EXERCISE - O

SINGLE CORRECT TYPE QUESTIONS

Properties of Charge and Coulomb's Law

1. If an object made of substance A rubs an object made of substance B, then A becomes positively charged and B becomes negatively charged. If, however, an object made of substance A is rubbed against an object made of substance C, then A becomes negatively charged. What will happen if an object made of substance B is rubbed against an object made of substance C?

(A) B becomes positively charged and C becomes positively charged.

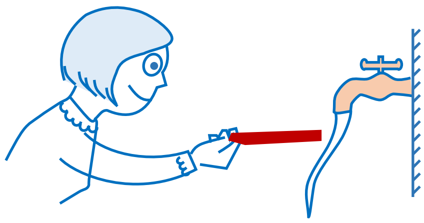
(B) B becomes positively charged and C becomes negatively charged.

(C) B becomes negatively charged and C becomes positively charged.

(D) B becomes negatively charged and C becomes negatively charged.

PES076

2. In normal cases thin stream of water bends toward a negatively charged rod. When a positively charged rod is placed near the stream, it will bend in the



(A) Opposite direction. (B) Same direction.

(C) It won't bend at all. (D) Can't be predicted.

PES077

3. Two charged bodies A and B exert repulsive forces on each other. If charge on A is more than that on B, which of the following statement is true.

(A) Body A experiences more Colombian force then B.

(B) Body A experiences less Colombian force then B.

(C) Both of them experience Colombian forces of equal magnitude.

(D) It depends whether the bodies can be treated as point like charges or not.

PES078

4. Given are four arrangements of three fixed electric charges. In each arrangement, a point labelled P is also identified — test charge, $+q$, is placed at point P. All of the charges are of the same magnitude Q, but they can be either positive or negative as indicated. The charges and point P all lie on a straight line. The distances between adjacent items, either between two charges or between a charge and point P, are all the same. Correct order of choices in a decreasing order of magnitude of force on P is

(A) II > I > III > IV (B) I > II > III > IV (C) II > I > IV > III (D) III > IV > I > II

PES079

5. Two particle of equal mass m and charge q are placed at a distance of 16 cm. They do not experience any force. The value of $\frac{q}{m}$ is

(A) I (B) $\sqrt{\frac{\pi\varepsilon_0}{G}}$ (C) $\sqrt{\frac{G}{4\pi\varepsilon_0}}$ (D) $\sqrt{4\pi\varepsilon_0 G}$

PES082

6. Two equally charged, identical metal spheres A and B repel each other with a force 'F'. The spheres are kept fixed with a distance 'r' between them. A third identical, but uncharged sphere C is brought in contact with A and then placed at the mid-point of the line joining A and B. The magnitude of the net electric force on C is

(A) F (B) $3F/4$ (C) $F/2$ (D) $F/4$

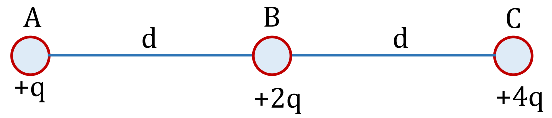
PES083

7. Two point charges placed at a certain distance r in air exert a force F on each other. Then the distance r' at which these charges will exert the same force in a medium of dielectric constant k is given by

(A) r (B) r/k (C) $r/\sqrt{k}$ (D) $r\sqrt{k}$

PES085

8. Three charges $+q$, $+2q$ and $+4q$ are connected by strings as shown in the figure. What is ratio of tensions in the strings AB and BC.



(A) 1 : 2 (B) 1 : 3 (C) 2 : 1 (D) 3 : 1

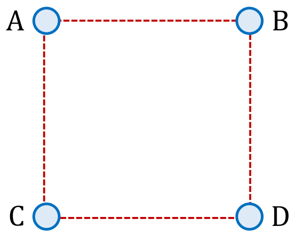
PES086

9. Two point charges A (4×10^{-9} C) and B (-16×10^{-9} C) are separated by a distance 20 cm in vacuum. Where must another point charge be placed, so that it does not experience any net force due to charges A and B?

(A) $20/3$ cm left of B
(B) $20/3$ cm right of B
(C) 20 cm left of A
(D) 20 cm right of A

PES092

10. Four charges are at the corners of a square as shown in the figure. Corners A and D have equal charge, while both B and C have a charge of +1 C. What is the charge on A so that the force on B is zero?



(A) –1.0 C (B) – 0.5 C (C) – 0.35 C (D) – 0.71 C

PES091

11. A charge q is placed at the center of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to

(A) $-Q/2$ (B) $-Q/4$ (C) $+Q/4$ (D) $+Q/2$

PES093

12. Two identical charges, 5 μC each, are in the air. What is the largest charge to be transferred from one charge to another, so that their interaction force decreases 2.5 times ?

