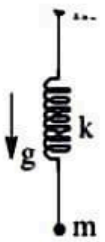
1. A mass m is hung on an ideal massless spring. Another equal mass is connected to the other end of the spring. The whole system is at rest. At t = 0, m is released and the system falls freely under gravity. Assume that natural length of the spring is L_0, its initial stretched length is L and the acceleration due to gravity is g. What is distance between masses as function of time?



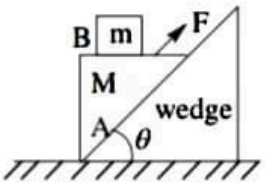
(A) $L_0+(L-L_0)\cos\sqrt{\frac{2k}{m}}t$

(B) $L_0+(L-L_0)\cos\sqrt{\frac{k}{m}}t$

(C) $L_0-2(L+2L_0)\cos\sqrt{\frac{2k}{m}}t$

(D) $L_0+(L-L_0)\sin\sqrt{\frac{2k}{m}}t$

2. Wedge is fixed on horizontal surface. Triangular block A of mass M is pulled upward by applying a constant force F parallel to incline of the wedge as shown in the figure and there is no friction between the wedge and the block A, while coefficient of friction between A and block B of mass m is μ. If there is no relative motion between A and B then frictional force developed between A and B is



(A) $\left[\frac{F+(m+M)g\sin\theta}{(m+M)}\right]m\cos\theta$

(B) μmg

(C) $\left[\frac{F-(m+M)g\sin\theta}{(m+M)}\right]m\cos\theta$

(D) $\mu mg/2$

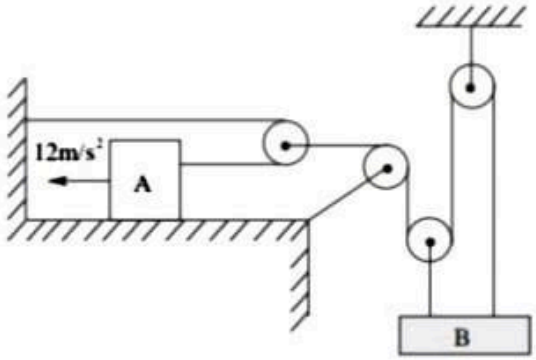
3. Assuming only translational motion of blocks A and B. Find the acceleration of B.

(A) $6m/s^2$

(B) $2m/s^2$

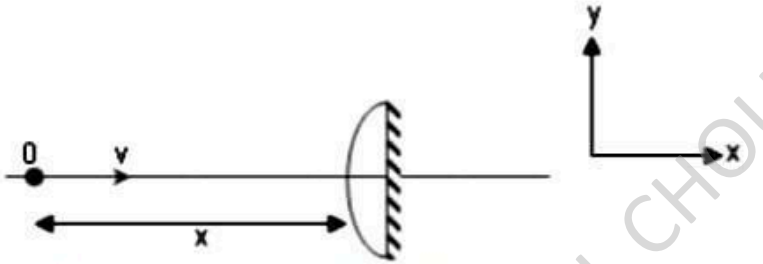
(C) $4m/s^2$

(D) None of these



(One or More than one correct type)

4. When object 'O' moves towards a fixed lens mirror combination, select correct choice/choices:



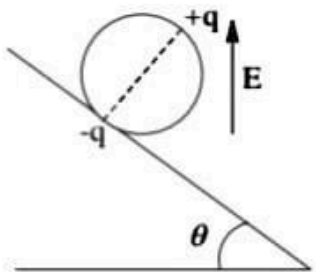
(A) Image moves towards negative x-axis

(B) Speed of image and object may be same

(C) Image may move faster than object

(D) Image may come closer to arrangement

5. Two point charges $+q$ and $-q$ are fixed on diametrically opposite point on the uniform ring, such that $-q$ is at bottom and is in contact with a perfect insulator incline plane. Total mass is equal to m. It remains in equilibrium on the rough inclined plane in the presence of uniform vertical electric field $\vec{E}$. Then



