PHYSICS

DPP

DAILY PRACTICE PROBLEMS

NO. 01

TARGET : JEE (Advanced) 2015

Course: VIJETA (JPAD) & VIJAY (JRAD) **Date : 08-04-2015**

TEST INFORMATION

TEST : PART TEST (PT)-1 (3 HOURS) (**Test Date : 15-04-2015**)

Syllabus : Geometrical Optics, Electrostatics, Gravitation, Kinematics, Newton's laws of motion, Friction.

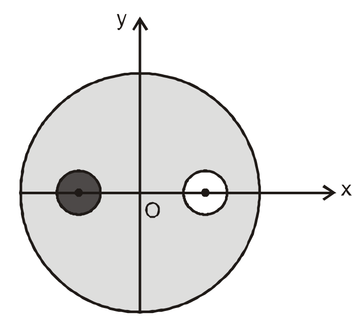
This DPP is to be discussed (11-04-2015)

PT-1 to be discussed (17-04-2015)

DPP No. # 01

Total Marks : 165	**Max. Time : 180 min.**	
Single choice Objective ('–1' negative marking) Q.1 to Q.17	**(3 marks 3 min.)**	**[51, 51]**
Multiple choice objective ('–1' negative marking) Q.18 to Q.23	**(4 marks 4 min.)**	**[24, 24]**
Integer type Questions ('–1' negative marking) Q.24 to 32	**(4 marks 5 min.)**	**[36, 45]**
Comprehension ('–1' negative marking) Q.33 to Q.42	**(3 marks 3 min.)**	**[30, 30]**
Match the Following Q.43 to Q.45 (no negative marking) (2 × 4 or 5)	**(8 marks 10 min.)**	**[24, 30]**

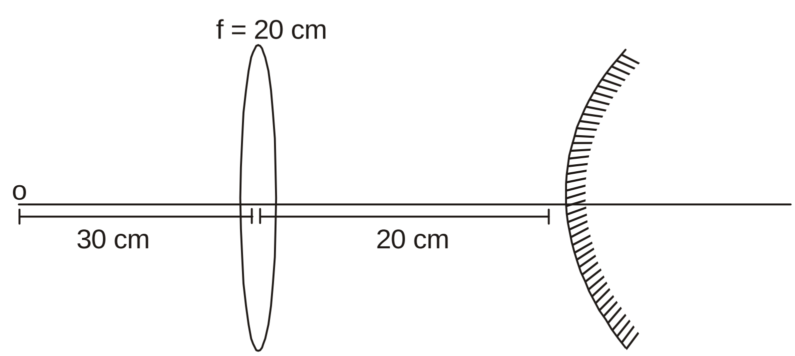
1. Consider a solid sphere of density ρ and radius 4R. Centre of the sphere is at origin. Two spherical cavities centered at (2R, 0) and (–2R, 0) are created in sphere. Radii of both cavities is R. In left cavity material of density 2ρ is filled while second cavity is kept empty. What is gravitational field at origin.



(A) $\frac{G\rho\pi R}{3}$ (B) $\frac{2G\rho\pi R}{3}$

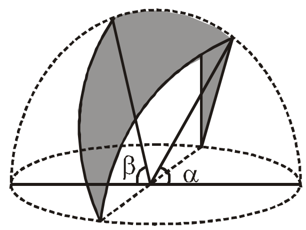
(C) $\frac{4G\rho\pi R}{3}$ (D) $\frac{3G\rho\pi R}{2}$

2. The lens shown is equiconvex having refractive Index. 1.5. In the situation shown the final image of object coincides with the object. The region between lens and mirror is now filled with a liquid of Rrefractive Index 2. Then find the separation between O & image formed by convex mirror.



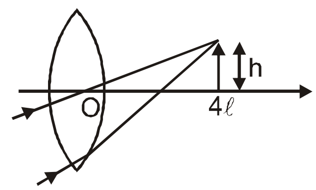
(A) 33 cm (B) 66 cm (C) 16 cm (D) 32 cm

3. The electric field at the centre of a uniformly charged hemispherical shell is E_0. Now two portions of the hemisphere are cut from either side and remaining portion is shown in figure. If $\alpha = \beta = \frac{\pi}{3}$, then electric field intensity at centre due to remaining portion is



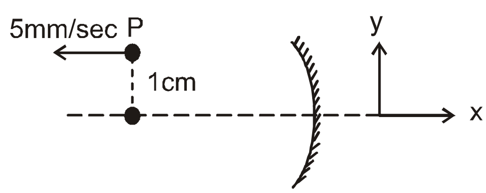
(A) $\frac{E_0}{3}$ (B) $\frac{E_0}{6}$ (C) $\frac{E_0}{2}$ (D) E_0

4. A thin converging lens L_1 forms a real image of an object located far away from the lens as shown in the figure. The image is located a distance 4ℓ and has height h. A diverging lens of focal length ℓ is placed 2ℓ from lens L_1. Another converging lens of focal length 2ℓ is placed 3ℓ from lens L_1. The height of final image thus formed is (Both diverging and converging lenses are placed at right side of L_1 -



(A) h (B) $\frac{h}{2}$ (C) 4h (D) 2h

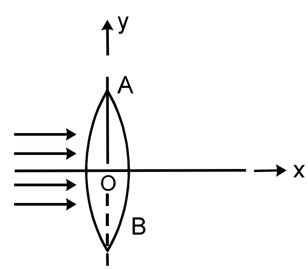
5. A point object P is moving towards left with speed 5 mm/sec parallel to optical axis of a concave mirror of focal length f = 20 cm. The seperation between object and optical axis is 1 cm. Find velocity of image of object in vector form when foot of perpendicular from object on the optical axis is at a distance 30 cm from pole.



