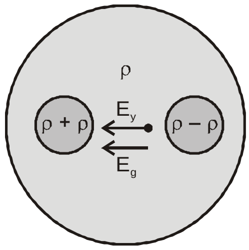
PHYSICS

1. Above distribution can be represented as shown in figure.
Gravitational field due to sphere of radius R at a distance 2R



$$E_g = \frac{G\rho \frac{4}{3}\pi R^3}{4R^2} = \frac{G\rho\pi R}{3}$$

So Net field at centre will be $2F_g = \frac{2G\rho\pi R}{3}$

2. **Case-I**
Radius of curvature of lens is 20 cm
Image formed by convex lens should be at centre of curvature of mirror

$$\frac{1}{V} + \frac{1}{30} = \frac{1}{20}$$

$$\frac{1}{V} = \frac{1}{20} - \frac{1}{30} \Rightarrow V = 60 \text{ cm}$$

Radius curvature of mirror should be 40 cm.
Case-II

$$\frac{2}{V_1} + \frac{1}{30} = \frac{1.5-1}{20} + \frac{2-1.5}{-20}$$

$\Rightarrow$ V = – 60
So for convex mirror u = – 80

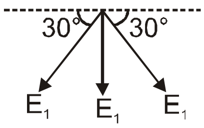
$$\frac{1}{V} - \frac{1}{80} = \frac{1}{20}$$

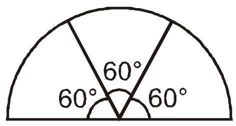
V = 16 cm
Seperation between object and this image O = 66 cm

3. Consider the whole hemisphere as three portion if electric field due to one portion is E_1
then $2E_1 \sin 30 + E_1 = E_0$

$2E_1 = E_0$

$$\Rightarrow E_1 = \frac{E_0}{2}$$





4. From 2nd lens $\frac{1}{v} - \frac{1}{2\ell} = \frac{1}{-\ell}$ or $v = -2\ell$

$m_1 = -1$

From 3rd lens $\frac{1}{v} - \frac{1}{-3\ell} = \frac{1}{2\ell}$ or $v = 6\ell$

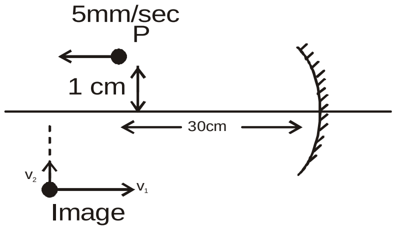
$m_2 = -2$
$h_i = (m_1 \times m_2)\, h_0$
$= 2h$

5. $\frac{1}{v}+\frac{1}{-30}=\frac{1}{-20}$

$v = -60$

$m=\frac{y_i}{y_o}=\frac{v}{u}$

$y_i = -2$ cm



for $\vec{v}_1$ $\vec{v}_1$ $\quad \vec{v}_1=-\frac{v^2}{u^2}(\vec{v}_p)$

$= -4\,(-5) = 20$ mm/sec

for $\vec{v}_2$ $\vec{v}_2$ $\quad \Rightarrow \quad \frac{y_i}{y_o}=\frac{v}{u}$

$y_i\, u = -\, y_o\, v$

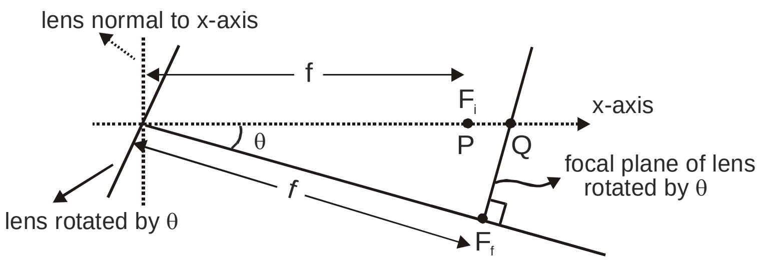
$\frac{dy_i}{dt}(u)+y_i\frac{du}{dt}=-y_o\frac{dv}{dt}$

$\frac{dy_i}{dt}(-30)+(-2)(-5)=-(20)$

$\frac{dy_i}{dt}=1$mm/sec

$V_i=20\hat{i}+\hat{j}$ mm/sec **Ans.**

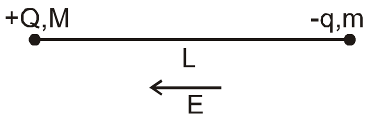
6. When the lens is tilted by θ, the image is formed at the intersection (Q) of focal plane of lens in tilted position and x-axis.



As the lens oscillates. The image shifts on x-axis in between P and Q.

