25 \times 10^{-2} m$ of the main scale but now the 45^{th} division of Vernier scale coincide with one of the main scale divisions. the length of the thin metallic wire is $2m$ and its cross-sectional ares is $8 \times 10^{-7} m^2$. the least count of the Vernier scale is

$1.0 \times 10^{-5} m$. the maximum percentage error in the Young's modulus of the wire is

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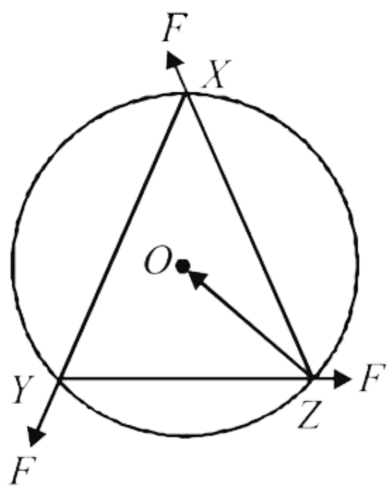
3. A uniform circular disc of mass 1.5 kg and raius 0.5 m is initially ar rest on a horiozntal frictonless surface. Three forces of equal matgnitude F = 0.5 N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc (see figure). One second after applying the forces the angular speed of the disc in $rads^{-1}$ is



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4. Two parallel wires in the plane of the paper are distance X_0 apart. A point charge is moving with speed u between the wires in the same plane at a distance X_1 from one of the wires. When the wires carry current of magnitude I in the same direction , the radfius of curvature of the path of the point charge is R_1. In contrast, if the currentsd I in the two wires have directions opposite to each other, the radius of curvature of the path is R_2. if $\frac{X_0}{X_1} = 3$, the value of $\frac{R_1}{R_2}$ is

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5. To find the distance d over which a signal can be seen clearly in foggy conditions, a railways engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity $(\text{power}/\text{area})$ S of the light from the signal and its frequency f. The engineer finds that d is proportional to $S^{1/n}$. The value of n is.

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6. A galvanometer gives full scale deflection with 0.006 A current. By connecting in to a 4990Ω resistance, it can be converted into a voltmeter of range 0-30V. If connected to a $\frac{2n}{249}\Omega$ resistance, it becomes an ammeter of range $0 - 1.5A$. The value of n is

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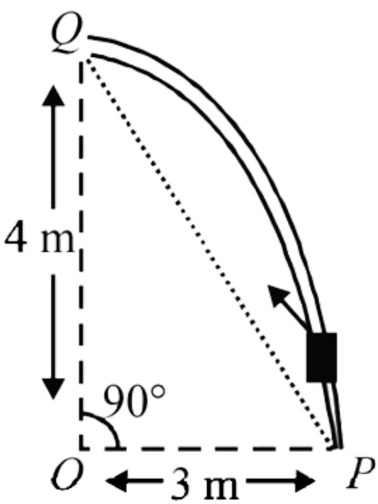
7. Constant as eliptical rail PQ in the varticle plain with $OP = \; = 3m$ and $OQ = 4m$. A block of mass 1 kg is pailed along the rail from P to Q with a force of $18N$, which is always parallel to less PQ Assuming are frictionless losess , the kinetic energy the block when 0 reches Q is $(n \times 10)$ pales . THe velie of a (Take acceleration due to gravity) $= 10ms^{-2}\big)$



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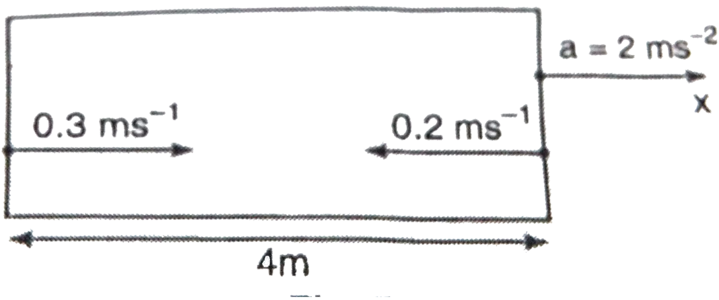
8. A rocket is moving in a gravity free space with a constnat acceleration of $2ms^{-1}$ along +x direction (see Fig.5.126). The length of a chamber inside the rocket is 4m. A ball is thrown from th left end of the chamber in +x direction with a speed of 0.3 ms^{-1} relaitve to the rocket. At the same time , another ball is thrown in -x direction with a speed of 0.2ms^(-1)` from its right and relative to the rocket. the time in seconds when the two balls hit each other is:



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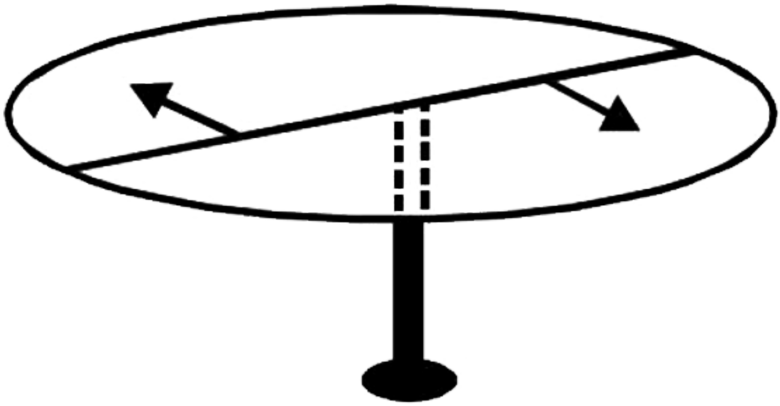
9. A horizontal circular platform of radius 0.5 m and mass axis. Two massless spring toy-guns, each carrying a steel ball of mass 0.05 kg are attached to the platform at a distance 0.25m from the centre on its either sides along its diameter (see figure). Each gun simultaneously fires the balls horizontally and perpendicular to the diameter in opposite directions. After leaving the platform, the balls have horizontal speed of $9ms^{-1}$ with respect to the ground. The rotational speed of the platform in $rads^{-1}$ after the balls leace the platform is



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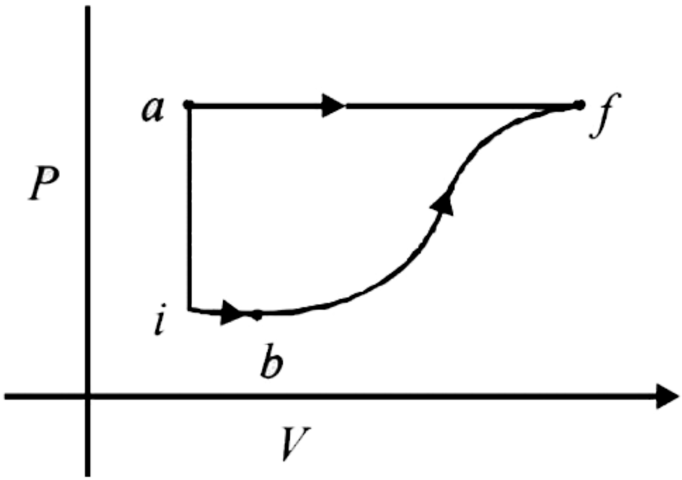
10. A thermodynamic system is taken from an initial state I with internal energy U_i = - $100J$ to the final state f along two different paths iaf and ibf, as schematically shown in the figure. The work done by the system along the pat af, ib and bf are $W_{af} = 200J$, $W_{ib} = 50J$ and $W_{bf} = 100J$ respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf}, Q_{ib}, Q_{bf} respectively. If the internal energy of the system in the state b is $U_b = 200J$ and $Q_{iaf} = 500J$, The ratio $\frac{Q_{bf}}{Q_{ib}}$ is



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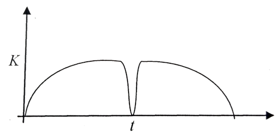
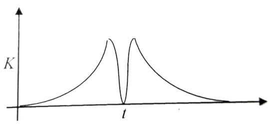
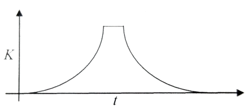
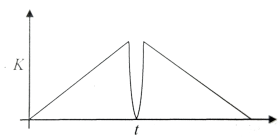
SECTION - 1 (ONLY ONE OPTION CORRRECT TYPE)

1. A tennis ball dropped on a barizoontal smooth surface , it because back to its original postion after hiting the surface the force on the bell during the collision is propertional to the length of compression of the bell . Which one of the following skethes desches discribe the variation of its kinetic energy K with time 1 mass apporiandly ? The figure as only illistrative and not to the scale .

A. 

B. 

C. 

D. 

Answer: B

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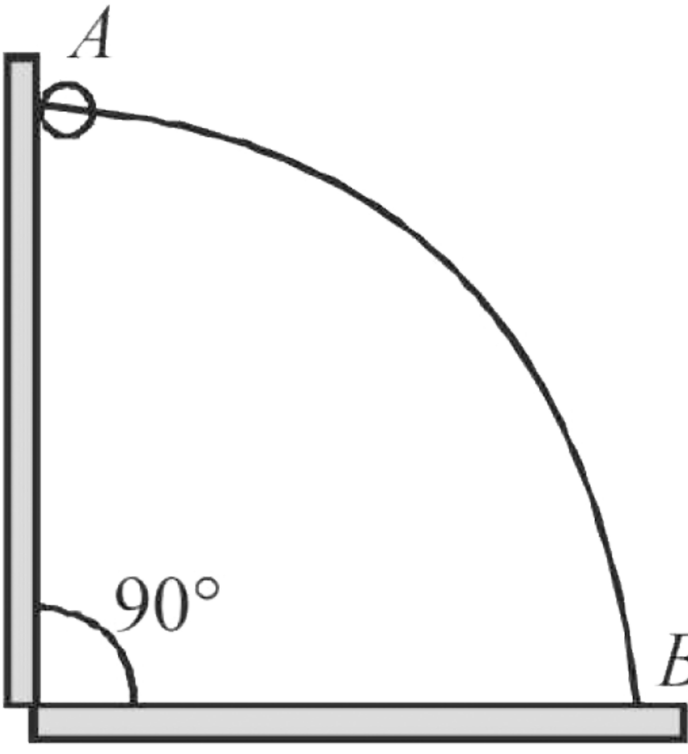
2. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is



A. always radially outwards

B. always radially inwards

C. radially outwards initially and radially inwards later.

D. radially inwards initially and radially outwards later.

Answer: D

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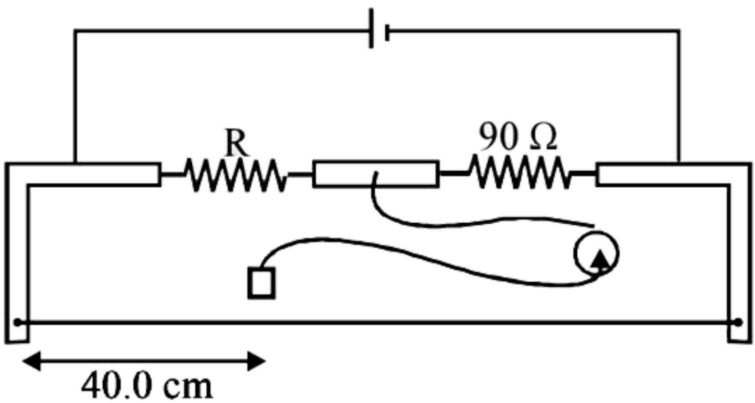
3. During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at $40.0cm$ using a standard resistance of 90Ω, as shown in the figure. The least count of the scale used in the metre bridge is 1mm. The unknown resistance is



A. $60 \pm 0.15\Omega$

B. $135 \pm 0.56\Omega$

C. $60 \pm 0.25\Omega$

D. $135 \pm 0.23\Omega$

Answer: C

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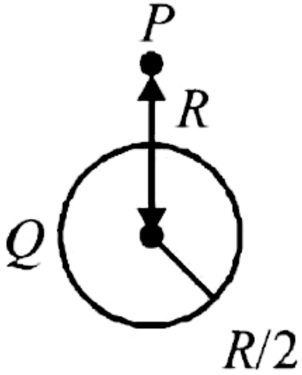
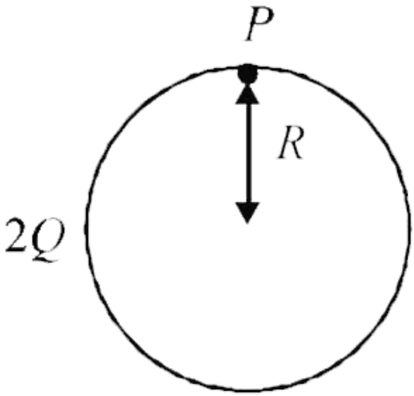
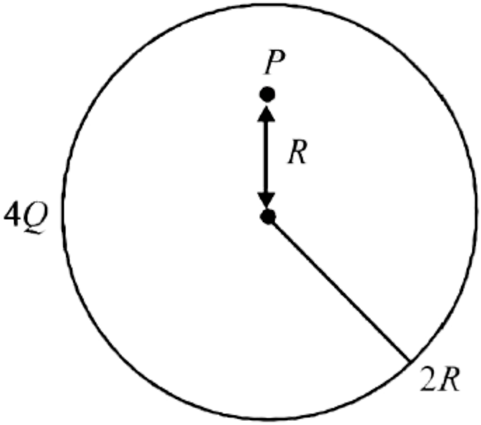
4. Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii $R/2$, R and 2R respectively, as shown in figure. If magnitude of the electric fields at point P at a distance R from the centre of sphere 1,2 and 3 are E_1, E_2 and E_3 respectively, then



Sphere 1



Sphere 2



Sphere 3

A. $E_1 > E_2 > E_3$

B. $E_3 > E_1 > E_2$

C. $E_2 > E_1 > E_3$

D. $E_3 > E_2 > E_1$

Answer: C

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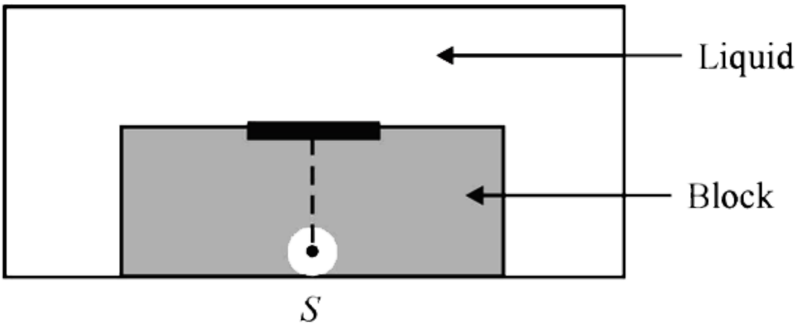
5. A point source S is placed at the bottom of a tranparent block of height 10mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is `



A. 1.21

B. 1.3

C. 1.36

D. 1.42

Answer: C

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6. Parallel rays of light of intensity $I = 912WM^{-2}$ are incident on a spherical black body kept in surroundings of temperature 300K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}$ $Wm^{-2}K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to

A. 330k

B. 660k

C. 990k

D. 1550k

Answer: A

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7. A metal is illumimated by light of two different wavelength $248nm$ and $310nm$. The maximum speeds of the photoelectrons corresponding in these wavelength are u_1 and u_2 respectively . If the ratio $u_1 : u_2 = 2 : 1$ and $hc = 1240eVnm$, the work function of the meal is nearly

A. $3.7eV$

B. $3.2eV$

C. $2.8eV$

D. $2.5eV$

Answer: A

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8. If λ_{Cu} is the wavelength of K_α X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the K_αX-ray line of molybdenum (atomic number 42),then the ratio $\lambda_{Cu}/\lambda_{Mo}$ is close to

A. 1.99

B. 2.14

C. 0.50

D. 0.48

Answer: B

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9. A planet of radius $R = \frac{1}{10} \times (radiusofEarth)$ has the same mass density as Earth. Scientists dig a well of depth $\frac{R}{5}$ on it and lower a wire of the same length and a linear mass density $10^{-3} kgm(\_1)$ into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it inplace is (take the radius of Earth $= 6 \times 10^6 m$ and the acceleration due to gravity on Earth is $10ms^{-2}$

A. 96N

B. 108N

C. 120N

D. 150N

Answer: B

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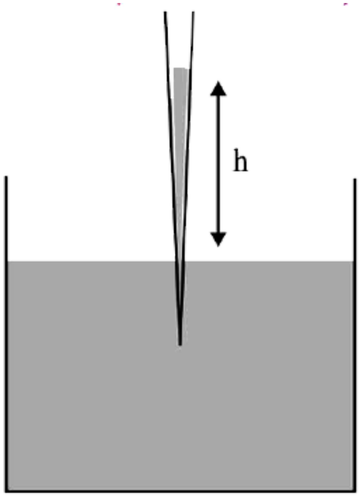
10. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a high h, where the radius of its cross section is b. If the surface tension of water is S, its density if ρ, and its contact angle with glass is θ, the value of h will be (g is the acceleration due to gravity)



A. $\frac{2s}{b\rho g}\cos(\theta - \alpha)$

B. $\frac{2s}{b\rho r}\cos(\theta + \alpha)$

C. $\frac{2s}{b\rho r}\cos(\theta + \alpha/2)$

D. $\frac{2s}{b\rho r}\cos(\theta + \alpha/2)$

Answer: D

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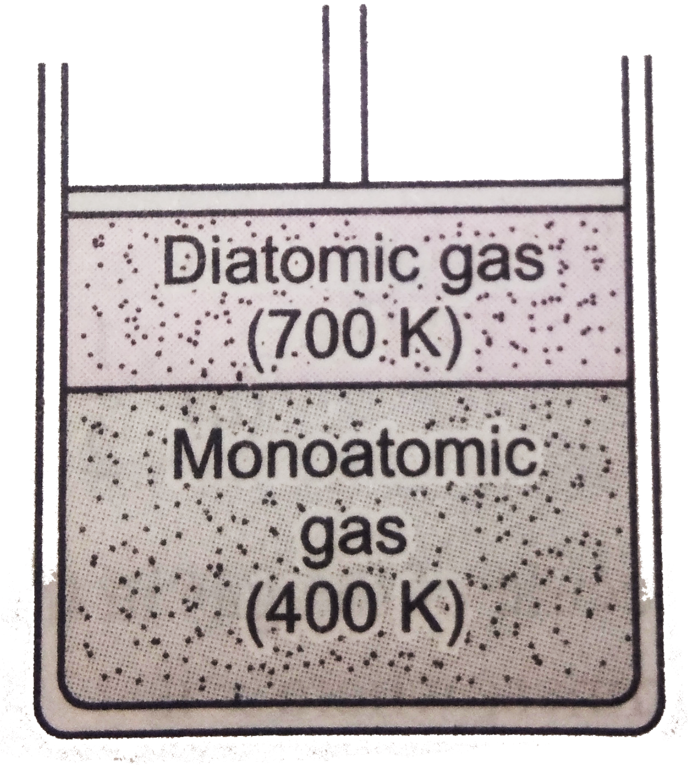
SECTION -2 COMPREHENSION TYPE

1. In Fig., a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. the lower compartment of the container is filled with 2 moles of an ideal monoatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. the heat capacities per mole of an ideal monoatomic gas are $C_v = \frac{3}{2}R$ and $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_{ve} = \frac{5}{2}R$ and $C_P = \frac{7}{2}R$.

Consider the partition to be rigidly fixed so that it does not move. when equilibrium is achieved, the final temperature of the gases will be



A. 550 K

B. 525 K

C. 513 K

D. 490 K

Answer: D

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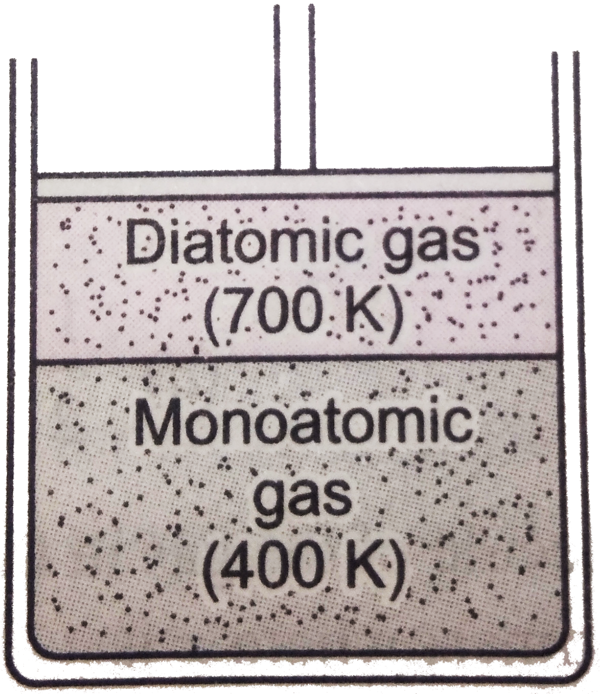
2. In Fig., a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. the lower compartment of the container is filled with 2 moles of an ideal monoatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. the heat capacities per mole of an ideal monoatomic gas are $C_{\upsilon} = \frac{3}{2}R$ and $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_{\upsilon e} = \frac{5}{2}R$ and $C_P = \frac{7}{2}R$.

Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. the total work done by the gases till the time they achieve equilibrium will be



A. 250 R

B. 200 R

C. 100 R

D. −100R

Answer: D

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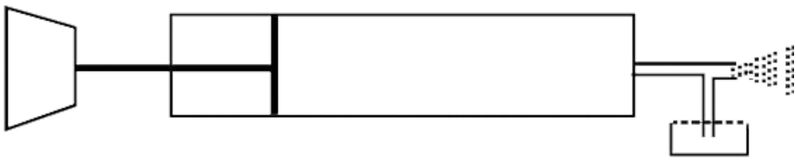
3. A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20mm and 1mm respectively. The upper end of the container is open to the atmosphere.



If the piston is pushed at a speed of $5mms^{-1}$, the air comes out of the nozzle with a speed of

A. $0.1ms^{-1}$

B. $1ms^{-1}$

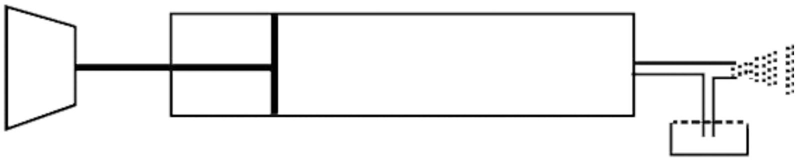
C. $2ms^{-1}$

D. $8ms^{-1}$

Answer: C

Watch Video Solution

4. A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20mm and 1mm respectively. The upper end of the container is open to the atmosphere.



If the density of air is ρ_a, and that of the liquid ρ_l, then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to

A. $\frac{\sqrt{\rho a}}{\rho l}$

B. $\sqrt{\rho a \rho l}$

C. $\frac{\sqrt{\rho l}}{\rho a}$

D. ρl

Answer: A

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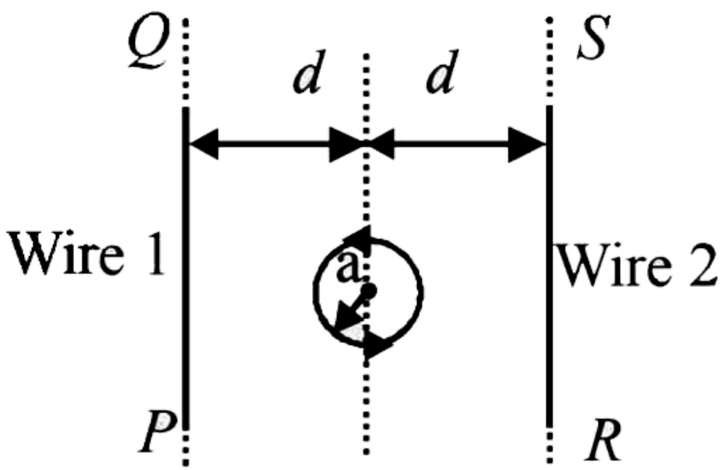
5. The figure shows a circular loop of radius a with two long parallel wires ($vmbered1$ and 2) all in the plane of the paper . The distance of each wire from the centre of the loop is d. The loop and the wire are carrying the same current I. The current in the loop is in the counterclockwise direction if seen from above.

(q) The magnetic fields(B) at P due to the currents in the wires are in opposite directions.

(r) There is no magnetic field at P.

(s) The wires repel each other.



(4) When $d \approx a$ but wires are not touching the loop , it is found that the net magnetic field on the axis of the loop . In that case

A. current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx a$

B. current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx a$

C. current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx 1.2a$

D. current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx 1.2a$

Answer: C

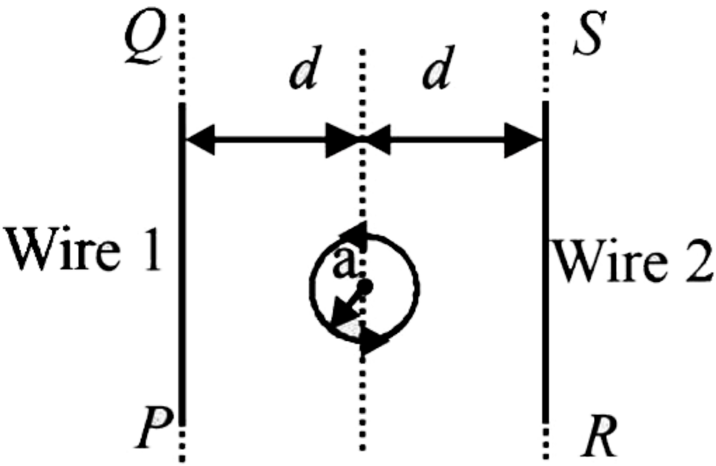
Watch Video Solution

6. The figure shows a circular loop of radius a with two long parallel wires $(vmbered1 \text{ and } 2)$ all in the plane of the paper . The distance of each wire from the centre of the loop is d. The loop and the wire are carrying the same current I. The current in the loop is in the counterclockwise direction if seen from above.

(q) The magnetic fields(B) at P due to the currents in the wires are in opposite directions.

(r) There is no magnetic field at P.

(s) The wires repel each other.



(5) Consider $d >> a$, and the loop is rotated about its diameter parallel to the wires by $30°$ from the position shown in the figure. If the currents in the wire are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop).

A. $\dfrac{\mu_0 I^2 a^2}{d}$

B. $\frac{\mu_0 I^2 a^2}{2d}$

C. $\frac{\sqrt{3}\mu_0 I^2 a^2}{d}$

D. $\frac{\sqrt{3}\mu_0 I^2 a^2}{2d}$

Answer: B

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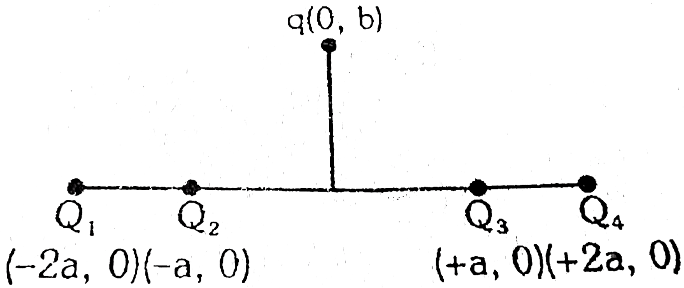
SECTION -3 (MATCHING LIST TYPE)

1. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis at $x = -2a, -a, +a$ and $+2a$, respectively. A positive charge q is placed on the positive y axis at a distance $b > 0$. Four options of the signs of these charges are given in List I. The direction of the forces on the charge q is given in List II. Match List I with List II and select the correct answer using the code given below the lists.



	List-I		List-II
(P)	Q_1, Q_2, Q_3, Q_4 all positive	(1)	$+x$
(Q)	Q_1, Q_2 positive, Q_3, Q_4 negative	(2)	$-x$
(R)	Q_1, Q_4 positive, Q_2, Q_3 negative	(3)	$+y$
(S)	Q_1, Q_3 positive, Q_2, Q_4 negative	(4)	$-y$

A. P-3, Q-1, R-4, S-2

B. P-4, Q-2, R-3, S-1

C. P-3, Q-1, R-2, S-4

D. P-4, Q-2, R-1, S-3

Answer: A

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2. Four combinations of two thin lenses are given in List I. The radius of curvature of all curved surfaces is r and the refractive index of all the lenses is 1.5 Match lens combinations in List I with their focal length in List II and select the correct answer using the code given below the lists.

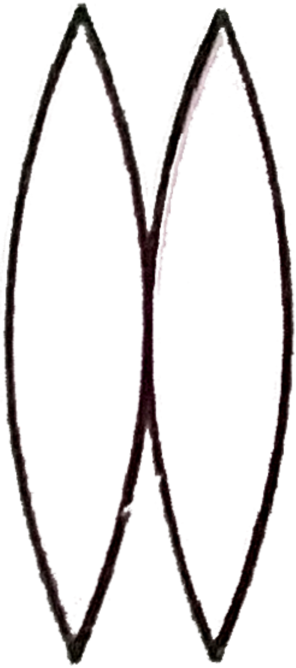
(A) $(p) 2r$

(B) $(q) \frac{r}{2}$

(C) (r) - r

(D) $(s) r.$

Code :

(A) 

(B) 

(C)

(D)

A. P-1, Q-2, R-3, S-4

B. P-2, Q-4, R-3, S-1

C. P-4, Q-1, R-2, S-3

D. P-2, Q-1, R-3, S-4

Answer: B

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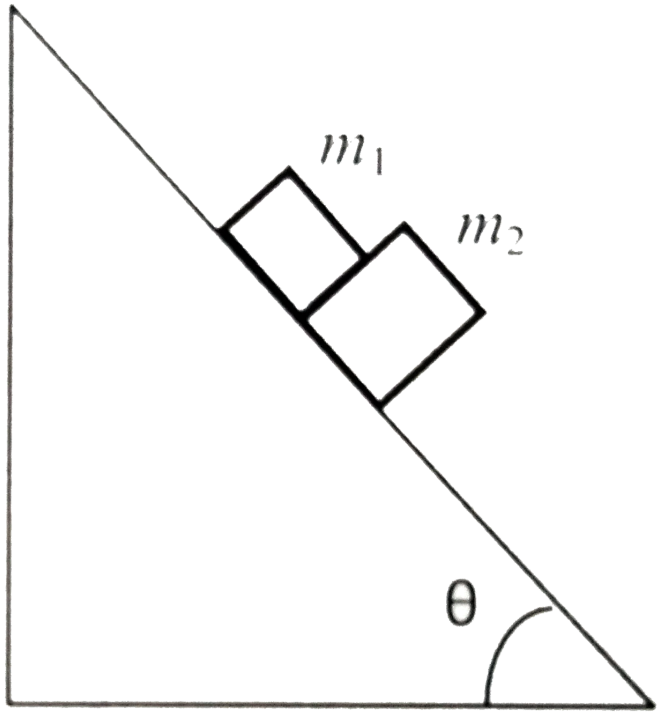
3. A block of mass m1 = 1 kg another mass m2 = 2 kg, are placed together (see figure) on an inclined plane with angle of inclination θ. Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g

[Useful information : $\tan\left(5.5^\circ\right) \approx 0.1, \tan\left(11.5^\circ\right) \approx 0.2, \tan\left(16.5^\circ\right) \approx 0.3$

].