(A) $\vec{V}_i = 20\hat{i} + 4\hat{j}$ mm/sec (B) $\vec{V}_i = 20\hat{i} + \hat{j}$ mm/sec

(C) $\vec{V}_i = 20\hat{i} - \hat{j}$ mm/sec (D) $\vec{V}_i = 20\hat{i}$ mm/sec

6. Monochromatic light rays parallel to x-axis strike a convex lens AB. If the lens oscillates such that AB tilts upto a small angle θ (in radian) on either side of y-axis, then find the distance between extreme positions of oscillating image (f = focal length of the lens) :



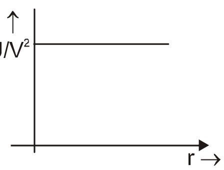
(A) $2f(\sec\theta - 1)$ (B) $f\sec^2\theta$

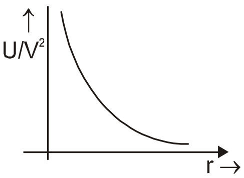
(C) $f(\sec\theta - 1)$ (D) the image will not move

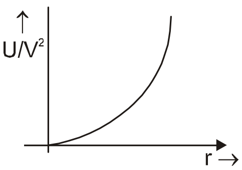
7. Two point charges having charge +Q, –q and mass M, m respectively are separated by a distance L. They are released from rest in a uniform electric field E. The electric field is parallel to line joining both the charges and is directed from negative to positive charge. For the separation between particles to remain constant, the value of L is ($K = \frac{1}{4\pi\epsilon_0}$)

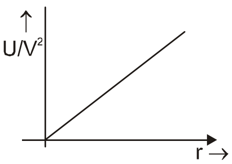
(A) $\sqrt{\frac{(M+m)KQq}{E(qM+Qm)}}$ (B) $\sqrt{\frac{(M+m)KQq}{E(qm+QM)}}$ (C) $\sqrt{\frac{mMKQq}{E(qM+Qm)}}$ (D) $\sqrt{\frac{mMKQq}{E(QM+qm)}}$

8. At distance ' r ' from a point charge, the ratio $\frac{U}{V^2}$ (where ' U ' is energy density and ' V ' is potential) is best represented by :

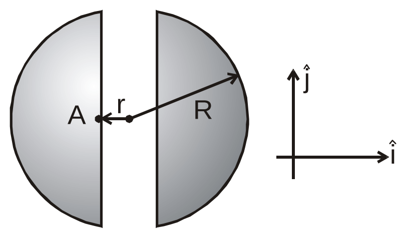
(A) 

(B) 

(C) 

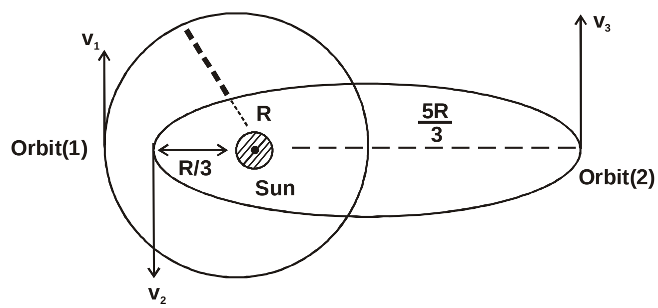
(D) 

9. A cylindrical portion of radius r is removed from a solid sphere of radius R and uniform volume charge density ρ in such a way that the axis of the hollow cylinder coincides with one of the diameters of the sphere. (r is negligible compared to R). Then the electric field intensity at point A is



(A) $\frac{\rho r}{3\varepsilon_0}\hat{i}$ (B) $-\frac{\rho r}{3\varepsilon_0}\hat{i}$ (C) $\frac{\rho r}{6\varepsilon_0}\hat{i}$ (D) $-\frac{\rho r}{6\varepsilon_0}\hat{i}$

10. Two satellites revolve around the 'Sun' as shown in the figure. First satellite revolves in a circular orbit of radius R with speed v_1. Second satellite revolves in elliptical orbit, for which minimum and maximum distance from the sun are $\frac{R}{3}$ and $\frac{5R}{3}$ respectively. Velocities at these positions are v_2 and v_3 respectively. The correct order of speeds is



(A) $v_2 > v_3 > v_1$ (B) $v_3 < v_2 < v_1$ (C) $v_2 > v_1 > v_3$ (D) $v_2 > v_3 = v_1$

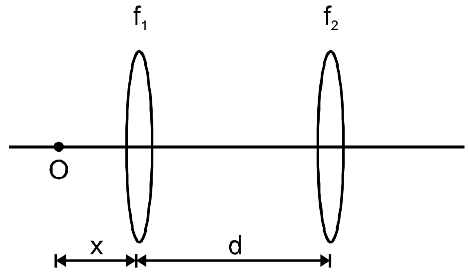
11. A small area is removed from a uniform spherical shell of mass M and radius R. Then the gravitational field intensity near the hollow portion is

(A) $\frac{GM}{R^2}$ (B) $\frac{GM}{2R^2}$ (C) $\frac{3GM}{2R^2}$ (D) Zero

12. A meteorite approaching a planet of mass M (in the straight line passing through the centre of the planet) collides with an automatic space station orbiting the planet in a circular trajectory of radius R. The mass of the station is ten times as large as the mass of the meteorite. As a result of the collision, the meteorite sticks in the station which goes over to a new orbit with the minimum distance R/2 from the planet. Speed of the meteorite just before it collides with the planet is : .

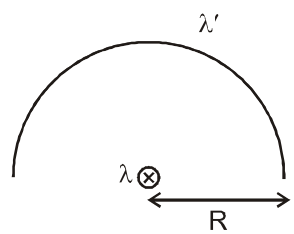
(A) $\sqrt{\frac{58GM}{R}}$ (B) $\sqrt{\frac{38GM}{R}}$ (C) $\sqrt{\frac{28GM}{R}}$ (D) $\sqrt{\frac{18GM}{R}}$

13. Two converging lenses have focal length f_1 and f_2 ($f_1 > f_2$). The optical axis of the two lenses coincide. This lens system is used to from an image of real object. It is observed that final magnification of the image does not depend on the distance x. Whole arrangement is shown in figure. Final magnification is :



(A) $-\dfrac{f_1}{f_2}$ (B) $-\dfrac{f_2}{f_1}$ (C) $-\dfrac{f_1}{f_1+f_2}$ (D) $-\dfrac{f_2}{f_1-f_2}$

14. In the figure shown an infinitely long wire of uniform linear charge density λ is kept perpendicular to the plane of figure such that it extends upto infinity on both sides of the paper. Find the electrostatic force on a semicircular ring kept such that its geometrical axis coincides with the wire. The semicircular ring has a uniform linear charge density λ'.