$\therefore$ Distance between two extreme position of the image = PQ = $\frac{f}{\cos\theta}-f=f(\sec\theta-1)$ **Ans.**

7. In order to maintain constant separation, the particles must have the same acceleration. Assuming the system of both charges to accelerate towards left. Applying Newton's second law.



$QE-\frac{KQq}{L^2}=Ma$ .... (1)

Under given condition the acceleration of both charges should be same and should also be equal to acceleration of centre of mass of both the charges.

$a=\frac{F_{net}}{\text{total mass}}=\frac{(Q-q)E}{m+M}$ .... (2)

Hence from equation (1) and (2) we get $\quad L=\sqrt{\frac{(M+m)KQq}{E(qM+Qm)}}$

8. $U = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\frac{\varepsilon_0 K^2 Q^2}{r^4}$

$V = \frac{KQ}{r}$

$$\frac{U}{V^2} = \frac{\frac{1}{2}\varepsilon_0 K^2 \frac{Q^2}{r^4}}{\frac{K^2Q^2}{r^2}} = \frac{1}{2}\frac{\varepsilon_0}{r^2}$$

because $\frac{U}{V^2} \propto \frac{1}{r^2}$

so the correct option is B.

9. Field at A

due to the solid sphere without the cylindrical cavity

$E_1 = -\frac{\rho r}{3\varepsilon_0}\hat{i}$

field at A due to the cylinder of length 2R (which can be assumed to be infinite, since r << R)

$E_2 = \frac{2K(\rho\pi r^2)}{r}(-\hat{i}) = -\frac{\rho}{2\varepsilon_0} r\,\hat{i}$

$\therefore$ net field $E = E_1 - E_2 = \frac{\rho r}{6\varepsilon_0}\hat{i}$

10. $V_1 = \sqrt{\frac{GM}{R}}$ (orbital velocity in circular path)

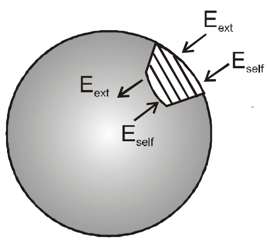
For elliptical orbit

conservation of angular momentam $mV_2\frac{R}{3} = \frac{5R}{3}mV_3$

conservation of energy– $\frac{GMm}{R/3} + \frac{1}{2}mV_2^2 = \frac{-GMm}{5R/3} + \frac{1}{2}mV_3^2$

Solving $V_2 = \sqrt{\frac{5GM}{R}}$ and $V_3 = \sqrt{\frac{GM}{5R}}$

11. Consider a small area (shaded strip)



here E_{self} = Gravitational field due to this strip

and E_{ext} = Gravitational field due to the rest of spherical shell.

E_{in} = Gravitational field just inside the strip due to whole shell.

E_{out} = Gravitational field just outside the strip due to whole shell.

$E_{in} = E_{ext} - E_{self} = 0$

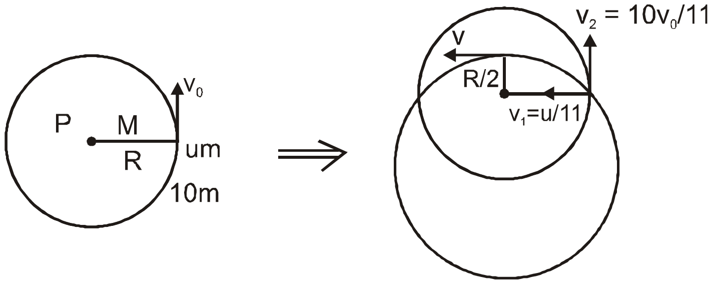
$\Rightarrow E_{ext} = E_{self}$

$E_{out} = E_{ext} + E_{self} = \frac{GM}{R^2}$ $\Rightarrow E_{ext} = \frac{GM}{2R^2}$

After the shaded area has been removed there is no E_{self} and only $E_{ext.}$

hence, $E_{net} = E_{ext} = \frac{GM}{2R^2}$

12. A s the space station is moving in circular orbit,



$$\frac{GM(10m)}{R^2} = \frac{(10m)\,v_0^2}{R}$$

$\Rightarrow \quad v_0 = \sqrt{\frac{GM}{R}}$ ...(i)

Let u be the velocity of meteorite.
Velocity of the space station after collision can be obtained from momentum conservation.

