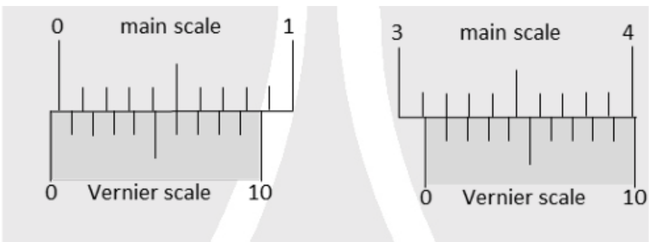
PHYSICS

BOOKS - JEE ADVANCED PREVIOUS YEAR

JEE ADVANCED 2021

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

Answer:

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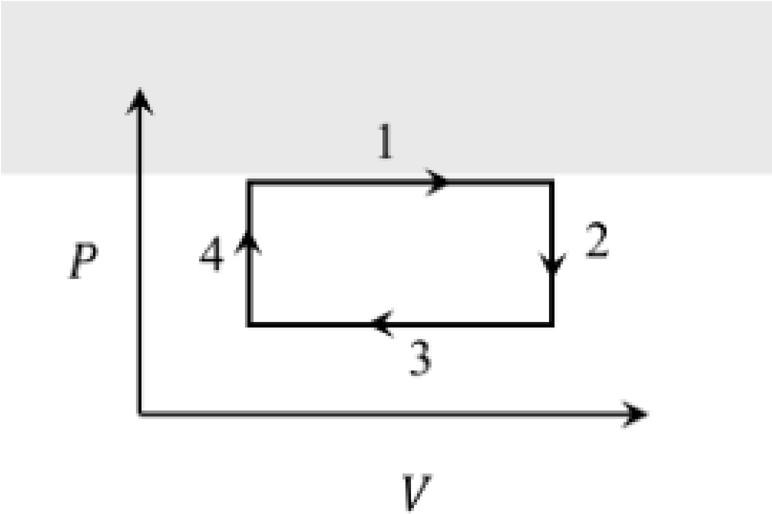
2. An ideal gas undergoes a four step cycle as shown in the P-V diagram below. During this cycle heat is absorbed by the gas in



A. steps 1 and 2

B. steps 1 and 3

C. steps 1 and 4

D. steps 2 and 4

Answer:

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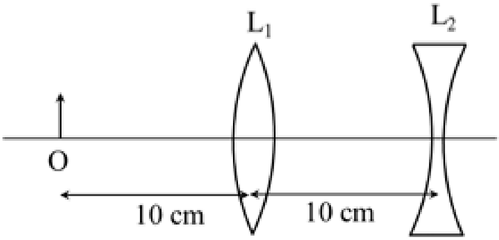
3. An extended object is placed at point O, 10cm in front of a convex lens L1 and concave lens L2 is placed 10 cm behind it as shown in figure. The radii of curvature of all curved surfaces in both the lenses are 20cm. The refractive index of both the lenses is 1.5. The total magnification of this lens 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

Answer:

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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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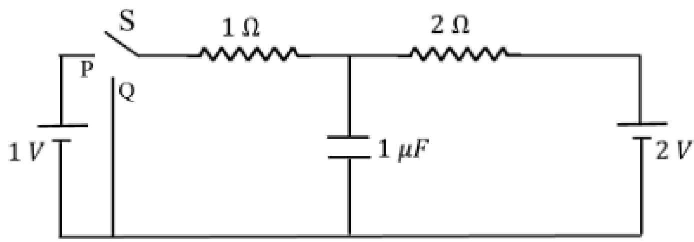
7. In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor become $q1\mu C$. The S is switched to psition Q. After a long time, the charge on the capacitor is $q2\mu C$

. The magnitude of q1 is



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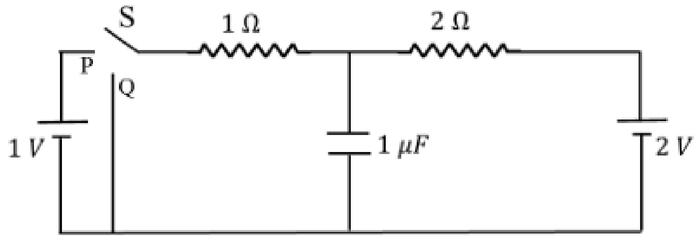
8. In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor become $q1\mu C$. The S is switched to psition Q. After a long time, the charge on the capacitor is $q2\mu C$

