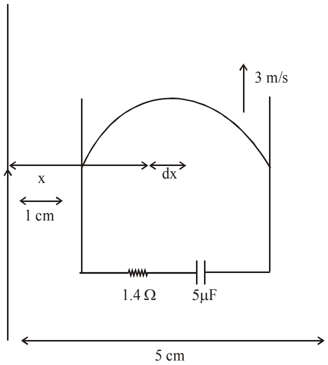
Sol



$$d\varepsilon = 3\frac{\mu_0(2)}{2\pi x}dx$$

$$\varepsilon = \frac{3\mu_0}{\pi}\int_1^4 \frac{1}{x}dx$$

$$= \frac{3\mu_0}{\pi}(\ell n4)$$

$$= 3 \times 4 \times 10^{-7} \times 2 \times 0.7$$

$$= 16.8 \times 10^{-7} \text{ volt}$$

$$q_{max} = 5 \times 10^{-6} \times 16.8 \times 10^{-7}$$

$$= 84 \times 10^{-13}$$

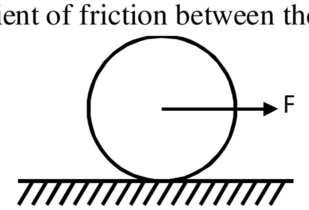
$$8.4 \times 10^{-12} \text{ C}$$

$$I_{max} = \frac{\varepsilon}{R} = \frac{16.8\times10^{-7}}{1.4}$$

$$= 12 \times 10^{-7}$$

$$= 1.2 \times 10^{-6} \text{ A}$$

16. A cylinder is placed on a rough horizontal surface. A force F is applied as shown in figure such that it rolls without slipping. Coefficient of friction between the cylinder and the horizontal surface is μ.



(A) Acceleration of centre of mass does not depend on whether cylinder is solid or hollow.

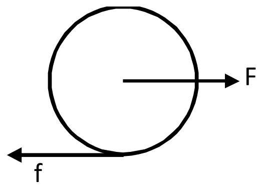
(B) The magnitude of force of friction will be always μ mg.

(C) Acceleration of centre of mass is $\frac{F}{2m}$ for a thin walled cylinder.

(D) Maximum acceleration of centre of mass is 2 μg

Ans. **(C, D)**

Sol. (A)



$F - f = ma_{cm}$

$fR = I\alpha$

$a_{cm} = R\alpha$

$F = \frac{Ia_{cm}}{R^2} = ma_{cm}$

$a_{cm} = \frac{F}{I/R^2 + m}$

(B) $fR = \frac{IF}{\left(\frac{I}{R^2} + m\right)R}$

$f = \frac{F}{I + mR^2}$

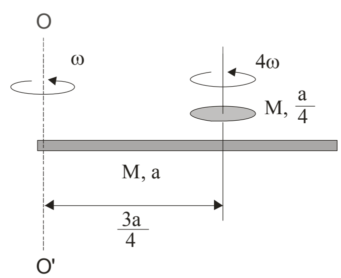
depends on F

(C) For thin walled cylinder $I = mR^2$, $a_{cm} = \frac{F}{2m}$

(D) $\mu\, mg\, R = I\alpha$ $\quad \alpha = \frac{\mu mgR \times 2}{mR^2}$

$\alpha = \frac{2\mu g}{R}$

17. A rod of mass M and length 'a' has a disc of mass M and radius $\frac{a}{4}$ placed at a distance $\frac{3a}{4}$ from fixed end of the rod. The rod rotates about axis passing through left end and disc rotates with angular velocity 4ω about its axis. If angular momentum of system about OO' is $\frac{nMa^2\omega}{48}$. Find n



Ans. 49

Sol $\frac{Ma^2}{3}\omega + \frac{M\left(\frac{a}{4}\right)^2}{2}4\omega + M\left(\frac{3a}{4}\right)^2\omega$

$= \frac{Ma^2\omega}{3} + \frac{Ma^2\omega}{8} + \frac{9Ma^2\omega}{16}$

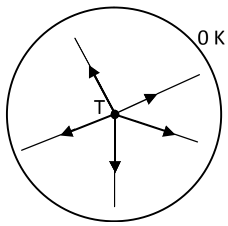
$= \frac{16Ma^2\omega + 6Ma^2\omega + 27Ma^2\omega}{48}$

$= \frac{49Ma^2\omega}{48}$

18. A small particle of initial temperature 200 K is placed at the centre of a large spherical container of temperature 0 K. At time t_1 temperature of particle was 100 K and at time t_2 temperature of small particle becomes 50 K. Then $\frac{t_2}{t_1}$ will be. [All surfaces behaves as a black body]

Ans. **9**

Sol.



$T_s = 0$ K

$T_i = 200$ K, e = 1

$$-Ms\frac{dT}{dt} = \frac{dQ}{dt} = \sigma eAT^4$$

$$-\frac{dT}{dt} = \frac{\sigma AT^4}{Ms}$$

$$\frac{\sigma A}{Ms}\int_{t_i}^{t_f} dt = -\int_{T_i}^{T_f}\frac{dT}{T^4}$$

$$\frac{\sigma A}{Ms}(t_f - t_i) = +\frac{1}{3}\left(\frac{1}{T_f^3} - \frac{1}{T_i^3}\right)$$

$$\frac{\frac{\sigma A}{Ms}(t_1 - 0) = \frac{1}{3}\left(\frac{1}{100^3} - \frac{1}{(200)^3}\right)}{\frac{\sigma A}{Ms}(t_2 - 0) = \frac{1}{3}\left(\frac{1}{(50)^3} - \frac{1}{(200)^3}\right)}$$

$$\frac{t_1}{t_2} = \frac{\frac{(200)^3 - (100)^3}{(100)^3(200)^3}}{\frac{(200)^3 - (50)^3}{(50)^3(200)^3}} = \frac{\frac{4^3 - 2^3}{2^3}}{4^3 - 1^3} = \frac{56}{8 \times 63} = \frac{1}{9}$$

19. Singly charge sulphur atom and alpha particle are accelerated by same potential difference and then these are projected normally in to uniform magnetic field, so that they are moving in circle. What will be the ratio of their radius.

Ans. **4**

Sol. $r = \frac{\sqrt{2mqV}}{qB} \Rightarrow r \propto \sqrt{\frac{m}{q}}$

$$\Rightarrow \frac{r_1}{r_2} = \sqrt{\frac{m_1}{m_2}\left(\frac{q_2}{q_1}\right)} = \sqrt{\frac{32}{4}\frac{(2)}{(1)}} = 4$$