(A) $\sqrt{11}$ μC (B) 4 μC (C) $\sqrt{13}$ μC (D) $\sqrt{15}$ μC

PES094

13. A point charge $-3q$ is positioned at point (2, –1, 3) of a Cartesian coordinate system. A test point charge $2q$ is placed at point (3, 0, 4). Which of the following is the unit vector in the direction of the force acting on the test charge? All the coordinates are in meters.

(A) $\hat{i}+\hat{j}+\hat{k}$ (B) $-(\hat{i}+\hat{j}+\hat{k})$ (C) $(\hat{i}+\hat{j}+\hat{k})/\sqrt{3}$ (D) $-(\hat{i}+\hat{j}+\hat{k})/\sqrt{3}$

PES090

14. Two-point charge of 100 μC and –4 μC are positioned at points $(-2\sqrt{3}, 3\sqrt{3}, -4)$ and $(4\sqrt{3}, -5\sqrt{3}, 6)$ respectively of a Cartesian coordinate system. Find the force vector on the –4 μC charge? All the coordinates are in meters.

(A) $9\times10^{-4}(3\sqrt{3}\hat{\imath}-4\sqrt{3}\hat{\jmath}+5\hat{k})$ (B) $9\times10^{-4}(-3\sqrt{3}\hat{\imath}+4\sqrt{3}\hat{\jmath}-5\hat{k})$

(C) $2.25\times10^{-4}(-3\sqrt{3}\hat{\imath}+4\sqrt{3}\hat{\jmath}-5\hat{k})$ (D) $2.25\times10^{-4}(3\sqrt{3}\hat{\imath}-4\sqrt{3}\hat{\jmath}+5\hat{k})$

PES095

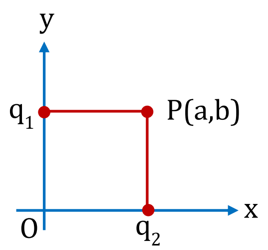
Electric Field

15. Five positive equal charges are placed at vertices of a regular hexagon and net electric field at the centre is E_1. A negative charge having equal magnitude is placed sixth vertex and then net electric field is E_2. Find $\frac{E_2}{E_1}$.

(A) 2 (B) 1 (C) 3 (D) None of these

PES096

16. Two point charges q_1 = 2 μC and q_2 = 1 μC are placed at distances b = 1 cm and a = 2cm from the origin on the y and x axes as shown in figure the electric field vector at point $P(a, b)$ will subtend an angle θ with x-axis given by -



(A) $\tan\theta = 1$ (B) $\tan\theta = 2$

(C) $\tan\theta = 3$ (D) $\tan\theta = 4$

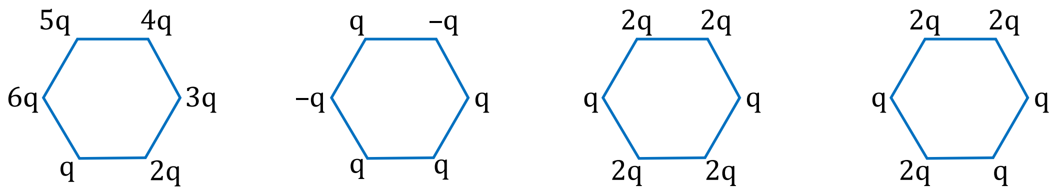
PES115

17. There are two point charges q_1 and q_2 lying on a circle of unit radius. Electric field intensity at the center of circle due to these charges is $\vec{E}$. Find the position vector of the center with respect to q_2 if the position vector of the center with respect to q_1 is $\vec{r}_1$.

(A) $\frac{\vec{E}+kq_1\vec{r}_1}{kq_2}$ (B) $-\left(\frac{\vec{E}+kq_1\vec{r}_1}{kq_2}\right)$ (C) $\frac{kq_1\vec{r}_1-\vec{E}}{kq_2}$ (D) $\frac{\vec{E}-kq_1\vec{r}_1}{kq_2}$

PES097

18. Figure below shows regular hexagon, with different charges placed at the vertices. In which of the following cases is the electric field at the centre zero?



I **II** **III** **IV**

(A) IV (B) III (C) I (D) II

PES116

19. Two point charges $3\mu C$ and $2.5\ \mu C$ are placed at point A (1, 1, 2)m and B (0, 3, –1)m respectively. Find out electric field intensity vector at point $C(3, 3, 3)m$.