. The magnitude of q2 is



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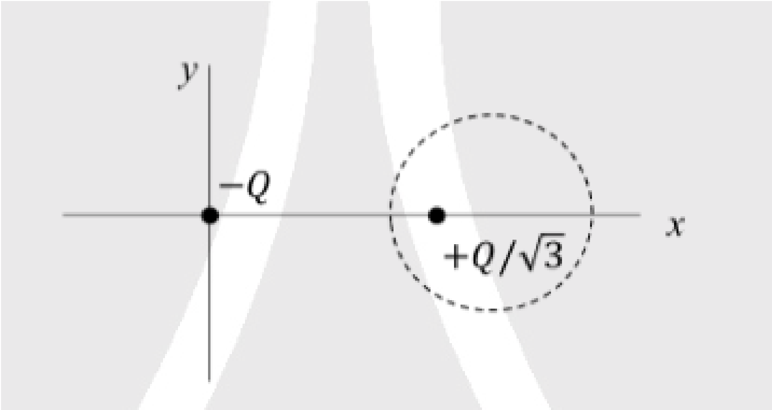
9. Two point charges $-Q$ and $+\frac{Q}{\sqrt{3}}$ are placed in the xy plane at the origin (0,0) and a point (2,0) resp as shown in figure. This results in an equipotential circle of radius R and potential V=0 in the xy plane with its center at

(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

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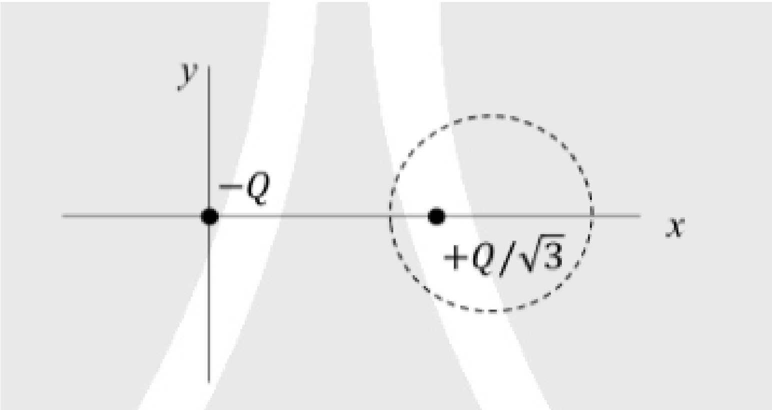

The value of b is ....m

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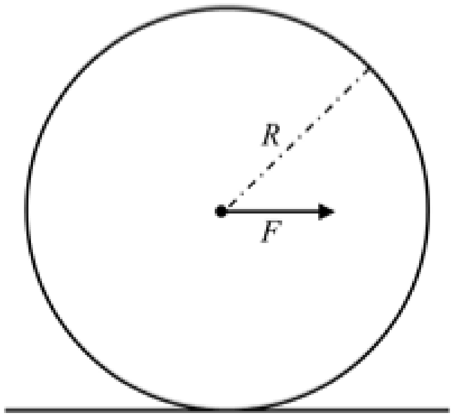
11. A horizontal force F is applied at the centre of mass of a cylindrical object of mass m and radius R, perpendicular to its axis as shown in figure. The coefficient of friction between the object and the ground is μ. The center of mass of the object has an acceleration a. The acceleration due to gravity 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 $\mu m g$

D. For a thin-walled hollow cylinder $a = \frac{F}{2}m$

Answer:

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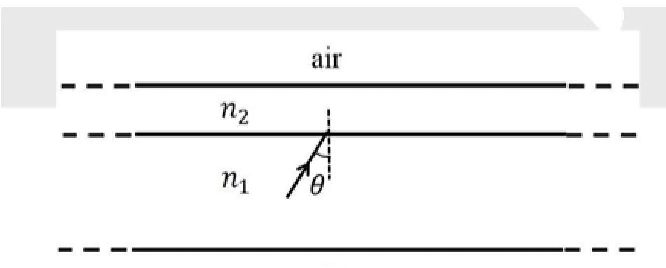
12. A wide slab consisting of two media of refractive indices n_1 and n_2 is placed in air as shown in figure. A ray of light is incident from medium n_1 to n_2 at an angle θ where $\sin(\theta)$ is slightly larger than $\frac{1}{n_1}$. Take refractive index of air as 1. Which of the following statements 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 $\overrightarrow{L}$ and $\overrightarrow{\tau}$ resp. If $\hat{k} = \hat{\imath} x \hat{\jmath}$ then which of the following statements is/are correct?