List I

P. $\theta = 5^{\circ}$

Q. $\theta = 10^{\circ}$

R. $\theta = 15^{\circ}$

S. $\theta = 20^{\circ}$

List II

1. $m_2 g \sin\theta$

2. $(m_1 + m_2) g \sin\theta$

3. $\mu m_2 g \cos\theta$

4. $\mu (m_1 + m_2) g \cos\theta$

A. P-1, Q-1, R-1, S-

B. P-2, Q-2, R-2, S-3

C. P-2, Q-2, R-2, S-4

D. P-2, Q-2, R-3, S-3

Answer: D

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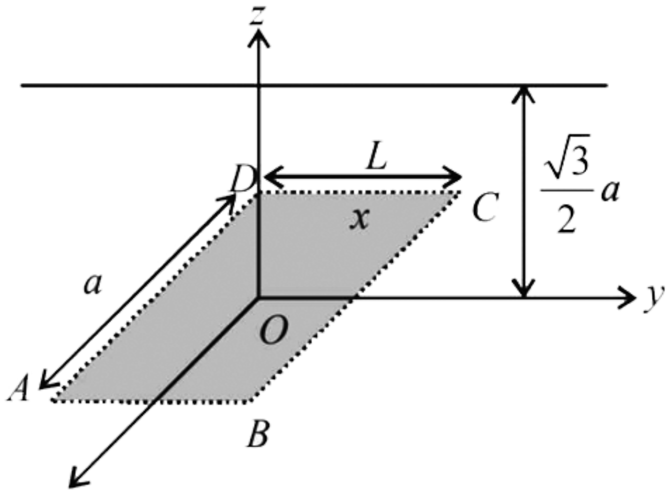
Section-1

1. An infinity long uniform line charge distribution of charge per unit length λ lies parallel to the y-axis in the $y - z$ plane at $z = \frac{\sqrt{3}}{2}$ a(see figure). If the magnitude of the flux of the electric field through the rectangular surface ABCD lying in the $x - y$ plane with its centre at the origin is

$\frac{\lambda L}{\neq \psi lon_0}$ (ε_0 = permittivity of free space), then the value of n is



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2. Consider a hydrogen atom with its electron in the n^{th} orbital An electomagnetic radiation of wavelength $90nm$ is used to ionize the atom . If the kinetic energy of the ejected electron is $10.4eV$, then the value of n is (hc = 1242 eVnm)

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3. A bullet is fired vertically upwards with a velocity υ from the surface of a spherical planet when it reaches its maximum height, its acceleration due to the planet's gravity is $\frac{1}{4}th$ of its value at the surface of the planet. If the escape velocity from the planet is $V_{\text{escape}} = \upsilon\sqrt{N}$, then the value of N is : (ignore energy loss due to atmosphere).

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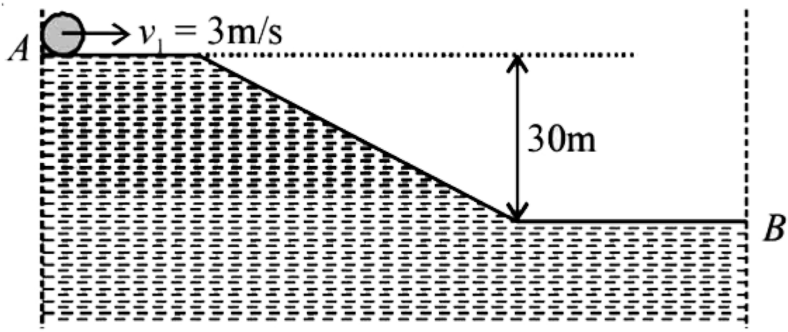
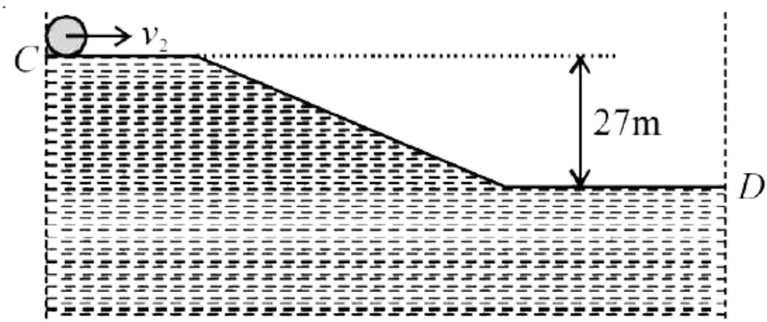
4. Two identical uniform discs roll without slipping on tow different sufaces AB and CD (see figure) starting at A and C with linear speeds v_1 and v_2 respectively, and always remain in contact with the surfaces. If they reach B and D with the same linear speed $v_1 = 3m/sthenv_2 \in m/sis\left(g = 10m/s^2\right)$





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5. Two spherical stars 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 $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is

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6. A nuclear power supplying electrical power to a villages uses a radioactive material of half life T year as the 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 the village for a maximum period of nT years , then the value of n is

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7. 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 the 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 (reflactive index = 1), 2d is the separation between the slits and m is an integer. The value of P is ....

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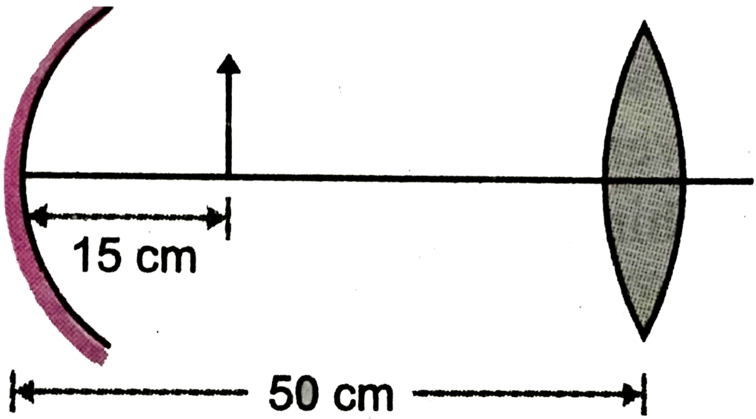
8. Consider a concave mirror and a convex lens (refractive index 1.5) of focal length $10cm$ each separated by a distance of $50cm$ in air (refractive index = 1) as shown in the Fig. An object is placed at a distance of $15cm$ from the mirror. Its erect image formed by this combination has magnification M_1. When this set up is kept in a medium of refractive index $7/6$, the magnification becomes M_2. The magnitude $\left(\frac{M_2}{M_1}\right)$ is :



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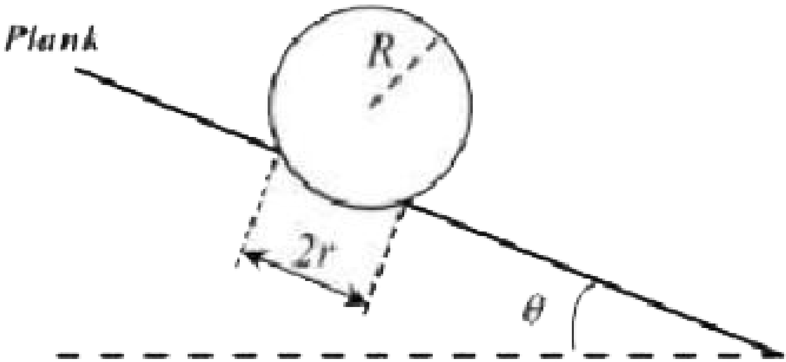
9. A football of radius R is kept on a hole radius r ($r < R$) made on a plank kept horizontally. One end of the plank is now lifted so that it gets tilted making an angle θ from the horizontal as shown in the figure below.

The maximum value of θ so that the football does not start rolling down the plank satisfies (figure is schematic and not drawn to scale)



A. $\sin\theta = \frac{r}{R}$

B. $\tan\theta = \frac{r}{R}$

C. $\sin\theta = \frac{r}{2R}$

D. $\cos\theta = \frac{r}{2R}$

Answer: A

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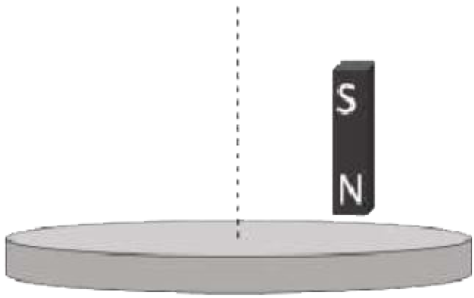
10. A light disc made of aluminum (a nonmagnetic material) is kept horizontally and is free to rotate about its axis as shown in the figure. A strong magnet is held vertically at point above the disc away from its at



A. rote in the direction opposite to the

B. rotate in the same direction as the sirection of magnet's otion

C. not rotate and its temperature will remain unchanged

D. not rotate but its temperature will slowly ries

Answer: B

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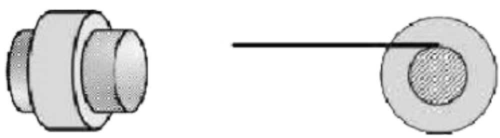
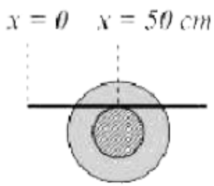
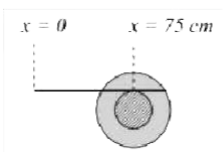
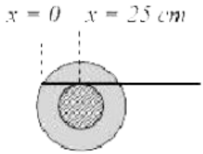
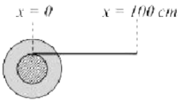
11. A small roller of diameter 20 cm has an axle of diameter 10 cm (see figure below on the left). It is on a horizontal floor and a meter scale is positioned horizontally on its axle with one edge of the scale on top of the axel (see figure on the right). The scale is now pushed slowly on the axle so that it moves without slipping on the axle, and the roller without slipping. After the roller has moved 50 cm, the position of the scale will look like (figures are schematic and not drawn to scale)



A. 

B. 

C. 

D. 

Answer: B

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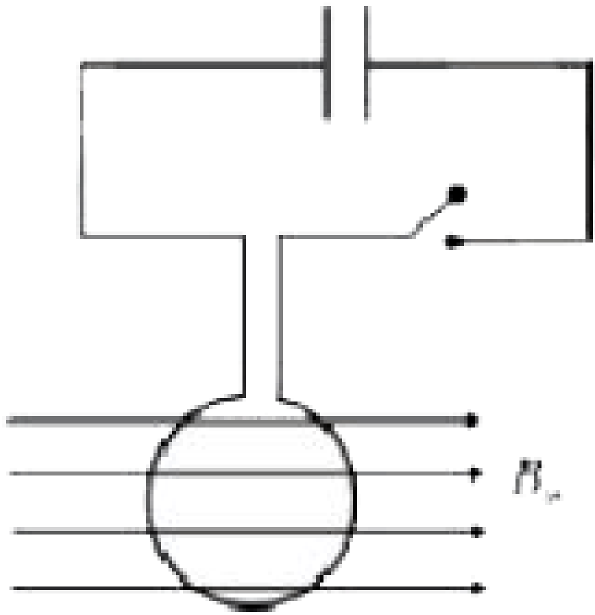
12. A circular coil of radius R and N turns has neglible resistance. As shown in the schematic figure. Its two wnds are connected to wires and it is hanging by those wires with its plane being vertical the wires are connected to a capacitor with charge Q through a switch. The coil is a horizontal uniform magnetic field B_o parallel to the plane of the coil. When the switch is closed, the capacitor gets discharged through the coil in a very short time. By the time capacitor is discharged fully, magnitude of the angular momentum gained by the coil will be (assume that the discharge time is so short that the coil has hardly rotated suring this time)



A. $\frac{\pi}{2}NQB_0R^2$

B. πNQB_0R^2

C. $2\pi NQR^2$

D. $4\pi NQB_0R^2$

Answer: B

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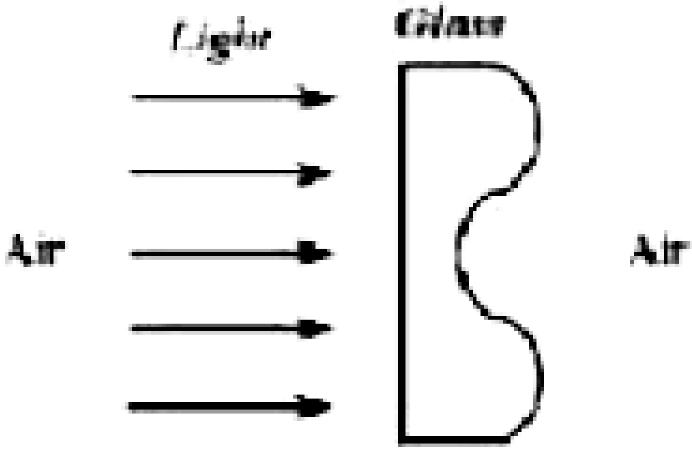
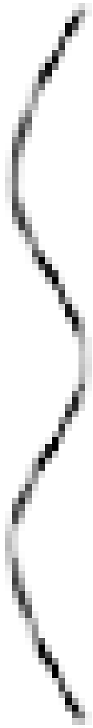
13. A parallel beam of light strikes a piece of transparent grass having cross section as shown in the figure below. Corrent shape of the emergent wave front will be (figures are schematic and not drawn to scale)





A.

B.

C.

D.

Answer: A

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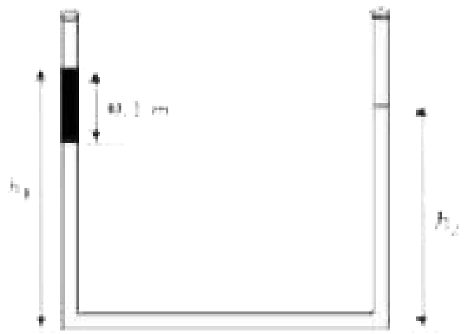
14. an open - ended U-tube cross - sectional area contains water (density 10^3Kg m^{-3}). Initially the water level stands at 0.29 m from the bottom in each arm. Kerosene oil (a wtare - immiscible liquid) of density 800 kg m^{-3} is added to the left arm until its length is 0.1 m, as shown in the schematic figure below. The ratio $\left(\frac{h_1}{h_2}\right)$ of the heights of the liquid in the two arms is



A. $\frac{15}{14}$

B. $\frac{35}{33}$

C. $\frac{7}{6}$

D. $\frac{5}{4}$

Answer: B

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Section-2

1. Consider a Vernier callipers in which each $1cm$ on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions in its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the 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, theleast 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.

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

A. $M \propto \sqrt{c}$

B. $M \propto \sqrt{G}$

C. $L \propto \sqrt{h}$

D. $L \propto \sqrt{G}$

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3. Two independent harmonic oscillators of equal mass are oscillating about the origin with angular frequencies `(omega_1) and (omega_2) and have total energies (E_1 and E_2), respectively. The variations of their momenta (p) with positions (x) are shown (s) is (are).

(##JMA_CHMO_C10_022_Q01##)

A. $E_1\omega_1 = E_2\omega_2$

B. $\frac{\omega_2}{\omega_1} = n^2$

C. $\omega_1 \omega_2 = n^2$

D. $\frac{E_1}{\omega_1} = (E_2)\omega_2$

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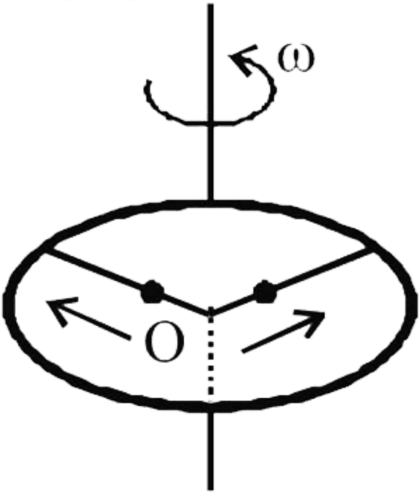
4. A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass $\frac{M}{8}$ at rest at O. These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some instant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



A. $\frac{2}{3}R$

B. $\frac{1}{3}R$

C. $\frac{3}{5}R$

D. $\frac{4}{5}R$

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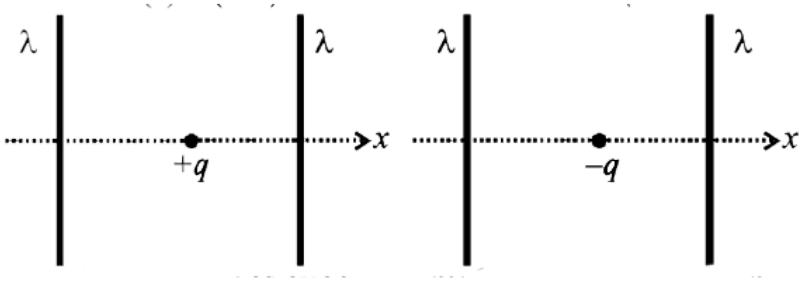
5. The figure below depict two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charges q and $-q$ are kept in equilibrium between them. The point charges are confined to move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



A. Both charges execute simple harmonic motion.

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

C. Charge +q executes simple harmonic motion while charge -q continues moving the direction of its displacement.

D. Charge -q executes simple harmonic motion while charge +q continues moving in the direction of its dispcement.

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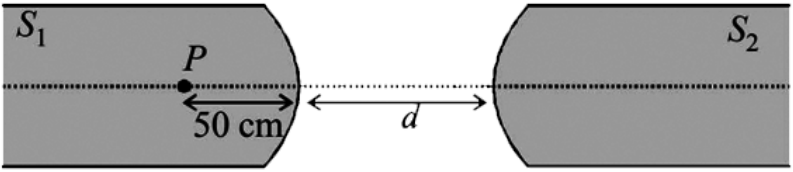
6. Two identical glass rods S_1 and S_2 (refractive index=1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emenating 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

Answer: B

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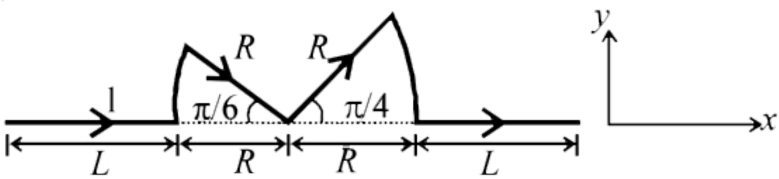
7. A conductor (shown in the figure) carrying constant current I is kept in the x - y plane in a uniform magnetic field $\vec{B}$. If $\vec{F}$ is the magnitude of the total magnetic force acting on the conductor, then the correct statement(s) is (are)



A. If $\vec{B}$ is along $\hat{z}$, $F \propto (L + R)$

B. If $\vec{B}$ is along $\hat{x}$, $F = 0$

C. If $\vec{B}$ is along $\hat{y}$, $F \propto (L + R)$

D. If $\vec{B}$ is along $\hat{z}$, $F = 0$

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8. A container of fixed volume has a mixture of a one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gasses are ideal, the correct statement (s) is (are)

A. The average energy per mole of the gas mixture is 2RT.

B. The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$

C. The ratio of the rms speed of helium atoms to that of hydrogen molecules is 1/2.

D. The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/\sqrt{2}$.

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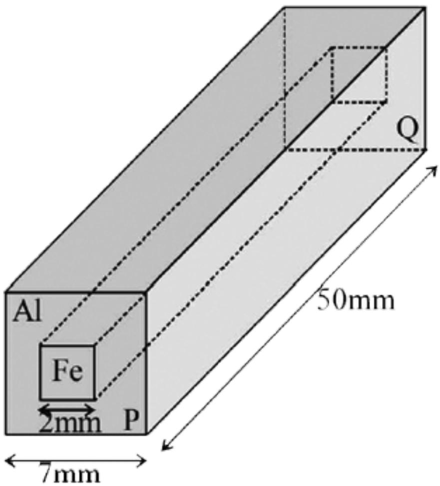
9. In an aluminium (Al) bar of square cross section, a square hole is drilled and is filled with iron (Fe) as shown in the figure. The electrical resistivities of Al and Fe are $2.7 \times \left(10^{-8}\right)\Omega m$ and $1.0 \times \left(10^{-7}\right)\Omega m,$ respectively. The electrical resistance between the two faces P and Q of the composite bar is



A. $\dfrac{2475}{64}\mu\Omega$

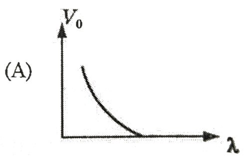
B. $\dfrac{1875}{64}\mu\Omega$

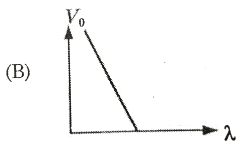
C. $\dfrac{1875}{49}\mu\Omega$

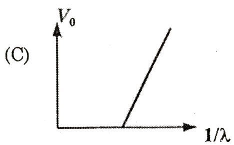
D. $\dfrac{2475}{132}\mu\Omega$

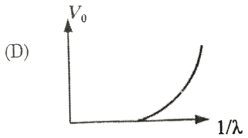
Watch Video Solution

10. For photo - electric effect with incident photon wavelength λ the stopping is V_0 identify the correct variation(s) of V_0 with λ and $1/\lambda$

A. 

B. 

C. 

D. 

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11. A particle of mass m moves in circular orbits with potential energy $N(r) = Fr$, wjere F is a positive constant and r its distance from the origin. Its energies are calculated using the Bohr model. If the radius of the the n^{th} orbit (here h is the Planck's constant)

A. $R\alpha n^{1/3}$ and $v\alpha n^{2/3}$

B. $R\alpha n^{2/3}$ and $v\alpha n^{1/3}$

C. $E = \frac{3}{2}\left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}$

D. $E = 2\left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}$

Answer: B::C

Watch Video Solution

12. The filament of a light bulb has surface has area $64mm^2$. The filament can considered as a black body at temperature 2500 K emitting radiation like a point source when viewed form far. At night the light bulb is observed from a distance of 100 m. Assume the pupil of the eyes of the observer to be circular with radius 3 mm. Then (Take Stefan-Boltzman constant $= 5.67 \times 10^{-8}$ Wm$^{-2}K^{-4}$, Wien's displacement constant $= 2.90 \times 10^{-3}$ m-k, Planck's constant $= 6.63 \times 10^{-8} Wm^{-2}K^{-4}$, Wien's displacement constant $= 2.90 \times 10^{-3}$m-K, Planck's constant $= 6.63 \times 10^{\cdot} - 34\big)$ js, speed of light in vacumm $= 3.00 \times 10^{8} ms^{-1}$)

A. power radiated by the filament is in the range 642 W to 645 W

B. radiated power entering into one of range 642 W to $3.25 \times 10^{-8} W$

C. the wavelength corresponding to maximum intensity is 1160 nm

D. taking the average wavelength of emitted radiation to be 1740 nm, the number of photons entering per second into one eye of the observer is in the range 2.75×10^{11} to 2.85×10^{11}

Answer: B::C::D

Watch Video Solution

13. Some times it is convenient to construct a system of units so that quantities can be expressed in terms of a quantity X as follows : [position] $= \left[X^{\alpha}\right]$, [speed] $= \left[X^{\beta}\right]$, [acceleration] $= \left[X^{p}\right]$, linear momentum] $= [$

.Then

A. $\alpha + p = 2\beta$

B. $p + q - r = \beta$

C. $p - q + r = \alpha$

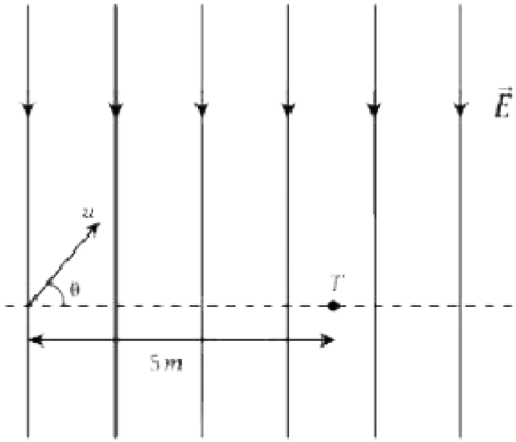
D. $p + q + r = \beta$

Answer: A::B

Watch Video Solution

14. A uniform electric field $\vec{e} = -4000\sqrt{3}\hat{y}NC^{-1}$ is applied in a region. A charged particle of mass m carrying positive charge q is projected in this region with an initial speen of $2\sqrt{10} \times 10^{6} ms^{-1}$. This particle is aimed to hit a target T, which is 5 m away from its entry point the field as shown schematically in the figure.

Take $\frac{q}{m} = 10^{10} Ckg^{-1}$, Then



A. the particle will hit T if projected at an angle 45 ° from the horizontal

B. the particle will hit T if projected at an angle 45 ° from horizontal

C. time taken by the particle to hit T could be $\sqrt{\frac{5}{6}}\mu s$ well as $\sqrt{\frac{5}{2}}\mu m$

D. time taken by the particle to hit T is $\sqrt{\frac{5}{3}}\mu s$.

Answer: C

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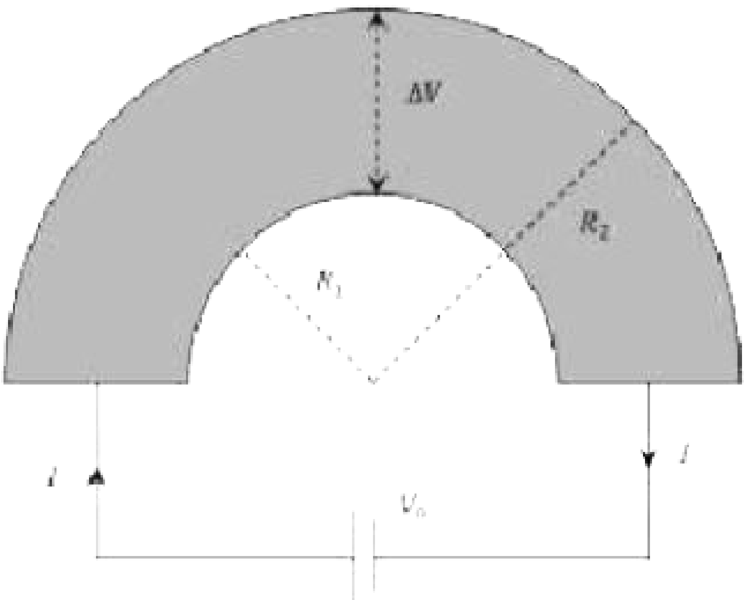
15. Shown in the figure is a semi - circular metallic strip that has thickness t and resistivity ρ its inner radius is R_1 and outer radius is R_2. It a voltage V_0 is applied between its two ends , a current I floes in it . In addition , it is observed that a transverse voltage ΔV develops between its inner and outer surfaces due to puerly kinetic effects of moving electrons (ignore any role of the magnetic field due to the current). Then (figure is schematic and not drawn to scale



A. $1 = \frac{V_0 t}{\pi \rho} In \left(\frac{R_2}{R_1} \right)$

B. the outer surface is at a higher voltage than inner surface

C. the outer surface is at a lower voltage than the inner surface

D. $\Delta V \propto 1^2$

Answer: A::C::D

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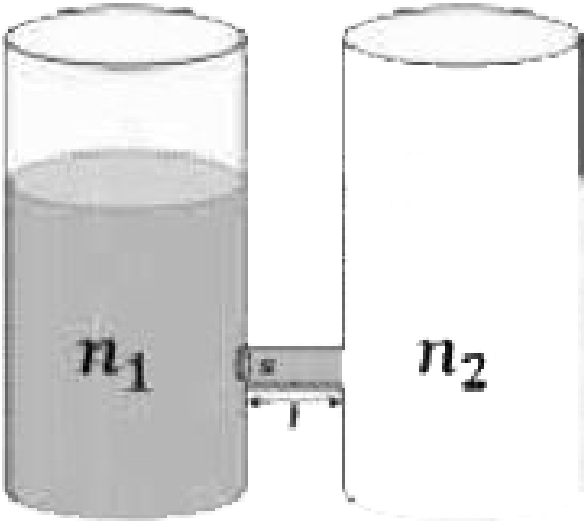
16. As shown schematically in the figure , two vessels contain water solutions (at temperature T) of potassium permanganate $\left(KMnO_4\right)$ of different concentrations n_1 and $n_2\left(n_1 > n_2\right)$ molecules per unit volume with $\Delta n = \left(n_1 - n_2 < \ < n_1\right.$. When they are connected by a tube of small length and cross - sectional area s, $KMnO_4$ starts to diffuse from the left to the right vassel through the tibe Consider the two collection of molecules to between as dilute ideal gases and the difference in their partial pressure in the two vassels causing the diffusion . The speed v of the molecules is limited by the viscous force $-\beta v$ on each molecule, where β is a constant . neglecting all terms of the order $(\Delta n)^2$ which of the following is / are correct ? (k_B is the Boltzmann constant)



A. the force causing the molecules to move across the tube is $\Delta n k_a T S$

B. force balance implies $n_1 \beta v l = \Delta n k_B T$

C. total number of molecues going across the tube per sec is $\left(\frac{\Delta n}{l}\right)\left(\frac{k_B T}{\beta}\right)S$

D. rate of molecules getting transferred through the tube does not change with time

Answer: A::B::C

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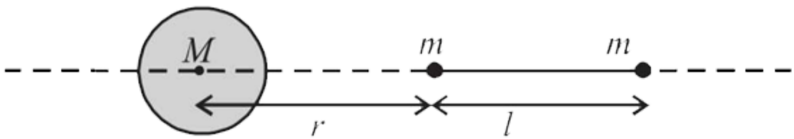
SECTION -1

1. A larger spherical mass M is fixed at one position and two identical point masses m are kept on a line passing through the centre of M. The point masses are connected by rigid massless rod of length l and this assembly is free to move along the line connecting them. All three masses interact only throght their mutual gravitational interaction. When the point mass nearer to M is at a distance r =3l form M, the tensin in the rod is zero for $m = k\left(\frac{M}{288}\right)$. The value of k is



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2. The energy of a system as a function of time t is given as $E(t) = A^2 \exp(-\alpha t)$, $\alpha = 0.2 s^{-1}$. The measurement of A has an error of $1.25\ \%$. If the error In the measurement of time is $1.50\ \%$, the percentage error in the value of $E(t)$ at t = 5 s` is

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3. The densitis of two solid spheres A and B of the same radii R very with radial distance $rasp_A(r) = k\left(\frac{r}{R}\right)$ and $p_B(r) = k\left(\frac{r}{(R)^5}\right.$, respectively, where k is a constant . The moments of inertia of the inividual spheres about axes passing throgh their centres are I_A and I_B respectively. if $\frac{I_B}{I_A} = \frac{n}{10}$, the value of n is

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4. Four harmonic waves of equal freuencies and equal intensity I_0 have phase angles $0, \frac{\pi}{3}, \frac{2\pi}{3}$ and π. When they are superposed, the intensity of the resulting wave is nI_0. The value of n is

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5. For a radioactive meterial , its activity A and rate of charge of its activity R are defined as $A = -\frac{dN}{dt}$ and $R = -\frac{dA}{dt}$ where $N(t)$ is the number of nuclei at time t .Two radioactive source P (mean life τ) and Q(mean life 2τ) have the same activity at $t = 2\tau R_p$ and R_Q respectively , if $\frac{R_p}{R_Q} = \frac{n}{e}$

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6. A monochromatic beam of light is incident at 60° on one face of an equilateral prism of refractive inder n and emerges from the opposite face making an angle θ with the normal. For $n = \sqrt{3}$, the value of θ is 60° and $\frac{d\theta}{dn} = m$. The value of m is.