(A) $[2500\hat{\imath} + 2000\hat{\jmath} + 1720\hat{k}]\ N/C$

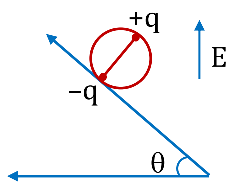
(B) $[2000\hat{\imath} + 2000\hat{\jmath} + 1720\hat{k}]\ N/C$

(C) $[1720\hat{\imath} + 2000\hat{\jmath} + 1720\hat{k}]\ N/C$

(D) $[2540\hat{\imath} + 2000\hat{\jmath} + 1720\hat{k}]\ N/C$

PES117

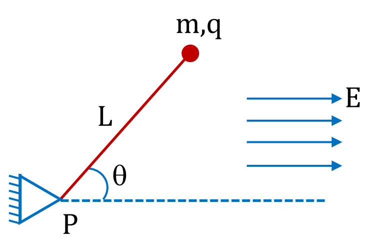
20. A wheel having mass m has charges $+q$ and $-q$ on diametrically opposite points. It remains in equilibrium on a rough inclined plane in the presence of uniform vertical electric field E =



(A) $\frac{mg}{q}$ (B) $\frac{mg}{2q}$ (C) $\frac{mg\tan\theta}{2q}$ (D) None

PES100

21. A particle of mass m and charge q is attached to a light rod of length L. The rod can rotate freely in the plane of paper about the other end, which is hinged at P. The entire assembly lies in a uniform electric field E also acting in the plane of paper as shown. The rod is released from rest when it makes an angle θ with the electric field direction. Determine the speed of the particle when the rod is parallel to the electric field.



(A) $\left(\frac{2qEL(1-\cos\theta)}{m}\right)^{1/2}$

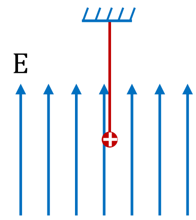
(B) $\left(\frac{2qEL(1-\sin\theta)}{m}\right)^{1/2}$

(C) $\left(\frac{qEL(1-\cos\theta)}{2m}\right)^{1/2}$

(D) $\left(\frac{2qEL\cos\theta}{m}\right)^{1/2}$

PES110

22. A positively charged pendulum is oscillating in a uniform electric field as shown in Figure. Its time period of SHM as compared to that when it was uncharged. ($mg > qE$)



(A) Will increase

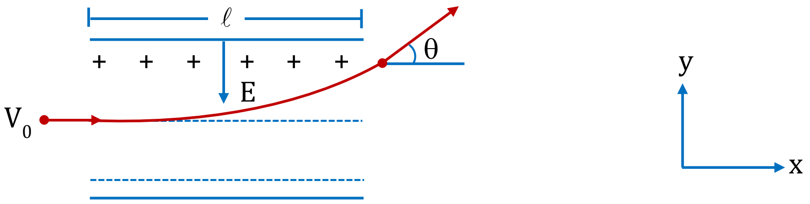
(B) Will decrease

(C) Will not change

(D) Will first increase then decrease

PES111

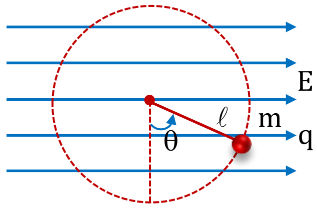
23. A uniform electric field $E = 91 \times 10^{-6}\ V/m$ is created between two parallel, charged plates as shown in figure. An electron enters the field symmetrically between the plates with a speed $v_0 = 4 \times 10^3\ m/s$. The length of each plate is $\ell = 1m$. Find the angle of deviation of the path of the electron as it comes out of the field. (Mass of the electron is $m = 9.1 \times 10^{-31}\ kg$ and its charge is $e = -1.6 \times 10^{-19}\ C$).



(A) θ = 30° (B) θ = 15° (C) θ = 45° (D) θ = 60°

PES112

24. A small ball of mass m and charge $+q$ tied with a string of length l, is rotating in a vertical circle under gravity and a uniform horizontal electric field E as shown. The tension in the string will be minimum for:-

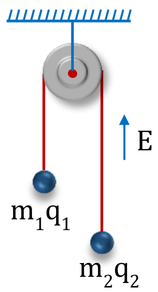


(A) $\theta = \tan^{-1}\left(\frac{qE}{mg}\right)$ (B) $\theta = \pi$ (C) $\theta = \pi - \tan^{-1}\left(\frac{qE}{mg}\right)$ (D) $\theta = \pi + \tan^{-1}\left(\frac{qE}{mg}\right)$

PES099

25. Two small balls are carrying masses and charges m_1, q_1 and m_2, q_2 respectively. The entire system is placed in uniform electric field $\vec{E}$ directed upward. If $(m_1 + m_2)\ g = (q_1 + q_2)E$, then the acceleration of centre of mass.