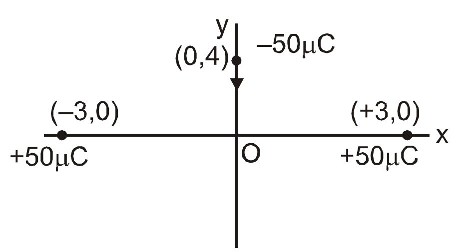


(A) $\dfrac{\lambda\lambda'}{\pi\varepsilon_0 R}$ (B) $\dfrac{\lambda\lambda'}{4\pi\varepsilon_0}$ (C) $\dfrac{\lambda\lambda'}{2\pi\varepsilon_0}$ (D) $\dfrac{\lambda\lambda'}{\pi\varepsilon_0}$

15. Consider a spherical planet rotating about its axis. The velocity of a point at equator is v. The angular velocity of this planet is such that it makes apparent value of 'g' at the equator half of value of 'g' at the pole. The escape speed for a polar particle on the planet expressed as multiple of v is :

(A) v (B) 2v (C) 3v (D) 4v

16. The figure shows two equal, positive charges, each of magnitude 50 μC, fixed at points (3, 0) m and (–3, 0)m respectively. A charge –50μC, moving along negative y–axis has a kinetic energy of 4J at the instant it crosses point (0,4)m. Determine the position of this charge where the direction of its motion reverses for the first time after crossing this point (neglect gravity).

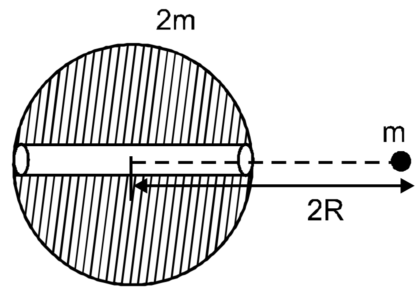


(A) $\left(0\text{m}, -7\sqrt{2}\text{m}\right)$ (B) $\left(0, -6\sqrt{2}\text{m}\right)$ (C) $(0, -5\sqrt{2})$ (D) $\left(0\text{m}, -4\sqrt{2}\,\text{m}\right)$

17. Orbital velocity of a satellite in its orbit (around earth) of radius r is v. It collides with another body in its orbit and comes to rest just after the collision. Taking the radius of earth as R, the speed with which it will fall on the surface of earth will be :

(A) $v\sqrt{\left(\dfrac{r}{R}-1\right)}$ (B) $v\sqrt{2\left(\dfrac{r}{R}-1\right)}$ (C) $\dfrac{v}{\sqrt{2\left(\dfrac{r}{R}+1\right)}}$ (D) $v\sqrt{2\left(\dfrac{r}{R}+1\right)}$

18. A solid spherical planet of mass 2m and radius 'R' has a very small tunnel along its diameter. A small cosmic particle of mass m is at a distance 2R from the centre of the planet as shown. Both are initially at rest, and due to gravitational attraction, both start moving toward each other. After some time, the cosmic particle passes through the centre of the planet. (Assume the planet and the cosmic particle are isolated from other planets)



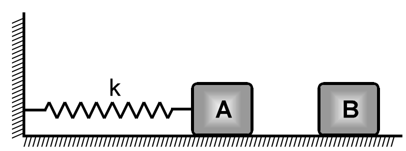
(A) Displacement of the cosmic particle till that instant is $\frac{4R}{3}$

(B) Acceleration of the cosmic particle at that instant is zero

(C) velocity of the cosmic particle at that instant is $\sqrt{\frac{8Gm}{3R}}$

(D) Total work done by the gravitational force on both the particle is $-\frac{2Gm^2}{R}$

19. In the figure shown A & B are two charged particles having charges q and – q respectively are placed on a non-conducting fixed horizontal smooth plane. B is fixed and A is attached to a non conducting massless spring of spring constant k. The other end of the spring is fixed. Mass of A is m, A and B are in equilibrium when the distance between them is r. Choose the correct options



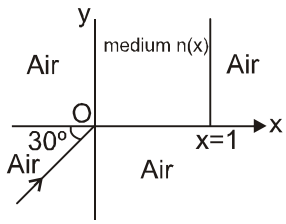
(A) time period of small oscillation of block A about is means position = $2\pi\sqrt{\frac{m}{k-\frac{q^2}{2\pi\epsilon_0 r^3}}}$.

(B) time period of small oscillation of block A about is means position = $2\pi\sqrt{\frac{m}{k+\frac{q^2}{2\pi\epsilon_0 r^3}}}$.

(C) to perform SHM, K must be greater than $\left(\frac{q^2}{2\pi\varepsilon_0 r^3}\right)$.

(D) to perform SHM, K must be greater than $\left(\frac{2q^2}{\pi\varepsilon_0 r^3}\right)$

20. A light ray enters into a medium whose refractive index varies along the x-axis as $n(x) = n_0\sqrt{1 + \frac{x}{4}}$ where $n_0 = 1$. The medium is bounded by the planes x = 0, x = 1 & y = 0. If the ray enters at the origin at an angle 30º with x–axis.



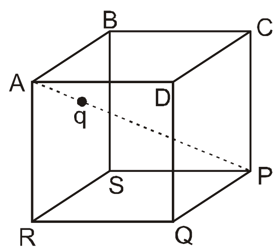
(A) equation of trajectory of the light ray is $y = [\sqrt{3+x} - \sqrt{3}]$

(B) equation of trajectory of the light ray is $y = 2[\sqrt{3+x} - \sqrt{3}]$

(C) the coordinate the point at which light ray comes out from the medium is $[1, 2(2-\sqrt{3})]$

(D) the coordinate the point at which light ray comes out from the medium is $[0, 2(2-\sqrt{3})]$

21. A charge 'q' is placed on the diagonal AP of a cube at a distance $\frac{AP}{3}$ from the point A. Choose the correct options.



(A) the sum of electric flux passing through the surfaces ABCD and PQRS is $\frac{q}{3\varepsilon_0}$

(B) the sum of electric flux passing through the surfaces ABCD and PQRS is $\frac{q}{8\varepsilon_0}$

(C) the flux through both the surfaces ABCD and PQRS are same

(D) the flux through the surfaces ABCD is larger than the flux through surface PQRS.

22. Two infinite, parallel, non–conducting thin sheets carry equal positive charge density σ. One is placed in the yz plane and the other at x = a. Take potential V = 0 at x = 0. Choose the correct statements

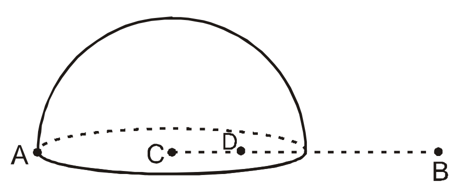
(A) For $0 < x < a$, potential V = 0.