$mu = (10m + m)\,v_1 \quad \Rightarrow \quad v_1 = \frac{u}{11}$

$10\,m\,.\,v_0 = (10\,m + m)\,v_2 \quad \Rightarrow \quad v_2 = \frac{10}{11}v_0$

Let v be the velocity of space station at closest distance
from angular momentum conservation

$10\,m\,v_0 \times R = 11\,mv\,\frac{R}{2} \quad \Rightarrow \quad v = \frac{20v_0}{11}$

from energy conservation

$$\frac{1}{2} \times (11\,m)\,(v_1^2 + v_2^2) - \frac{GM\,(11\,m)}{R} = \frac{1}{2} \times (11m)\,v^2 - \frac{GM.11m}{R/2}$$

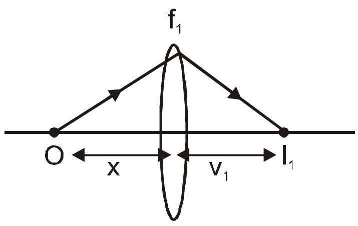
$$\Rightarrow \quad \left(\frac{u}{11}\right)^2 + \left(\frac{10v_0}{11}\right)^2 - \frac{2GM}{R} = \left(\frac{20v_0}{11}\right)^2 - \frac{4GM}{R}$$

$$\Rightarrow \quad \frac{u^2}{11^2} = \frac{400\,v_0^2}{11^2} - \frac{100\,v_0^2}{11^2} - \frac{2GM}{R}$$

$$\Rightarrow \quad u^2 = \frac{GM}{R}\,(400 - 100 - 242) = 58\,\frac{GM}{R}$$

Ans: $u = \sqrt{\frac{58\,GM}{R}}$

13. Image -1



$u_1 = -x$

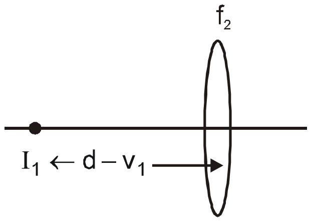
$$\frac{1}{v_1} - \frac{1}{-x} = \frac{1}{f_1}$$

$$v_1 = \frac{x f_1}{x - f_1}$$

$$m_1 = \frac{v_1}{u_1} = \frac{v_1}{-x} = -\left(\frac{f_1}{x - f_1}\right)$$

Image -2

$u_2 = -(d - v_1)$



$$\frac{1}{v_2} - \frac{1}{-(d-v_1)} = \frac{1}{f_2}$$

$$v_2 = \frac{(d-v_1)f_2}{d - v_1 - f_2}$$

$$m_2 = \frac{v_2}{-(d-v_1)} = -\left(\frac{f_2}{d - v_1 - f_2}\right)$$

$$m_1\, m_2 = \left(\frac{f_1}{x - f_1}\right)\left(\frac{f_2}{d - \frac{x f_1}{(x - f_1)} - f_2}\right) = \frac{f_1 f_2}{x(d - f_1 - f_2) - d f_1 + f_1 f_2}$$

Since m is independent of x

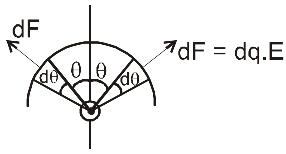
$\Rightarrow \quad (d - f_1 - f_2) = 0 \Rightarrow d = f_1 + f_2$

$\Rightarrow \quad m = -\dfrac{f_2}{f_1}$

14. The electrostatic field intensity at a point on the ring is $E = \dfrac{\lambda}{2\pi\varepsilon_0}\dfrac{1}{R}$.

The force on the elementary charge dq is

$dF = dq\, E = (\lambda' \, R d\theta) \,.\, \dfrac{\lambda}{2\pi\varepsilon_0}\dfrac{1}{R}$



The sine component of dF will get cancelled and cosine component will get added.
Net force on the ring

$$F = 2\int_0^{+\pi/2} dF\cos\theta = 2\int_0^{+\pi/2} \frac{\lambda.\lambda'}{2\pi\varepsilon_0}\, d\theta.\cos\theta = \frac{\lambda\lambda'}{\pi\varepsilon_0}$$

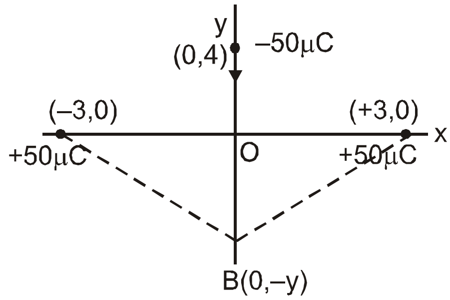
Ans. $\dfrac{\lambda\lambda'}{\pi\varepsilon_0}$

15. According to question (At equator)

$$Mg - \frac{Mv^2}{R} = \frac{Mg}{2} \quad \Rightarrow \quad v^2 = \frac{Rg}{2} = \frac{GM}{2R}$$

Using conservation of energy : $-\dfrac{GMm}{R} + \dfrac{1}{2}mv_e^2 = 0 \quad \Rightarrow \quad v_e^{\,2} = \dfrac{2GM}{R} = 4v^2$

16. The charge $-50\mu C$ will move in straight line along y–axis as it does not experience any force in x–direction. Let B be the location where the charge comes to rest momentarily and then return. Total energy of the system remain constant.