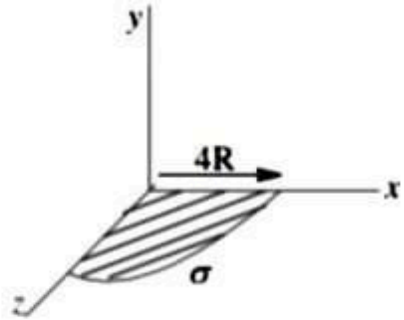
(A) The value of friction force is $mg\sin\theta$

(B) The value of friction force is less than $mg\sin\theta$

(C) The value of electric field is $\dfrac{mg}{2q}$

(D) The value of electric field is $\dfrac{mg\tan\theta}{2q}$

6. Quarter non–conducting disc of radius 4R having uniform surface charge density σ is placed in xz-plane then which of the following is the correct:



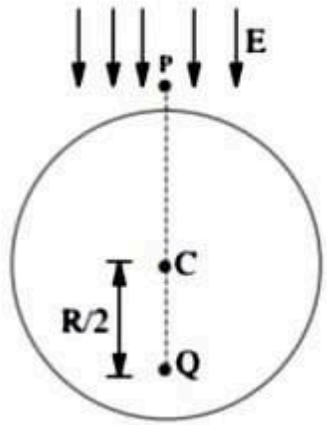
(A) Electric potential at (0, 3R, 0) is $\frac{\sigma R}{4\varepsilon_0}$

(B) Electric potential at (0,0,0) is $\frac{\sigma R}{2\varepsilon_0}$

(C) Electric field at (0, 3E, 0) is symmetric with x and z axis

(D) Electric field intensity at (-4R, 0, -4R) is equally inclined with x and z axis

7. A positive charge q is placed inside a neutral hollow conducting sphere of radius R, as shown in figure. Whole system is placed in uniform external vertical electric field pointing downward (line PCQ is also vertical) then select the correct statement(s) about electric field at point P. Point P is a point of the material inside the conductor.



(A) Electric field due to outer surface of sphere at point P is zero

(B) Magnitude of electric field due to inner surface of sphere at point P is $q/9\pi\varepsilon_0 R^2$

(C) Magnitude of electric field at point P, due to hollow sphere is less than E

(D) Direction of resultant electric field at point P due to charge q and hollow sphere is vertically upward

8. The particle displacement of a travelling longitudinal wave is represented by S = f (x, t). The midpoints of a compression zone and an adjacent rarefaction zone are represented by the letter 'C' and 'R'. Which of the following is true?

(A) $\left|\frac{\partial S}{\partial x}\right|_C = \left|\frac{\partial S}{\partial x}\right|_R$

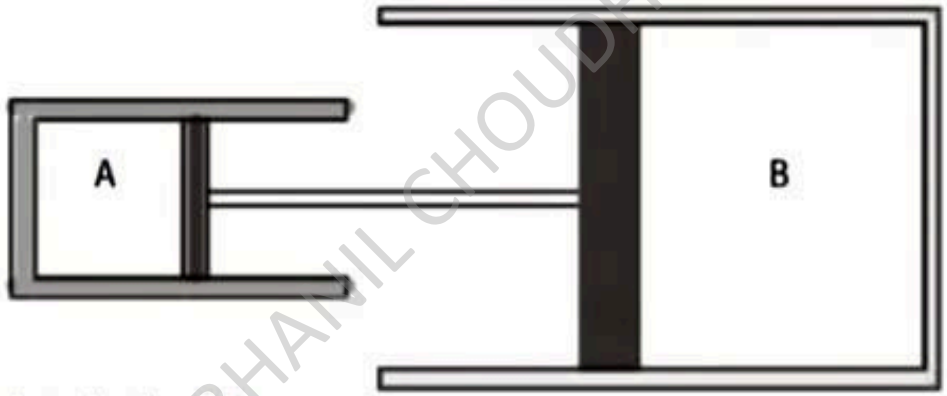
(B) $\left|\frac{\partial S}{\partial t}\right|_C = \left|\frac{\partial S}{\partial t}\right|_R = 0$

(C) $(\text{pressure})_C - (\text{pressure})_R = 2\left|\frac{\partial S}{\partial x}\right|_C .(\text{bulk modulus of air})$

(D) Particles of air are stationary mid-way between 'C' and 'R'.