(B) For $x > a$, potential $V = -\frac{\sigma}{\epsilon_0}(x-a)$

(C) For $x > a$, potential $V = \frac{\sigma}{\epsilon_0}(x-a)$

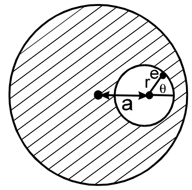
(D) For $x < 0$ potential $V = \frac{\sigma}{\epsilon_0}x$

23. In the figure shown there is a hollow hemisphere of radius 'R'. It has a uniform mass distribution having total mass m. The gravitational potential at points A, D and B are V_A, V_D and V_B respectively. Distance of D and B from centre C are R/2 and 2R respectively. The points C, D and B are lying on radial line of the hollow hemisphere.



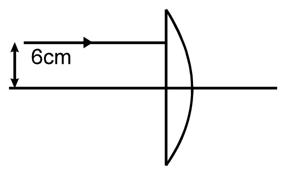
(A) $V_A = -\frac{Gm}{R}$, (B) $V_D = -\frac{Gm}{R}$ (C) $V_B = -\frac{Gm}{2R}$ (D) $V_A = V_D < V_B$

24. A cavity of radius r is present inside a fixed solid dielectric sphere of radius R, having a volume charge density of ρ. The distance between the centres of the sphere and the cavity is a. An electron is released inside the cavity at an angle $\theta = 45^0$ as shown. The electron (of mass m and charge –e) will take $\left(\frac{P\sqrt{2}\, m\, r\, \varepsilon_0}{e\, a\, \rho}\right)^{1/2}$ time to touch the sphere again. Neglect gravity. Find the value of P :



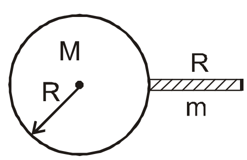
25. A planet revolves around the sun in elliptical orbit of semimajor axis 2×10^{12} m. The areal velocity of the planet when it is nearest to the sun is 4.4×10^{16} m^2/s. The least distance between planet and the sun is 1.8×10^{12} m. Find the minimum speed of the planet in km/s.

26. A light ray parallel to the principal axis is incident (as shown in the figure) on a planoconvex lens with radius of curvature of its curved part equal to 10 cm. Assuming that the refractive index of the material of the lens is 4/3 and medium on both sides of the lens is air, the distance of the point from the lens where this ray meets the principal axis is $\frac{2y}{7}$ cm then find value of y.



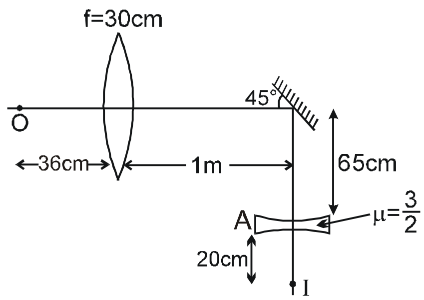
27. A satellite is orbiting around the earth in a circular orbit and in this orbit magnitude of its acceleration is 'a_1'. Now a rocket is fired in the direction of motion of satellite from the satellite due to which its speed instantaneously becomes half of initial, just after the rocket is fired acceleration of satellite has magnitude 'a_2' . Then the ratio $\frac{a_1}{a_2}$ is (Assume there is no external force other than the gravitational force of earth before and after the firing of rocket from the satellite)

28. A uniform thin rod of mass m and length R is placed normally on surface of earth as shown. The mass of earth is M and its radius is R. If the magnitude of gravitational force exerted by earth on the rod is $\frac{\eta GMm}{12R^2}$, then 'η' is

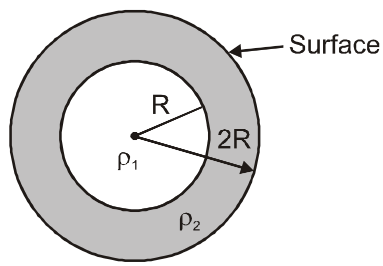


29. Two persons A and B wear glasses of optical powers (in air) $P_1 = +2$ D and $P_2 = +1$D respectively. The glasses have refractive index 1.5. Now they jump into a swimming pool and look at each other. B appears to be present at distance 2m (from A) to A. A appears to be present at distance 1m (from B) to B. The refractive index of water in the swimming pool, in the form $\frac{X}{10}$ and find X.

30. The final image I of the object O shown in the figure is formed at point 20 cm below a thin equi-concave lens, which is at a depth of 65 cm from principal axis. From the given geometry, calculate the radius of curvature in cm of lens kept at "A". (Refractive index of equi-convex lens is 1.5 and placed in air.

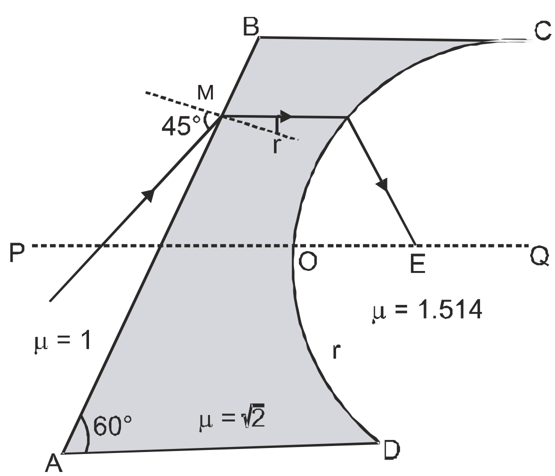


31. A planet is made of two materials of density ρ_1 and ρ_2 as shown in figure.



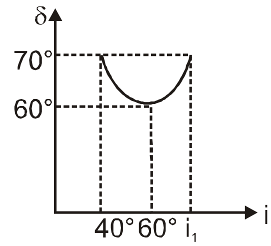
Acceleration due to gravity at surface of planet is same as at depth 'R'. The ratio $\frac{\rho_1}{\rho_2}$ is equal to $\frac{x}{3}$. Find the value of x.