$\therefore$ KE + PE

$$= 4 + \frac{1}{4\pi\varepsilon_0}\frac{(50\times10^{-6})(-50\times10^{-6})}{5}\times 2$$

$$= 0 + \frac{1}{4\pi\varepsilon_0}\frac{(50\times10^{-6})(-50\times10^{-6})}{\sqrt{3^2+y^2}}\times 2$$

$$\frac{1}{4\pi\varepsilon_0} = 9\times10^9\ Nm^2C^{-2}$$

$\therefore$ Solving for y

we get y = $6\sqrt{2}$ m. (since body is going down negative value is chosen)

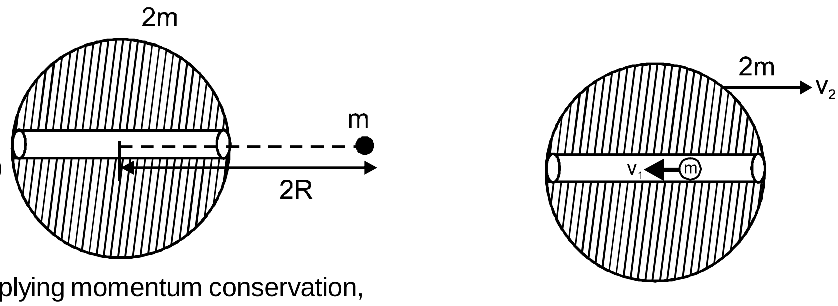
$\therefore$ The location is $\left(0,-6\sqrt{2}m\right)$.

17. $v = \sqrt{\frac{GM}{r}}$ ....(1)

$$-\frac{GMm}{r} = -\frac{GMm}{R} + \frac{1}{2}mv'^2 \quad ....(2)$$

From (1) and (2) we have v'= $v\sqrt{2(\frac{r}{R}-1)}$

18. (C)



Applying momentum conservation,

$0 = mv_1 - 2mv_2$

$\Rightarrow \quad v_2 = \frac{v_1}{2}$ ....(i)

From energy conservation,

$k_i + U_i = k_f + U_f$

$$0 + \left(-\frac{G(2m)}{2R}\right)m = \frac{1}{2}mv_1^2 + \frac{1}{2}(2m)\,v_2^2 + \left(-\frac{3}{2}\frac{G(2m)}{R}\right)(m) \quad ....(ii)$$

Solving eqn.(i) & (ii) get,

$$v_1 = \sqrt{\frac{8Gm}{3R}}$$

(A) COM will be fixed so,

$$S_{cm} = \frac{m_1s_1 + m_2s_2}{m_1+m_2}$$

$$0 = \frac{(m)(x) + (2m)(-(2R-x))}{m+2m} \quad \Rightarrow \quad x = \frac{4R}{3}$$

(B) $F_{net} = 0 \quad \Rightarrow \quad a = 0$

(D) $W_{gr} = U\downarrow \quad \Rightarrow \quad W_{gr} = \left(-\frac{G(2m)}{2R}\right)m - \left(-\frac{3}{2}\frac{G(2m)}{R}\right)m$.

19. Let x_0 = extension in the spring when A is in equilibrium. Then,

$$k\,x_0 = \frac{1}{4\pi\epsilon_0}\,\frac{q^2}{r^2} \qquad \text{..... (1)}$$

Now let A be shifted by a small distance x towards B. Then the resultant force towards A is,

$$F_{res} = k\,(x_0 + x) - \frac{q^2}{4\pi\epsilon_0 (r-x)^2} = k\,(x_0 + x) - \frac{q^2}{4\pi\epsilon_0 r^2}\left(1 - \frac{x}{r}\right)^{-2}$$

$$= k\,(x_0 + x) - \frac{q^2}{4\pi\epsilon_0 r^2}\left(1 + \frac{2x}{r}\right) \; ; \qquad x << r : \text{ Binomial expansion}$$