Paragraph for Questions 9 & 10

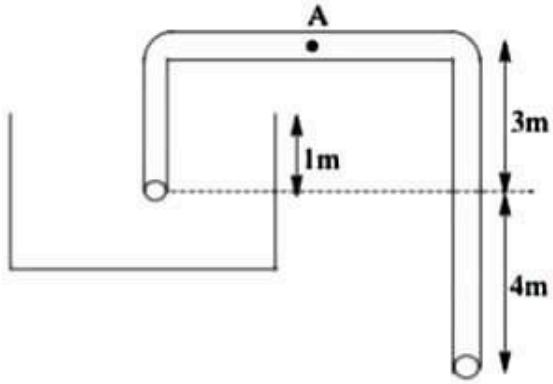
Two fixed and horizontal cylinders A and B having pistons (both massless) of cross sectional area 100 cm^2 and 200 cm^2 respectively, are connected by massless rod. The piston can move freely without friction. The cylinder A contains 100 gms of an ideal gas (γ = 1.5) at pressure $10^5 N/m^2$ and temperature T_0. The cylinder B contains identical gas at same temperature T_0 but has different mass. The piston are held at the state such that volume of gas in cylinder A and cylinder B are same and is equal to $10^{-2} m^3$. The walls and piston of cylinder A are thermally insulated where as gas in cylinder B is maintained at constant temperature T_0. The whole system is in vacuum. Now the pistons are slowly released and they move towards left and mechanical equilibrium is reached at the state when the volume of gas in cylinder A becomes $25 \times 10^{-4}\ m^3$.



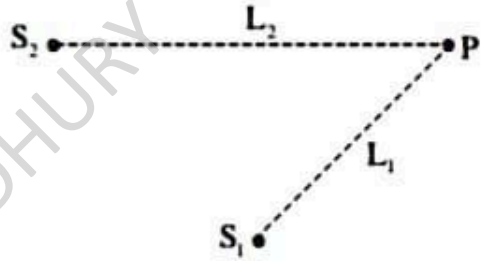
9. The mass of gas in cylinder B is
   (A) 200 gms
   (B) 600 gms
   (C) 500 gms
   (D) 1 kg

10. The change in internal energy of gas in cylinder A is :
   (A) 2000 J
   (B) 1000 J
   (C) 500 J
   (D) 3000 J

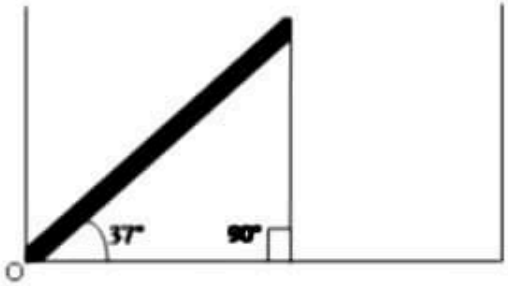
11. A liquid of specific gravity 0.5 is filled in a large container shown in figure. Area of cross section of tube is negligible as compare to the area of cross section of container then the magnitude of gauge pressure at point A is given by $\frac{x}{20}$ atm then x is :



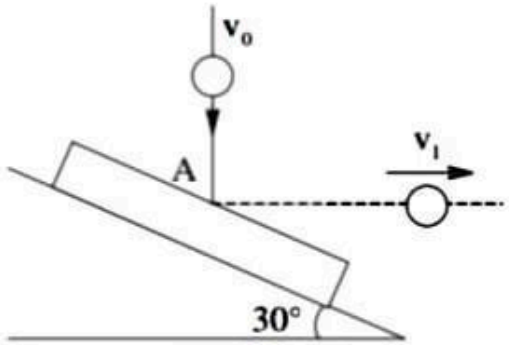
12. Two sound sources shown in the figure vibrate in phase. By moving S_1 along PS_1 consecutive minima are heard when L_1-L_2 has values, 20cm, 60cm and 100 cm. If the frequency of sound source is $\frac{1700}{n}$ Hz. Then find the value of n:
[Speed of sound is 340 m/s]