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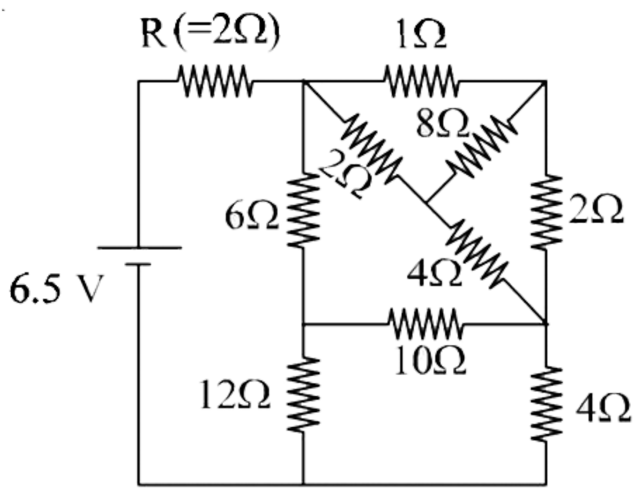
7. In the following circuit, the current through the resistor $R(= 2\Omega)$ is I amperes. The value of I is



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8. An electron is an excited state of Li^{2+} ion has angular momentum $3h/2\pi$. The de Broglie wavelength of the electron in this state is

$p\pi a_0\left(where a_0\right.$ is the bohr radius) The value of p is

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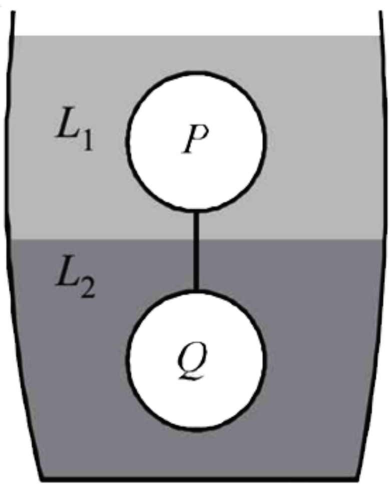
SECTION -2

1. Two spheres P and Q of equal radii have densities ρ_1 and ρ_2, respectively. The spheres are connected by a massless string and placed in liquids L_1 and L_2 of densities σ_1 and σ_2 and viscosities η_1 and η_2, respectively. They float in equilibrium with the sphere P in L_1 and sphere Q in L_2 and the string being taut(see figure). If sphere P alone in L_2 has terminal velocity $\vec{V}_p$ and Q alone in L_1 has terminal velocity $\vec{V}_Q$, then



A. $\frac{\left|\vec{V}_P\right|}{\left|\vec{V}_Q\right|} = \frac{\eta_1}{\eta_2}$

B. $\frac{\left|\vec{V}_P\right|}{\left|\vec{V}_Q\right|} = \frac{\eta_2}{\eta_1}$

C. $\vec{V}_P . \vec{V}_Q > 0$

D. $\vec{V}_P . \vec{V}_Q < 0$

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2. In terms of potential difference V, electric current I, permitivity ε_0, permeability μ_0 and speed of light c, the dimensionally correct equations (s) is (are) :

A. $\mu_0 I^2 = \varepsilon_0 V^2$

B. $\varepsilon_0 I = \mu_0 V$

C. $I = \varepsilon_0 c V$

D. $\mu_0 c I = \varepsilon_0 V$

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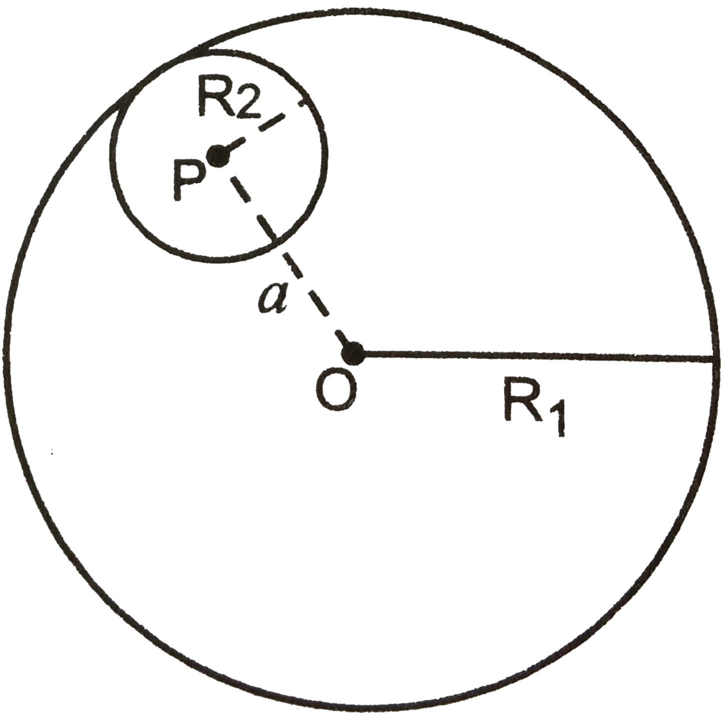
3. Consider a uniform spherical charge distribution of radius R_1 centred at the origin O. In this distribution a spherical cavity of radius R_2, centred at P with distance $OP = a = R_1 - R_2$ (fig) is made.If the electric field inside the cavity at position $\vec{r}$, then the correct statement is



A. $\vec{E}$ is uniform , its magnitude is independent of R_2 but its direction depends on $\vec{r}$

B. $\vec{E}$ is uniform , its magnitude depends on R_2 and its direction depends on $\vec{r}$

C. $\vec{E}$ is uniform , its magnitude is independent of a but its direction depends on $\vec{a}$

D. $\vec{E}$ is uniform and both its magnitude and direction depend on $\vec{a}$

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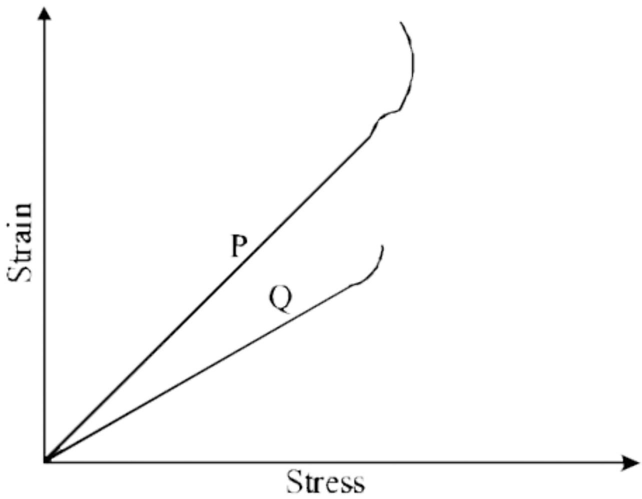
4. In plotting stress versus strain curves for two materials P and Q, a student by mistake puts strain on the y-axis and stress on the x-axis as shown in the figure. Then the correct statement(s) is (are)



A. P has more tensile strength than Q

B. P is more ductile than Q

C. P is more brittle than Q

D. The Young's modulus of P is more than that of Q

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5. A spherical body of radius R consists of a fluid of constant density and is in equilibrium under its own gravity. If P(r) is the pressure at r(rltR), then the correct option(s) is (are)

A. P (r-0) = 0

B. $\dfrac{P(r = 3R/4)}{P(r = 2R/3)} = \dfrac{63}{80}$

C. $\dfrac{P(r = 3R/5)}{P(r = 2R/5)} = \dfrac{16}{21}$

D. $\dfrac{P(r = R/2)}{P(r = R/3)} = \dfrac{20}{27}$

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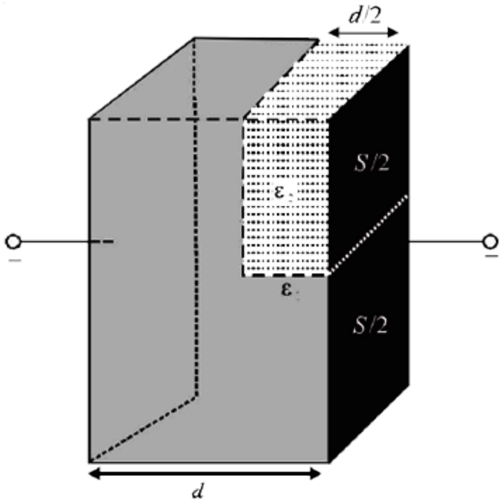
6. A parallel plate capacitor having plates of area S and plate separation d, has capacitance C_1 in air. When two dielectrics of different relative primitivities ($\varepsilon_1 = 2$ and $\varepsilon_2 = 4$) are introduced between the two plates as shown in the figure, the capacitance becomes C_2. The ratio $\frac{C_2}{C_1}$ is



A. $6/5$

B. $5/3$

C. $7/5$

D. $7/3$

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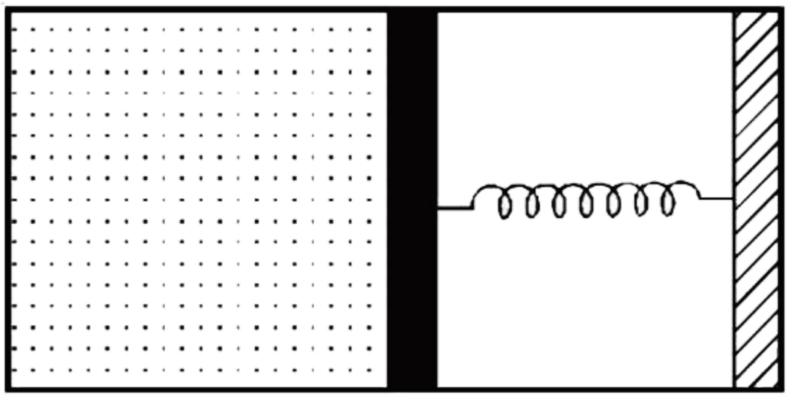
7. An ideal monoatomic gas is confined in a horizontal cylinder by a spring loaded piston (as shown in the figure). Initially the gas is at temperature T_1, pressure P_1 and volume $V_1$and the spring is in its relaxed state. The gas is then heated very slowly to temperature T_2,pressure $P_2$and volume V_2. During this process the piston moves out by a distance x. Ignoring the friction between the piston and the cylinder, the correct statement (s) is (are)



A. If $V_2 = 2V_1$ and $T_2 = 3T_1$, then the energy stored in the spring is $\frac{1}{4}P_1V_1$

B. $If V_2 = 2V_1$ and $T_2 = 2T_1$, then the change in internal energy is $3P_1V_1$

C. If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the work done by the gas is $\frac{7}{3}P_1V_1$

D. If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the heat supplied to the gas is $\frac{17}{6}P_1V_1$

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8. A fission reaction is given by $._{92}^{236}U \rightarrow ._{54}^{140}Xe + ._{54}^{140}Xe + ._{38}^{94}Sr + x + y$, where x and y are two particles. Considering $._{92}^{236}U$ to be at rest, the kinetic energies of the products are denoted by $K_{xe}, K_{Sr}, K_x(2MeV)$ and $K_y(2MeV)$, respectively. Let the binding energies per nucleon of $._{92}^{236}U, ._{54}^{140}Xe$ and $._{38}^{94}Sr$ be $7.5MeV, 8.5MeV$ and $8.5MeV$, respectively. Considering different conservation laws, the correct options (s) is (are)

A. x = n , y= n , $K_{Sr} = 129$ MeV , $K_{Xe} = 86MeV$

B. x = p , y = e^-, $K_{Sr} = 129MeV, K_{Xe} = 86$ MeV

C. x = p , y =n , $K_{Sr} = 129 MeV, K_{Xe} = 86 MeV$

D. x = n , y = n , $K_{Sr} = 86 MeV, K_{Xe} = 129$ MeV

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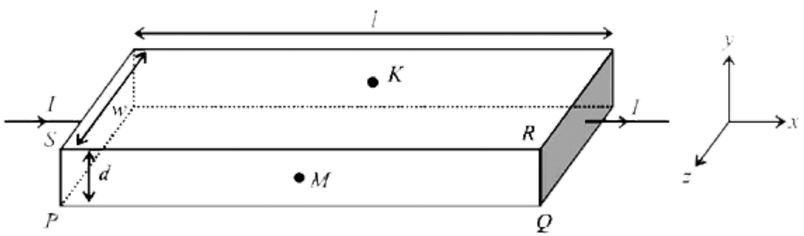
9. In a thin rectangular metallic strip a constant current I flows along the positive x - $direction$, as shown in the figure. The length , width and thickness of the strip are l, w and d, respectively.

A uniform magnetic field $\vec{B}$ is applied on the strip along the positive y - $direction$. Due to this, the charge carriers experience a net deflection along the z - $direction$. This results in accumulation of charge carriers on the surface $PQRS$ ansd apperance of equal and opposite charges on the face opposite to $PQRS$. A potential difference along the z - $direction$ is thus developed. Charge accumulation contiues untill the magnetic force is balanced by the electric force. The current is assumed to be uniformly distributed on the cross- section of the strip and carried by electrons.

Consider two different metallic strips (1 and 2) of the same material .

Their lengths are the same,widths are w_1 and w_2 and thickness are d_1 and d_2 respectively. Two points K and M are symmetrically located on the opposite faces parallel to the x - y plane (see figure) . V_1 and V_2 are the potential differences between K and M in strips 1 and 2, respectively . Then, for a given current I flowing through them in a given magnetic field strength B, the correct statement(s) is (are)



A. If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = 2V_1$

B. If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = V_1$

C. If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = 2V_1$

D. If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = V_1$

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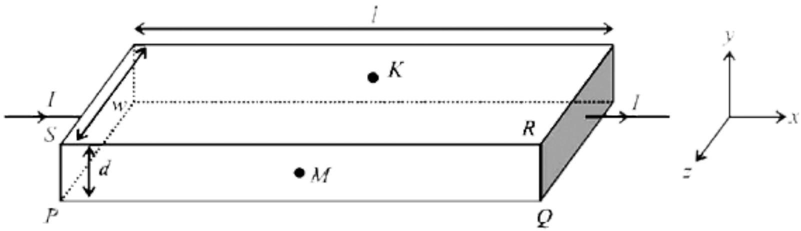
10. In a thin rectangular metallic strip a constant current I flows along the positive x-direction , as shown in the figure. The length , width and thickness of the strip are l, w and d, respectively.

A uniform magnetic field $\vec{B}$ is applied on the strip along the positive y - *direction* . Due to this, the charge carriers experience a net deflection along the z - *direction* . This results in accumulation of charge carriers on the surface $PQRS$ ansd apperance of equal and opposite charges on the face opposite to $PQRS$. A potential difference along the z - *direction* is thus developed. Charge accumulation contiues untill the magnetic force is balanced by the electric force. The current is assumed to be uniformly distributed on the cross- section of the strip and carried by electrons.

Consider two different metallic strips $(1 \text{ and } 2)$ of same dimensions n_1 and n_2, repectrively . Strip 1 is placed in magnetic field B_1 and strip 2 is placed in magnetic field B_2 , both along positive y - *directions*. Then V_1 and V_2 are the potential differences developed between K and M in strips 1 and 2 , respectively . Assuming that the current I is the same for both the strips, the correct option(s) is (are)



A. If $B_1 = B_2$ and $n_1 = 2n_2$ then $V_2 = 2V_1$

B. If $B_1 = B_2$ and $n_1 = 2n_2$, then $V_2 = V_1$

C. If $B_1 = 2B_2$ and $n_1 = n_2$, then $V_2 = 0.5V_1$

D. If $B_1 = 2B_2$ and $n_1 = n_2$ then $V_2 = V_1$

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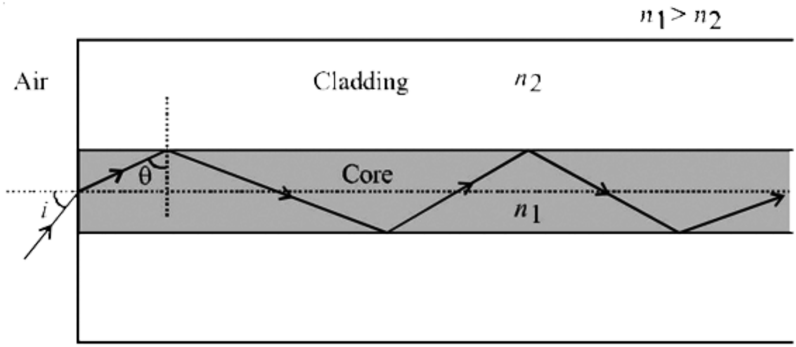
11. Light guidance in an optical fibre can be understood by considering a structure comprising of thin solid glass cylinder of refractive index n_1

surrounded by a medium of lower refractive index n_2. The light guidance in the structure takes place due to successive total internal reflectrions at the interface of the media n_1 and n_2 as shown in the fugure. All rays with the angle of incidence i less than a particular value i_m are confined in the medium of refractive index n_1. The numerical aprture (NA) of the structure is defined as $\sin i_m$

For two structure namely S_1 with $n_1 = \frac{\sqrt{45}}{4}$ and $n_2 = \frac{3}{2}$, and S_2 with $n_1 = \frac{8}{5}$ and $n_2 = \frac{7}{5}$ and taking the refractive index of water to be $\frac{4}{3}$ and that of air to be 1, the correct option (s) is (are) ? `



A. NA of S_1 immerged in water is the same as that of S_2 immersed in a liquid of refractive index $\frac{16}{3\sqrt{15}}$

B. NA of S_1 immersed in liquid of refractive index $\frac{6}{\sqrt{15}}$ is the same as that of S_2 immersed in water

C. NA of S_1 placed in air is the same as that of S_2 immersed in liquid of refractive index $\frac{4}{\sqrt{15}}$.

D. NA of S_1 placed in air is the same of S_2 placed in water

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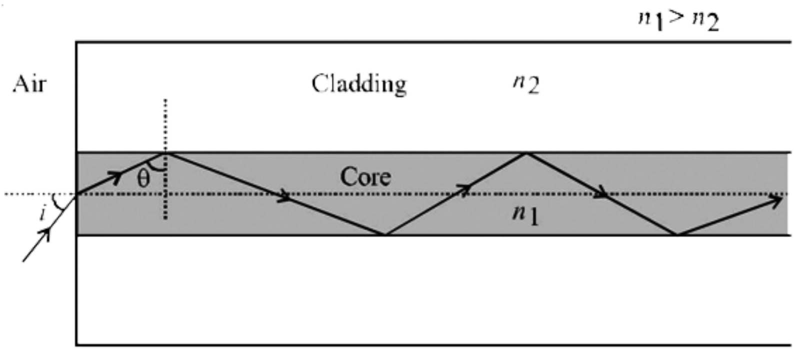
12. Light guidance in an optical fibre can be understood by considering a structure comprising of thin solid glass cylinder of refractive index n_1 surrounded by a medium of lower refractive index n_2. The light guidance in the structure takes place due to successive total internal reflectrions at the interface of the media n_1 and n_2 as shown in the fugure. All rays with the angle of incidence i less than a particular value i_m are confined in the medium of refractive index n_1. The numerical aprture (NA) of the structure is defined as $\sin i_m$

If two structure of same cross-sectional area, but different numerical apertures $NA_1$and $NA_2(NA_2 < NA_1)$ are joined longitudinally, the numerical aperture of the combined structure is `



A. $\frac{NA_1 + NA_2}{NA_1 + NA_2}$

B. $NA_1 + NA_2$

C. NA_1

D. NA_2

Answer: D

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PART-1 PHYSICS (SECTION 1)

1. In a historical experiment to determine Planck's constant, a metal surface was irradiated with light of different wavelengths. The emitted photoelectron energies were measured by applying a stopping potential. The relevant data for the wavelength (λ).) of incident light and the corresponding stopping potential $\left(V_0\right)$ are given below :

λ (μm)	V_0 (Volt)
0.3	2.0
0.4	1.0
0.5	0.4

Given that $c = 3 \times 10^8 ms^{-1}$ and $e = 1.6 \times 10^{-19} C$ Planck's constant (in units of J s) found from such an experiment is

A. 6.0×10^{-34}

B. 6.4×10^{-34}

C. 6.6×10^{-34}

D. 6.8×10^{-34}

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2. A uniform wooden stick of mass 1.6 kg and length l rests in an inclined mannar on a smooth, vertical wall of height $h(< l)$ such that a small portion of the stick extends beyond the wall. The reaction force of th wall on the stick is perpendicular to the stick. The stick makes an angle of 30° with the wall and the bottom of the stick is on a rough floor. The reaction of the wall on the stick is equal in magnitude to the reaction of the floor on the stick. The ratio h/l and the friectional force f at the bottom of the stick are $\left(g = 10ms^2\right)$

A. $\frac{h}{l} = \frac{\sqrt{3}}{16}, f = \frac{16\sqrt{3}}{3}N$

B. $\frac{h}{l} = \frac{\sqrt{3}}{16}, f = \frac{16\sqrt{3}}{3}N$

C. $\frac{h}{l} = \frac{3\sqrt{3}}{16}, f = \frac{8\sqrt{3}}{3}N$

D. $\frac{h}{l} = \frac{3\sqrt{3}}{16}, f = \frac{8\sqrt{3}}{3}N$

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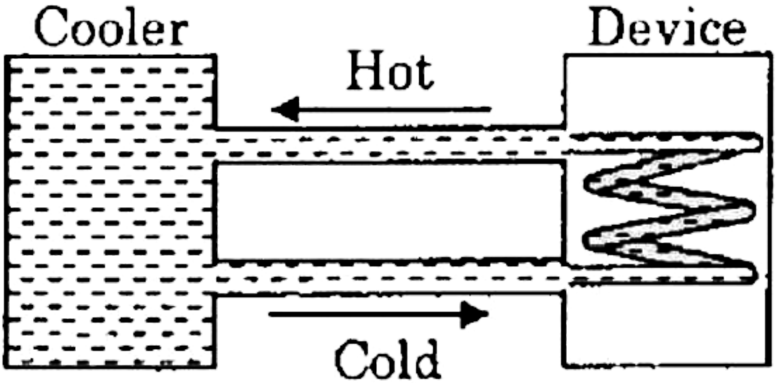
3. A water cooler of storages capacity 120 liters can cool water at a constant rate of P watts. In a closed circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3kW of heat (thermal load). The temperature of water fed into the device cannot exceed $30^{\circ}C$ and the entire stored 120 liters of water is initially cooled to $10^{\circ}C$. The entire system is thermally insulated. The minimum value of P (in watts) for which the device can be operated for 3hours is



(Specific heat of water is $4.2kJkg^{-1}K^{-1}$ and the density of water is $1000kgm^{-3}$)

A. 1600

B. 2067

C. 2533

D. 3933

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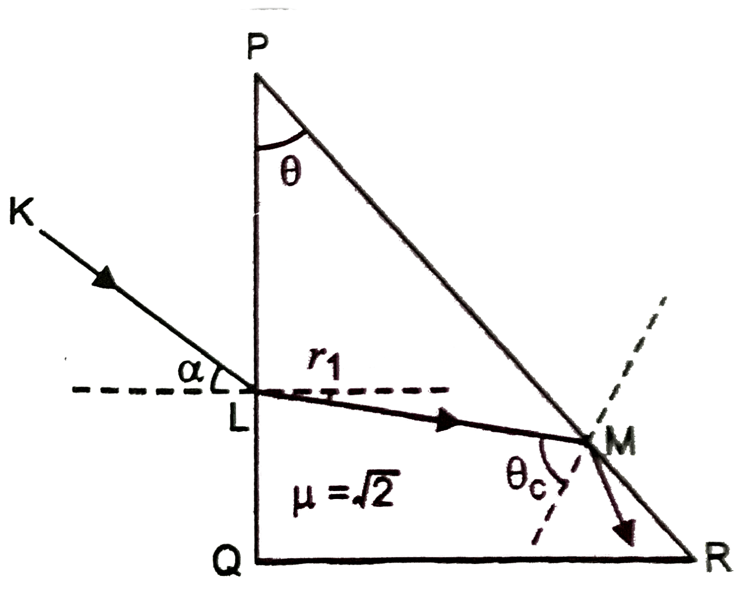
4. A parallel beam of light is incident from air at an angle α on the side of right angled triangular prism of refractive index $\mu = \sqrt{2}$. Light undergoes total internal reflection in the prism at the face PR when α has a minimum value of $45°$. The angle θ of the prism is.



A. $15°$

B. $22.5°$

C. $30°$

D. $45°$

Answer: A

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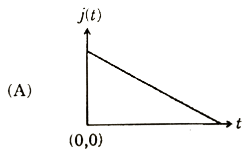
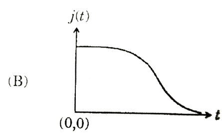
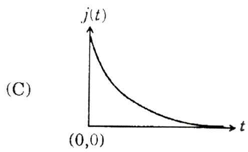
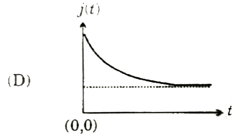
5. An infinite line charge of uniform electric charge density λ lies along the axis of an electrically conducting infinite cylindrical shell of radius R. At time $t = 0$, the space inside the cylinder is filled with a material of permittivity ε and electrical conductivity σ. The electrical conduction in the material follows Ohm's law. Which one of the following graphs best describes the subsequent variation of the magnitude of current density j(t) at any point in the material ?

A. 

B. 

C. 

D. 

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PART-1 PHYSICS (SECTION 2)

1. Highly excited states for hydrogen like atoms (also caleld Rydberg states) with nuclear charge Ze are degined by their orbit number n, where $n > \ > 1$. Which of the following statement (s) is `(are) true?

A. Relative change in the radii of two consecutive orbitals does not depend on Z

B. Relative change in the radii of two consecutive orbitals varies as $1/n$

C. Relative change in the energy of t\vo consecutive orbitals varies as $1/n^3$

D. Relative change in the angular mon1.enta of t\vo consecutive orbitals varies as $1/n$

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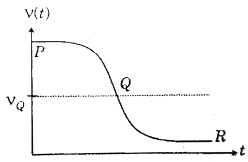
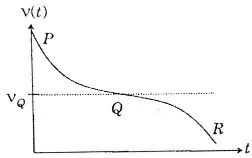
2. Two loudspeaker M and N are located $20m$ apart and emit sound at frequencies $118Hz$ and $121Hz$, respectively. A car is intially at a point P, $1800m$ away from the midpoint Q of the line MN and moves towards Q constantly at $60km/hr$ along the perpendicular bisector of MN. It crosses Q and eventually reaches a point R, $1800m$ away from Q. Let $v(t)$ represent the beat frequency measured by a person sitting in the car at time t. let v_P, v_Q and v_R be the beat frequencies measured at locations P,Q and R, respectively. The speed of sound in air is $330ms^{-1}$. Which of the following statement (s) is (are) true regarding the sound heard by the person?

A. $V_P + V_R = 2V_Q$

B. The rate of change in beat frequency is maximum when the car passes through Q

C. The plot below represents schematically t he variation of beat frequency with time 

D. The plot below represents schematically the variation of heat frequency with time 

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3. An incandescent bulb has a thin filament of tungsten that is heated to high temperature by passing an electric current. The hot filament emits black - body radiation. The filament is observed to break up at random to break up at random locations after a sufficiently long time of operation due to non-uniform evaporation of tungsten from the fialment. If the bulb is powered at constant voltage, which of the following statement (s) is (are) true?

A. The temperature distribution over the filament is uniform

B. The resistance over small sections of the filament decreases with time

C. The filament emits more light at higher band of frequencies before it breaks up

D. The filament consumes less electrical power towards the end of the life of the bulb

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4. A plano-covex lens is made of a material of refractive index n. When a small object is placed 30cm away in front of the curved surface of the lens, an image of double the size of the object is produced. Due to reflection from the convex surface of the lens, another faint image is observed at a distance of 10 cm away from the lens. Which of the following statement (s) is (are) true?

A. The refractive index of the lens is 2.5

B. The radius of cui-vature of the convex surface is 45 cm

C. The faint i1nage is erect and real

D. he focal length of the lens is 20 cm

Answer: A::D

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5. A length - scale (l) depends on the permittivity (ε) of a dielctric material. Boltzmann constant $\left(k_B\right)$, the absolute tempreture (T), the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the partcles. which of the following expression (s) for I is (are) dimensionally correct?

A. $l = \sqrt{\left(\frac{nq^2}{\varepsilon k_B T}\right)}$

B. $l = \sqrt{\left(\frac{\varepsilon k_B T}{nq^2}\right)}$

C. $l = \sqrt{\left(\frac{q^2}{\varepsilon n^{2/3} k_B T}\right)}$

D. $l = \sqrt{\left(\frac{q^2}{\varepsilon n^{1/3} k_B T}\right)}$

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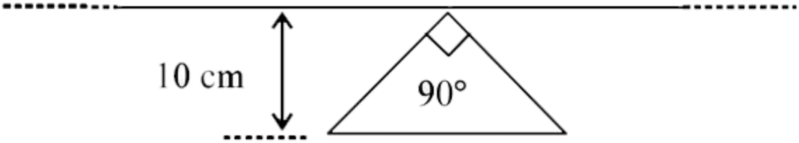
6. A conducting loop in the shape of a right angled isosceles triangle of height 10 cm is kept such that $90(\circ)$ vertex is very close to an infinitely long conducting wire (see the figure). The wire is electrically insulated from the loop. The hypotenuse of the triangle is parallel to the wire. Current in the triangular loop is in counterclockwise direction and increased at a constant rate of $10As^{-1}$. Which of the following statement(s) is(are) true?



A. The magnitude of induced emf in the wire is $\left(\frac{\mu_0}{\pi}\right)$ volt

B. If the loop is rotated at a constant angular speed about the wire, an additional emf of $\left(\frac{\mu_0}{\pi}\right)$ volt is induced in the wire

C. The induced current in the wire is in opposite direction to the current along the hypotenuse

D. There is a repulsive force between the wire and the loop

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7. The position vector $\vec{r}$ of a particle of mass m is given by the following equation

$\vec{r}(t) = \alpha t^3 \hat{i} + \beta^2 \hat{j},$

where $\alpha = 10/3ms^{-3}, \beta = 5ms^{-2}$ and m = 0.1kg. At t=1s, which of the following statement (s) is (are) true about the particle?

A. The velocity $\vec{v}$ is given by $\vec{v} = \left(10\hat{i} + 10\hat{j}\right)ms^{-1}$

B. The angular momenetum $\vec{L}$ with respect to the origin is given by

$\vec{L} = (-5/3)\hat{k}Nms$

C. The force $\vec{F}$ is given by $\vec{F} = \left(\hat{i} + 2\hat{j}\right)N$

D. The torque $\vec{r}$ with respect to the origin is given by

$\vec{r} = -(20/3)\hat{k}Nms$

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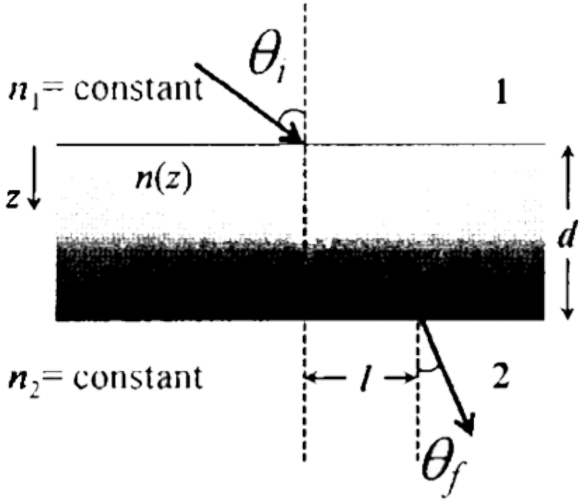
8. A transparent slab of thickness d has a refractive index n(z) that increases with z. Here z is the vertical distance inside the slab, measured from the top. The slab is placed between two media with uniform refractive indices n_1 and $n_2\left(>n_1\right)$, θ_0, from medium 1 and emerges in medium 2 with refraction angle $\theta_t$with a lateral displacement l.