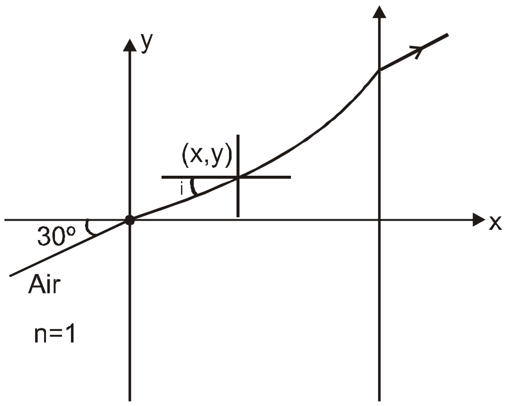
$$= \quad kx - \frac{q^2}{2\pi\epsilon_0 r^3}\,x \; ; \text{ using (1)} \qquad F_{res} = \left(k - \frac{q^2}{2\pi\epsilon_0 r^3}\right)x$$

$$\because \quad F \;\alpha\; x \;\; \therefore \;\text{SHM with } T = 2\pi\sqrt{\frac{m}{k - \dfrac{q^2}{2\pi\epsilon_0 r^3}}} \quad \text{Ans.}$$

For real T, $\quad k > \dfrac{q^2}{2\pi\epsilon_0 r^3} \quad \therefore \quad k_{min} = \dfrac{q^2}{2\pi\epsilon_0 r^3}$ Ans.

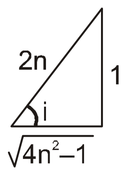
Ans. $T = 2\pi\sqrt{\dfrac{m}{k - \dfrac{q^2}{2\pi\epsilon_0 r^3}}}$, $k_{min} = \dfrac{q^2}{2\pi\epsilon_0 r^3}$

20.



(a) $1 \times \sin 30^\circ = n \sin i$

$\sin i = \dfrac{1}{2n}$



$\tan i = \dfrac{1}{\sqrt{4n^2 - 1}}$

$\dfrac{dy}{dx} = \dfrac{1}{\sqrt{x+3}} \qquad \displaystyle\int_0^y dy = \int_0^x (x+3)^{-1/2}\,dx$

$y = 2\left(\sqrt{x+3} - \sqrt{3}\right)$

(b) when $x = 1$

$y = 2(\sqrt{1+3} - \sqrt{3})$, $\qquad y = 2\left(2 - \sqrt{3}\right)$

$\therefore$ Position at which ray comes out of the medium is $(1, 2(2 - \sqrt{3}))$.

21. (a) We can easily see that charge q is placed symetrically to surface ABCD, ABSR and ADQR.
Charge q is also placed symetrically to rest of the surfaces.
If the flux through the surface ABCD is x and through RSPQ is y then the total flux will be 3x + 3y
Now by Gauss law
Now by Gauss law

$$\frac{q_{in}}{\varepsilon_0} = \phi$$

$\Rightarrow$ $3x + 3y = \frac{q}{\varepsilon_0}$

$\Rightarrow$ $x + y = \frac{q}{3\varepsilon_0}$

(b) Flux through two surfaces are not same flux via ABCD is larger.

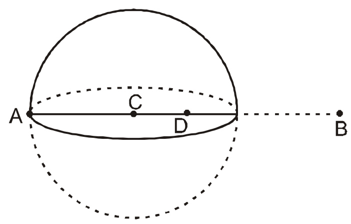
Ans. (a) $\frac{q}{3\varepsilon_0}$ **(b) Flux through two surfaces are not same flux via ABCD is larger.**

22. $0 < x < a : V = \left[-\int_0^x E_x dx\right] + V_{(0)} \quad = 0 \text{ (as } E_x = 0)$

$x > a \; ; \; V = -\int_a^x E_x dx + V_{(a)} \quad = \left[-\int_a^x \frac{\sigma}{\epsilon_0} dx\right] + V_{(a)} \quad = \quad -\frac{\sigma}{\epsilon_0}(x - a)$

$x < 0 \; ; \; V = -\int_0^x E_x dx + V_{(0)} \quad = -\left(-\frac{\sigma}{\epsilon_0}.x\right) + V_{(0)} \quad = \quad \frac{\sigma}{\epsilon_0}.x$.

23. Consider another identical hemisphere to complete a hollow spherical shell.
The potential at a point D due to half shell



$V_D = \frac{1}{2}$ × potential due to complete shell at D (due to symmetry) $= \frac{1}{2} \times \left(-\frac{G \cdot 2m}{R}\right) = -\frac{Gm}{R}$

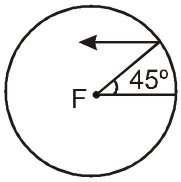
$V_A = \frac{1}{2}$ × potential due to complete shell at A $= \frac{1}{2} \times \left(-\frac{G \cdot 2m}{R}\right) = -\frac{Gm}{R}$

$V_B = \frac{1}{2}$ × potential due to complete shell at B (again due to symmetry) $= \frac{1}{2} \times -\frac{G \times 2m}{2R} = -\frac{Gm}{2R}$