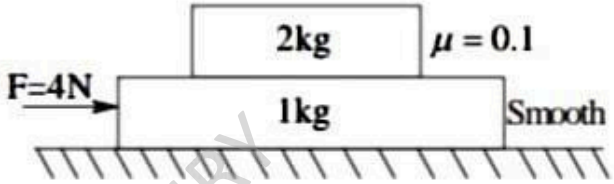
13. A cylindrical rod of uniform cross section, is attached at O in a water tank. The linear mass density of rod is $\lambda_0 x$, where x is distance of the element of the rod, from end O as shown in figure. If the tension in string is given by $\frac{10^4}{P}$ N then P is (Length of rod 1m, radius of area of cross section is $\frac{1}{\sqrt{\pi}}$ m, $\rho_{water}=1000 kg\,m^{-3}$, $g=10 ms^{-2}$, $\lambda_0=10^3$ in S.I. unit)



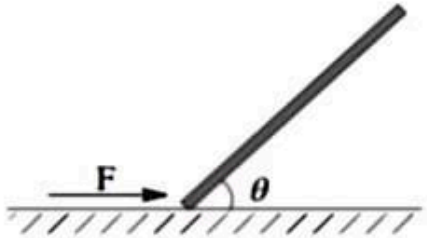
14. A steel ball falling vertically strikes a fixed rigid plate A with velocity v_0 and rebounds horizontally as shown. Assuming surface to be same and the effect of gravity on motion of ball to be neglected. If the coefficient of the restitution for the ball is 'e' then the value of $\frac{1}{e}$ is:



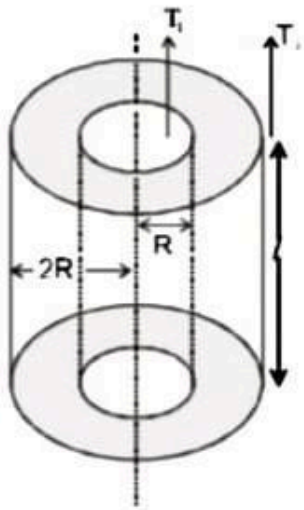
15. 2 kg block is kept on 1 kg block as shown. Both blocks are initially at rest. The friction between 1 kg block and fixed surface is absent and the coefficient of friction between 2kg block and 1 kg block is $\mu = 0.1$. A constant horizontal force F=4 N is applied on 1 kg block. If the work done by the friction on 1 kg block in 2s is – XJ, then find the value of X.



16. A force F is applied to a uniform, thin rod of mass 4 kg and length $\ell = 50$ cm. The rod has pure translational motion in the vertical plane along a smooth, horizontal surface as shown. If F = 60 N, the angle θ for translation of rod in the given orientation comes to be $\theta = \tan^{-1}\left(\frac{2}{X}\right)$. Find X.

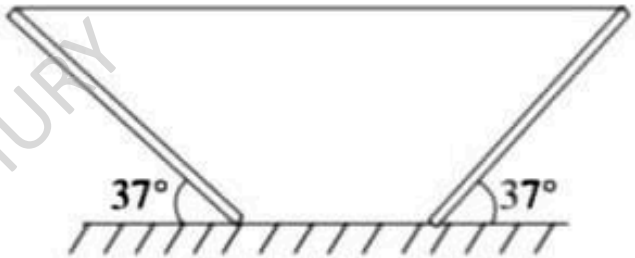


17. Inner surface of a cylindrical shell of length ℓ and of material of thermal conductivity k is kept at constant temperature T_1 and outer surface of the cylinder is kept at constant temperature T_2 such that $(T_1 > T_2)$ as shown in figure. Heat flows from inner surface to outer surface radially outward. Inner and outer radii of the shell are R and 2R respectively. Due to lack of space this cylinder has to be replaced by a smaller cylinder of length $\frac{\ell}{2}$ inner and outer radii $\frac{R}{4}$ and R respectively and thermal conductivity of material nk. If rate of radially outward heat flow remains same for same temperatures of inner and outer surface i.e. T_1 and T_2, then find the value of n.