Which of the following statement(s) is (are) true?



A. $n_1 \sin\theta_i = n_2 \sin\theta_r$

B. $n_1 \sin\theta_i = \left(n_2 - n_1\right)\sin\theta_r$

C. l is independent of n_2

D. l is fependent on n(z)

Answer: A::C::D

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PART-1 PHYSICS (SECTION 3)

1. A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (P) by the metal. The sensor has scale that displays $\log_2, \left(P/P_0\right)$, where P_0 is constant. When the metal surface is at a temperature of $487\,^\circ C$, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to $2767\,^\circ C$?

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2. The isotope $\_(5)^{12}B$ having a mass $12.014u$undergoes beta - decay to $_(6)^{12}C_6^{12}C$has an excited state of the nucleus $\left(\_(6)^{12}C^* at 4.041 MeV\right.$

above its ground state if $\_(5)^{12}E$ decay to $\_(6)^{12}C*$, the maximum kinetic energy of the β - particle in unit of MeV is $(1u = 931.5MeV/c^2$ where c is the speed of light in vaccuum) .

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3. A hydrogen atom in its ground state is irradiated by light of wavelength 970Å Taking $hc/e = 1.237 \times 10^{-6}$eV m and the ground state energy of hydrogen atom as $-13.6eV$ the number of lines present in the emmission spectrum is

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4. Consider two solid spheres P and Q each of density $8gmcm^{-3}$ and diameters 1cm and 0.5cm, respectively. Sphere P is dropped into a liquid of density $0.8gmcm^{-3}$ and viscosity $\eta = 3$ poiseulles. Sphere Q is dropped into a liquid of density $1.6gmcm^{-3}$ and viscosity $\eta = 2$ poiseulles. The ratio of the terminal velocities of P and Q is

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5. Two inductors L_1(inductors 1 mH, internal resistance 3 Ω) and L_2 (inductance 2mH, internal resistance 4Ω),and a resistor R(resistance12ω) are all connected in parallelacross a 5 V battery. The circuit is switched on at time t=0. The ratio of the maximum to the minimum current $\left(I_{\max}/I_{\min}\right)$ drawn from the battery is

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PART I : PHYSICS (SECTION 1)

1. The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R is given by

$$E = \frac{3Z(Z - 1)e^2}{5}\left(4\pi e_0 R\right)$$

The measured masses of the neutron $\_(1)^1H,_7^{15}N$ and $,_8^{16}O are 1.008665u, 1.007825u, 15.000109u$ and $15.003065u$, respectively Given that the ratio of both the $\_(7)^{12}N$ and $\_(8)^{15}O$

nucleus are same , 1 u = = 931.5 Me Vc^2 (c is the speed of light) and $e^2 / \left(4\pi e_0\right) = 1.44 MeV$ fm Assuming that the difference between the binding energies of _ $7^{15}N$ and _(8)^(15) O ` is purely due to the electric energy , The radius of the nucleus of the nuclei is

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2. As accident in a nuclear laboratory resulting in deposition of a certain amount of radioactive material of half life 18days inside the laboratory Tests revealed that the radiation was 64 times more than the permissible level required for save operation of the laboratory what is the minimum number of days after which the laboratory can be considered safe for use?

A. 64

B. 90

C. 108

D. 120

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3. A gas is enclosed in a cylinder with a movable frictionless piston. Its initial thermodynamic state at pressure $P_i = 10^5$ Pa and volume $V_i = 10^{-3} m^3$ changes to a final state at $P_f = (1/32) \times 10^5 Pa$ and $V_f = 8 \times 10^{-3} m^3$ in an adiabatic quasi-static process, such that $P^3V^3 = constant$. Consider another thermodynamic process that brings the system form the same initial state to the same final state in two steps: an isobaric expansion at P_i followed by an isochoric (isovolumetric) process at volume V_r. The amount of heat supplied to the system i the two-step process is approximately

A. 112 J

B. 294 J

C. 588 J

D. 813 J

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4. The ends Q and R of two thin wires, PQ and RS, are soldered (joined) together. Initially each of the of wire has a length of 1m at $10^{\circ} C$. Now the end P is maintained at $10^{\circ} C$, while the ends S is heated and maintained at $400^{\circ} C$. The system is thermally insultated from its surroundings. If the thermal conductivity of wire PQ is twice that of the wire RS and the coefficient of linear thermal expansion of PQ is $1.2 \times 10^{-5} K^{-1}$, the change in length of the wire PQ is

A. 0.78mm

B. 0.90 mm

C. 1.56 mm

D. 2.34 mm

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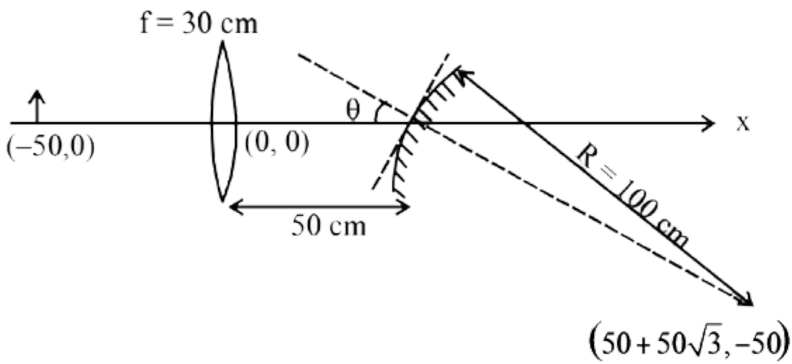
5. A small object is placed 50 cm to the left of a thin convex lens of focal length 30 cm. A convex spherical mirror of radius of curvature 100 cm is placed to the right of the lens at a distance of 50 cm. The mirror is tilted such that the axis of the mirror is at an angle $\theta = 30 degree$ to the axis of the lens, as shown in the figure

If the origin of the coordinate system is taken to be at the centre of the lens, the coordinates (in cm) of the point (x, y) at which the image is formed are



A. (0,0)

B. $\left(50 - 25\sqrt{3}, 25\right)$

C. $\left(25, 25\sqrt{3}\right)$

D. $\left(125/3, 25/\sqrt{3}\right)$

Answer: C

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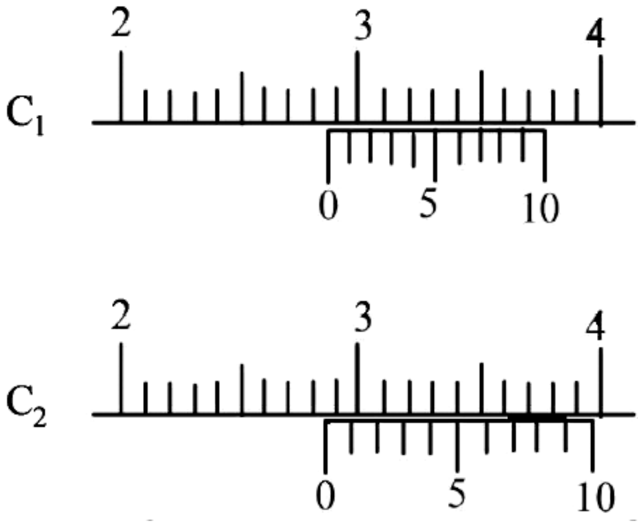
6. There are two Vernier calipers both of which have $1cm$ divided into 10 equal divisions on the main scale. The vernier scale of the calipers $\left(c_1\right)$ has 10 equal divisions that correspond to 9 main scale divisions. The Vernier scale of the other calipers $\left(C_2\right)$ has 10 equal divisions tgat correspond to 11 main scale divisions. the reading of the two calipers are shown in the figure. the measured values (in cm) by calipers C_1 and C_2 respectively, are



A. 2.85 and 2.82

B. 2.87 and 2.83

C. 2.87 and 2.86

D. 2.87 and 2.87

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7. Consider an expanding sphere of instantaneous radius ? whose total mass remains constant. The expansion is such that the instantaneous density ρ remains uniform throughout the volume. The rate of fractional change in density $\left(\frac{dp}{\rho dp}\right)$ is constant. The velocity v of any point on the surface of the expanding sphere is proportional to

A. R

B. R^3

C. $\frac{1}{R}$

D. $R^{2/3}$

Answer: A

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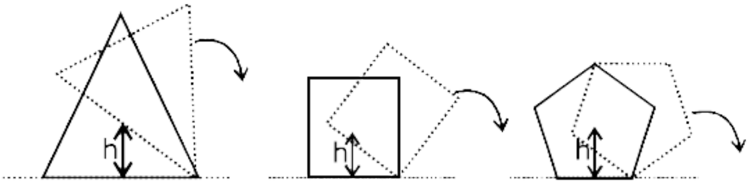
8. Consider regular polygons with number of sides n = 3, 4, 5 ...... as shown in the figure, The center of mass of all the polygons is at height h from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted,. The maximum increase in height of the locus of the center of mass for each polygton is Δ. Then Δ depends on n and h as



A. $\Delta = h\sin^2\left(\frac{\pi}{h}\right)$

B. $\Delta = h\left(\frac{1}{\cos\left(\frac{\pi}{n}\right)} - 1\right)$

C. $\Delta = h\sin\left(\frac{2\pi}{n}\right)$

D. $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$

Answer: B

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9. A photoelectric material having work-function ϕ_0 is illuminated with light of wavelength $\lambda\left(\lambda < \frac{hc}{4_0}\right)$. The fastest photoelectron has a de Broglie wavelength λ_d. A change in wavelength of the incident light by $\Delta\lambda$ results in a change $\Delta\lambda_d$ in λ_d. Then the ration $\Delta\lambda_d/\Delta\lambda$ is proportional to

A. λ_d/λ

B. λ_d^2/λ^2

C. λ_d^2/λ

D. λ_d^3/λ^2

Answer: D

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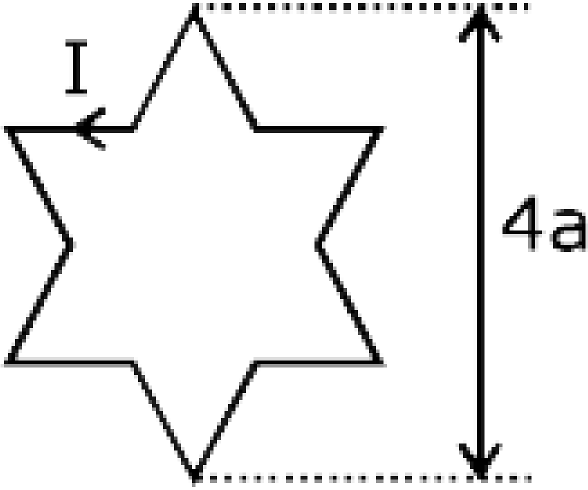
10. A symmetric star shaped conducting wire loop is carrying a steady state current I as shown in the figure. The distance between the diametrically opposite vertices of the star is 4a. The magnitude of the magnetic field at the center of the loop is



A. $\frac{\mu_0 I}{4\pi a} 6\left[\sqrt{3} - 1\right]$

B. $\frac{\mu_0 I}{4\pi a} 6\left[\sqrt{3} + 1\right]$

C. $\frac{\mu_0 I}{4\pi a} 3\left[\sqrt{3} + 1\right]$

D. $\frac{\mu_0 I}{4\pi a} 3\left[2 - \sqrt{3}\right]$

Answer: A

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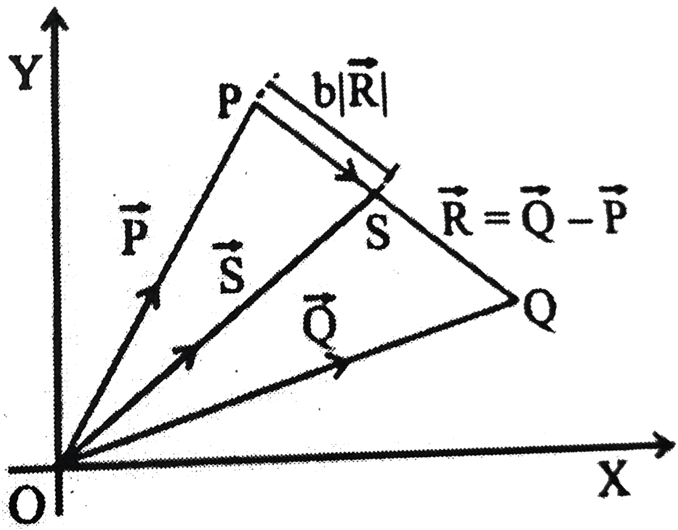
11. Three vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ are shown in the figure. Let S be any point on the vector $\vec{R}$. The distance between the points P and S is $b\left|\vec{R}\right|$. The general relation among vectors $\vec{P}$, $\vec{Q}$ and $\vec{S}$ is:



A. $\vec{S} = (1 - b)\vec{P} + b\vec{Q}$

B. $\vec{S} = (b - 1)\vec{P} + b\vec{Q}$

C. $\vec{S} = \left(1 - b^2\right)\vec{P} + b\vec{Q}$

D. $\vec{S} = (1 - b)\vec{P} + b^2\vec{Q}$

Answer: A

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12. A rocket is launched normal to the surface of the earth, away from the sun, along the line joining the sun and the earth. The sun is 3×10^5 times heavier than the earth and is at a distance 2.5×10^4 times larger than the radius of the earth. the escape velocity from earth's gravitational field is $u_e = 11.2kms^{-1}$. The minmum initial velocity $(u_e) = 11.2kms^{-1}$. the minimum initial velocity (u_s) required for the rocket to be able to leave the sun-earth system is closest to (Ignore the rotation of the earth and the presence of any other planet

A. $v_s = 22kms^{-1}$

B. $v_s = 42kms^{-1}$

C. $v_s = 62kms^{-1}$

D. $v_s = 72kms^{-1}$

Answer: B

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13. A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of time is $\delta T = 0.01$ seconds and he measures the depth of the well to be $L = 20$ meters. Take the acceleration due to gravity $g = 10ms^{-2}$ and the velocity of sound is $300ms^{-1}$. Then the fractional error in the measurement, $\delta L / L$, is closest to

A. $0.2\ \%$

B. $1\ \%$

C. $3\ \%$

D. $5\ \%$

Answer: B

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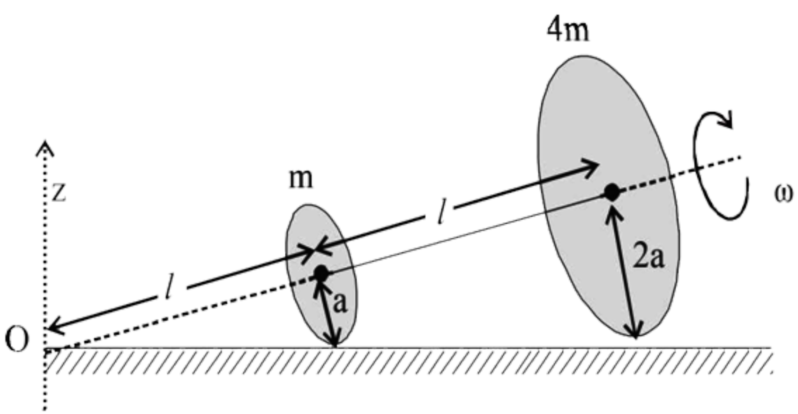
PART I : PHYSICS (SECTION 2)

1. Two thin circular discs of mass m and 4m, having radii of a and 2a, respectively, are rigidly fixed by a massless, rigid rod of length $l = \sqrt{24a}$ through their centres. This assembly is laid on a firm and flat surface, and set rolling without slipping on the surface so that the angular speed about the axis of the rod is ω. The angular momemtum of the entire assembly about the point 'O' is $vacL$ (see the figure). Which of the follwing statement (s) is (are) true?



A. The centre of mass of the assembly rotates about the z-axis with an angular speed of $\omega/5$

B. The magnitude of angular momentum of center of mass of the assembly about the point O is $81ma^2\omega$

C. the magnitude of angular momenttun of the asse1nbly about its center of mass is $17ma^2\omega/2$

D. The magnitude of the z-component of $\vec{L}$ is $55ma^2\omega$

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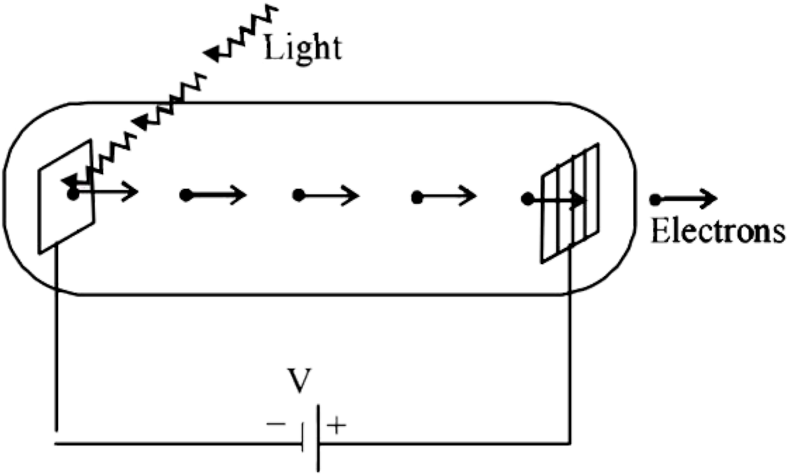
2. Light of wavelength λ_{ph}falls on a cathode plate inside a vacuum tube as shown in the figure .The work function of the cathode surface is ϕ and the anode is a wire mesh of conducting material kept at distance d from the cathode. A potential different V is maintained between the electrodes. If the minimum de Broglie wavelength of the electrons passing through the anode is λ_e which of the following statement (s) is (are) true?



A. λ_e decreases with increase in ϕ and λ_{ph}

B. λ_e is approximately halved, if dis doubled

C. For large potential difference $(V > > \phi / e), \lambda_e$ is approximately halved if V is made four times

D. λ_e increases at the same rate as λ_{ph} for $\lambda_{ph} < hc / \phi$

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3. In an experiment to determine the acceleration due to gravity g, the formula used for the time period of a periodic motion is $T = 2\pi\sqrt{\left(7\frac{R - r}{5g}\right.}$. The values of R and r are measured to be $(60 \pm 1)mm$ and $(10 \pm 1)mm$, respectively. In five successive measurement, the time period is found to be $0.52s, 0.56s, 0.57s, 0.54s$ and $0.59s$. the least count of the watch used for the measurement of time period is $0.01s$. Which of the following statement (s) is (are) true?

A. The error in the measure1nent of r is 10%

B. The error in the n1easuren1ent of T is 3.57%

C. The error in the measurement of T is 2%

D. The error in the determined value of g is 11 %

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4. Consider two identical galvanometers and two identical resistors with resistance R. If the internal resistance of the galvanometers $R_C < R/2$, which of the following statement(s) about any one of the galvanometers is (are) true?

A. The maximum voltage range is obtained when all· the components are connected in series

B. The maximum voltage range is obtained when the two resistors and one galvanometer are connected in series, and the second galvano1neter is connected in parallel to the first galvanometer

C. The maximum current range is obtained when all the components are connected in parallel

D. The maximum current range is obtained when the two galvanometers are connected in series and the combination is connected in parallel with both the resistors

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5. A block with mass (M) is connected by a massless spring with stiffness constant (k) to a rigid wall and moves without friction on a horizontal surface. The block oscillates with small amplitude A about an equilibrium position (x_0). Consider two cases : (i) when the block is at (x_0) , and (ii) when the block is at $x = x_0 + A$. In both the cases, a particle with mass m(lt M) is softly placed on the block after which they strick to each other. Which of the following statement (s) is (are) true about the motion after the mass (m) is placed on the mass (M) ?

A. The amplitude of oscillation in the first case changes by a factor of $\sqrt{\frac{M}{m+M}}$ whereas in the second case it remains unchanged

B. The final time period of oscillation in both the cases is same

C. The total energy decreases in both the cases

D. The instantaneous speed at x_0 of the combined masseR decreases in both the cases

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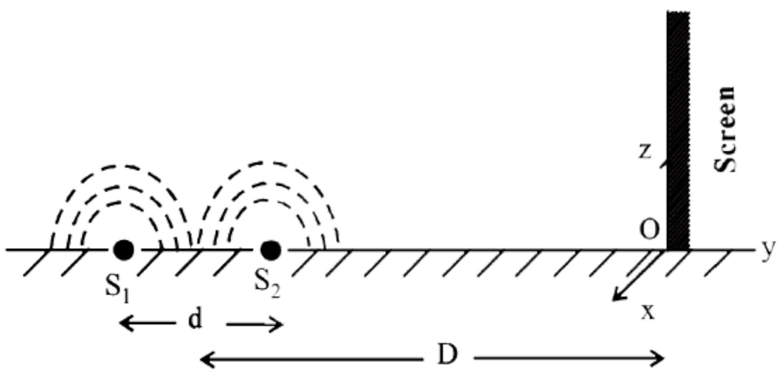
6. While conduction the Young's double slit experiment, a student replaced the two slits with a large opaque plate in the x-y plane containing two small holes that act as two coherent point sources $\left(S_1, S_2\right)$ emitting light of wavelength 600nm. The student mistakenly placed the screen parallel to the x-z plane (f or $z > 0$) at a distance D=3 m from the mid-point of $S_1 S_2$, as shown schematically in the figure. The distance between the sources $d = 0.6003mm$. The origin O is at the intersection of the screen and the line joining S_1S_2. Which of the following is (are) true of the intensity pattern of the screen?



A. Straight bright and dark bands parallel to the x-axis

B. The region very close to the point O will be dark

C. Hyperbolic bright and dark bands with foci symmetrically placed about O in the x-direction

D. Semi circular bright and dark bands centered at point O

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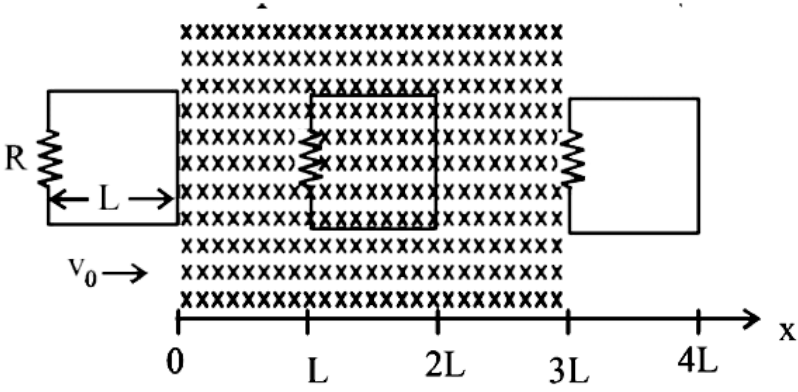
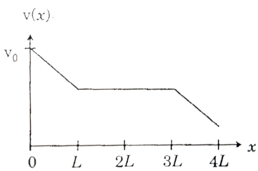
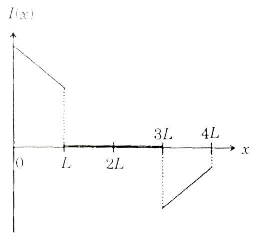
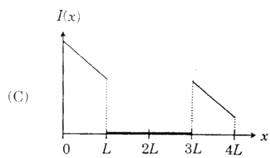
7. A rigid wire loop of square shape having side of length L and resistance R is moving along the x-axis with a constant velocity v_0 in the plane of the paper. At $t = 0$, the right edge of the loop enters a region of length 3L where there is a uniform magnetic field B_0 into the plane of the paper, as shown in the figure. For sufficiently large v_0 the loop eventually crosses the region. Let x be the location of the right edge of the loop. Let v(x), I(x) and F(x) represent the velocity of the loop, current in the loop, and force on the loop, respectively, as a function of x. Counter-clockwise current is taken as positive.

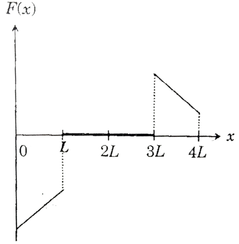


. Which of the following schematic plot(s) is (are) correct? (Ignore gravity)

A. 

B. 

C. 

D. 

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8. A uniform magnetic field B exists in the region between x=0 and $x = \frac{3R}{2}$ (region 2 in the figure) pointing normally into the plane of the paper. A particle with charge + Q and momentum p directed along x-axis enters region 2 from region 1 at point $P_1(y = -R)$. Which of the following option(s) is/are correct?

A. For $S > \frac{2}{3}\frac{p}{QR}$, the particle will re-enter region 1

B. For $\frac{8}{13}\frac{p}{QR}$, the particle will enter region 3 through the point Q_S. on x-axis

C. When the particle re-centers region 1 through the longest possible path in region 2, the magnitude of the change in its linear momentum between point P_1 and the farthest point from y-axis is $p/\sqrt{2}$

D. For a fixed S , particles of same charge P and same velocity v, the distance between then point P_1 and the point of re-entre into region 1 is inversely proportional to the mass of the particle

Answer: A

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9. The instananeous voltages at three terminals marked X,Y and Z are given by

V

$V_Y = V_0 \sin\left(\omega t + \frac{2\pi}{3}\right)$ and $V_Z = V_0 \sin\left(\omega t + \frac{4\pi}{3}\right)$.

An ideal volmeter is configured to read rms value of the potential difference between its terminal. It is connected between points X and Y and then between Y and Z. The reading(s) of the voltmeter will be

A. $V_{XY}^{rm} = V_0\sqrt{\frac{3}{2}}$

B. $V_{XY}^{rm} = V_0\sqrt{\frac{1}{2}}$

C. $V_{XY}^{rm} = V_0$

D. independent of the choice og the two terminals

Answer: A::D

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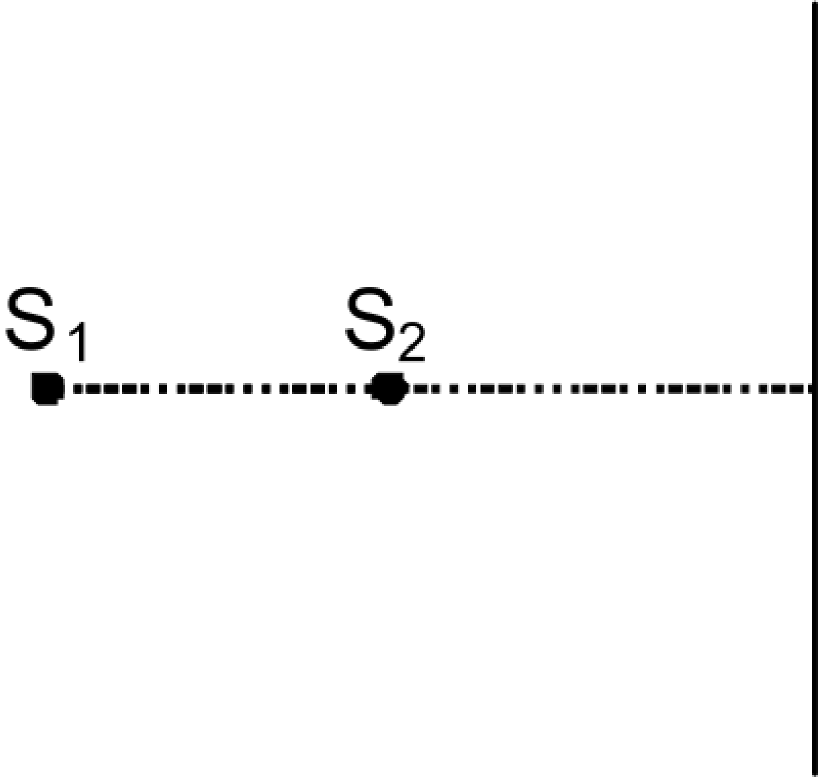
10. Two coherent monochromatic point sources S_1 and S_2 are placed in front of an infinite screen as shown in figure. Wavelength of the light emitted by both the sources is zero. Initial phase difference between the sources is zero.



Initially $S_1S_2 = 2.5\lambda$ and the number of bright circular rings on the screen in n_1. if the distance S_1S_2 is increased and made 5.7λ, the number of bright circular rings becomes n_2. the difference n_2 - n_1 is

A. A dark spot will be formed at the point P_2

B. At P_2 the order of the fringe will be maximum

C. The total number of fringes produced between P_1 and P_S in the first quadrant is close to 3000

D. The angular separation between two consecutive bright spots decreases as we move from P_1toP_2 along the first quadrant

Answer: B::C

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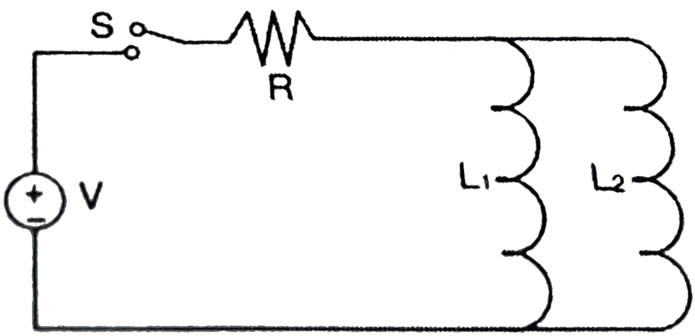
11. A source of constant voltage V is connected to a resistance R and two ideal inductor L_1 and L_2 through a switch S as shown. There is no mutual inducance between the two inductors. The swtich S is initially open. At t=0, the switch is closed and current begins to flow. Which of the following options is / are correct ?



A. After a long time, the current through L_1 will be $\frac{P}{R}\frac{L_2}{L_1+L_2}$

B. After a long time, the current through L_2 will be $\frac{V}{R}\frac{L_2}{L_1+L_2}$

C. The ratio of the currents throug L_1 and L_2 is fixes at all times

$(t > 0)$

D. At $t = 0$, the current through the resistance $R is \frac{Q}{R}$

Answer: A::B::C

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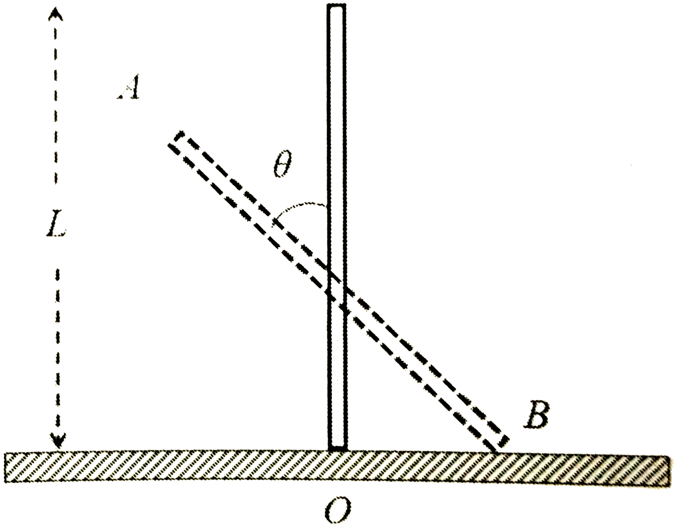
12. A rigid uniform bar AB of length ? is slipping from its vertical position on a frictionless floor (as shown in the figure). At some instant of time, the angle made by the bar with the vertical is θ. Which of the following statements about its motion is/are correct?