Ans. $v_A = v_D = -\frac{Gm}{R}, \; v_B = -\frac{Gm}{2R}$

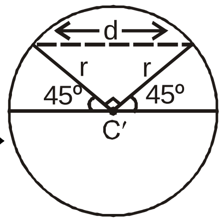
24. Electric field inside the cavity = $\frac{\rho\vec{a}}{3\varepsilon_0}\left[\begin{array}{c}\text{here } \vec{a} = \text{along line joining} \\ \text{Centers of sphere and cavity}\end{array}\right]$

Force on the electron inside the cavity = $\frac{\rho\vec{a}}{3\varepsilon_0}$ (e)

Cavity ⟶ 

acceleration = $\frac{\rho ae}{3\varepsilon_0 m.}$

Now for distance d = $\sqrt{r^2 + r^2}$ = $\sqrt{2}\,r$

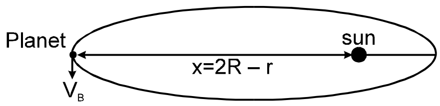
Cavity ⟶ 

by S = ut + 1/2 at², $\sqrt{2}\,r = \frac{1}{2} \times \frac{\rho ae}{3m\varepsilon_0}\, t^2$ $\Rightarrow t = \left(\frac{6\sqrt{2}\, rm\varepsilon_0}{ea\rho}\right)^{1/2}$

25. Area covered by line joining planet and sun in time dt is

$dS = \frac{1}{2}x^2 d\theta$; Areal velocity = dS /dt = $\frac{1}{2}x^2 d\theta$ /dt = $\frac{1}{2}x^2\omega$

where x = distance between planet and sun
and ω = angular speed of planet about sun.
From Keplers second law Areal velocity of planet is constant.



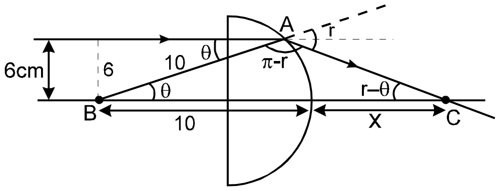
At farthest position

$A = dS/dt = \frac{1}{2}(2R - r)^2\,\omega = \frac{1}{2}(2R - r)\,[(2R - r)\,\omega] = \frac{1}{2}(2R - r)\,V_B$

or $V_B = \frac{2A}{2R - r}$ (least speed). (Using values)

V_B = 40 km/s.

26. R = 10cm



Applying snell's law $\frac{\sin\theta}{\sin r} = \frac{3}{4}$ $\Rightarrow$ r = 53°

By sine law in Δ ABC $\frac{\sin(r-\theta)}{10} = \frac{\sin(\pi - r)}{(10+x)}$; $\frac{10+x}{10} = \frac{4}{5\,(\sin r\cos\theta - \cos r\sin\theta)}$

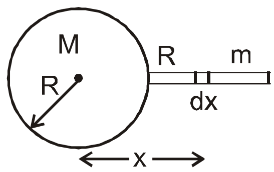
$= \frac{4}{5\left(\frac{4}{5}\times\frac{4}{5} - \frac{3}{5}\times\frac{3}{5}\right)}$; $10 + x = \frac{200}{7}$ $\Rightarrow$ $x = \frac{200-70}{7} = \frac{130}{7}$

27. $a_1 = \frac{F}{m} = \frac{GM}{r^2}$

It is same in both cases

$\therefore \quad \frac{a_1}{a_2} = 1$

28. $F = \int_R^{2R} \frac{GM\left(\frac{m}{R}\right)dx}{x^2} = \frac{GMm}{2R^2}$



29. we have f_1 = 50 cm and f_2 = 100 cm

let the real distance between A and B be x. Also let refractive index of liquid be μ. Then

$$\frac{1}{f_1} = \left(\frac{3}{2}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \Rightarrow \left(\frac{1}{R_1}-\frac{1}{R_2}\right) = \frac{2}{f_1}$$

$$\frac{1}{f_1'} = \left(\frac{3}{2\mu}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \Rightarrow \frac{1}{f_1'} = \frac{2}{f_1}\left(\frac{3-2\mu}{2\mu}\right)$$

and $\frac{1}{f_2'} = \frac{2}{f_2}\left(\frac{3-2\mu}{2\mu}\right)$

Now, for A we have

$$-\left(\frac{1}{200}\right) - \left(\frac{1}{-x}\right) = \frac{2}{50}\left(\frac{3-2\mu}{2\mu}\right)$$

$\Rightarrow \quad \frac{1}{x} = \frac{1}{200} + \frac{2}{50}\left(\frac{3-2\mu}{2\mu}\right)$ ...(1)