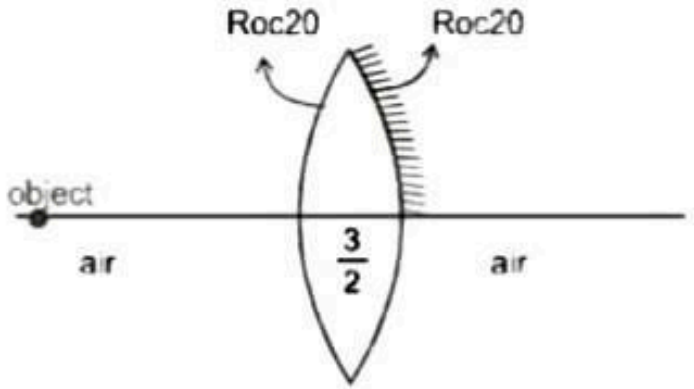


18. In a certain hypothetical radioactive decay process, species A decays into species B and species B decays
in to species C according to the given reactions.
A→2B + particles + energy
B→3C + particles + energy
The decay constant for species A is $\lambda_1 = 1\ sec^{-1}$ and that for species B is $\lambda_2 = 100\ sec^{-1}$. Initially 10^4 moles of species of A were present, while there were none of B and C. It was found that species B reaches its maximum number at a time t_0 = 2 ln (10) sec. Calculate the value of maximum number of moles of B.

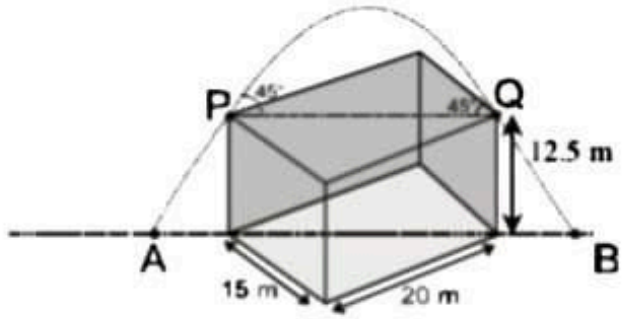
19. Two uniform identical rods of same mass are tied together with the help of a string and balanced as shown in the figure. The minimum coefficient of friction for which the system will remain in equilibrium in the position is $\frac{2}{x}$. The value of 'x' is



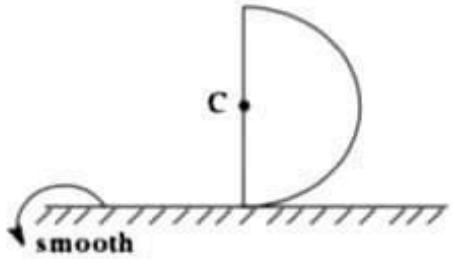
20. Distance between two images formed by upper and lower part of the point object placed at 30 cm from given lens is (60 + x) cm, then the value of x is:



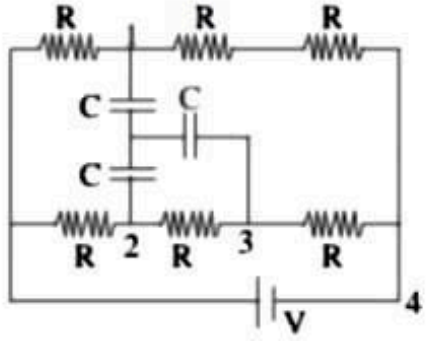
21. A commander fires a shell at certain angle of projection from 'A' which clears the building (cuboid) of dimensions 20 × 15 × 12.5 m^3 in its diagonal plane. Shell just clears the roof diagonally at points P and Q and falls on the other side of the building at B, and makes 45° angle with horizontal at P and Q as shown in the figure. If the range AB of the shell is $N\times\sqrt{3}$ metre then find N. ($g = 10\ m/s^2$)