32. Figure shows an irregular block of material of refractive index $\sqrt{2}$. A ray of light strikes the face AB as shown in figure. After refraction it is incident on a spherical surface CD of radius of curvature 0.4 m, (with centre lying on the line PQ) and enter a medium of refractive index 1.514 to meet PQ at E. Find the distance OE. in nearest interger in meters (point M is very near to line PQ)



COMPREHENSION -1

The curve of angle of incidence versus angle of deviation shown has been plotted for prism.



33. The value of refractive index of the prism used is

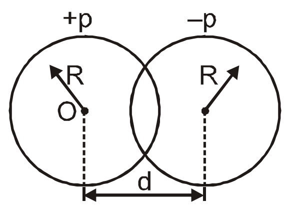
(A) $\sqrt{3}$ (B) $\sqrt{2}$ (C) $\sqrt{3}/\sqrt{2}$ (D) $2/\sqrt{3}$

34. The value of angle i_1 in degrees is

(A) 40° (B) 60° (C) 70° (D) 90°

COMPREHENSION -2

There are two non-conducting spheres having uniform volume charge densities ρ and $-\rho$. Both spheres have equal radius R. The spheres are now laid down such that they overlap as shown in the figure.



35. The electric field E in the overlap region is

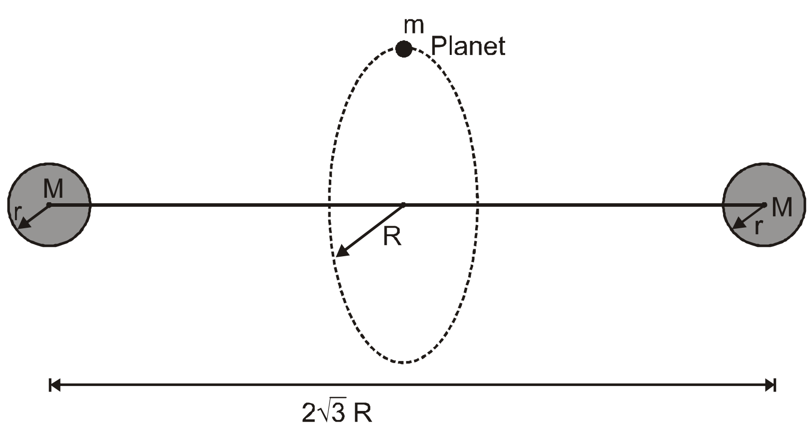
(A) non uniform (B) zero (C) $\frac{\rho}{3\epsilon_0}d$ (D) $\frac{\rho}{3\epsilon_0}R$

36. The potential difference ΔV between the centers of the two spheres for d = R is :

(A) $\frac{\rho}{3\epsilon_0}d^2$ (B) $\frac{\rho}{\epsilon_0}d^2$ (C) zero (D) $\frac{2\rho}{\epsilon_0}d^2$

COMPREHENSION -3

Consider a hypothetical solar system, which has two identical massive suns each of mass M and radius r, seperated by a seperation of $2\sqrt{3}$ R (centre to centre). (R >>>r). These suns are always at rest. There is only one planet in this solar system having mass m. This planet is revolving in circular orbit of radius R such that centre of the orbit lies at the mid point of the line joining the centres of the sun and plane of the orbit is perpendicular to the line joining the centres of the sun. Whole situation is shown in the figure.



Answer the following qustion regarding to this solar system.

37. Speed of the planet is :

(A) $\sqrt{\frac{GM}{8R}}$
(B) $\sqrt{\frac{GM}{4R}}$

(C) $\sqrt{\frac{GM}{2R}}$
(D) $\sqrt{\frac{GM}{3R}}$

38. Average force on the planet in half revolution is :

(A) $\frac{GMm}{4\pi R^2}$
(B) $\frac{GMm}{4R^2}$

(C) $\frac{GMm}{2\pi R^2}$
(D) $\frac{GMm}{8R^2}$

39. Duration of one year for this planet is :

(A) $\frac{4\pi R^{3/2}}{\sqrt{GM}}$
(B) $\frac{2\pi R^{3/2}}{\sqrt{GM}}$

(C) $\frac{\pi R^{3/2}}{\sqrt{GM}}$
(D) $\frac{3\pi R^{3/2}}{\sqrt{GM}}$

COMPREHENSION -4

A charge q is divided into three equal parts and placed symmetrically on a circle of radius r. The same charge is divided into four equal parts and placed symmetrically on the same circle. The electric field intensities at the centre of the circle in two situations are zero.

40. The ratio of electric potentials at the centre in the two situations is

(A) $\frac{2}{\sqrt{3}}$
(B) $\frac{1}{1}$
(C) $\frac{4}{3}$
(D) $\frac{16}{9}$

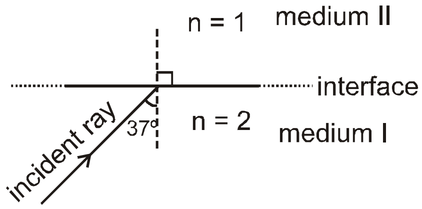
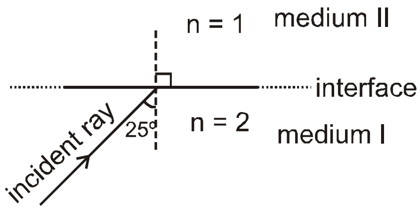
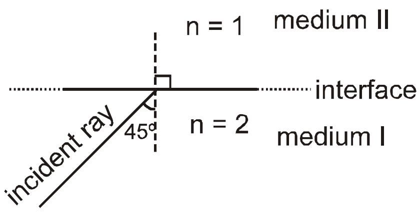
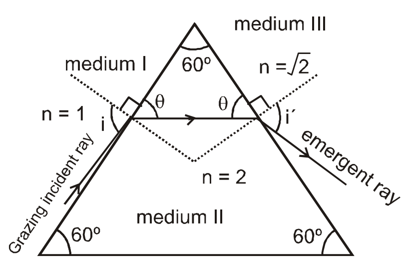
41. The potential energy of the system in first situation where the charge is divided into three equal parts is

(A) $\frac{1}{4\pi\varepsilon_o}\frac{q^2}{r}$
(B) $\frac{1}{36\pi\varepsilon_o}\frac{q^2}{r}$
(C) $\frac{1}{12\sqrt{3}\pi\varepsilon_o}\frac{q^2}{r}$
(D) $\frac{1}{12\pi\varepsilon_o}\frac{q^2}{r}$

42. If a charge (part charge) is removed from one location in both the situations, the ratio of magnitudes of the electric field intensities at the centre is

(A) $\frac{1}{2}$
(B) $\frac{1}{1}$
(C) $\frac{2}{3}$
(D) $\frac{4}{3}$

43. Match the proper entries from column-2 to column-1 using the codes given below the columns, if deviation in the Column–II is the magnitude of total deviation (between incident ray and finally refracted or reflected ray) to lie between 0º and 180º. Here n represents refractive index of medium.