Also for B we have

$$-\frac{1}{100} - \left(-\frac{1}{x}\right) = \frac{2}{100}\left(\frac{3-2\mu}{2\mu}\right)$$

so, $\frac{1}{x} = \frac{1}{100} + \frac{2}{100}\left(\frac{3-2\mu}{2\mu}\right)$ ....(2)

from (1) and (2) we get

$$\Rightarrow \quad \frac{2(3-2\mu)}{100\ (2\mu)} + \frac{1}{100} = \frac{1}{200} + \frac{2(3-2\mu)}{50\ (2\mu)}$$

$$\Rightarrow \quad \frac{2(3-2\mu)}{(2\mu)}\left[\frac{1}{50}-\frac{1}{100}\right] = \frac{1}{100}-\frac{1}{200} = \frac{1}{200}$$

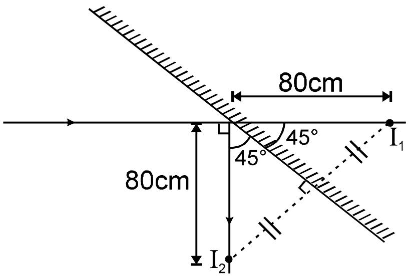
$$\Rightarrow \quad \frac{(3-2\mu)}{2\mu} = \frac{1}{2} \qquad \Rightarrow\ 6-4\mu = \mu$$

$$\text{so } \mu = \frac{6}{5} = \frac{12}{10}$$

30. Image formation due to convex lens

$$\frac{1}{v}-\frac{1}{-36} = \frac{1}{30} \qquad \Rightarrow\ v = \frac{30\times 36}{6} = 180 \text{ cm}$$

This image will act like a virtual object for mirror and after reflection from mirror its image (shown by I_2) will be formed at 80 cm below optical axis of convex lens.



For concave lens, this image will be object at a position of 15 cm below the lens.
For final image formed by concave lens.

$$\frac{1}{20}-\frac{1}{15} = \frac{1}{f} \qquad \Rightarrow\ \frac{1}{f} = -\frac{5}{300}$$

Also,

$$\frac{1}{f} = (\mu-1)\left(-\frac{1}{R}-\frac{1}{R}\right)$$

or $$-\frac{5}{300} = \left(\frac{3}{2}-1\right)\left(-\frac{2}{R}\right) \qquad \Rightarrow\ R = \frac{300}{5}$$

R = 60 cm

Ans. radius of curvature = 60 cm

31. $$\frac{GM}{(2R)^2} = \frac{GM'}{R^2}$$

$$\frac{M}{4} = M'$$

$$\frac{4}{3}\pi R^3\rho_1 + \frac{4}{3}\pi(8R^3-R^3)\rho_2 = 4\left(\frac{4}{3}.\pi R^3.\ \rho_1\right)$$

$$\rho_1 + 7\rho_2 = 4\rho_1$$

$$\frac{\rho_1}{\rho_2} = \frac{7}{3}.$$

33. $\delta = i + e - A$

$\delta_{min} = 60°$ when $i = e$

$\therefore 60° = 2i - A = 2(60°) - A$ $\therefore A = 60°$

$$\therefore \mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60+60}{2}\right)}{\sin\left(\frac{60}{2}\right)} = \sqrt{3}$$

34. When angle of incidence is i_1, $e = 40°$

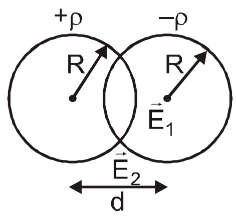
(from reversibility of ray)

also $\delta = 70°$

$\therefore 70° = i_1 + 40° - A$

$\therefore i_1 = 90°$

35. $\vec{E} = \frac{kQ}{x^2}$



$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{\frac{4}{3}\pi x^3\rho}{x^2} = \frac{\rho d}{3\varepsilon_0}(d - x)$$

$$E_{net} = E_1 + E_2 = \frac{\rho(d-x)}{3\varepsilon_0} + \frac{\rho x}{3\varepsilon_0}$$