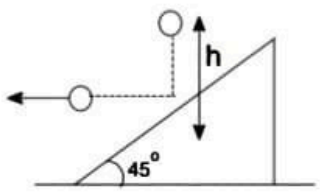
22. If angular acceleration of the uniform disc just after release from rest position shown in figure is $\frac{8\pi g}{NR}$, then calculate N. (C is centre of semi-circular disc.) ($\pi^2 = 10$)



23. In the show circuit, all three capacitor are identical and have capacitance $C\mu F$ each. Each resistor has resistance of $R\Omega$. An ideal cell of emf V volts is connected as shown. If the magnitude of potential difference across capacitor C_3 in steady state is $\frac{a}{b}V$ then value of $a \times b$ is:



1. A body dropped over a fixed rough inclined plane of inclination 45° from height h. If after collision velocity of body becomes horizontal then co-efficient of restitution if co-efficient of friction is 1/2.



(A) $\frac{1}{2}$ (B) $\frac{1}{3}$

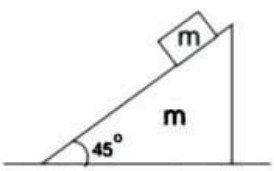
(C) $\frac{1}{4}$ (D) 1

2. A body is moving along straight line such that it velocity represented through x and velocity gradient is represented through y then relation between x and y for movement under constant acceleration may be

(A) xy=const (B) $x^2 - y^2 = const$

(C) $x^2 + y^2 = const$ (D) $y^2 = 4ax$

3. A block having mass m is placed over a inclined plane of same mass and inclination 45° if co-efficient of friction between all surface is same and it is μ. Now system set free to move then



(A) For $\mu > 1$ block over incline will move but wedge don't

(B) For $0.2 < \mu < 1$ block will move but wedge will not

(C) For $\mu = 0.15$ both will move

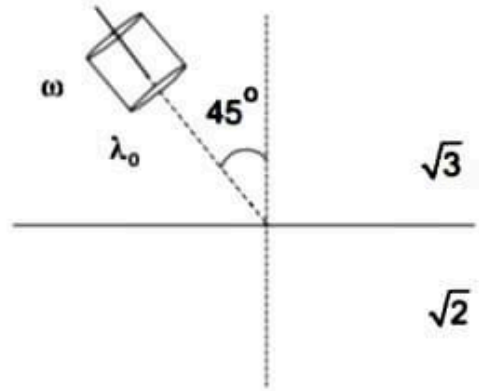
(D) It is not possible to move wedge without moving block over wedge

4. Let 1.0 kg of super cooled water at temp $-10^\circ C$ kept in a container and crushed ice at temp $\theta = -20^\circ C$ kept in another container. How much ice have to add the water so that whole water freezes. Specific heat of water $S_w = 4.2 \times 10^3\ J/kg-k$. Specific heat of ice $S_i = 2.1 \times 10^3\ J/kg-k$. Latent heat of meeting ice $L = 336\ kJ\,kg^{-1}$ meeting point $\theta = 0^\circ C$. Neglecting Heat capacity of vessel and surrounding.

(A) 14 kg (B) 7 kg

(C) 5 kg (D) can't find

5. A Beam of light having wavelength λ_0 and wattage ω falls over a surface separating two medium of refractive index $\sqrt{3}$ *and* $\sqrt{2}$ respectively as shown in figure. Force exerted by beam of light over and along surface are $F_\perp$ *and* $f_\parallel$



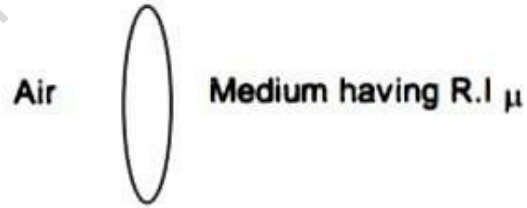
(A) $\frac{(\sqrt{3}-1)}{\sqrt{6}}-\frac{\omega}{C}=F_\perp$

(B) $F_\parallel = 2\sqrt{3}\,\frac{\omega}{C}$

(C) $\frac{(\sqrt{3}+1)}{\sqrt{6}}-\frac{\omega}{C}=F_{\perp r}$

(D) $F_\parallel = 0$

6. An equiconvex lens of focal length 20 cm having a glass of refractive index 3/2 is used in a medium air on left side and another medium having refractive index μ on a right side of lens as shown in figure.