A. The particle arrives at point (x = l, y = -h)

at time t = 2s

B. $\overrightarrow{\tau} = 2\hat{k}$ when the particle passes

through the point (x = l, y = -h)

C. $\overrightarrow{L} = 4\hat{k}$ when the particle passes

through the point (x = l, y = -h)

D. $\overrightarrow{\tau} = \hat{k}$ when the particle passes

through the point (x = 0, y = -h)

Answer:

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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

Answer:

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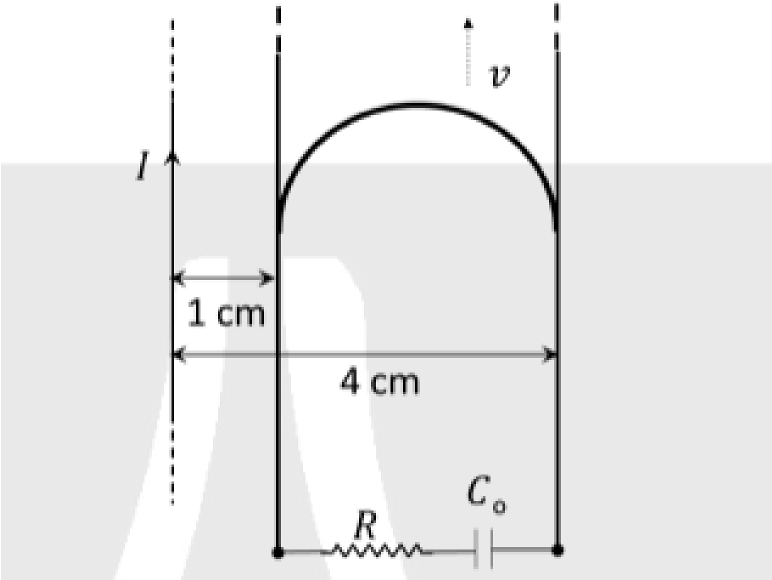
15. A long straight wire carries a current I = 2A. A semi circular conducting rod is placed beside it on two conducting parallel rails of negligible resistance. Both rails are parallel to wire. The wire , the rod, and the railslie in same horizontal plane as shownin figure. Two ends of semi circular 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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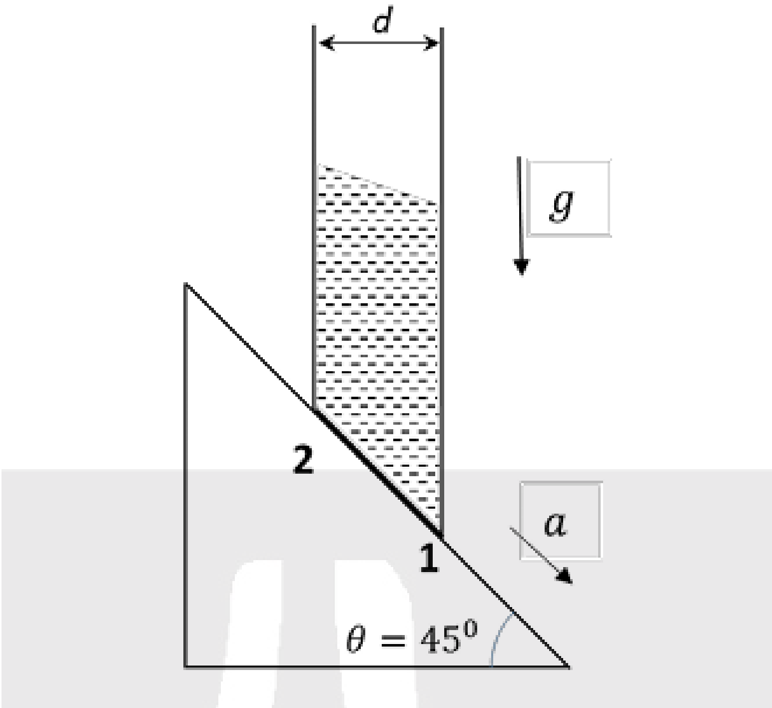
16. A cylindrical tube with its base as shown is filled with water. It is moving down with a constant acceleration a along a fixed inclined plane with angle $\theta = 45^0$ P1 and P2 are pressure points 1 and 2 resp located at base of tube. Let $\beta = \dfrac{P1 - P2}{\rho g d}$. Which statement is true?