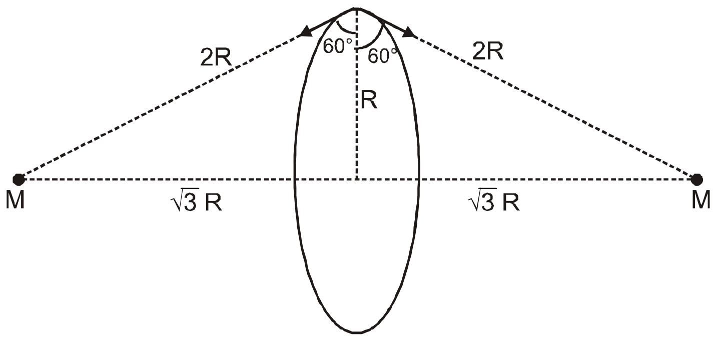
$$E = \frac{\rho d}{3\varepsilon_0}$$

36. $V = -\int E - dx$

$$\int_{v_1}^{v_2} V = -\int_0^d \frac{\rho d}{3\varepsilon_0} dx \; ; \; V_2 - V_1 = -\frac{\rho d^2}{3\varepsilon_0} ; |\Delta V| = \frac{\rho d^2}{3\varepsilon_0}$$

37 to 39.

Sol.



$$F_{net} = 2\left(\frac{GMm}{4R^2}\right)\cos 60° = \frac{GMm}{4R^2}$$

$$F_{net} = \frac{GMm}{4R^2} = \frac{mv^2}{R} \Rightarrow v = \sqrt{\frac{GM}{4R}} = \frac{1}{2}\sqrt{\frac{GM}{R}}$$

$$T = \frac{2\pi R}{v} = \frac{4\pi R^{3/2}}{\sqrt{GM}}$$

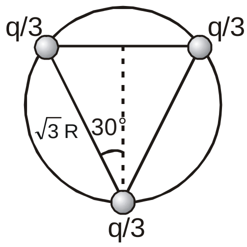
Average force on planet in half revolution.

$$F_{avg} = \frac{2mv}{T/2} = \frac{4mv}{T} = \frac{4mv}{\frac{2\pi R}{v}} = \frac{2mv^2}{\pi R} = \frac{GMm}{2\pi R^2}$$

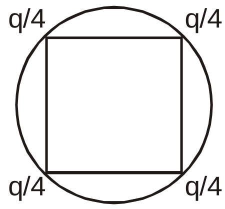
40 to 42.

Potentials at the centre

$v_1 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$; $v_2 = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$



situation A



situation B

Potential energy in situation I is

$$U_1 = 3 \times \frac{1}{4\pi\varepsilon_0}\frac{(q/3)^2}{(\sqrt{3}R)} = \frac{1}{12\sqrt{3}\pi\varepsilon_0}\frac{q^2}{R}$$

When one charge is removed, the field intensity at the centre is due to the removed charge only.

$$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q/3}{r^2}$$

$$E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q/4}{r^2} \qquad \therefore \frac{E_1}{E_2} = \frac{4}{3}$$

43. $C = \sin^{-1}\left(\frac{1}{2/1}\right) = 30°$

for $i = 37$, TIR so , $\delta = \pi - 2\,(37°) = 104°$

$i = 25$, Refraction $\delta < \frac{\pi}{2} - C$

$i = 45°$, TIR so , $\delta = \pi - 2\left(\frac{\pi}{4}\right) = 90°$

By applying snells law for prism :

$i = 90$,

$r_1 = 30$, $r_2 = 30$

$e = 45$

$\delta = 90 + 45 - 60 = 75°$

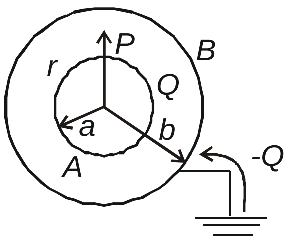
44. (A) Electrostatic potential energy = $\frac{1}{4\pi\epsilon_0}\frac{(-Q)^2}{2a} = \frac{Q^2}{8\pi\epsilon_0 a}$

(B) Electrostatic potential energy = $\frac{1}{4\pi\epsilon_0}\left[\frac{(-Q)\times(-Q)}{5a/2} + \frac{(-Q)^2}{2(5a/2)}\right] = \frac{3}{20}\frac{Q^2}{\pi\epsilon_0 a}$

(C) Electrostatic potential energy = $\frac{1}{4\pi\epsilon_0}\frac{3Q^2}{5a} = \frac{3}{20}\frac{Q^2}{\pi\epsilon_0 a}$

(D) Electrostatic potential energy = $\frac{1}{4\pi\epsilon_0}\left[\frac{3Q^2}{5a} + \frac{(-Q)^2}{2(2a)} + \frac{(-Q)\times(-Q)}{2a}\right] = \frac{27Q^2}{80\pi\epsilon_0 a}$

45.



Field at P is only due to A = $\frac{kQ}{(2)^2} = \frac{kQ}{4}$

Potential at P = $V_{\text{due to A}} + V_{\text{due to B}} = \frac{kQ}{2} - \frac{kQ}{3}$

Electric field outside B is due to 'A's Induced charge on B + A's charge = zero.