(A) Character of lens will be diversing for $\mu > 2$

(B) Focal length of lens will be 40 cm for $\mu = 4$ and character will be diversing

(C) Object distance and image distance with respect to lens will be same for $\mu = 2$

(D) Character of lens can't be explained

7. A solid metal cylinder rotates with angular speed ω about its axis of symmetry. The cylinder is in a region having uniform magnetic field B along its axis then

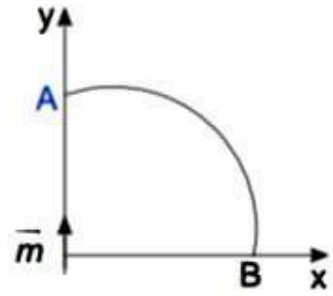
(A) Electric field inside cylinder will be proportional to $\perp r$ distance from axis of rotation if $\omega \neq \frac{eB}{m}$

(B) Electric field, inside cylinder is radially away from axis of rotation of $\omega > \frac{eB}{m}$

(C) Charge density inside the cylinder may be positive, negative or zero accordingly ω and direction of magnetic field

(D) For $\omega = \frac{eB}{m}$ and $\vec{B} \parallel \vec{\omega}$ charge density inside cylinder is zero.

8. A quarter circular conducting ring of large radius R with centre at origin where a magnetic dipole of moment $\vec{m}$ is placed as shown in figure. When the ring rotates at angular velocity ω about the y axis electromotive force induced between its end is



(A) Zero

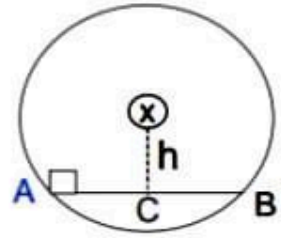
(B) $\frac{\mu_0 m\omega}{2\pi r}$

(C) $\frac{\mu_0 m\omega}{4\pi r}$

(D) $\frac{\mu_0 m\omega}{8\pi r}$

Paragraph for Questions 09 & 10

A small insect having mass m is in rest at one end of a horizontal platform placed inside a circular cage as shown in figure. Circular cage is pivot about its centre and cage inner surface is smooth. Now insect start its motion on platform such that platform and cage is in rest. Radius of cage is R.



9. Time taken by insect to move from A to B on platform

(A) $\pi\sqrt{\frac{h}{g}}$

(B) $2\pi\sqrt{\frac{h}{g}}$

(C) $\left\{\frac{\sqrt{R^2-h^2}}{g}\right\}^{\frac{1}{2}}$

(D) can't find

10. Speed of insect when it passes is

(A) $\sqrt{\frac{gh}{2}}$

(B) $\sqrt{2gh}$

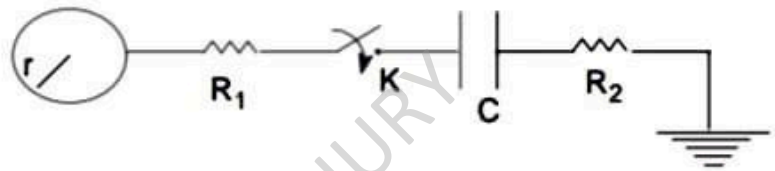
(C) $h\sqrt{\frac{g}{h}}$

(D) $\sqrt{R^2-h^2}\sqrt{\frac{g}{h}}$

Paragraph for Questions 11 & 12

A charged spherical shell of radius r is connected to a capacitor of capacity C through two resistances R_1 *and* R_2 as shown in figure. Initially charged on sphere is Q_0.