A. The midpoint of the bar will fall vertically downward

B. The trajectory of the point ? is a parabola

C. Instantaneous torque about the point in contact with the floor is proportional to $\sin\theta$

D. When the bar makes an angle θ with the vertical, the displacement of its midpoint from the initial position is proportional to $(1-\cos\theta)$

Answer: A::C::D

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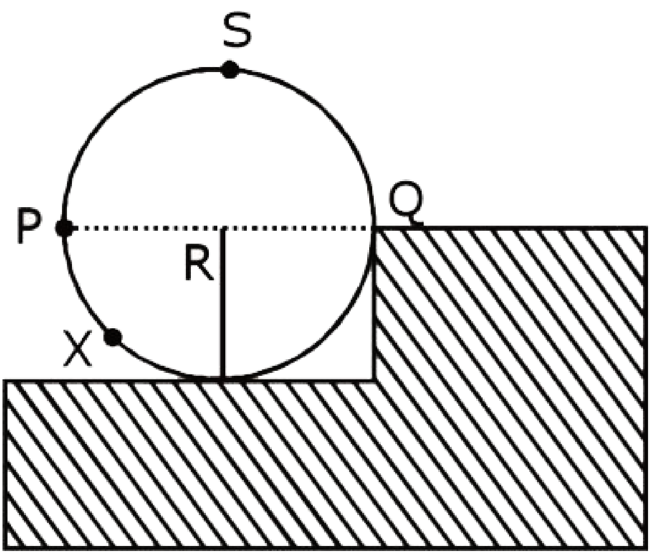
13. A wheel of radius R and mass M is placed at the bottom of a fixed step of height R as shown in the figure. A constant force is continuously applied on the surface of the wheel so that it just clims the step without slipping. Consider the torque τ about an axis normal to the plane of the paper passing through the point Q. Which of the following options is/are correct?



A. If the force is applied at point P tangentially then τ decreases continuously as the wheel climbs

B. If the force is applied normal to the circumference at point ? then τ is constant

C. If the force is applied normal to the circumference at point ? then τ _xDF0F_ is zero

D. If the force is applied tangentially at point ? then $1 \neq 0$ but the wheel never climbs the step

Answer: A::D

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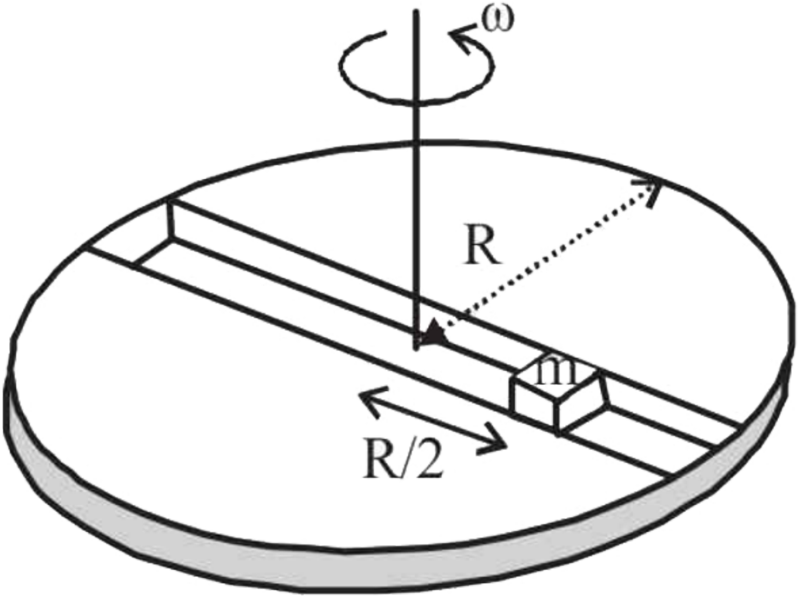
PART I : PHYSICS (SECTION 3)

1. A frame of reference that is accelerated with respect to an inertial frame of reference is called a non-inertial frame of reference. A coordinate system fixed on a circular disc rotating about a fixed axis with a constant angular velocity ω is an example of non=inertial frame of reference. The relationship between the force $\vec{F}_{rot}$ experienced by a particle of mass m moving on the rotating disc and the force $\vec{F}_{\in}$ experienced by the particle in an inertial frame of reference is

$$\vec{F}_{rot} = \vec{F}_{in} + 2m\left(\vec{v}_{rot} \times \vec{\omega}\right) + m\left(\vec{\omega} \times \vec{r}\right) \times \vec{\omega}.$$

where $\vec{v}_{rot}$ is the velocity of the particle in the rotating frame of reference and $\vec{r}$ is the position vector of the particle with respect to the centre of the disc.

Now consider a smooth slot along a diameter fo a disc of radius R rotating counter-clockwise with a constant angular speed ω about its vertical axis through its center. We assign a coordinate system with the origin at the center of the disc, the x-axis along the slot, the y-axis perpendicular to the slot and the z-axis along the rotation axis $\left(\vec{\omega} = \omega\hat{k}\right)$. A small block of mass m is gently placed in the slot at $\vec{r}(R/2)\hat{i}$ at $t = 0$ and is constrained to move only along the slot.



The distance r of the block at time is

A. $\frac{R}{4}\left(e^{\omega t} + e^{-\omega t}\right)$

B. $\frac{R}{2}\cos\omega t$

C. $\frac{R}{4}\left(e^{\omega t} + e^{-\omega t}\right)$

D. $\frac{R}{2}\cos\omega t$

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2. A frame of reference that is accelerated with respect to an inertial frame of reference is called a non-inertial frame of reference. A coordinate system fixed on a circular disc rotating about a fixed axis with a constant angular velocity ω is an example of non=inertial frame of reference. The relationship between the force $\vec{F}_{rot}$ experienced by a particle of mass m moving on the rotating disc and the force $\vec{F}_{\in}$ experienced by the particle in an inertial frame of reference is

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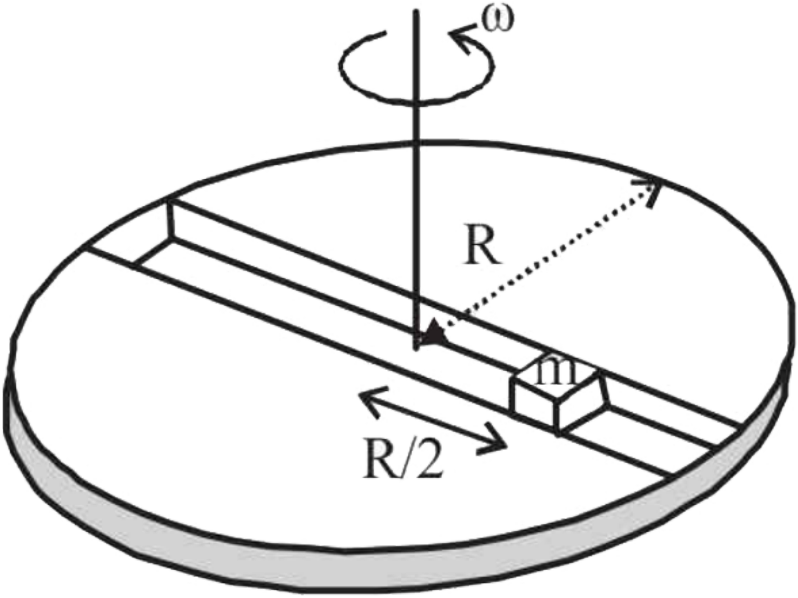

The net reaction of the disc on the block is

A. $\frac{1}{2}m\omega^2R\left(e^{2\omega t} - e^{-2\omega t}\right)\hat{j} + mg\hat{k}$

B. $\frac{1}{2}m\omega^2R\left(e^{2\omega t} - e^{-2\omega t}\right)\hat{j} + mg\hat{k}$

C. $-m\omega^2R\cos\omega t\hat{j} - mg\hat{k}$

D. $m\omega^2\sin\omega t\hat{j} - mg\hat{k}$

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Part I : PHYSICS (Section 3)Paragraph 2

1. One twirls a circular ring (of mass and radius) near the tip of one's finger as shown in Figure 1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is ?. The finger rotates with an angular velocity 2_0. The rotating ring rolls without slipping on the outside of a smaller circle described by the point where the ring and the finger is in contact (Figure 2). The coefficient of friction between the ring and the finger is μ and the acceleration due to gravity is g.

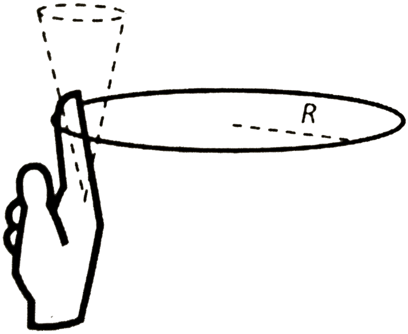

Figure 1

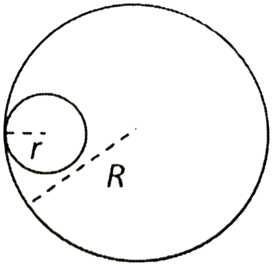

Figure 2

The minimum vlaue of ω_0 below which the ring will drop down is

A. $M2_0^sR^2$

B. $\frac{1}{2}M2_c^3\left(X_1\right)^2$

C. $M\omega + \ +_0^2(R - \tau)^s$

D. $\frac{3}{2}M\omega_0^2(R - r)^2$

Answer: A::B::C::D

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2. One twirls a circular ring (of mass and radius) near the tip of one's finger as shown in Figure 1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is ?. The finger rotates with an angular velocity 2_0. The rotating ring rolls without slipping on the outside of a smaller circle described by the point where the ring and the finger is in contact (Figure 2). The coefficient of friction between the ring and the finger is μ and the acceleration due to gravity is g.

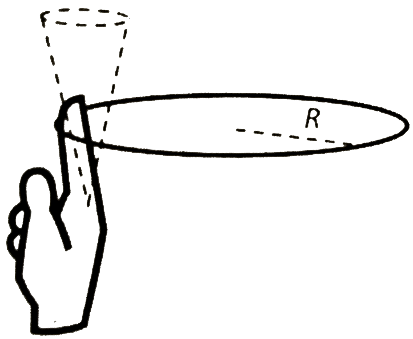

Figure 1

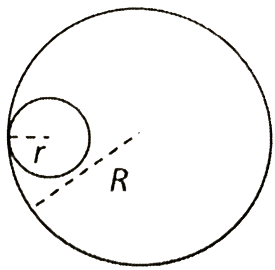

Figure 2

The minimum vlaue of ω_0 below which the ring will drop down is

A. $\sqrt{\dfrac{g}{\mu(R - r)}}$

B. $\sqrt{\frac{g}{\mu(R - r)}}$

C. $\sqrt{\frac{3g}{2\mu(R - r)}}$

D. $\sqrt{\frac{g}{2\mu(R - r)}}$

Answer: A

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SECTION 1

1. The potential energy of a particle of mass ? at a distance ? from a fixed point ? is given by $V(r) = kr^2/2$, where ? is a positive constant of appropriate dimensions. This particle is moving in a circular orbit of radius ? about the point ?. If ? is the speed of the particle and ? is the magnitude of its angular momentum about ?, which of the following statements is (are) true?

A. $v = \sqrt{\frac{k}{2m}}R$

B. $v = \sqrt{\frac{k}{m}}R$

C. $L = \sqrt{mk}R^2$

D. $L = \sqrt{\frac{mk}{2}}R^2$

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2. Consider a body of mass 1.0 at rest at the origin at time $t = 0$. A force $\vec{F} = \left(\alpha t\hat{i} + \beta\hat{j}\right)$ is applied on the body, where $\alpha = 1.0Ns^{-1}$ and $\beta = 1.0N$. The torque acting on the body about the origin at time $t = 1.0s$ is $\vec{\tau}$. Which of the following statements is (are) true?

A. $\left|\vec{\tau}\right| = \frac{1}{3}Nm$

B. The torque $\vec{\tau}$ is the direction of the unit vector $+\hat{k}$

C. The velocity of the body at $t = 1s$ is $\vec{v} = \frac{1}{2}\left(\hat{i} + 2\hat{j}\right)ms^{-1}$

D. The magnitude of displacement of the body at $t = 1s$ is $\frac{1}{6}m$

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3. A uniform capillary tube of inner radius r is dipped vertically into a beaker filled with water. The water rises to a height h in the capillary tube above the water surface in the beaker. The surface tension of water is σ. The angle of contact between water and the wall of the capillary tube is θ. Ignore the mass of water in the meniscus. Which of the following statements is (are) true?

A. For a given material of the capillary tube, h decreases with increase in r

B. For a given material of the capillary tube, h in independent of σ

C. If this expriment is performed in a lift going up with a constant acceleration, then h decreases

D. h is proportional to contact angle θ

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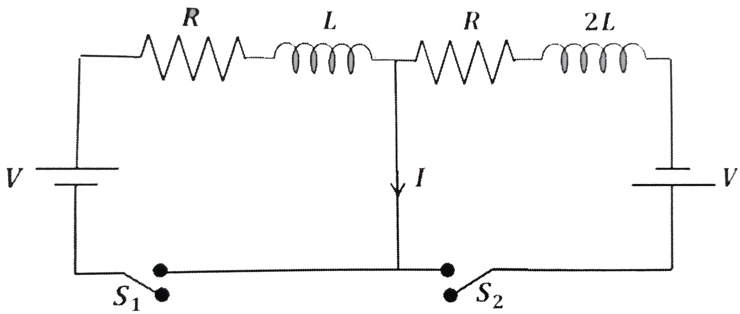
4. In the figure below, the switches S_1 and S_2 are closed simultaneously at $t = 0$ and a current starts to flow in the circuit. Both the batteries have the same magnitude of the electromotive force (emf) and the polarities are as indicated in the figure. Ignore mutual inductance between the inductors. The current ? in the middle wire reaches its maximum magnitude I_{max} at time $t = \tau$. Which of the following statements is (are) true?



A. $I_{max} = \frac{V}{2R}$

B. $I_{max} = \frac{V}{4R}$

C. $\tau = \frac{L}{R} \text{ In } 2$

D. $\tau = \frac{2L}{R} \text{ In } 2$

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5. Two infinitely long straight wires lie in the xy-plane along the lines $x = \pm R$. The wire located at $x = +R$ carries a constant current I_1 and the wire located at $x = -R$ carries a constant current I_2. A circular loop of radius R is suspended with its centre at $\left(0, 0, \sqrt{3}R\right)$ and in a plane parallel to the xy-plane. This loop carries a constant current ? in the clockwise direction as seen from above the loop. The current in the wire is taken to be positive if it is in the $+\hat{J}$ direction. Which of the following statements regarding the magnetic field $\vec{B}$ is (are) true?

A. If $I_1 = I_2,\ \text{then}\ \vec{B}$ cannot be equal to zero at the origin (0, 0, 0)

B. If $I_1 > 0\ \text{and}\ I_2 < 0,\ \text{then}\ \vec{B}$ can be equal to zero at the origin (0, 0, 0)

C. If $I_1 < 0\ \text{and}\ I_2 > 0,\ \text{then}\ \vec{B}$ can be equal to zero at the origin (0, 0, 0)

D. If $I_1 = I_2$, then the z-component of the magnetic field at the centre of the loop is $\left(-\frac{\mu_0 I}{2R}\right)$

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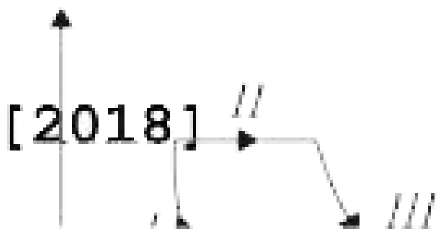
6. One mole of a monatomic ideal gas undergoes a cyclic process as shown in the figure (where V is the volume and T is the temperature). Which of the statements below is (are) true?



A. Process I is an isochoric process

B. In process II, gas absorbs heat

C. In process IV, gas releases heat

D. Processes I and III are not isobaric

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SECTION 2

1. Two men are walking along a horizontal straight line in the same direction. The man in front walks at a speed 1.0 ms^{-1} and the man behind walks at a speed $2.0ms^{-1}$. A third mad is standing at a height 12m above the same horizontal line such that all three men are in a vertical plane. The two walking men are blowing identical whistles which emit a sound of frequency 1430 Hz. The speed of sound in air is 330 ms^{-1}. At the instant, when the moving men are 10 m apart, the stationary man is equidistant from them. The frequency of beats in Hz, heard by the stationary man at this instant, is

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2. A ring and a disc are initially at rest, side by side, at the top of an inclined plane which makes an angle 60° with the horizontal. They start to roll without slipping at the same instant of time along the shortest path. If the time difference between their reaching the ground is $\left(2 - \sqrt{3}\right) / \sqrt{10s}$ 2– 3 / 10s, then the height of the top of the inclined plane, in metres, is ____________ . Take $g = 10ms^{-2}$

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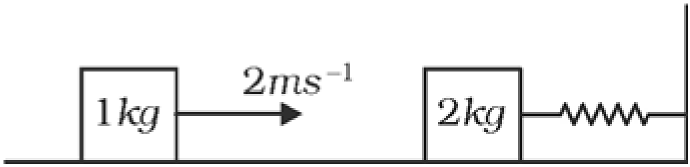
3. A spring-block system is resting on a frictionless floor as shown in the figure. The spring constant is $2.0Nm^{-1}$ and the mass of the block is 2.0 kg. Ignore the mass of the spring. Initially the spring is in an unstretched condition. Another block of mass 1.0 kg moving with a speed of $2.0ms^{-1}$ collides elastically with the first block. The collision is such that the 2.0 kg block does not hit the wall. The distance, in metres, between the two blocks when the spring returns to its unstretched position for the first time after the collision is



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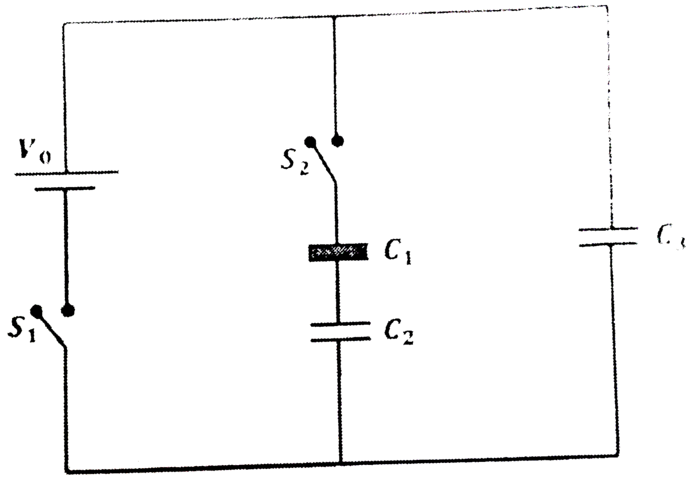
4. Three identical capacitors C_1, C_2 and C_3 have a capacitance of $1.0 \mu F$ each and they are uncharged initially. They are connected in a circuit as shown in the figure and C_1 is then filled completely with a dielectric material of relative permittivity ε_r. The cell electromotive force (emf) $V_0 = 8V$. First the switch S_1 is closed while the switch S_2 is kept open. When the capacitor C_3 is fully charged, S_1 is opened and S_2 is closed simultaneously. When all the capacitors reach equilibrium, the charge on

C_3 is found to be $5\mu c$. The value of ε_r = __________.



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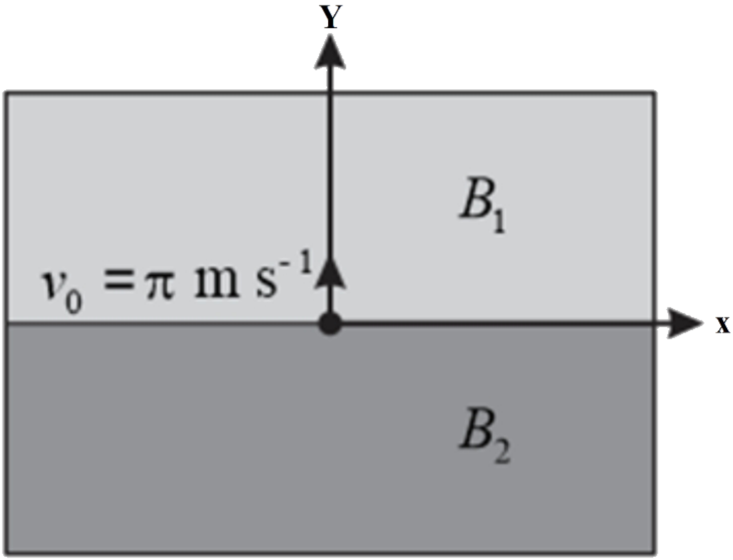
5. In the XY- plane , the region $y > 0$ has a uniform magnetic field $B_1\hat{k}$ and the region $y < 0$has another uniform magnetic field $B_2\hat{k}$. A positively charged particle is projected from the origin along the positive y- axis with speed $v_0 = \pi ms^{-1}$ at t=0 , as shown in the figure . Neglect gravity in this problem . Let t=T be the time when the particle crosses the X- axis from below for the first time . If $B_2 = 4B_1$, the average speed to the particle , in ms^{-1}, along the x- axis in the time interval T is ________ .



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6. Sunlight of intensity $1.3 kWm^{-2}$ is incident normally on a thin convex lens of focal length 20 cm. Ignore the energy loss of light due to the lens and assume that the lens aperture size is much smaller than its focal length. The average intensity of light, in kW m^{-2}, at a distance 22 cm from the lens on the other side is ________.

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7. Two conducting cylinders of equal length but different radii are connected in series between two heat baths kept at temperatures $T_1 = 300K$ and $T_2 = 100K$, as shown in the figure. The radius of the bigger cylinder is twice that of the smaller one and the thermal conductivities of the materials of the smaller and the larger cylinders are K_1 and K_2 respectively. If the temperature at the junction of the two cylinders in the steady state is 200 K, then $K_1/K_2 =$ ________.

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SECTION 3 PARAGRAPH 3

1. In electromagnetic theory, the electric and magnetic phenomena are related to each other. Therefore, the dimensions of electric and magnetic quantities must also be related to each other. In the questions below, [E] and [B] stand for dimensions of electric and magnetic fields respectively, while $\left[\in_0\right]$ and $\left[\mu_0\right]$ stand for dimensions of the permittivity and permeability of free space respectively. [?] and [?] are dimensions of length and time respectively. All the quantities are given in SI units.

The relation between [E] and [B] is

A. $[E] = [B][L][T]$

B. $[E] = [B][L]^{-1}[T]$

C. $[E] = [B][L][T]^{-1}$

D. $[E] = [B][L]^{-1}[T]^{-1}$

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2. In electromagnetic theory, the electric and magnetic phenomena are related to each other. Therefore, the dimensions of electric and magnetic quantities must also be related to each other. In the questions below, [E] and [B] stand for dimensions of electric and magnetic fields respectively, while $\left[\in_0\right]$ and $\left[\mu_0\right]$ stand for dimensions of the permittivity and permeability of free space respectively. [?] and [?] are dimensions of length and time respectively. All the quantities are given in SI units.

The relation between $\left[\epsilon_0\right]$ and $\left[\mu_0\right]$ is

A. $\left[\mu_0\right] = \left[\epsilon_0\right][L]^2[T]^{-2}$

B. $\left[\mu_0\right] = \left[\epsilon_0\right][L]^{-2}[T]^2$

C. $\left[\mu_0\right] = \left[\epsilon_0\right]^{-1}[L]^2[T]^{-2}$

D. $\left[\mu_0\right] = \left[\epsilon_0\right]^{-1}[L]^{-2}[T]^2$

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3. If the measurement errors in all the independent quantities are known, then it is possible to determine the error in any dependent quantity. This is done by the use of series expansion and truncating the expansion at the first power of the error. For example, consider the relation $z = x/y$.If the errors in x, y and z are Δx, Δy and Δz, respectively, then

$$z \pm \Delta z = \frac{x \pm \Delta x}{y \pm \Delta y} = \frac{x}{y}\left(1 \pm \frac{\Delta x}{x}\right)\left(1 \pm \frac{\Delta y}{y}\right)^{-1}.$$

The series expansion for $\left(1 \pm \frac{\Delta y}{y}\right)^{-1}$, to first power in $\Delta y/y$. is $1 \pm (\Delta y/y)$

. The relative errors in independent variables are always added. So the error in z will be

$$\Delta z = z\left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right).$$

The above derivation makes the assumption that $\Delta x/x < < 1, \Delta y/y < < 1$. Therefore, the higher powers of these quantities are neglected.

In an experiment the initial number of radioactive nuclei is 3000. It is found that 1000 ± 40 nuclei decayed in the first 1.0 s. For $|x| < < 1, \text{In}(1 + x) = x$ up to first power in x. The error $\Delta\lambda$, in the determination of the decay constant λ, $\text{in } s^{-1}$, is

A. 0.04

B. 0.03

C. 0.02

D. 0.01

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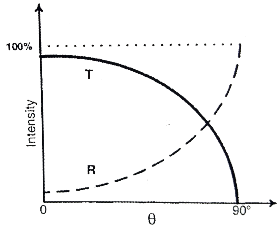
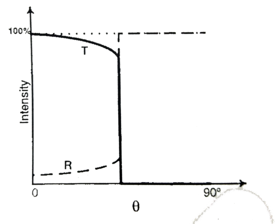
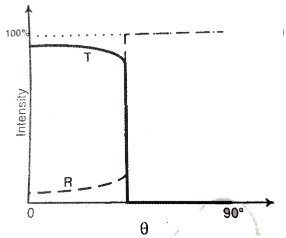
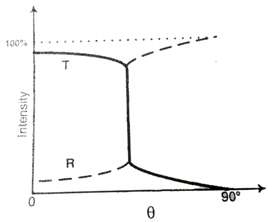
PHYSICS SECTION - I : Single correct Answer Type

1. A light ray travelling in glass medium is incident of glass- air interface at an angle of incidence θ. The reflected (R) and transmitted (T) intensities, both as function of θ, are plotted The correct sketch is

A. 

B. 

C. 

D. 

Answer: C

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2. A satellite is moving with a constant speed 'V' in a circular orbit about the earth. An object of mass 'm' is ejected from the satellite such that it just escapes form the gravitational pull of the earth. At the tme of its ejection, the kinetic energy of the object is

A. $\frac{1}{2}mV^2$

B. mV^2

C. $\frac{3}{2}mV^2$

D. $2mV^2$

Answer: B

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3. A point mass is subjected to two simultaneous sinusoidal displacements in x - $direction$, $x_1(t) = A\sin(\omega)t$ and $x_2(t) = A\sin\left(\left(\omega t + \frac{2\pi}{3}\right)\right.$. Adding a third sinusoidal displacement $x_3(t) = B\sin(\omega t + \phi)$ brings the mas to a complete rest. The values of (B) and (phi) are.

A. $\sqrt{2}A, \frac{3\pi}{4}$

B. $A, \frac{4\pi}{3}$

C. $\sqrt{3}A, \frac{5\pi}{6}$

D. $A, \frac{\pi}{3}$

Answer: B

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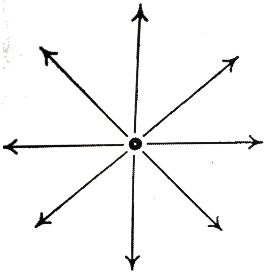
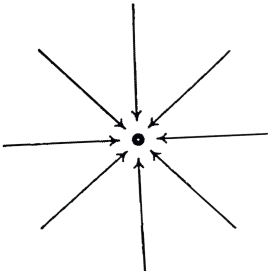
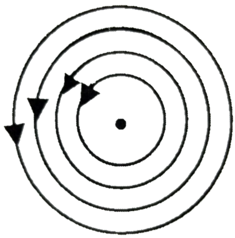
4. Which of the field patterns given below is valid for electric field as well as for magnetic field?



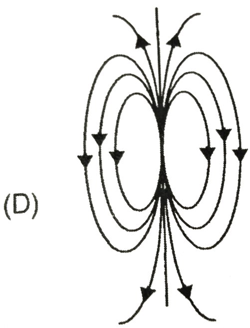
A.



B.



C.



D.

Answer: C

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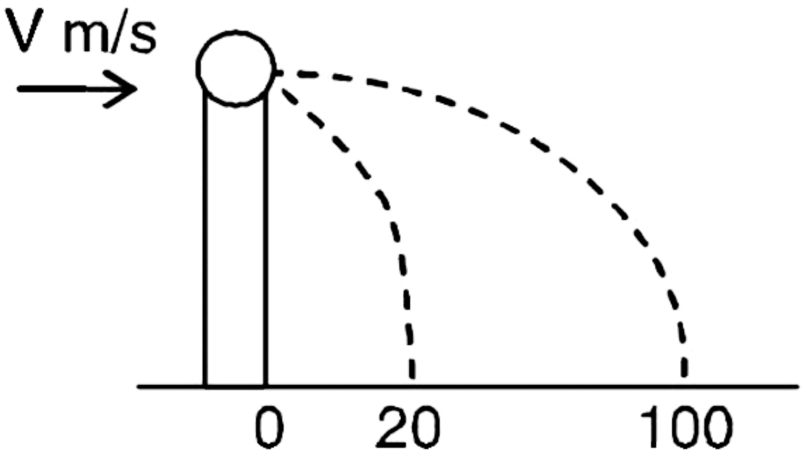
5. A ball of mass 0.2 kg rests on a vertical post of height 5 m. A bullet of mass 0.01 kg, travelling with a velocity Vm/s in a horizontal direction, hits the centre of the ball. After the collision, the ball and bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The velocity V of the bullet is



A. 250m/s

B. $250\sqrt{2}m/s$

C. $400m/s$

D. 500m/s

Answer: D

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6. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is $0.5mm$ and there are 50 divisions on the circular scale. The reading on the main scale is $2.5mm$ and that on circular scale is 20 divisions. if the measured mass of the ball has a relative error of 2%, the relative percentage error in the density is

A. 0.9%

B. 2.4%

C. 3.1%

D. 4.2%

Answer: C

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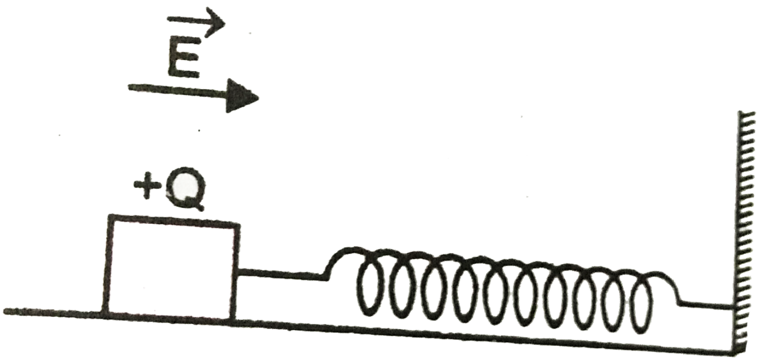
7. A wooden block performs SHM on a frictionless surface with frequency, v_0. The block carries a charge $+Q$ on its surface. If now a uniform electric field $\vec{E}$ is switched on as shwon in figure., then the SHM of the block will be



A. of the same frequency and with shifted mean poistion

B. of the same frequency and with the same mean position

C. of changed frequency and with shifted mean position

D. of changed frequency and with the same mean position.

Answer: A

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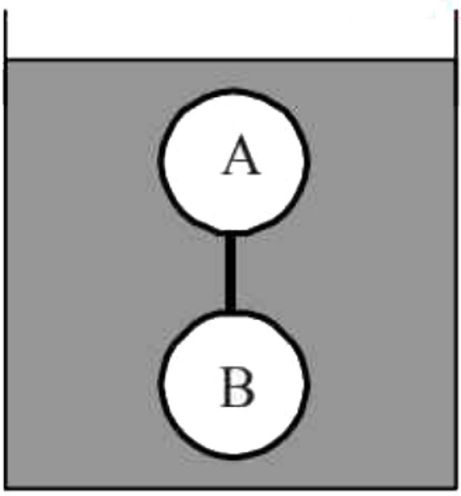
PHYSICS SECTION - II : Multiple correct Answer Type

1. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into an equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if



A. $d_A < d_F$

B. $d_B > d_F$

C. $d_A > d_F$

D. $d_A + d_B = 2d_F$

Answer: A::B::D

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2. A sereis R-C circuit is connected to AC voltage source. Consider two cases, (A) when C is without a dielectric medium and (B) when C is filled with dielectric of constant 4. The current I_R through the resistor and voltage V_c across the capacitor are compared in the two cases. Which of the following is/ are true?