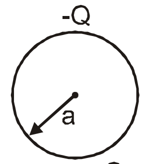
Column–I	**Column–II**
(P) 	(1) deviation in the light ray is greater than 90º
(Q) 	(2) deviation in the light ray is less than 90º
(R) 	(3) deviation in the light ray is equal to 90°
(S) 	(4) Speed of finally reflected or refracted light is same as speed of incident light.

	(P)	(Q)	(R)	(S)
(A)	4	2	1	3
(B)	1	2	4	2
(C)	3	1	4	2
(D)	2	4	1	3

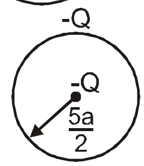
44. In each situation of column-I, some charge distributions are given with all details explained. In column -II The electrostatic potential energy and its nature is given situation in column -II. Match the proper entries from column-2 to column-1 using the codes given below the columns,

Column-I

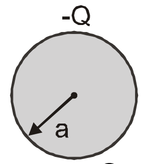
(P) A thin shell of radius a and having a charge – Q uniformly distributed over its surface as shown



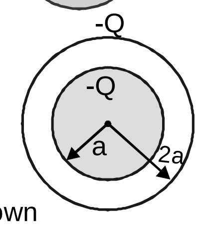
(Q) A thin shell of radius $\frac{5a}{2}$ and having a charge – Q uniformly distributed over its surface and a point charge – Q placed at its centre as shown.



(R) A solid sphere of radius a and having a charge – Q uniformly distributed throughout its volume as shown.



(S) A solid sphere of radius a and having a charge – Q uniformly distributed throughout its volume. The solid sphere is surrounded by a concentric thin uniformly charged spherical shell of radius 2a and carrying charge –Q as shown



Column-II

(1) $\frac{1}{8\pi \in_0}\frac{Q^2}{a}$ in magnitude

(2) $\frac{3}{20\pi \in_0}\frac{Q^2}{a}$ in magnitude

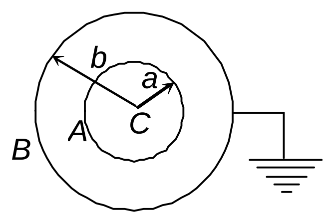
(3) $\frac{27Q}{80\pi \in_0}\frac{Q^2}{a}$ in magnitude

(4) Positive in sign

	(P)	(Q)	(R)	(S)
(A)	1	2	4	3
(B)	4	1	2	3
(C)	1	2	3	4
(D)	2	4	3	1

45. A conducting sphere A of radius a, with charge Q is placed concentrically inside a conducting shell B of radius b. B is earthed, C is the common centre of A and B. If P is the point between shells A and B at distance r from center C then Match the proper entries from column-2 to column-1 using the codes given below the columns,

(use : a = 1m, b = 3m, r = 2 m and K = $\frac{1}{4\pi\varepsilon_0}$)



Column - I		Column - II	
(P)	Electric field at point P is	(1)	$\frac{2KQ}{3}$
(Q)	Electric potential at point P is ($v_\infty = 0$)	(2)	zero
(R)	Electric potential difference between A and B is	(3)	$\frac{KQ}{4}$
(S)	Electric field outside the shell B at distance 5 m from centre C is	(4)	$\frac{KQ}{6}$

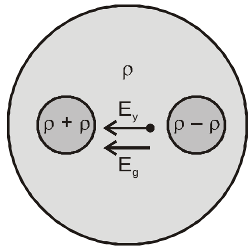
	(P)	(Q)	(R)	(S)
(A)	3	1	2	4
(B)	1	2	3	4
(C)	2	3	4	1
(D)	3	4	1	2

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

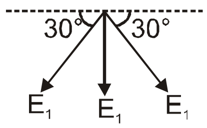
$$\frac{1}{V} - \frac{1}{80} = \frac{1}{20}$$

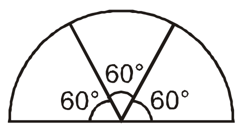
V = 16 cm
Seperation between object and this image O = 66 cm

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 2[nd] lens $\frac{1}{v} - \frac{1}{2\ell} = \frac{1}{-\ell}$ or $v = -2\ell$

$m_1 = -1$

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

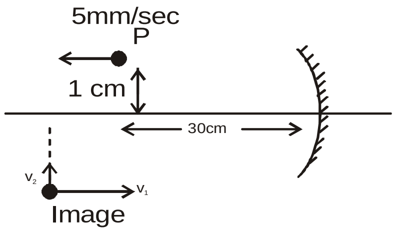
$m_2 = -2$
$h_i = (m_1 \times m_2)\, h_0$
$= 2h$

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

$v = -60$

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

$y_i = -2$ cm



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

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

for $\vec{v}_2$ $\vec{v}_2$ $\qquad \Rightarrow \qquad \dfrac{y_i}{y_o}=\dfrac{v}{u}$

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

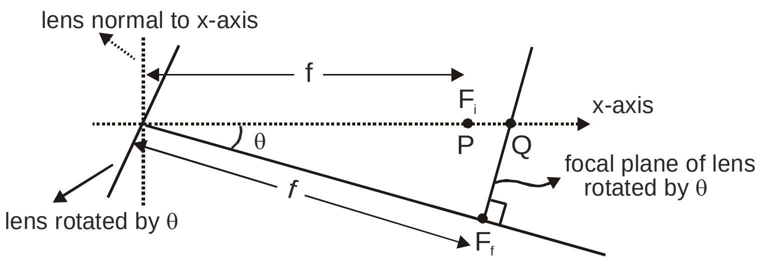
$\dfrac{dy_i}{dt}(u)+y_i\dfrac{du}{dt}=-y_o\dfrac{dv}{dt}$

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

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

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

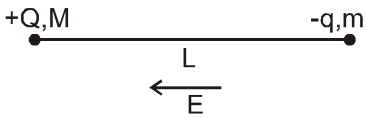
6. When the lens is tilted by θ, the image is formed at the intersection (Q) of focal plane of lens in tilted position and x-axis.