11. Charge on capacitor C after long time as switch k gets closed.



(A) zero

(B) Q_0

(C) $\frac{cQ_0}{c+4\pi\epsilon_0 r}$

(D) can't find

12. Heat energy developed across resistor R_1 after long time interval as switch gets closed.

(A) $\frac{Q_0^2 c}{8\pi\epsilon_0 r(c+4\pi\epsilon_0 r)}\left(\frac{R_1}{R_1+R_2}\right)$

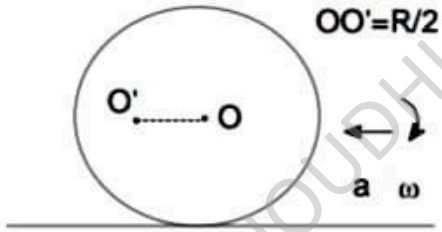
(B) $\frac{R_1 Q_0^2 4\pi\epsilon_0 r}{c(R_1+R_2)(c+4\pi\epsilon_0 r)}$

(C) $\frac{Q_0^2}{2c}$

(D) $\frac{Q_0^2 R_1 c}{4\pi\epsilon_0 r(c+4\pi\epsilon_0 r)(R_1+R_2)}$

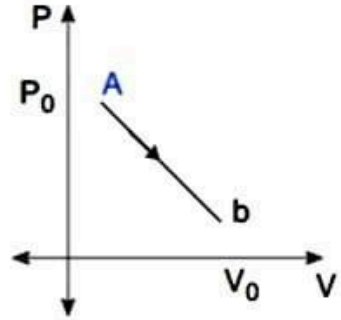
13. If a tap above empty rectangular basin able to fill it in time t_1=3 min and small hole at bottom able to make it completely empty from filled stage in time t_2=2 min. Now both tap and hole are opened simultaneously (At initial stage basin is completely empty). The maximum height up to which liquid may filled in basin is $\frac{H_0}{n}$ find $n\{H_0 = Height\ of\ basin\}$

14. A non uniform sphere of radius R=50 cm accelerating over a rough horizontal surface with $a = 10\,ms^{-2}$ and angular velocity $\omega = 5\sqrt{2}\,rad\,s^{-1}$ such that it rolls without slipping over surface. If minimum coefficient of friction for given motion is $\mu = \frac{1}{k}$. Then k (position of C.O.M is given in figure) is



O=Geometric centre
O'=C.O.M

15. One mole of monoatomic gas undergoes a linear process A→B shown in P-V diagram. Volume of gas from where process turn from an endothermic to an exothermic is $\frac{n}{(2n-2)}V_0$ find n.



16. A small positively charged ball of mass m is suspended by insulator thread of negligible mass. Another similar positively charged small ball moved very slowly from large distance until it is in original position of first ball. As a result first ball rises by height h. Work done in this process is nmgh then n is

17. An observer moving with uniform velocity towards a stationary sound source observes frequency f=170 Hz over a distance of x=80 m. If frequency of sound is f_0=160 Hz and sound travel with speed $c = 340\,ms^{-1}$. Then duration of beep emitted by source is n. Find n.

18. Water drop is stuck between two plates of glass. Distance between plates of glass is d where diameter of water drop disc D>>d. If surface tension of water is T and angle of contact is 0°. Force between plates is $\left\{T\frac{\pi D^2}{d}\right\}x\frac{1}{K}$. Find K.

19. One night a person of height h=1.8 m is standing on the bank of a straight canal. There is no wind and no ripples on water surface. On the opposite bank a lamp is installed at height H=5.4 m on a lamppost. Light emanated from the lamp, appears as a bright spot after reflection from the water surface. When a person starts walking along the bank the spot appears to him moving at constant speed u_0 relative to ground. Speed of person is $\frac{(n+1)}{n}u_0$. Find n.

20. Let current I uniformly distributed uniformly over circumference of hollow cylinder of L and radius R. If L>>R then force enerted by one half of cylinder on other is $\frac{\mu_0 I^2}{K\pi^2 R}\cdot L$. Find K.