A. $I_R^A > I_R^B$

B. $I_R^A < I_R^B$

C. $V_C^A > V_C^B$

D. $V_C^A > V_C^B$

Answer: B::C

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3. Which of the following statement(s) is/are correct ?

A. If the electric due to a point charge varies as r^{-25} instead of r^2, then the Gauss law will still be valid.

B. The Gauss law can be used to calculate the field distribution around an electric dipole.

C. If the electric field between two point charges is zero somewhere, then the sign of the two charges is the same.

D. The work done by the external force in moving a unit positive charge from point A at potential V_A to point B at potential V_B is $\left(V_B - V_A\right)$

Answer: C::D

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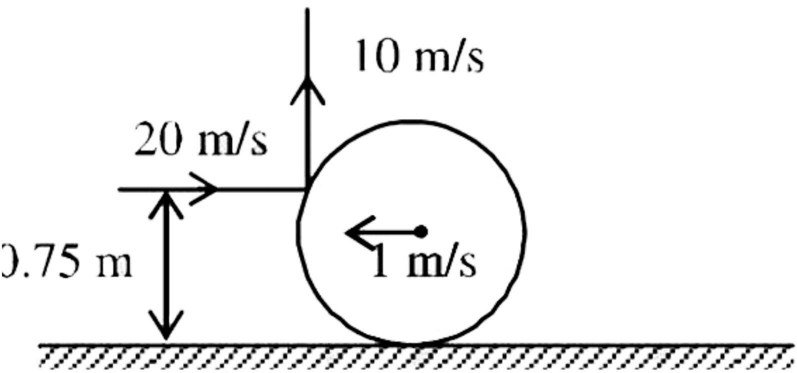
4. A thin ring of mass 2kg and radius 0.5 m is rolling without on a horizontal plane with velocity 1m/s. A small ball of mass 0.1kg, moving with velocity 20 m/s in the opposite direction hits the ring at a height of 0.75m and goes vertically up with velocity 10m/s. Immediately after the collision



A. the ring has pure totation about its stationary CM.

B. the ring comes to a complete stop.

C. friction between the ring and the ground is to the left.

D. there is no friction between the ring and the ground.

Answer: A::C

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PHYSICS SECTION - III Integer Answer Type

1. A train is moving along a straight line with a constant acceleration 'a' . A boy standing in the train throws a ball forward with a speed of $10m/s$, at an angle of $60(\circ)$ to the horizontal. The boy has to move forward by $1.15m$ inside the train to catch the ball back at the initial height . the acceleration of the train , in m/s^2 , is

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2. A block of mass 0.18 kg is attached to a spring of force constant 2N/m. The coefficient of friction between the block and the floor is 0.1. Initially, the block is at rest and the spring is unstretched. An impulse is given to the block.

The block slides a distance of 0.06 m and comes to rest for the first time.

The initial velocity of the block in m/s is v=N/10. Then, N is

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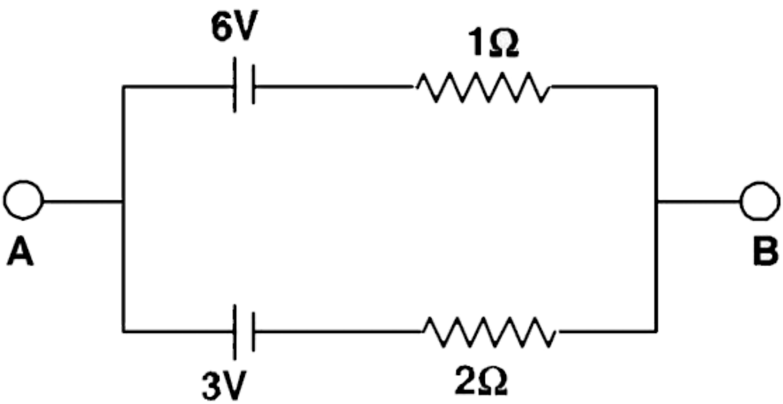
3. Two batteries of different emfs and different internal resistances are connected as shown. The voltage across AB in volts is.



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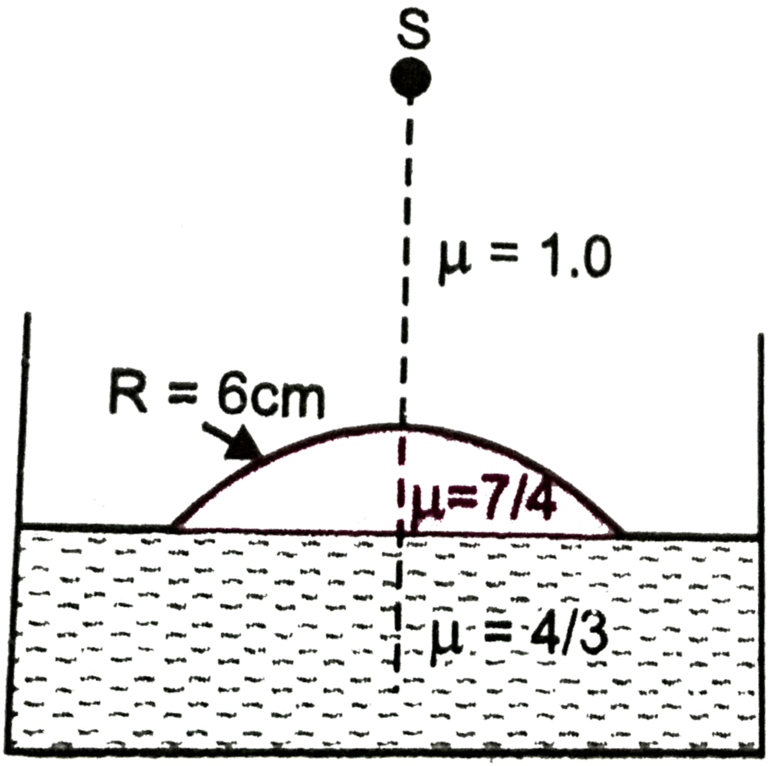
4. Water (with refractive index = 4/3) in a tank is $18cm$ deep. Oil of refraction index $7/4$ lies on water making a convex surface of radius of curvature $R = 6cm$ as shown in Fig. Consider oil to act as a thin lens. An object S is placed $24cm$ above water surface. The location of its image is at xcm above the bottom of the tank. Then x is.



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5. A series R-C combination is connected to an AC voltage of angular frequency $\omega = 500 radian/s$. If the impendance of the R-C circuit is $R\sqrt{1.25}$, the time constant (in millisecond) of the circuit is

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6. A silver of radius $1cm$ and work function $4.7eV$ is suspended from an insulating thread in freepace. It is under continuous illumination of $200nm$ wavelength light. As photoelectron are emitted the sphere gas charged and acquired a potential . The maximum number of photoelectron emitted from the sphere is $A \times 10^{e}(where 1 < A < 10)$ The value of z is

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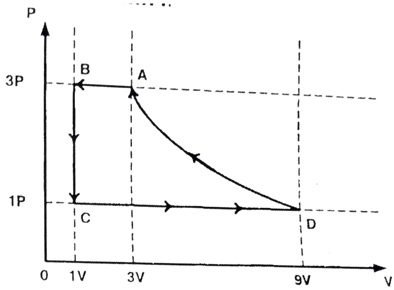
PHYSICS SECTION - IV Matrix Match Type

1. One mole of a monatomic ideal gas is taken through a cycle ABCDA as shown in the P-V diagram. Column II gives the characteristics involved in the cycle. Match them with each of the processes given in Column I.



Column I	Column II
(A) Process $A \rightarrow B$	(p) Internal energy decreases.
(B) Process $B \rightarrow C$	(q) Internal energy increases.
(C) Process $C \rightarrow D$	(r) Heat is lost.
(D) Process $D \rightarrow A$	(s) Heat is gained.
	(t) Work is done on the gas.

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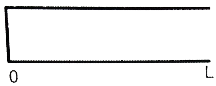
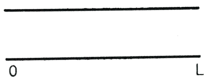
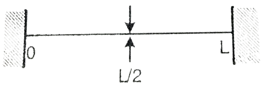
2. Column I shows four systems, each of the same length L, for producing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as λ_f. Match each system with statements given in Column II describing the nature and wavelength of the standing waves.

Column I	Column II
(A) Pipe closed at one end 	(p) Longitudinal waves
(B) Pipe open at both ends 	(q) Transverse waves
(C) Stretched wire clamped at both ends 	(r) $\lambda_f = L$
(D) Stretched wire clamped at both ends and at mid-point 	(s) $\lambda_f = 2L$
	(t) $\lambda_f = 4L$

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SECTION-3

1. Put a unifrom meter scale horizontally on your extended index fingers with the left one at 0.0 cm and the right one at 90.00 cm when you attempt to move both the fingers slowly towards the center , initially only the left finger slips with respect to to the scale and the right finger does not . after some distance, the left finger stops and the right one starts slipping . Then the right finger stops at a distance XR from the center (50.00 cm) of the scale and the left one starts slopping again . This happens because to the difference in the fiictional forces on the two fingers . it the coefficients of static and dynamic between the fingers and the scale are 0.4 and 0.32 respectively , the value of XR (in cm is ....

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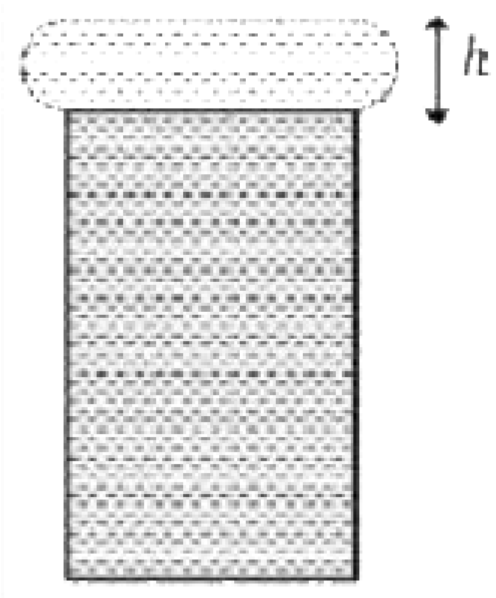
2. When water is filled caerfully in a glass . One can fill it to a height h above the rim of glass due to the surface tension of water . To calculate h just before water starts flowing model the shape of the water above the rim as a disc of thickness h having semicircular edges as shown achematically in the figure When the pressure of water at the bottom of this disc exceeds what can be withstood due to the surface lension , the water surface breaks near the rim and water starts flowing form there if the density of water, its surface tension and the acceleration due to gravity are $10^3 kgm^{-3}, 0.07 Nm^{-1}$ and $10 ms^{-2}$, respectively, the value of h (in mm) is ________



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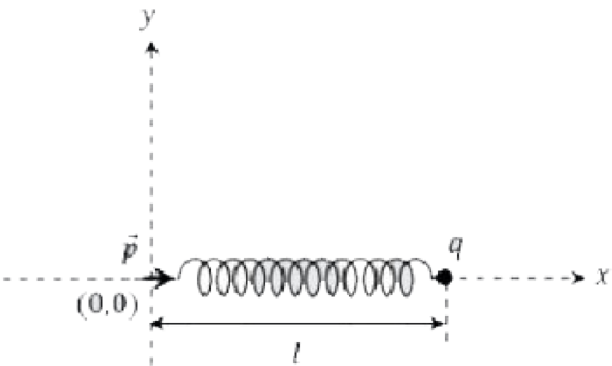
3. One end of a spring of negligible unstretched length and spring constant k is fixed at the origin (0,0) . A point particle of mass m carrying a positive charge q attached at its other end . The entire system is kept on a smooth horizontal surface . When a point dipole p pointing towards

the charge q is fixed at the origin , the spring gets stretched to a length l and attains a new equilibrium positition (see figure below) . if the point mass is now displaced slightly by $\Delta l < < l$ from its equilibrium position and released it is found to oscillate at frequency $\frac{1}{\delta}\sqrt{\frac{k}{m}}$. The value of δ is _______.



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4. Consider one mole of helium gas enclosed in a container at initial pressure $P_1$and volume V_1 . It expands isothermally to volume V_1 After this , the gas expands adiabatically and its volume becomes $32V_1$. The work done by the gas during isothermal and adiabatic expansion processes are W_{iso} and W_{adia} respectively . if the radio $\frac{W_{iso}}{W_{adia}} = fIn2$, then f is ________ .

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5. A stationary tuning fork is in resonance with an air column in a pipe . If the tuning fork is moved with a speed of $2ms^{-1}$ in front of the open end of the pipe and parallel to it , the length of the pipe should be changed for the resonance to occur with the moving tuning fork if the speed of sound in air is $320ms^{-1}$, the smallest value of the percentage change required in the length of the pipe is _______.

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6. A circular disc of radius carries surface charge density $= \sigma_0 \left(1 - \frac{r}{R}\right)$, where σ_0 is a constant and is the distance from the center of the disc Electric flux through a lange spherical surface that endcloses the charged disc completely is ϕ_0. electric flux through another spherical surface of radius $\frac{R}{4}$ and consentri with the disc is ϕ. Then the ratio $\frac{\phi_0}{\phi}$ is ________.

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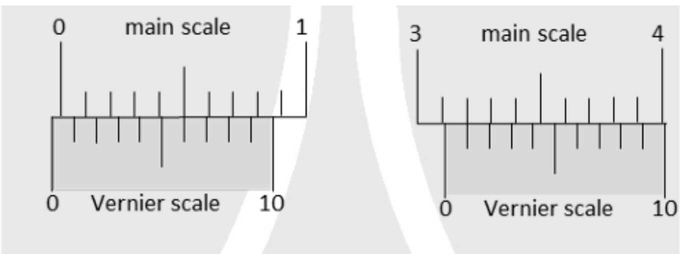
QUESTION

1. The smallest division on the main scale of a vernier calipers is 0.1cm. Ten divisions of the vernier scale correspond to nine divisions of the main scale. The figure below on the left shows the reading of this calipers with no gap between in two jaws. The figure on the right shows the reading with a solid sphere held between the jaws. The correct diameter of the sphere is.



A. 3.07 cm

B. 3.11 cm

C. 3.15 cm

D. 3.17 cm

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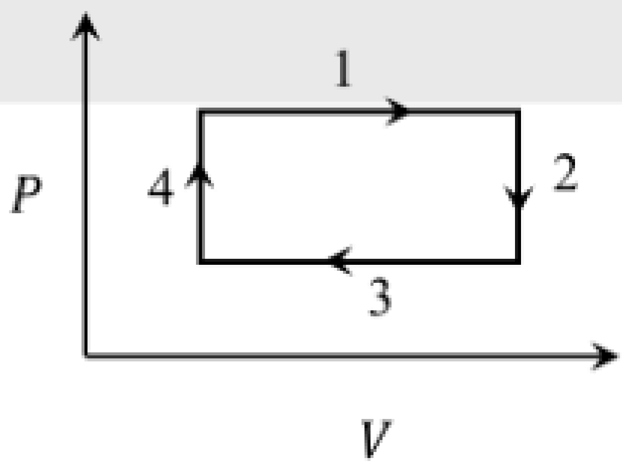
2. An ideal gas undergoes a four step cycle as shown in the P-V diagram below. During this cycle heat is absorbed by the gas in



A. steps 1 and 2

B. steps 1 and 3

C. steps 1 and 4

D. steps 2 and 4

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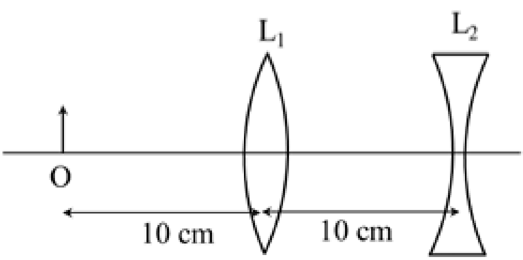
3. An extended object is placed at point O, 10cm in front of a convex lens L1 and concave lens L2 is placed 10 cm behind it as shown in figure. The radii of curvature of all curved surfaces in both the lenses are 20cm. The refractive index of both the lenses is 1.5. The total magnification of this lens system is.



A. 0.4

B. 0.8

C. 1.3

D. 1.6

Answer: B

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4. A heavy nucleus Q of half life 20 minutes undergoes alpha decay with probability of 60% and beta decay with probability of 40%. Initially number of Q nuclei is 1000. The number of alpha decay of Q in the first one hour is.

A. 50

B. 75

C. 350

D. 525

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5. A projectile is thrown from a point O on the ground at an angle 45^0 from the vertical and with a speed $5\sqrt{2}\frac{m}{s}$. The projectile at highest point of its tracjectory splits into two equal parts. One part falls vertically down to the ground 0.5s after the splitting. The other part t seconds after the splitting falls to the ground at a distance x meters from the point O. The acceleration due to gravity $g = 10\frac{m}{s^2}$. The value of t is

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6. A projectile is thrown from a point O on the ground at an angle 45^0 from the vertical and with a speed $5\sqrt{2}\frac{m}{s}$. The projectile at highest point of its tracjectory splits into two equal parts. One part falls vertically down to the ground 0.5s after the splitting. The other part t seconds after the splitting falls to the ground at a distance x meters from the point O. The acceleration due to gravity $g = 10\frac{m}{s^2}$. The value of x is

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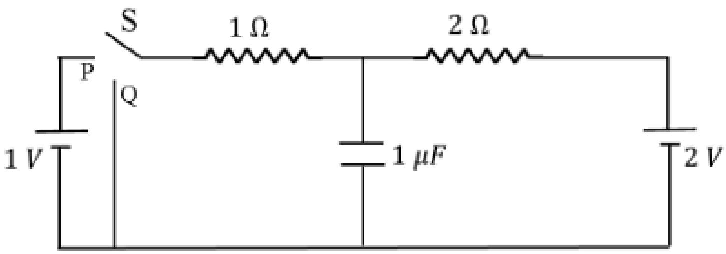
7. In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor become $q1\mu C$. The S is switched to psition Q. After a long time, the charge on the capacitor is $q2\mu C$. The magnitude of q1 is



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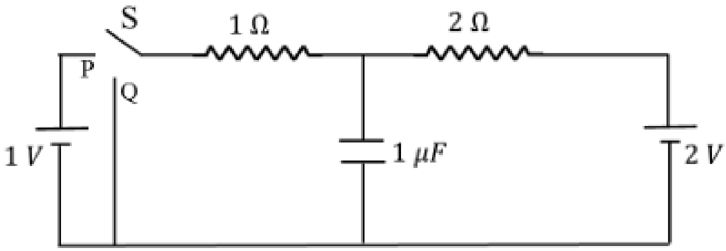
8. In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor become $q1\mu C$. The S is switched to psition Q. After a long time, the charge on the capacitor is

$q2\mu C$. The magnitude of q2 is



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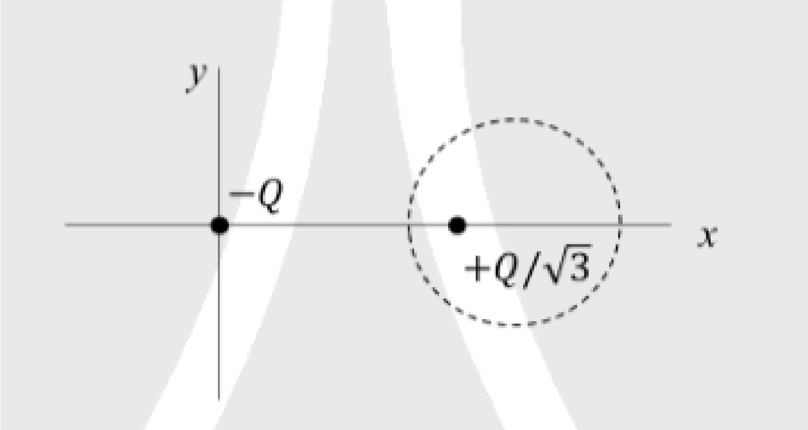
9. Two point charges $-Q$ and $+\frac{Q}{\sqrt{3}}$ are placed in the xy plane at the origin (0,0) and a point (2,0) resp as shown in figure. This results in an equipotential circle of radius R and potential V=0 in the xy plane with its center at (b,0). All lengths are measured in meters.



The value of R is ....m

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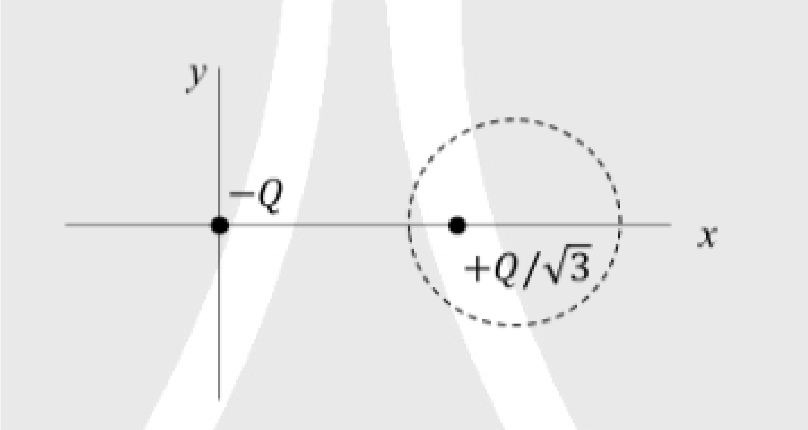
10. Two point charges -Q and $+\frac{Q}{\sqrt{3}}$ are placed in the xy plane at the origin (0,0) and a point (2,0) resp as shown in figure. This results in an equipotential circle of radius R and potential V=0 in the xy plane with its center at (b,0). All lengths are measured in meters.



The value of b is ....m

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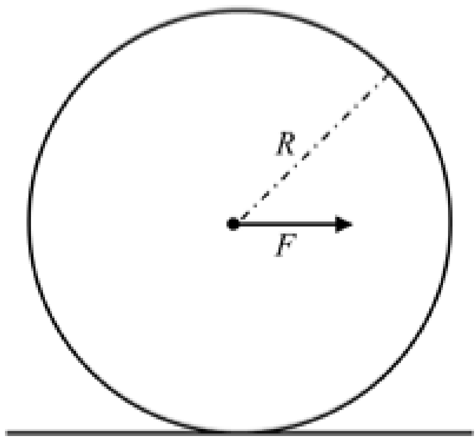
11. A horizontal force F is applied at the centre of mass of a cylindrical object of mass m and radius R, perpendicular to its axis as shown in figure. The coefficient of friction between the object and the ground is μ. The center of mass of the object has an acceleration a. The acceleration due to gravity is g. Given that the object rolls without slipping, which of the following statement(s) is/are correct?.



A. For the same F, the value of a does not depend on whether the cylinder is solid or hollow.

B. For a solid cylinder the maximum possible value of a id $2\mu g$

C. The magnitude of the frictional force on the object due to the ground is always μmg

D. For a thin-walled hollow cylinder $a = \frac{F}{2}m$

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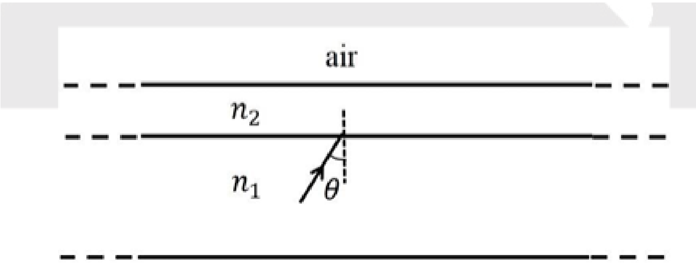
12. A wide slab consisting of two media of refractive indices n_1 and n_2 is placed in air as shown in figure. A ray of light is incident from medium n_1 to n_2 at an angle θ where $\sin(\theta)$ is slightly larger than $\frac{1}{n_1}$. Take refractive index of air as 1. Which of the following statements is/are correct?



A. The light ray enters air if $n_2 = n_1$

B. The light ray is finally reflected back into the medium of refractive index n_1 if $n_2 < n_1$

C. The light ray is finally reflected back into the medium of refractive index n_1 if $n_2 > n_1$

D. The light ray is reflected back into the medium of refractive index n_1 if $n_2 = 1$

Answer: A

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13. A particle of mass M = 0.2 kg is initially at rest in xy plane at a point (x = -l, y = -h) where l = 10m and h = 1m. The particle is accelerated at time t = 0 with a constant acceleration $a = 10\frac{m}{s^2}$ along the positive x-direction. Its angular momentum and torque w.r.t origin in SI units are represented by $\vec{L}$ and $\vec{\tau}$ resp. If $\hat{k} = \hat{i}x\hat{j}$ then which of the following statements is/are correct?

A. The particle arrives at point (x = l, y = -h) at time t = 2s

B. $\vec{\tau} = 2\hat{k}$ when the particle passes through the point (x = l, y = -h)

C. $\vec{L} = 4\hat{k}$ when the particle passes through the point (x = l, y = -h)

D. $\vec{\tau} = \hat{k}$ when the particle passes through the point (x = 0, y = -h)

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14. Which of the following statement is/are correct about the spectrum of hydrogen atom?

A. ratio of longest wavelength to shortest wavelength in balmer series is 9/5

B. there is an overlap between wavelength ranges of balmer and paschen series

C. wavelength of lyman series are given by $\left(1+\frac{1}{m^2}\right)\lambda_0$ where λ_0 is shortest wavbelength of lyman series and m is an integer

D. wavelength ranges of lyman and balmer series do not overlap

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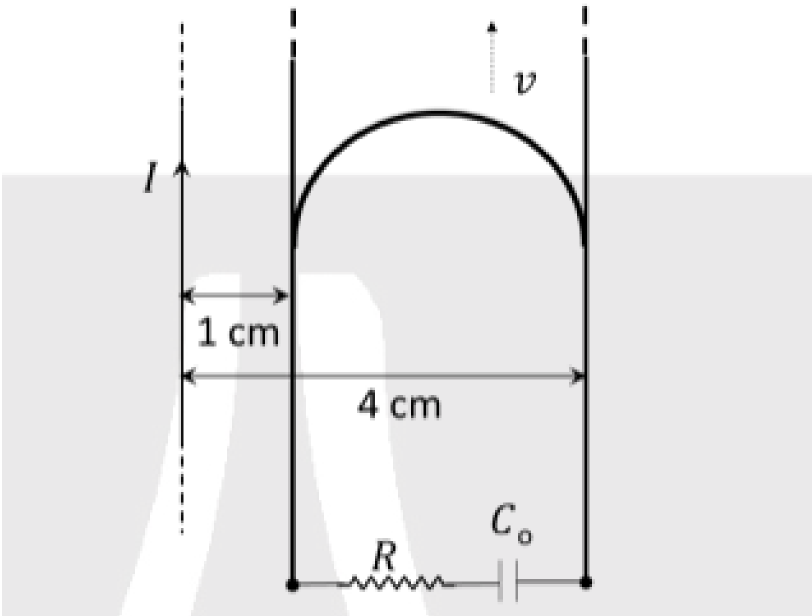
15. A long straight wire carries a current I = 2A. A semi circular conducting rod is placed beside it on two conducting parallel rails of negligible resistance. Both rails are parallel to wire. The wire , the rod, and the railslie in same horizontal plane as shownin figure. Two ends of semi circular rod are at distances 1 cm and 4 cm from the wire. At time t = 0 rod starts moving on the rails with a speed v = 3 m/s. A resistor R= 1.4 ohm and capacitor $C_0 = 5\mu F$ are connected in series between rails. At time t = 0, C_0 is uncharged. Which of the following statements is/are correct?



A. maximum current through R is 1.2 x 10^{-6} A

B. maximum current through R is 3.8 x 10^{-6} A

C. maximum charge on capacitor C_0 is 8.4×10^{-11} C

D. maximum charge on capacitor C_0 is 2.4 x 10^{-12} C

Answer: A

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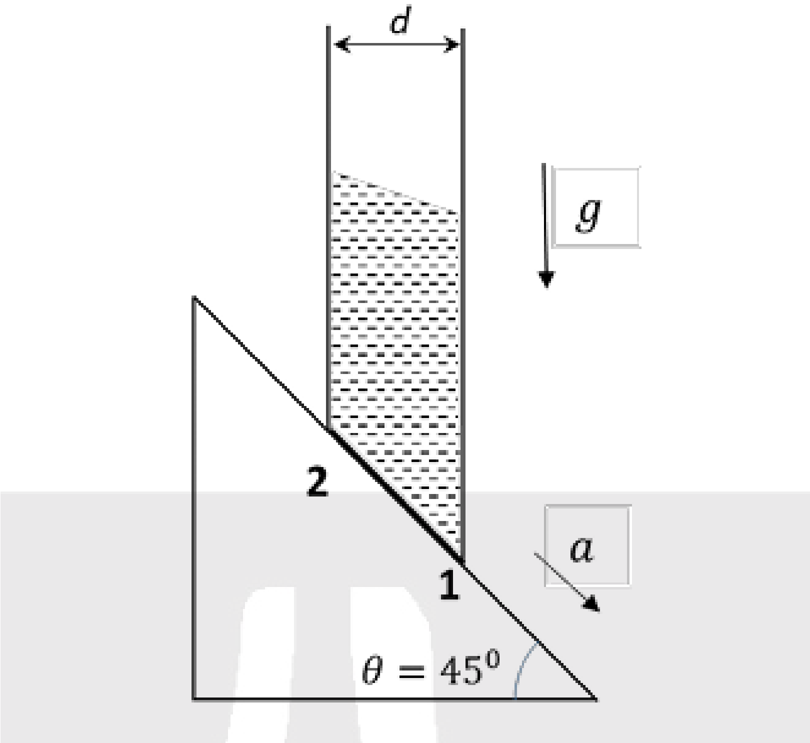
16. A cylindrical tube with its base as shown is filled with water. It is moving down with a constant acceleration a along a fixed inclined plane with angle $\theta = 45^0$ P1 and P2 are pressure points 1 and 2 resp located at base of tube. Let $\beta = \frac{P1 - P2}{\rho g d}$. Which statement is true?