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 = $\dfrac{f}{\cos\theta}-f=f(\sec\theta-1)$ **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.



$QE-\dfrac{KQq}{L^2}=Ma \qquad$ .... (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.

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

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

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

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

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

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)

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

$\therefore$ 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)

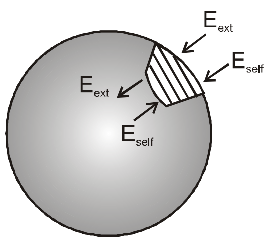
For elliptical orbit

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.



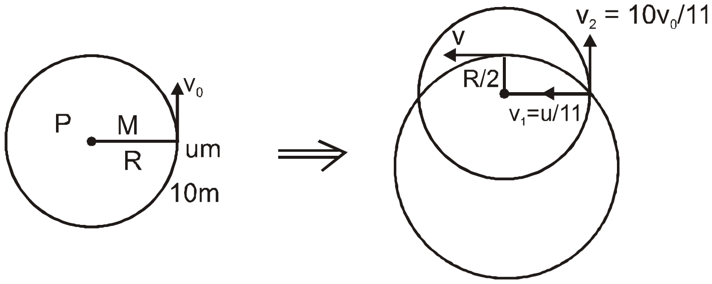
$E_{in} = E_{ext} - E_{self} = 0$
$\Rightarrow E_{ext} = E_{self}$

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

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

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

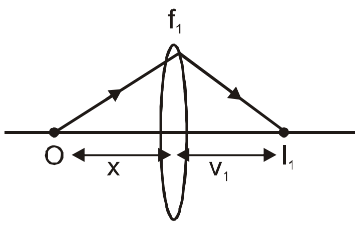
$$\Rightarrow \quad \left(\frac{u}{11}\right)^2 + \left(\frac{10v_0}{11}\right)^2 - \frac{2GM}{R} = \left(\frac{20v_0}{11}\right)^2 - \frac{4GM}{R}$$

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

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

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

13. Image -1



$u_1 = -x$

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

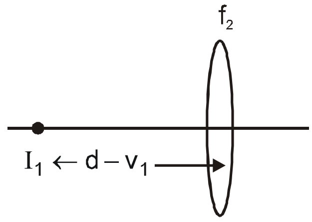
$$v_1 = \frac{x f_1}{x - f_1}$$

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

Image -2

$u_2 = -(d - v_1)$

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



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

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

$$m_1\, m_2 = \left(\frac{f_1}{x-f_1}\right)\left(\frac{f_2}{d-\frac{xf_1}{(x-f_1)}-f_2}\right) = \frac{f_1f_2}{x(d-f_1-f_2)-df_1+f_1f_2}$$

Since m is independent of x

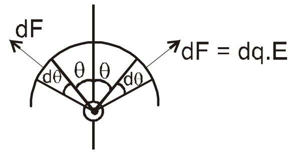
$\Rightarrow \quad (d - f_1 - f_2) = 0 \Rightarrow d = f_1 + f_2$

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

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

The force on the elementary charge dq is

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



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

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

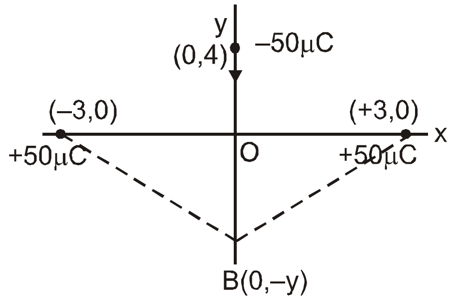
Ans. $\frac{\lambda\lambda'}{\pi\varepsilon_0}$

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 : $-\frac{GMm}{R} + \frac{1}{2}mv_e^2 = 0 \quad \Rightarrow \quad v_e^{\,2} = \frac{2GM}{R} = 4v^2$

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)

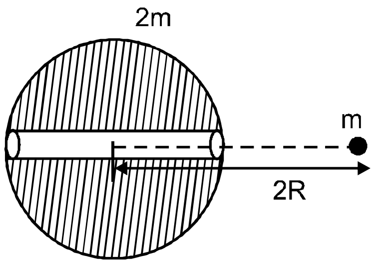
$\therefore$ The location is $\left(0,-6\sqrt{2}m\right)$.

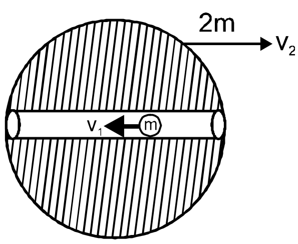
17. $v=\sqrt{\frac{GM}{r}}$ ....(1)

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

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

18. (C)





Applying momentum conservation,

$$0 = mv_1 - 2mv_2$$

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

From energy conservation,

$$k_i + U_i = k_f + U_f$$

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

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,

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

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

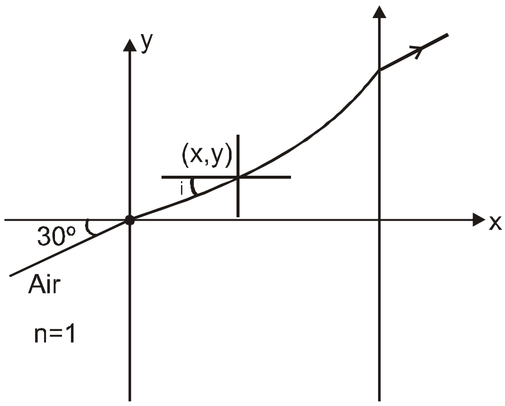
$$= \qquad k\,x - \frac{q^2}{2\pi\epsilon_0 r^3}\,x \;; \;\text{ using (1)} \qquad\qquad F_{res} = \left(k - \frac{q^2}{2\pi\epsilon_0 r^3}\right)x$$

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

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

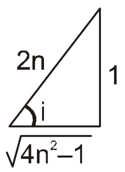
Ans. $T = 2\pi\sqrt{\dfrac{m}{k - \dfrac{q^2}{2\pi\epsilon_0 r^3}}}$, $k_{min} = \dfrac{q^2}{2\pi\epsilon_0 r^3}$

20.