A. $\beta = 0$ when $a = \dfrac{g}{\sqrt{2}}$

B. $\beta > 0$ when $a = \dfrac{g}{\sqrt{2}}$

C. $\beta = \frac{sqr(2) - 1}{\sqrt{2}}$ when $a = \frac{g}{2}$

D. $\beta = \frac{1}{\sqrt{2}}$ when $a = \frac{g}{2}$

Answer:

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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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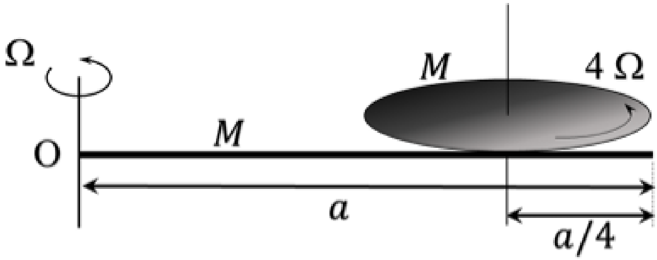
18. A thin rod of mass M and length a is free to rotate in horizontal plane about a fixed vertical axis passing through point O. A thin circular disc of mass M and of radius a/4 is pivoted on this rod with its center at a distance a/4 from the free end so that it can rotate freely about its vertical 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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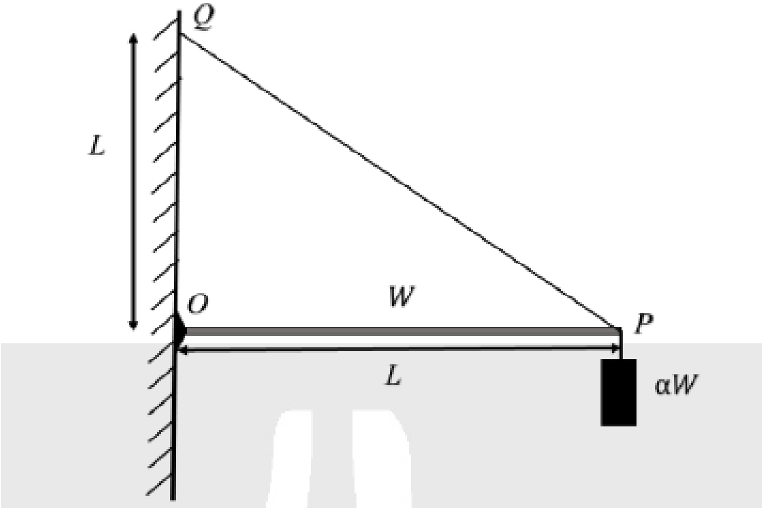
20. One end of a horizontal uniform beam of weight W and length L is hinged on a vertical wall at point O and its other end is supported by a light inextensible rope. The other end of the rope is fixed at point Q at a height L above the hinge at point O. A block of weight αW is attached at the point 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 $\alpha > 1.5$

Answer:

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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 $f_s = 0.5 f_0$

D. $u = 0.5v$ anf $f_s = 1.5 f_0$

Answer:

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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

$$\delta(n) = 2.8x10^{-3}$$

Answer:

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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

Answer:

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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 $\mu = \frac{M_P M_Q}{M_P + M_Q}$

Answer:

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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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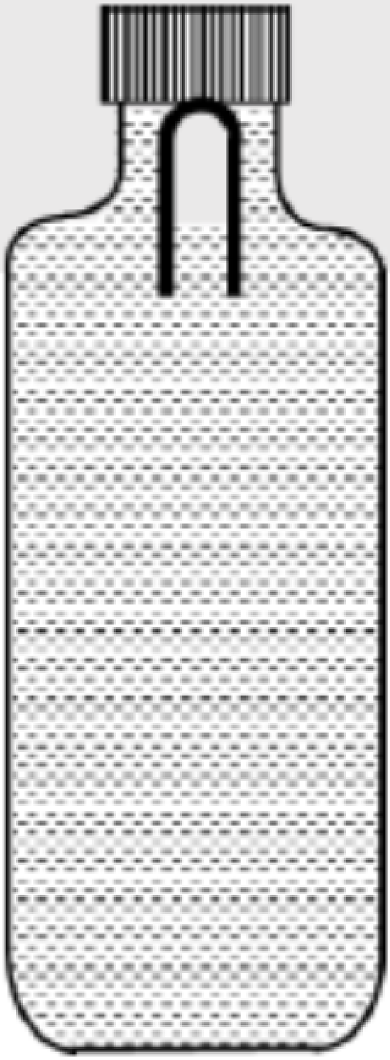
26. A soft plastic bottle filled with water of density 1 gm/cc carries an inverted glass test tube with some air(ideal gas) trapped as shown in the figure. The test-tube has a mass of 5gm and it is made of a thick glass of density 2.5 gm/cc. Initially the bottle is sealed at atmospheric pressure $p_0 = 10^5 Pa$ 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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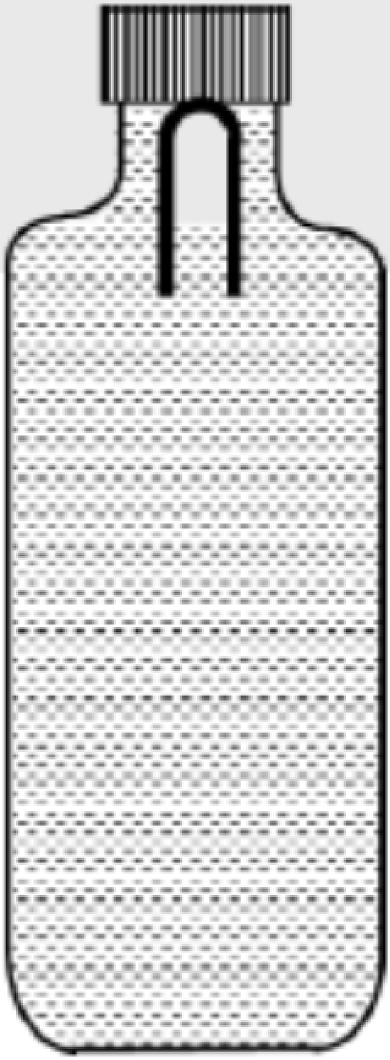

Value of Y is

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28. A pendulum consists of a bob of mass $m = 0.1$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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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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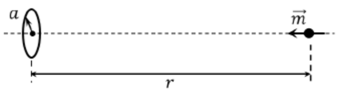
32. A special metal S conducts electricity without any resistance. A closed wire loop made of S does not allow any change in flux through itself by inducting a suitable current to generate a compensating flux. This current gives rise to a magnetic moment which in turn repels the source of magnetic field 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 $\frac{k m_1 m_2}{r^4}$ 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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Paragraph

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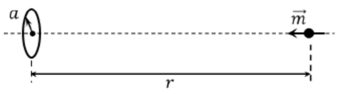

Work done in bringing dipole from infinity to a distance r from center of the loop by given process is proportional to

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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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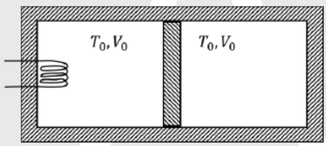

Value of $\frac{T_R}{T_0}$

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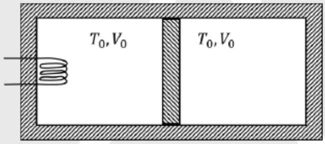
Paragraph

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 $\dfrac{Q}{RT_0}$

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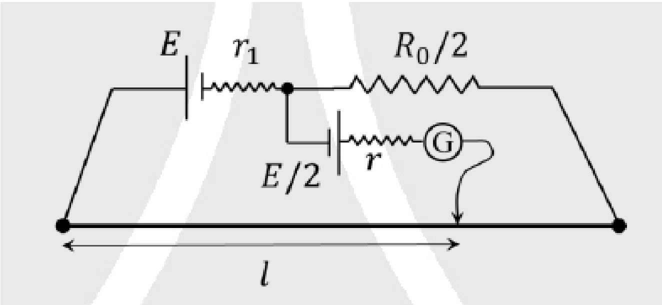
36. In order to measure internal resistance r1 of a cell emf E, a meter bridge of wire resistance $R_0 = 50\Omega$, a resistance $\dfrac{R_0}{2}$

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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