A. $\beta = 0$ when $a = \frac{g}{\sqrt{2}}$

B. $\beta > 0$ when $a = \frac{g}{\sqrt{2}}$

C. $\beta = \frac{sqr(2) - 1}{\sqrt{2}}$ when $a = \frac{g}{2}$

D. $\beta = \frac{1}{\sqrt{2}}$ when $a = \frac{g}{2}$

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17. An α particle (mass = 4amu) and a singly charged sulfur ion (mass 32 amu) are initially at rest. They are accelerated through potential V and then allowed to pass into a region of uniform magnetic field which is normal to velocities of the particles. Within this region the α particle and the sulfur ion move in circular orbits of radii r_a and r_s resp. The ratio $\left(\frac{r_s}{r_a}\right)$ is

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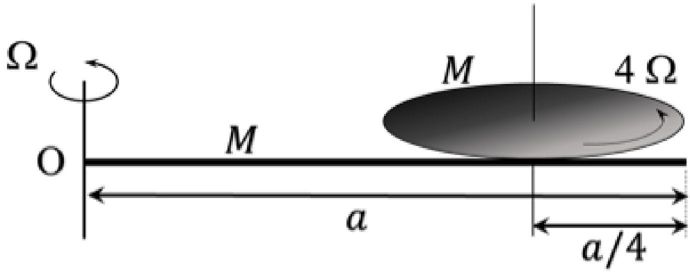
18. A thin rod of mass M and length a is free to rotate in horizontal plane about a fixed vertical axis passing through point O. A thin circular disc of mass M and of radius a/4 is pivoted on this rod with its center at a distance a/4 from the free end so that it can rotate freely about its vertical axis. Assume that both rod and disc have uniform density and they remain horizontal during motion. An outside stationary observer finds the rod rotating with an angular velocity Ω and the disc rotating about its vertical axis with angular velocity 4Ω. Total angular momentum of system about point O is $\left(\frac{Ma^2\Omega}{48}\right)n$. The value of n is



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19. A small object is placed at the center of a large evacuated hollow spherical container. Assume that the container is maintained at 0K. At time t = 0 the temperature of object is 200K. The temperature of the object becomes 100K at $t = t_1$ and 50K at $t = t_2$. Assume objectand container to be ideal black bodies. The heat capacity of object does not depend on temperature. Ratio $\frac{t_2}{t_1}$ is

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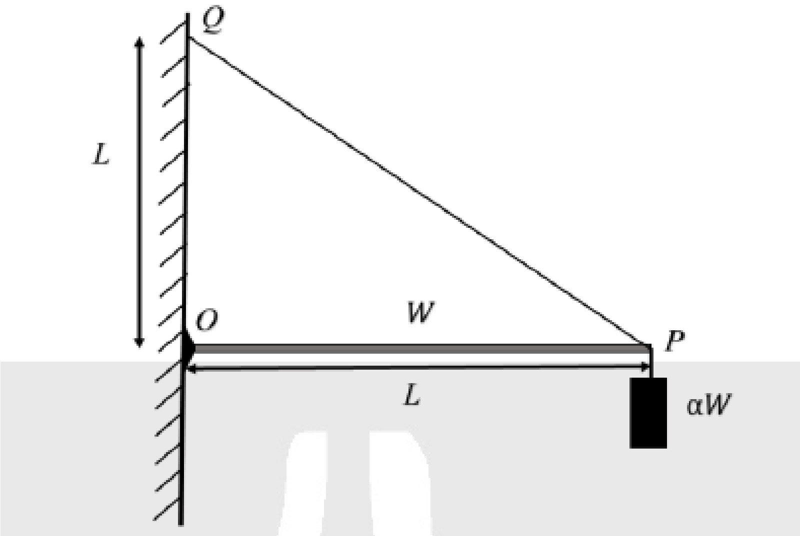
20. One end of a horizontal uniform beam of weight W and length L is hinged on a vertical wall at point O and its other end is supported by a light inextensible rope. The other end of the rope is fixed at point Q at a height L above the hinge at point O. A block of weight αW is attached at the point Q at a height L above the hinge at point O. A block of weight αW is attached at the point P of the beam as shown in the figure. The rope can sustain a maximum tension of $2(\sqrt{2})W$. Which of the following statements is/are correct?



A. vertical component of reaction force at O does not depend on α

B. horizontal component of reaction force at O is equal to W for $\alpha = 0.5$

C. tension in rope is 2W for $\alpha = 0.5$

D. rope breaks if $\alpha > 1.5$

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21. A source approaching with speed u towards the open end of a stationary pipe of length L is emitting a sound of frequency f_s. The farther end of the pipe is closed. The speed of sound in air is v anf f_0 is the fundamental frequency of the pipe. For which of the following combination of u and f_s will the sound reaching the pipe lead to a resistance.

A. $u = 0.8v$ anf $f_s = f_0$

B. $u = 0.8v$ anf $f_s = 2f_0$

C. $u = 0.8v$ anf $f_s = 0.5f_0$

D. $u = 0.5v$ anf $f_s = 1.5f_0$

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22. For a prism angle $\theta = 60^0$ the refractive indices of the left half and right half are resp, n1 and n2 (n2gen1) as shown in figure. The angle of incidence i is chosen such that the incident light rays will have minimum deviation if n1 = n2 = n = 1.5. For case of unequal refractive indices n1 = n and $n2 = n + \partial at(n)$ the angle of emergence $e = i + \delta(e)$. Which of the following statement is/are correct?

A. value of $\delta(e)$ (in radians) is greater than that of $\delta(n)$

B. value of $\delta(e)$ (in radians) is propotional $\delta(n)$

C. $\delta(e)$ lies between 2.0 and 3.0 milliradians $\delta(n) = 2.8x10^{-3}$

D. $\delta(e)$ lies between 1.0 and 1.6 milliradians $\delta(n) = 2.8x10^{-3}$

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23. A physical quantity $\vec{S}$ is defined as $\vec{S} = \frac{\vec{E} x \vec{B}}{\mu_0}$. $The \dim ensionof$vec(S)`

are the same as the dimension of which of the following quantities?

A. energy/(charge x current)

B. force/(length x time)

C. energy/volume

D. power/area

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24. A heavy nucleus N at rest undergoes fission $N \rightarrow P + Q$ are two lighter nuclei.Let $\delta = M_N$ - M_P - MQ. Speeds of P and Q are v_p and v_q resp. If c is speed of light which of the following statement is/are correct?

A. $E_P + E_Q = c^2\delta$

B. $E_P = \left(\frac{M_P}{M_P + MQ}\right)c^2\delta$

C. $\frac{V_P}{V_Q} = \frac{M_Q}{M_P}$

D. magnitude of momentum for P as well as Q is $c\sqrt{2\mu\delta}$ where

$\mu = \frac{M_P M_Q}{M_P + M_Q}$

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25. Two concentric circular loops one of radius R and other of radius 2R lie in the xy plane with the origin as their common center . Smaller loop carries current I1 in anticlockwise direction and larger loop carries I2 in clockwise direction with $I_2 > 2I_1$, vec(B)(x,y)` denotes magnetic feld at a point (x,y) in xy-plane. Which of the following statements are correct?

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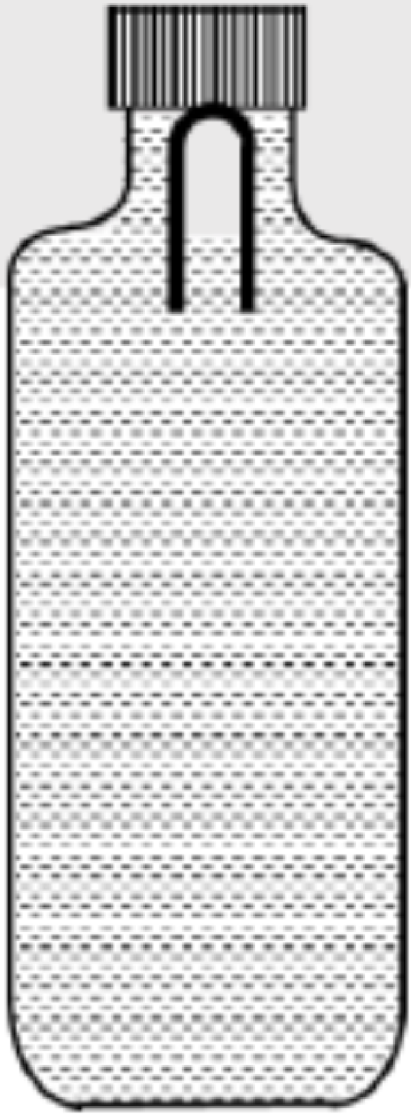
26. A soft plastic bottle filled with water of density 1 gm/cc carries an inverted glass test tube with some air(ideal gas) trapped as shown in the figure. The test-tube has a mass of 5gm and it is made of a thick glass of density 2.5 gm/cc. Initially the bottle is sealed at atmospheric pressure $p_0 = 10^5 Pa$ so that the volume of the trapped air is $v_0 = 3.3c$. When the bottle is squeezed from outside at constant temperature, the pressure inside rises and the volume of the trapped air reduces. It is found that the test tube begins to sink at pressure $p_0 + \delta(p)$ without changing its orientation. At this pressure the volume of the trapped air is v_0 - $\delta(v)$. Let $\delta(v) = X$ and $\delta(p)$ = Y x $10^3 Pa$



Value of X is

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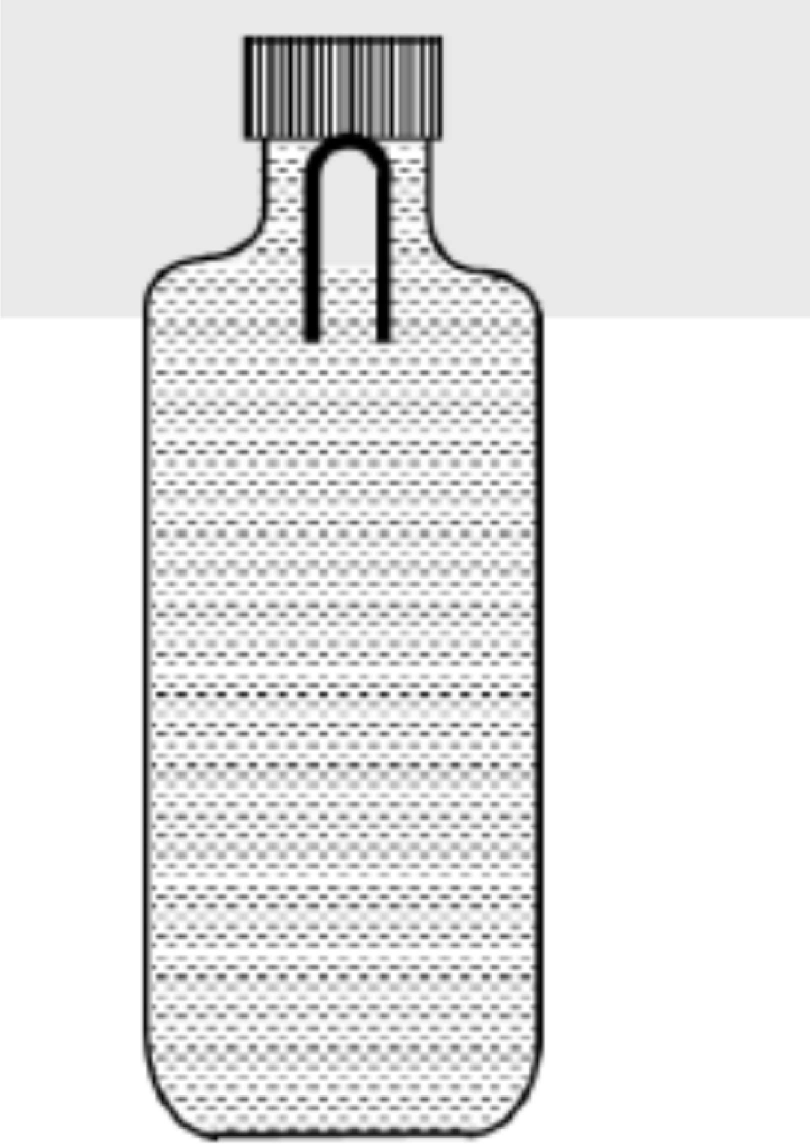
27. A soft plastic bottle filled with water of density 1 gm/cc carries an inverted glass test tube with some air(ideal gas) trapped as shown in the figure. The test-tube has a mass of 5gm and it is made of a thick glass of density 2.5 gm/cc. Initially the bottle is sealed at atmospheric pressure $p_0 = 10^5 Pa$ so that the volume of the trapped air is $v_0 = 3.3c$. When the bottle is squeezed from outside at constant temperature, the pressure inside rises and the volume of the trapped air reduces. It is found that the test tube begins to sink at pressure $p_0 + \delta(p)$ without changing its orientation. At this pressure the volume of the trapped air is v_0 - $\delta(v)$. Let $\delta(v) = X$ and $\delta(p)$ = Y x $10^3 Pa$



Value of Y is

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28. A pendulum consists of a bob of mass $m = 0.1\text{kg}$ and a massless inextensible string of length $l = 1.0m$. It is suspended from a fixed point at height $h = 0.9m$ above a frictionless horizontal floor. Initially, the bob of the pendulum is lying on the floor at rest vertically below the point of suspension. A horizontal impulse $P = 02.\ kg - m/s$ is imparted to the bob lifts off the floor. The magnitude of the angular momentum of the pendulum about the point of suspension just before the bob lifts off is J kg-m^2/s. The kinetic energy of the pendulum just after the lift-off js K Joules.

The value of J is ___

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29. A pendulum consists of a bob of mass $m = 0.1\text{kg}$ and a massless inextensible string of length $l = 1.0m$. It is suspended from a fixed point at height $h = 0.9m$ above a frictionless horizontal floor. Initially, the bob of the pendulum is lying on the floor at rest vertically below the point of suspension. A horizontal impulse $P = 02.\ kg - m/s$ is imparted to the bob lifts off the floor. The magnitude of the angular momentum of the pendulum about the point of suspension just before the bob lifts off is J kg-m^2/s. The kinetic energy of the pendulum just after the lift-off js K Joules.

The value of K is ___

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30. In a circuit a metal filament lamp is connected in series with a capacitor of capacitance $C\mu F$ across a 200V 50Hz supply. Power consumed by lamp is 500W while voltage drop across it is 100V. Assume tht there is no inductive load in the circuit . Take rms values of the voltages . The magnitude of the phase angle between current and supply voltage is ψ. Value of C is

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31. In a circuit a metal filament lamp is connected in series with a capacitor of capacitance $C\mu F$ across a 200V 50Hz supply. Power

consumed by lamp is 500W while voltage drop across it is 100V. Assume tht there is no inductive load in the circuit . Take rms values of the voltages . The magnitude of the phase angle between current and supply voltage is ψ. Value of ψ is

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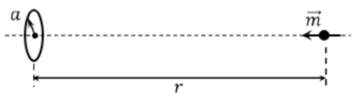
32. A special metal S conducts electricity without any resistance. A closed wire loop made of S does not allow any change in flux through itself by inducting a suitable current to generate a compensating flux. This current gives rise to a magnetic moment which in turn repels the source of magnetic field or flux. Consider such a loop, of radius a, with its center at the origin. A magnetic dipole of moment m is brought along the axis of this loop from infinity to a point at distance r(>> a) from the center of the loop with its north pole always facing the loop, as shown in the figure below. The magnitude of magnetic field of a dipole m at a point on its axis at distance r is $\frac{\mu_0 m}{2\pi r^3}$. The magnitude of the force between two magnetic dipoles with moments m_1 and m_2 separated by a distance r on common axis with their north pole facing each other is $\frac{km_1m_2}{r^4}$ where k is a constant of appropriate dimensions. The direction of this force is along line joining two dipoles.

Paragraph

A special metal S conducts electricity without any resistance. A closed wire loop, made of S, does not allow any change in flux through itself by inducing a suitable current to generate a compensating flux. The induced current in the loop cannot decay due to its zero resistance. This current gives rise to a magnetic moment which in turn repels the source of magnetic field or flux. Consider such a loop, of radius a, with its center at the origin. A magnetic dipole of moment m is brought along the axis of this loop from infinity to a point at distance r ($\gg a$) from the center of the loop with its north pole always facing the loop, as shown in the figure below.

The magnitude of magnetic field of a dipole m, at a point on its axis at distance r, is $\frac{\mu_0}{2\pi}\frac{m}{r^3}$, where μ_0 is the permeability of free space. The magnitude of the force between two magnetic dipoles with moments, m_1 and m_2, separated by a distance r on the common axis, with their north poles facing each other, is $\frac{k\, m_1 m_2}{r^4}$, where k is a constant of appropriate dimensions. The direction of this force is along the line joining the two dipoles.



When the dipole m is placed at a distance r from center of the loop the current induced in the loop will be proportional to

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33. A special metal S conducts electricity without any resistance. A closed wire loop made of S does not allow any change in flux through itself by inducting a suitable current to generate a compensating flux. This current gives rise to a magnetic moment which in turn repels the source of magnetic field or flux. Consider such a loop, of radius a, with its center at the origin. A magnetic dipole of moment m is brought along the axis of this loop from infinity to a point at distance r(>> a) from the center of the loop with its north pole always facing the loop, as shown in the figure below. The magnitude of magnetic field of a dipole m at a point on its axis at distance r is $\frac{\mu_0 m}{2\pi r^3}$. The magnitude of the force between two magnetic dipoles with moments m_1 and m_2 separated by a distance r on common axis with their north pole facing each other is $\frac{km_1m_2}{r^4}$ where k is a constant of appropriate dimensions. The direction of this force is along line joining two dipoles.

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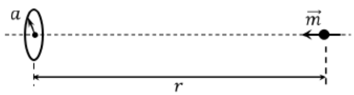

Work done in bringing dipole from infinity to a distance r from center of the loop by given process is proportional to

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34. A thermally insulating cylinder has a thermally insulating and frictionless movable partition in the middle, as shown in the figure below. On each side of the partition, there is one mole of an ideal gas , with specific heat at constant volume, $C_v = 2R$. Here, R is the gas constant. Initially, each side has a volume V_0 and temperature T_0. The left side has an electric heater, which is turned on at very low power to transfer heat Q to the gas on the left side. As a result the partition moves slowly towards the right reducing the right side volume to $\frac{V_0}{2}$. Consequently, the gas temperature on the left and the right sides become T_L and T_R, respectively. Ignore the changes in the temperatures of the cylinder, heater and the partition.

Paragraph

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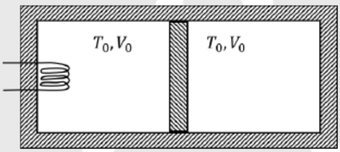

Value of $\frac{T_R}{T_0}$

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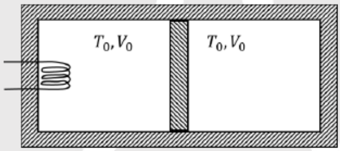
Paragraph

A thermally insulating cylinder has a thermally insulating and frictionless movable partition in the middle, as shown in the figure below. On each side of the partition, there is one mole of an ideal gas, with specific heat at constant volume, $C_V = 2R$. Here, R is the gas constant. Initially, each side has a volume V_0 and temperature T_0. The left side has an electric heater, which is turned on at very low power to transfer heat Q to the gas on the left side. As a result the partition moves slowly towards the right reducing the right side volume to $V_0/2$. Consequently, the gas temperatures on the left and the right sides become T_L and T_R, respectively. Ignore the changes in the temperatures of the cylinder, heater and the partition.



35. Value of

$$\frac{Q}{RT_0}$$

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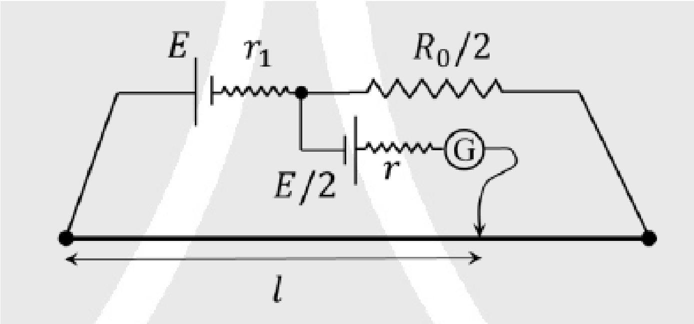
36. In order to measure internal resistance r1 of a cell emf E, a meter bridge of wire resistance $R_0 = 50\Omega$, a resistance $\frac{R_0}{2}$ another cell of emf E/2 and galvanometer G are used in circuit. If null point is founded at l =

72cm. then value of $r1$



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37. Distance between two stars of masses $3M_S$ and $6M_S$ is 9R.R is the mean distance between Earth and Sun and M_S is mass of Sun. Two stars orbit around their common center of mass in circular orbits with period nT. Value of n is

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38. In a photoemission experiment the maximum KE of photoelectrons from metalsP,Q,R are E_P, E_Q, E_R and they are related by $E_p = 2E_Q = 2E_r$. In this experiment the same sources of monochromatice light is used for metals P and Q while a different source of monochromatic light is used for metal R. Work functions for metals P,Q,R are 4 eV, 4.5eV and 5.5eV. Energy of incident photon used for metal R in eV is

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PHYSICS (SECTION 1)

1. A particle of mass 1 kg is subjected to a force which depends on the position as $\vec{F} = -k\left(x\hat{i} + y\hat{j}\right)\ \mathrm{kg\ m\ s^{-2}}$ with k = $\mathrm{kg\ s^{-2}}$ .At time t = 0 the particle's position $\vec{r} = \left(\frac{1}{\sqrt{2}}\hat{i} + \sqrt{2}\hat{j}\right)$ m and its velocity $\vec{v} = \left(-\sqrt{2}\hat{i} + \sqrt{2}\hat{j} + \frac{2}{\pi}\hat{k}\right)ms^{-1}$. Let v_x and v_y denote the x and the y components of the particle's velocity respectively . Ignore gravity . When z = 0.5 m , the value of $\left(xv_y - yv_x\right)$ is ____ m^2s^{-1} .

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2. In a radioactive chain reaction, ${}_{90}^{230}Th$ nucleus decays into ${}_{84}^{214}Po$ nucleus. The ratio of the number of α to number of β^- particles emitted in this process is ____.

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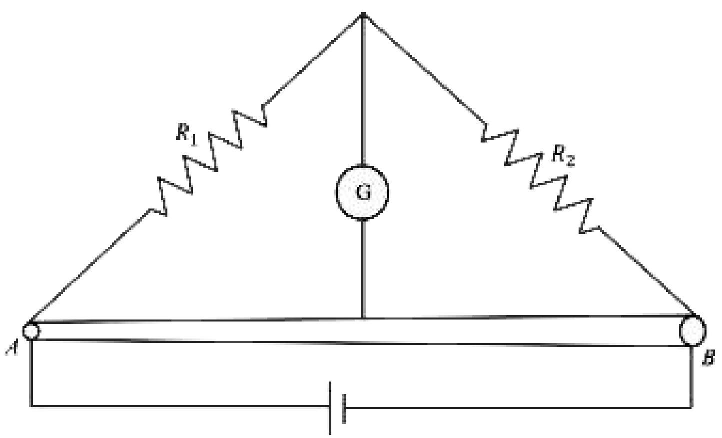
3. Two resistances $R_1 = X\Omega$ and $R_2 = 1\Omega$ are connected to a wire AB of uniform resistivity, as shown in the figure, The radius of the wire linearly along its axis from 2.2 mm at A to 1 mm at B. A galvanometer (G) connected to the center of the wire, 50 cm from each and along its axis shows zero deflection when A and B are connected to a battery. The value of X is ______.



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4. In a particular system of units , a physical quantity can be expressed in terms of the electic charge e , electron mass m_e , Planck's constant h , and Coulomb's constant $k = \frac{1}{4\pi\varepsilon}$, where ε_0 is the permittivity of vacumm . In terms of these physical constants , the dimension of the magnetic field is $[B] = [e]^{\alpha}\left[m_e\right]^{\beta}[h]^{\gamma}[k]^{\delta}$. The value of $\alpha + \beta + \gamma + \delta$ is ________.

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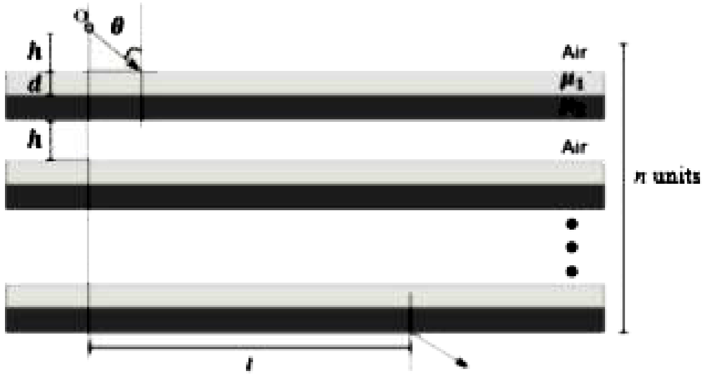
5. Consider a configuration of n identical units , each consisting of three layers . The first layer is a column of air of height $h = \frac{1}{3}$ cm , and the second and third layers are of equal thickness d = $\frac{\sqrt{3} - 1}{2} cm$, and the refractive indices $\mu_1 = \sqrt{\frac{3}{2}}$ and $\mu_2 = \sqrt{3}$, respectively . A light source O is placed on the top of the first unit , as shown in the figure .A ray of light from O is incident on the second layer of the first unit at an angle of $\theta = 60^{\circ}$ to the normal . For a specific value of n , the ray of light emerges from the bottom of the configuration at a distance $l = \frac{8}{\sqrt{3}}$ cm , as shown in the figure . The values of n is ___.



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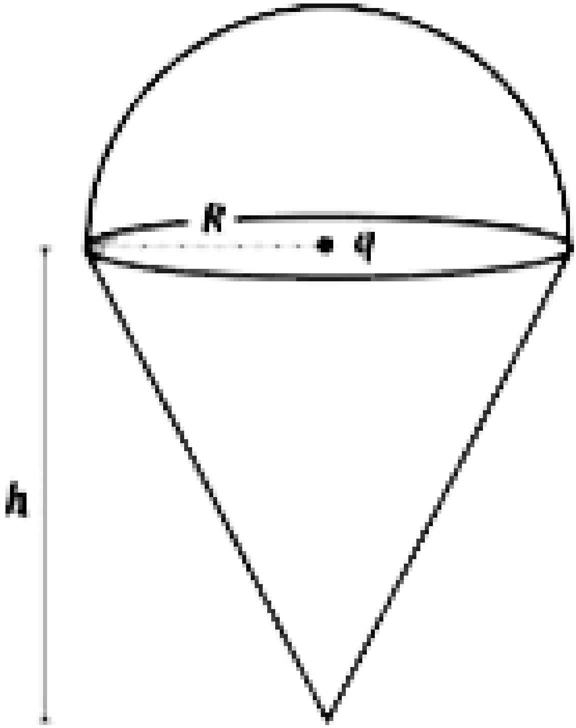
6. A charge q is surrounded by a closed surface consisting of an inverted cone of height h and base radius R , and a hemisphere of radius R as shown in the figure . The electric flux through the conical surface is $\frac{n\,q}{6\varepsilon_0}$ (

in SI units). The value of n is _____.



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7. On a frictionless horizontal plane , a bob of mass m = 0.1 kg is attached to a spring with natural length $l_0 = 0.1$ m . The spring constant is $k_1 = 0.009 Nm^{-1}$ when the length of the spring $l > l_0$ and is $k_2 = 0.016 Nm^{-1}$ when $l < l_0$ .Initially the bob is released from l = 0.15 m

.Assume that Hooke's law remains valid throughout the motion . If the time period of the full oscillation is T =$(n\pi)$ s, then the integer closest to n is ____.

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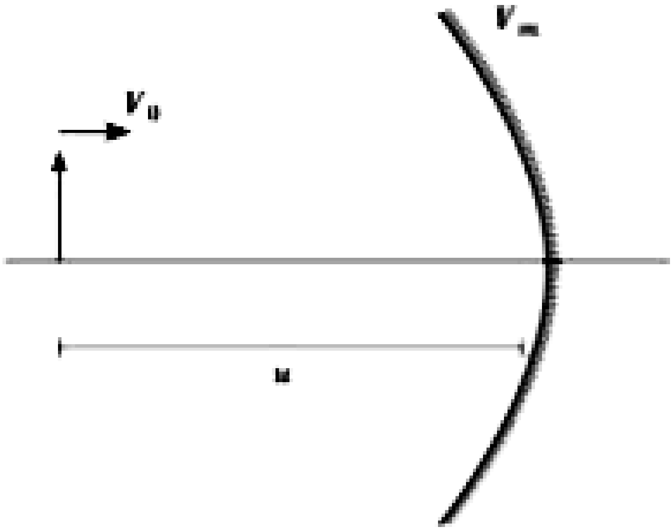
8. An object and a concave mirror of focal length f = 10 cm both move along the principal axis of the mirror with constant speeds . The object moves with speed $V_0 = 15 cms^{-1}$ towards the mirror with respect to a laboratory frame . The distance between the object and the mirror at a given moment is denoted by u . When u = 30 cm , the speed of the mirror V_m is such that the image is instaneously at rest with respect to the laboratory frame , and the object forms a real image .The magnitude of

V_m is ______ cm s^{-1}.



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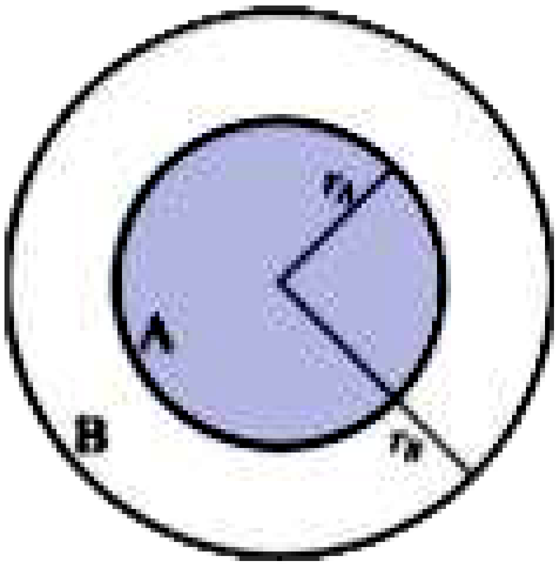
PHYSICS (SECTION 2)

1. In the figure, the inner (shaded) region A represents a sphere of radius $r_A = 1$, within which the electrostatic charge density varies with the radial distance r from the center as $\rho_A = kr$, where k is positive. In the spherical shell B of outer radius r_B, the electrostatic charge density varies as $\rho_\beta = \frac{2k}{r}$. Assume that dimensions are taken care of .All physical quantities are in their SI units .



Which of the following statements (s) is (are) correct ?

A. If $r_B = \sqrt{\frac{3}{2}}$,then the electric field is zero everywhere outside B.

B. If $r_B = \frac{3}{2}$,then the electric potential just outside B is $\frac{k}{\varepsilon_0}$.

C. If $r_B = 2$, then the total charge of the configuration is $15\pi k$

D. If $r_B = \frac{5}{2}$, then the magnitude of the electric field just outside B is $\frac{13\pi k}{\varepsilon_0}$.

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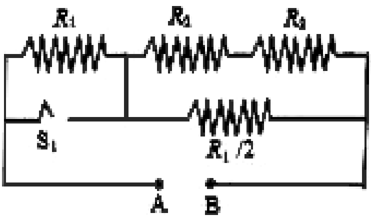
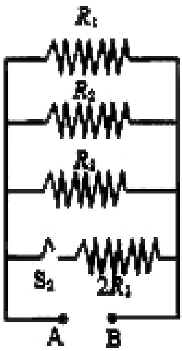
2. In Circuit-1 and Circuit-2 shown in the figures $R_1 = 1\Omega, R_2 = 2\Omega$ and $R_3 = 3\Omega P_1$ and P_2 are the power dissipations in Circuit-1 and Circuit-2 when the switches S1 and S2 are in open conditions, respectively . Q_1 and Q_2 are the power dissipations in Circuit-1 and Circuit-2 when the switches S_1 and $S_2$are in closed conditions, respectively.