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

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



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

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

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

(b) $\quad$ when $x = 1$

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

$\therefore \quad$ 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

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

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

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

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

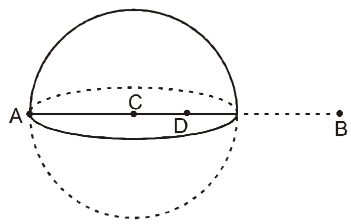
Ans. (a) $\frac{q}{3\varepsilon_0}$ **(b) Flux through two surfaces are not same flux via ABCD is larger.**

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

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

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

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) $= \frac{1}{2} \times \left(-\frac{G \cdot 2m}{R}\right) = -\frac{Gm}{R}$

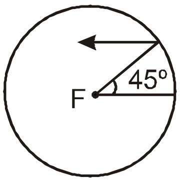
$V_A = \frac{1}{2}$ × potential due to complete shell at A $= \frac{1}{2} \times \left(-\frac{G \cdot 2m}{R}\right) = -\frac{Gm}{R}$

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

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

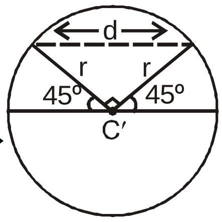
24. Electric field inside the cavity = $\dfrac{\rho\vec{a}}{3\varepsilon_0}\left[\begin{array}{c}\text{here } \vec{a} = \text{along line joining} \\ \text{Centers of sphere and cavity}\end{array}\right]$

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

Cavity $\longrightarrow$ 

acceleration = $\dfrac{\rho a e}{3\varepsilon_o m.}$

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

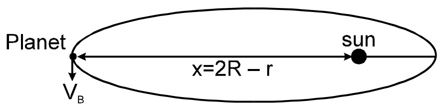
Cavity $\longrightarrow$ 

by S = ut + 1/2 at^2 , $\sqrt{2}\,r = \dfrac{1}{2} \times \dfrac{\rho a e}{3m\varepsilon_0}\, t^2$ $\qquad \Rightarrow t = \left(\dfrac{6\sqrt{2}\,rm\varepsilon_0}{e a \rho}\right)^{1/2}$

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

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

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



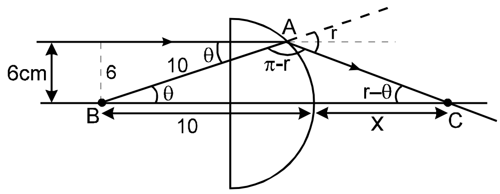
At farthest position

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

or $\qquad V_B = \dfrac{2A}{2R - r}$ (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 $\frac{\sin(r-\theta)}{10} = \frac{\sin(\pi - r)}{(10+x)}$; $\frac{10+x}{10} = \frac{4}{5\,(\sin r\cos\theta - \cos r\sin\theta)}$

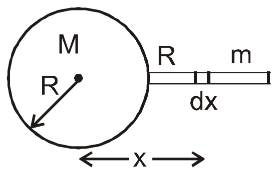
$= \frac{4}{5\left(\frac{4}{5}\times\frac{4}{5} - \frac{3}{5}\times\frac{3}{5}\right)}$; $10 + x = \frac{200}{7}$ $\Rightarrow$ $x = \frac{200-70}{7} = \frac{130}{7}$

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

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

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

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

Now, for A we have

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

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

Also for B we have

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

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

from (1) and (2) we get

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

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

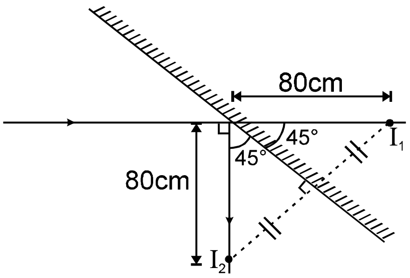
$$\Rightarrow \quad \frac{(3-2\mu)}{2\mu} = \frac{1}{2} \qquad \Rightarrow\ 6 - 4\mu = \mu$$

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

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 $i = e$

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

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

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

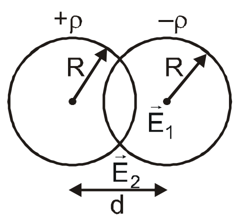
(from reversibility of ray)

also $\delta = 70°$

$\therefore 70° = i_1 + 40° - A$

$\therefore i_1 = 90°$

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



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

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

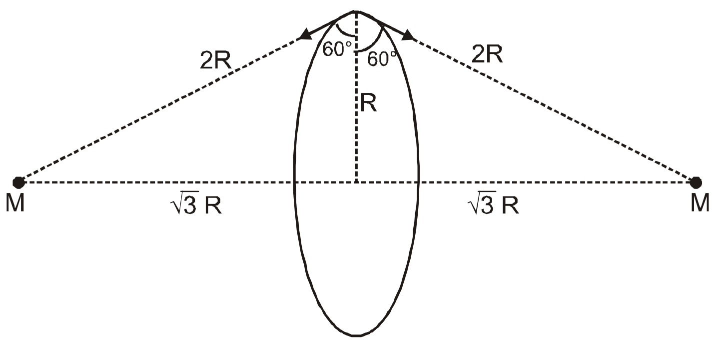
$$E = \frac{\rho d}{3\varepsilon_0}$$

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.



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

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

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

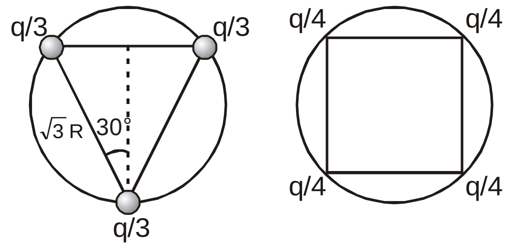
Average force on planet in half revolution.

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

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

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

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

By applying snells law for prism :

$i = 90$,

$r_1 = 30$, $\qquad r_2 = 30$

$e = 45$

$\delta = 90 + 45 - 60 = 75°$

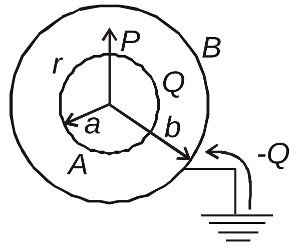
44. (A) Electrostatic potential energy = $\frac{1}{4\pi\epsilon_0}\frac{(-Q)^2}{2a} = \frac{Q^2}{8\pi\epsilon_0 a}$

(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.