Circuit-1



Circuit-2

Which of the following (s) is (are) correct ?

A. When a voltage source of 6 ? is connected across A and B in both circuits$P_1 < P_2$ s

B. When a constant current source of 2 ??? is connected across A and B in both circuits,$P_1 > P_2$

C. When a voltage source of 6 ? is connected across A and B in Circuit-$1Q_1 > P_1$

D. When a constant current source of 2 ??? is connected across A and B in both circuits,$Q_2 < Q_1$

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3. A bubble has surface tension S. The ideal gas inside the bubble has ratio of specific heats $\gamma = \frac{5}{3}$ .The bubble is exposed to the atmosphere and it always retains its spherical shape. When the atmospheric pressure is P_{a_1} the radius of the bubble is found to be r_1 and the temperature of the enclosed gas is T_1. When the atmospheric pressure is P_{a2} ,the radius of the bubble and the temperature of the enclosed gas are r_2 and T_2

,respectively .

Which of the following statement(s) is(are) correct?

A. If the surface of the bubble is a perfect heat insulator, then $\left(\frac{r_1}{r_2}\right)^5 = \frac{P_{a2} + \frac{2S}{r_2}}{P_{a1} + \frac{2S}{r_1}}$.

B. If the surface of the bubble is a perfect heat insulator, then the total internal energy of the bubble including its surface energy does not change with the external atmospheric pressure

C. If the surface of the bubble is a perfect heat conductor and the change in atmospheric temperature is negligible, then $\left(\frac{r_1}{r_2}\right)^3 = \frac{P_{a2} + \frac{4S}{r_2}}{P_{a1} + \frac{4S}{r_1}}$

D.) If the surface of the bubble is a perfect heat insulator, then $\left(\frac{T_2}{T_1}\right)^{\frac{5}{2}} = \frac{P_{a2} + \frac{4S}{r_2}}{P_{a1} + \frac{4S}{r_1}}$

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4. A disk of radius R with uniform positive charge density σ is placed on the xy plane with its center at the origin. The Coulomb potential along the z-axis is

$$V(z) = \frac{\sigma}{2\varepsilon_0}\left(\sqrt{R^2 + z^2} - z\right).$$

A particle of positive charge ? is placed initially at rest at a point on the z axis with ?$z = z_0$ and $z_0 > 0$. In addition to the Coulomb force, the particle experiences a vertical force $\vec{F} = -c\hat{k}$ with $c > 0$. Let$\beta = \frac{2c\varepsilon_0}{q\sigma}$ Which of the following statement(s) is(are) correct?

A. For $\beta = \frac{1}{4}$ and $z_0 = \frac{25}{7}$, the particle reaches the origin

B. For $\beta = \frac{1}{4}$ and $z_0 = \frac{3}{7}$ R , the particle reaches the origin.

C. For $\beta = \frac{1}{4}$ and $z_0 = \frac{R}{\sqrt{3}}$ the particle returns back to $z = z_0$

D. For $\beta > 1$ and $z_0 > 0$,the particle always reaches the origin.

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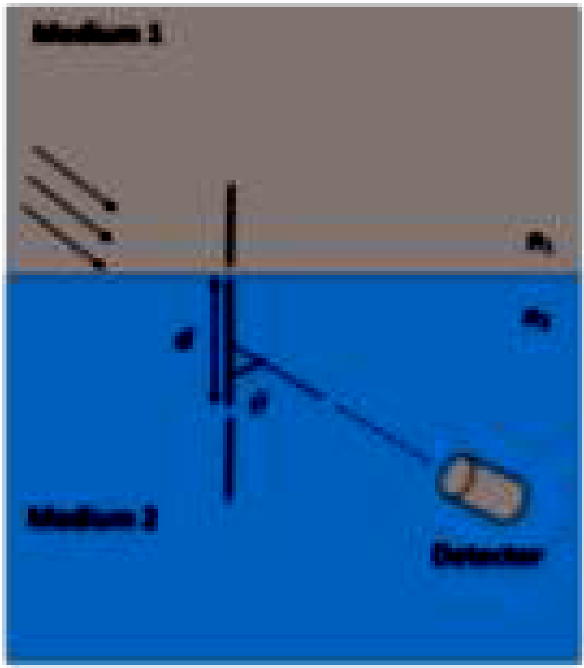
5. A double slit setup is shown in the figure. One of the slits is in medium 2 of refractive index?n_2. The other slit is at the interface of this medium with another medium 1 of refractive index$n_1\left(\neq n_2\right)$. The line joining the slits is perpendicular to the interface and the distance between the slits is ?. The slit widths are much smaller than d. A monochromatic parallel beam of light is incident on the slits from medium 1. A detector is placed in medium 2 at a large distance from the slits, and at an angleθ ? from the line joining them, so that ?θ equals the angle of refraction of the beam. Consider two approximately parallel rays from the slits received by the detector.



Which of the following statement(s) is(are) correct?

A. The phase difference between the two rays is independent of ?.

B. The two rays interfere constructively at the detector

C. The phase difference between the two rays depends on n_1 but is independent of n_2.

D. The phase difference between the two rays vanishes only for certain values of ? and the angle of incidence of the beam, with θ being the corresponding angle of refraction.

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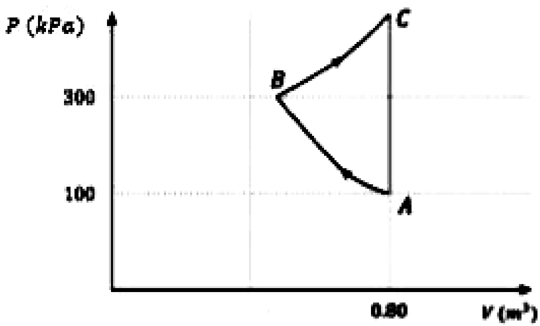
6. In the given P-V diagram, a monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is is first compressed adiabatically from state A to state B. Then it expands isothermally from state B to state C. [Given $\left(\frac{1}{3}\right)^{0.6} \cong 0.5, In2 \cong 0.7$]



Which of the following statement(s) is(are) correct?

A. The magnitude of the total work done in the process $A \rightarrow BC$ is 144 kJ.

B. The magnitude of the work done in the process $B \rightarrow C$ is 84 kJ .

C. The magnitude of the work done in the process $A \rightarrow B$ is 60 kJ .

D. The magnitude of the work done in the process $C \rightarrow A$ is zero .

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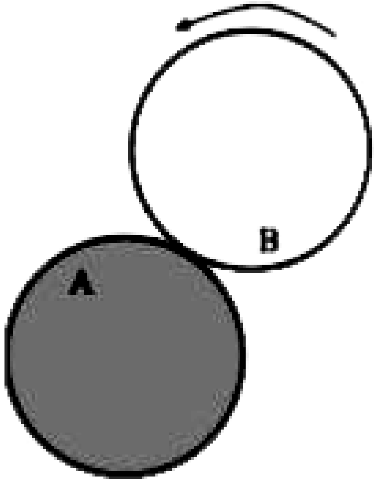
PHYSICS (SECTION 3)

1. A flat surface of a thin uniform disk A of radius R is glued to a horizontal table. Another thinuniform disk B of mass M and with the same radius R rolls without slipping on the circumference of A, as shown in the figure. A flat surface of B also lies on the plane of the table. The center of mass of B has fixed angular speed ω about the vertical axis passing through the center of A. The angular momentum of B is $nM\omega R^2$

with respect to the center of A. Which of the following is the value of n?



A. 2

B. 5

C. $\frac{7}{2}$

D. $\frac{9}{2}$

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2. When light of a given wavelength is incident on a metallic surface, the minimum potential needed to stop the emitted photoelectrons is 6.0 V. This potential drops to 0.6 V if another source with wavelength four times that of the first one and intensity half of the first one is used. What are the wavelength of the first source and the work function of the metal, respectively? $\left[\text{Take}\frac{hc}{e} = 1.24 \times 10^{-6}\ \text{J m C}^{-1}\right]$

A. $1.72 \times 10^{-7}m, 1.20eV$

B. $1.72 \times 10^{-7}m, 5.60eV$

C. $3.78 \times 10^{-7}m, 5.60eV$

D. $3.78 \times 10^{-7}m, 1.20eV$

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3. Area of the cross-section of a wire is measured using a screw gauge. The pitch of the main scale is0.5 mm. The circular scale has 100 divisions and for one full rotation of the circular scale, the mainscale shifts by two divisions. The measured readings are listed below.

Measurement condition	Main scale reading	Circular scale reading
Two arms of gauge touching each other without wire	0 division	4 divisions
Attempt-1: With wire	4 divisions	20 divisions
Attempt-2: With wire	4 divisions	16 divisions

What are the diameter and cross-sectional area of the wire measured using the screw gauge?

A. 2.22 ± 0.02 mm, $\pi(1.23 \pm 0.02)\text{mm}^2$

B. 2.22 ± 0.01mm, $\pi(1.23 \pm 0.01)\ \text{mm}^2$

C. $2.14 \pm 0.02\ \text{mm}, \pi(1.14 \pm 0.02)\ \text{mm}^2$

D. $2.14 \pm 0.01\ \text{mm}, \pi(1.14 \pm 0.01)\ \text{mm}^2$

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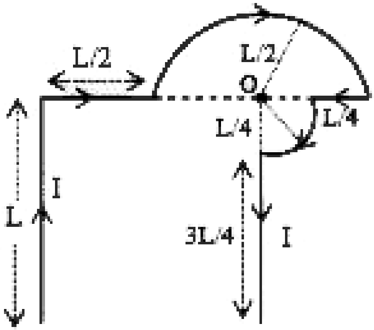
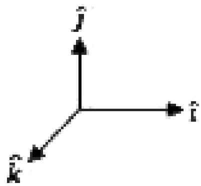
4. Which one of the following options represents the magnetic field $\vec{B}$ at O due to the current flowing in the given wire segments lying on the xy plane?





A. $\vec{B} = \frac{-\mu_0 I}{L}\left(\frac{3}{2} + \frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

B. $\vec{B} = -\frac{\mu_0 l}{L}\left(\frac{3}{2} + \frac{1}{2\sqrt{2}\pi}\right)\hat{k}$

C. $\vec{B} = \frac{-\mu_0 I}{L}\left(1 + \frac{1}{4\sqrt{2}\pi}\right)\hat{k}$

D. $\vec{B} = \frac{-\mu_0 I}{L}\left(1 + \frac{1}{4\pi}\right)\hat{k}$

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PHYSICS (SECTION-1)

1. Two spherical stars A and B have densities ρ_A and ρ_B , respectively . A and B have the same radius , and their masses M_A and M_B are related by $M_B = 2M_A$. Due to an interaction process , star A loses some of its mass , so that its radius is halved , while its spherical shape is retained , and its density remains ρ_A . The entire mass lost by A is deposited as a thick spherical shell on B with the density of the shell being ρ_A . if υ_A and υ_B are the escape velocities from A and B after the interaction process , the ratio $\frac{\upsilon_B}{\upsilon_A} = \sqrt{\frac{10n}{15^{1/3}}}$. the value of n is _____.

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2. The minimum kinetic energy needed by an alpha particle to cause the nuclear reaction ${}_{7}^{16}N + {}_{2}^{4}He \rightarrow {}_{1}^{1}H + {}_{8}^{19}O$ in a laboratory frame is n (in MeV) . Assume that ${}_{7}^{16}N$ is at rest in the laboratory frame . The masses of ${}_{7}^{16}N, {}_{2}^{4}He, {}_{1}^{1}H$ and ${}_{8}^{9}O$ can be taken to be 16.006 u , 4.003 u , 1.008 u and 19.003 u respectively where 1 u = 930 $MeVc^{-2}$. The value of n is ___

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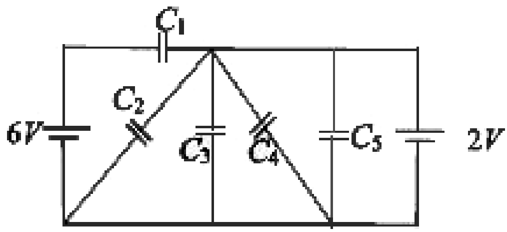
3. In the following circuit $C_1 = 12\mu F, C_2 = C_3 = 4\mu F$ and $C_4 = C_5 = 2\mu F$.

The charge stored in C_3 is ____ μC



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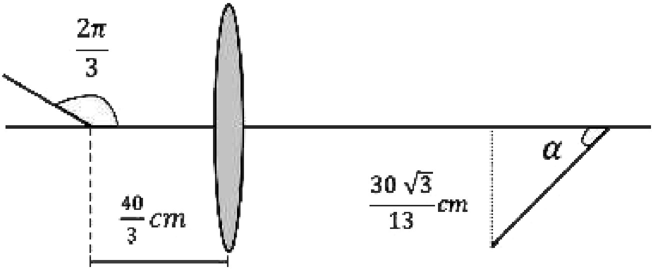
4. A rod of length 2 cm makes an angle $\frac{2\pi}{3}$ rad with the principal axis of a thin convex lens. The lens has a focal length of 10 cm and is placed at a distance of $\frac{40}{3} cm$ from the object as shown in the figure . The height of the image is $\frac{30\sqrt{3}}{13} cm$ and the angle made by it with respect to the principal axis is α rad . The value of α is $\frac{\pi}{n}$ rad , where n is ____.



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5. At time t=0 ,a disk of radius 1 m starts to roll without slipping on a horizontal plane with and angular acceleration of $\alpha = \frac{2}{3}\text{rad } s^{-2}$. A small stone is stuck to the disk At. T=0 , it is at the contact point of the disk and the plate . Later at time $t = \sqrt{\pi s}$. the stone detaches itself and flies off tanngentially from the disk . The maximum height (in m) reaction by the stone measured from the plane is $\frac{1}{2} + \frac{x}{10}$. the value of x is ___ [Take $g = 10ms^{-2}$]

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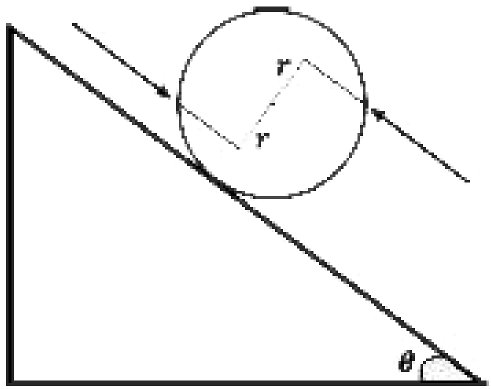
6. A solid sphere of mass 1 kg and radius 1 m rolls without slipping on a fixed inclined plane with an angle of inclination $\theta = 30^\circ$ from the horizontal Two forces of magnitude 1 N each , parallel to the incline , act on the sphere , both at distance $r = 0.5m$ from the center of the sphere , as shown in the figure . The acceleration of the sphere down the plane is ____ ms^{-2}. $\left(\text{take} g = 10ms^{-2}.\right)$



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7. Consider an Lc circuit with inductance L=0 0.1 H and capacitance $c = 10^{-3}F$, , Kept on a plane the Area of the circuit is $1m^2$. It is placed in a constant mahnetic field of strength B_0 which is increasing Linearly as B=

$B_0 + \beta t$ with $\beta = 0.04 Ts^{-1}$. The maximum magnitude of the current in the circuit is _____ mA .

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8. A projectile is fixed from horizontal ground with speed v and projection angle θ. When the acceleration due to gravity is g the range of the projectile is d . If at the highest point in its $g' = \frac{g}{0.81}$ then the new range is $d' = nd$. The value of n is ______.

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PHYSICS (SECTION-2)

1. A medium having dielectric constant K > 1 fills the space between the plates of a parallel plate capacitor. The plates have large area, and the distance between them is d. The capacitor is connected to a battery of voltage V, as shown in Figure (a). Now, both the plates are moved by a distance of $\frac{d}{2}$ from their original positions, as shown in Figure(b).

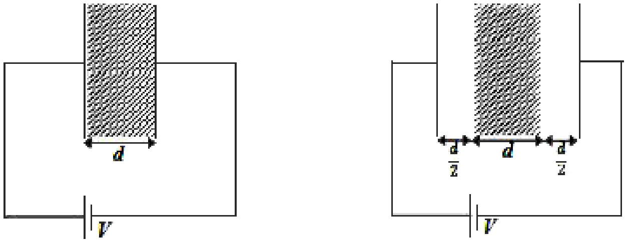

Figure (a) Figure (b)

In the process of going from the configuration depicted in Figure (a) to that in Figure (b), which of the following statement(s) is(are) correct?

A. The electric field inside the dielectric material is reduced by a factor of 2K

B. The capacitance is decreased by a factor of $\frac{1}{k+1}$

C. The voltage bwtween the capacitor plates is increased by a fator of $(k+1)$.

D. `the work done in the process DOES NOT depend on the presence of the dielectric material .

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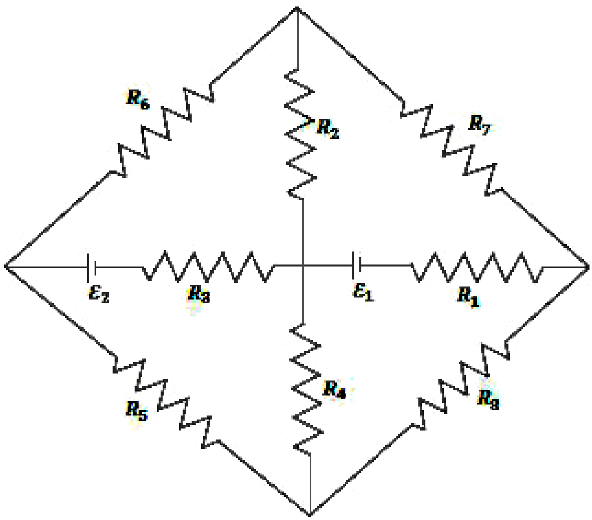
2. The figure shows a circuit having eight resistances of 1Ω reach , labelled R_1 to R_g and two ideal batteries with voltages $\varepsilon_1 = 12V$ and $\varepsilon_2 = 6V$



Which of the following statement(s) is(are) correct?

A. The magnitude of current flowing through R_1 is 7.2 A.

B. The magnitude of current flowing through R_2 is $1.2A$.

C. The magnitude of current flowing through R_3 is 4.8 A.

D. The magnitude of current flowing through R_5 is 2.4 A.

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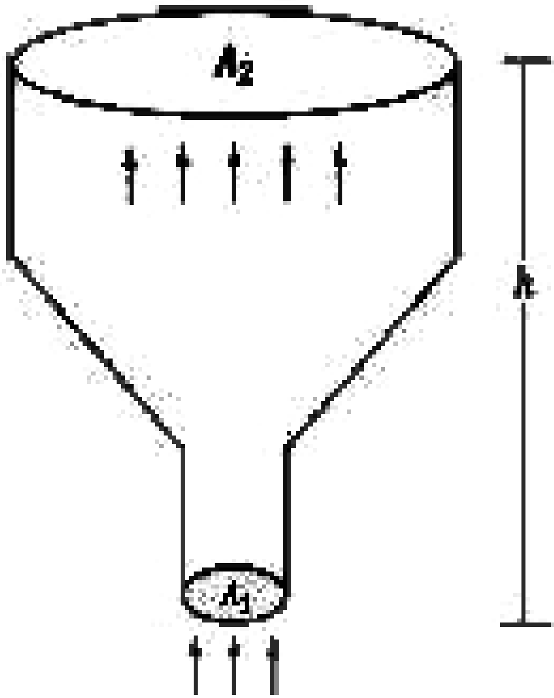
3. An ideal gas of density $\rho = 0.2 kgm^{-3}$ enters a chimney of height h at the rate of $\alpha = 0.8 kgs^{-1}$ from its lower end, and escapes through the upper end as shown in the figure. The cross-sectional area of the lower end is $A_1 = 0.1 m^2$ and the upper end is $A_2 = 0.4 m^2$ The pressure and the temperature of the gas at the lowerend are 600 ?? and 300 ?, respectively, while its temperature at the upper end is 150 k . The chimney is heat insulated so that the gas $\gamma = 2$. Ignore atmospheric pressure .



Which of the following statement(s) is(are) correct?

A. The pressure of the gas at the upper end of the chimney is 300 p a.

B. The velocity of the gas at the lower end of the chimney is 40 ms^{-1}

and at the upper end is $20 ms^{-1}$

C. The height of the chimney is 590 m.

D. The density of the gas at the upper end is 0.05 kgm^{-3}

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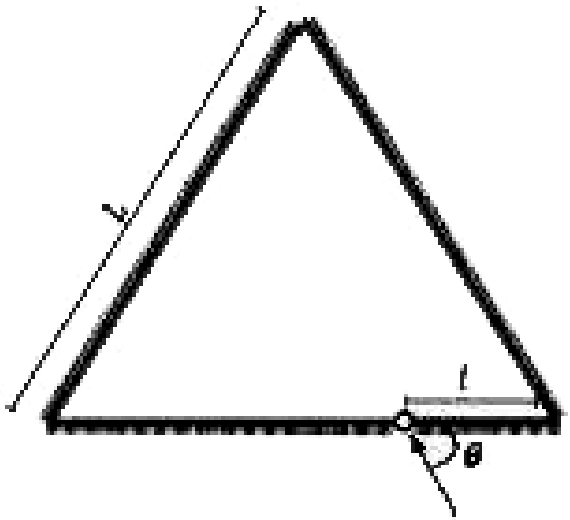
4. Three plane mirrors form an equilateral triangle with each side of length l. There is a small hole at a distance $l > 0$ from one of the corners as shown in the figure . A ray of light is passed through the hole at an angle θ and can only come out through the same hole . The cross section of the mirror configuration and the ray of light lie on the same plane .



which of the following statement (s) and (are) correct ?

A. The ray of light will come out for $\theta = 30^\circ$, for $0 < l < L$.

B. there is an angle for $l = \frac{L}{2}$ at which the ray of light will come out after two reflections

C. The ray of light will NEVER come out for $\theta = 60^\circ$, and $l = \frac{L}{3}$

D. The ray of light will come out for $\theta = 60^\circ$, and $0 < l < \frac{L}{2}$ after six reflections

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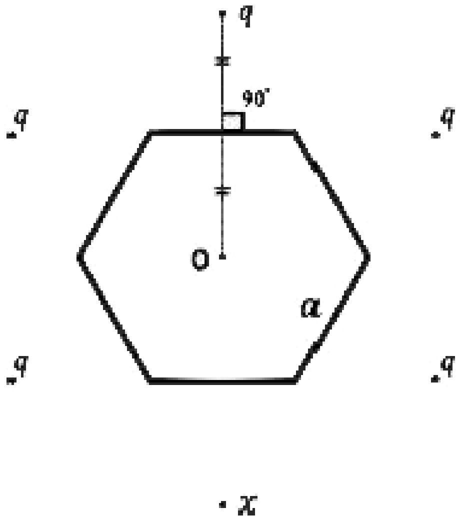
5. Six chargres are placed around a regular hexagon of side length a as shown in the figure . Five of then have charge q, and the remaining one has charge x, The perpendicular from each charge to the nearest hexagon side passes through the center O of the hexagon and is bisected by the side .



which of the following statement(s) is (are) correct in SI units ?

A. When x=q , the magnitude of the electric field at O is units ?

B. When x=-q , the magnitude of the electric field at O is $\frac{q}{6\pi\varepsilon_0 a^2}$

C. when $x = 2q$, the potential at O is $\frac{7q}{4\sqrt{3}\pi\varepsilon_0 a}$

D. When $x = -3q$, the potential at O is - $\frac{3q}{4\sqrt{3}\pi\varepsilon_0 a}$

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6. The binding energy of nucleons in a nucleus can be affected by the pairwise Coulomb repulsion. Assume that all nucleons are uniformly distributed inside the nucleus. Let the binding energy of a proton be E_b^p and the binding energy of a neutron be E_b^n in the nucleus .

which of the following statement(s) is (are) correct ?

A. E_b^p - E_b^n is proportional to Z(Z-1) where Z is the atomic number of the nucleus

B. E_b^p - E_b^n is proportional to $A^{-\frac{1}{2}}$ where A is the mass number of the nucleus

C. E_b^p - E_b^n is positive

D. E_b^p increase if the nucleus undergoes a beta decay emitting a position .

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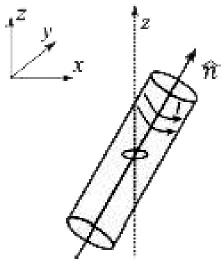
PHYSICS (SECTION-3)

1. A small circular loop of area A and resistance R is fixed on a horizontal xy -plane with the center of the loop always on the axis $\hat{n}$ of a long solenoid . The solenoid has m turns per unit length and carries current I counterclockwise as shown in the figure . THe magnetic field due to the solenoid is in $\hat{n}$ direction, List -I gives time dependences of $\hat{n}$ in terms of a constant angular frequency ω , List - II gives the torques experienced by the circular loop at time $t = \frac{\pi}{6\omega}$ Let $\alpha = \frac{A^2\mu_0^2m^2I^2\omega}{2R}$



List-I	List-II
(I) $\frac{1}{\sqrt{2}}(\sin\omega t\,\hat{j} + \cos\omega t\,\hat{k})$	(P) 0
(II) $\frac{1}{\sqrt{2}}(\sin\omega t\,\hat{i} + \cos\omega t\,\hat{j})$	(Q) $-\frac{\alpha}{4}\hat{i}$
(III) $\frac{1}{\sqrt{2}}(\sin\omega t\,\hat{i} + \cos\omega t\,\hat{k})$	(R) $\frac{3\alpha}{4}\hat{i}$
(IV) $\frac{1}{\sqrt{2}}(\cos\omega t\,\hat{j} + \sin\omega t\,\hat{k})$	(S) $\frac{\alpha}{4}\hat{j}$
	(T) $-\frac{3\alpha}{4}\hat{i}$

which one of the following options is correct ?

A. $I \to Q, II \to P, III \to S, IV \to T$

B. $I \to S, II \to T, III \to Q, IV \to P$

C. $I \to Q, II \to P, III \to S, IV \to R$

D. $I \to T, II \to Q, III \to P, IV \to R$

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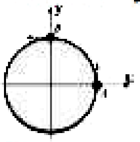
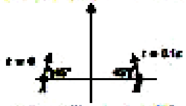
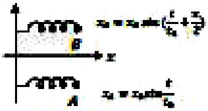
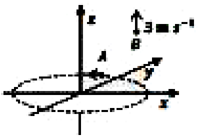
2. List I describes four systems, each with two particles A and B in relative motion as shown in figures. List II gives possible magnitudes of their relative velocities (inms^{-1}) at time $t = \frac{\pi}{3}$ S.

List-I	List-II
(I) A and B are moving on a horizontal circle of radius 1 m with uniform angular speed $\omega = 1$ rad s^{-1}. The initial angular positions of A and B at time $t = 0$ are $\theta = 0$ and $\theta = \frac{\pi}{2}$, respectively.	(P) $\frac{\sqrt{3}+1}{2}$
(II) Projectiles A and B are fired (in the same vertical plane) at $t = 0$ and $t = 0.1$ s respectively, with the same speed $v = \frac{5\pi}{\sqrt{2}}$ m s^{-1} and at 45° from the horizontal plane. The initial separation between A and B is large enough so that they do not collide. ($g = 10$ m s^{-2}).	(Q) $\frac{(\sqrt{3}-1)}{\sqrt{2}}$
(III) Two harmonic oscillators A and B moving in the x direction according to $x_A = x_0 \sin\frac{t}{t_0}$ and $x_B = x_0 \sin\left(\frac{t}{t_0} + \frac{\pi}{2}\right)$ respectively, starting from $t = 0$. Take $x_0 = 1$ m, $t_0 = 1$ s.	(R) $\sqrt{10}$
(IV) Particle A is rotating in a horizontal circular path of radius 1 m on the xy plane, with constant angular speed $\omega = 1$ rad s^{-1}. Particle B is moving up at a constant speed 3 m s^{-1} in the vertical direction as shown in the figure. (Ignore gravity.)	(S) $\sqrt{2}$
	(T) $\sqrt{25\pi^2+1}$









which one of the following options is correct ?

A. $I \rightarrow R, II \rightarrow P, III \rightarrow Q, IV \rightarrow S$

B. $I \rightarrow S, II \rightarrow P, III \rightarrow Q, IV \rightarrow R$

C. $I \rightarrow S, II \rightarrow T, III \rightarrow P, IV \rightarrow S$

D. $I \rightarrow T, II \rightarrow P, III \rightarrow R, IV \rightarrow S$

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3. List I describes thermodynamic processes in four different systems. List II gives the magnitudes (either exactly or as a close approximation) of possible changes in the internal energy of the system due to the process

List-I	List-II
(I) 10^{-3} kg of water at $100^{\circ}C$ is converted to steam at the same temperature, at a pressure of 10^5 Pa. The volume of the system changes from 10^{-6} m^3 to 10^{-3} m^3 in the process. Latent heat of water $= 2250$ kJ/kg.	(P) 2 kJ
(II) 0.2 moles of a rigid diatomic ideal gas with volume V at temperature 500 K undergoes an isobaric expansion to volume 3 V. Assume $R = 8.0$ $J\ mol^{-1}K^{-1}$.	(Q) 7 kJ
(III) One mole of a monatomic ideal gas is compressed adiabatically from volume $V = \frac{1}{3}$ m^3 and pressure 2 kPa to volume $\frac{V}{8}$.	(R) 4 kJ
(IV) Three moles of a diatomic ideal gas whose molecules can vibrate, is given 9 kJ of heat and undergoes isobaric expansion.	(S) 5 kJ
	(T) 3 kJ

Which one of the following options is correct?

A. I - T, II - R, III - S, IV - Q,

B. I - S, II - P, III- T, IV - P,

C. I - P, II - R, III - T, IV - Q.

D. I - Q, II - R, III - S, IV - T,

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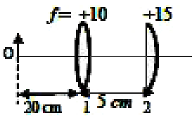
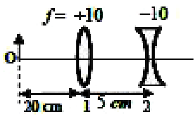
4. List I contains four combinations of two lenses (1 and 2) whose focal lengths (in cm) are indicated in the figures. In all cases, the object is placed 20 cm from the first lens on the left, and the distance between the two lenses is 5 cm. List II contains the positions of the final images.

List-I

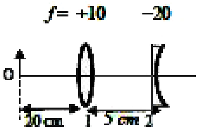
(I)



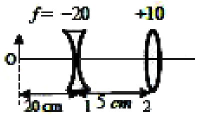
(II)



(III)



(IV)



List-II

(P) Final image is formed at 7.5 cm on the right side of lens 2.

(Q) Final image is formed at 60.0 cm on the right side of lens 2.

(R) Final image is formed at 30.0 cm on the left side of lens 2.

(S) Final image is formed at 6.0 cm on the right side of lens 2.

(T) Final image is formed at 30.0 cm on the right side of lens 2.

Which one of the following options is correct?

A. (I) - P, (II) - R, (III) - Q, (IV) - T

B. (I) - Q, (II) - P, (III) - T, (IV) - S

C. (I) - P, (II) - T, (III) - R, (IV) - Q

D. (I) - T, (II) - S, (III) - Q, (IV) - R

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