(Neglect the interaction between balls).



(A) is necessarily zero

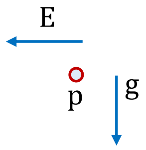
(B) is not necessarily zero

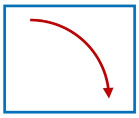
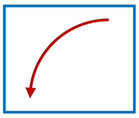
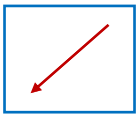
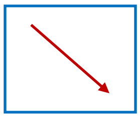
(C) is directed downward

(D) None

PES105

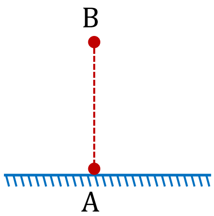
26. A negatively charged particle p is placed, initially at rest, in a constant, uniform gravitational field and a constant, uniform electric field as shown in the diagram. What qualitatively, is the shape of the trajectory of the electron ?



(A)  (B)  (C)  (D) 

PES101

27. Particle B of charge Q and mass m is in equilibrium under weight and electrostatics force applied by a fixed charged A, which is directly beneath the particle B as shown in figure. When particle B is disturbed along vertical, the equilibrium is



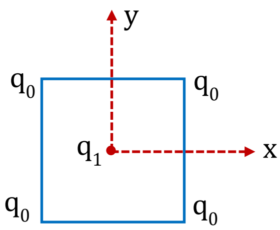
(A) stable (B) unstable

(C) neutral (D) there can not be in equilibrium

PES098

28. Four equal charges q_0 each, are kept fixed on the vertices of a square of side 'a'. Charge q_1 is kept at the center of the square as shown in the figure. Then which statement is correct ?

(Here charge q_1 is restricted to move perpendicular to XY plane i.e. along z-axis)



(A) charge q_1 is always in stable equilibrium.

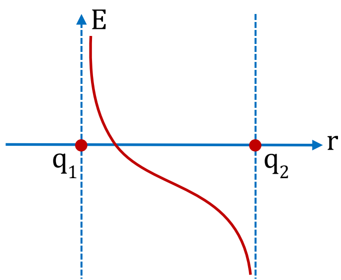
(B) charge q_1 is in unstable equilibrium.

(C) charge q_1 is always in stable equilibrium only if q_1 and q_0 have different (opposite) signs.

(D) charge q_1 is always in stable equilibrium only if q_1 and q_0 have same signs.

PES103

29. The variation of electric field between the two charges q_1 and q_2 along the line joining the charges is plotted against distance from q_1 (taking rightward direction of electric field as positive) as shown in the figure. Then the correct statement is :-



(A) q_1 and q_2 are positive and $q_1 < q_2$

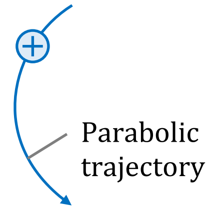
(B) q_1 and q_2 are positive and $q_1 > q_2$

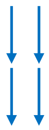
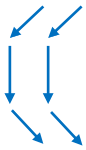
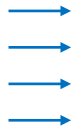
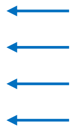
(C) q_1 is positive and q_2 is negative and $q_1 < q_2$

(D) q_1 and q_2 are negative and $q_1 < q_2$

PES109

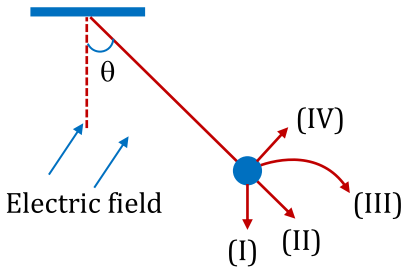
30. Which electric field is responsible for the proton's trajectory as shown below ?



(A)  (B)  (C)  (D) 

PES113

31. A small object of mass M and charge Q is connected to an insulating massless string in vacuum on Earth. A uniform electric field exists throughout the region of the vacuum as indicated. The mass remains in static equilibrium at an angle of θ with the vertical as shown in the figure. When the string is cut, which of the illustrated paths best indicates the trajectory of the mass?

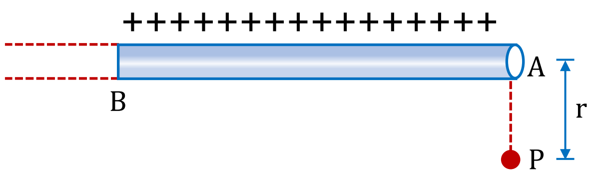


(A) I (B) II

(C) III (D) IV

PES104

32. A semi-infinite insulating rod has linear charge density λ. The electric field at the point P shown in figure is :-

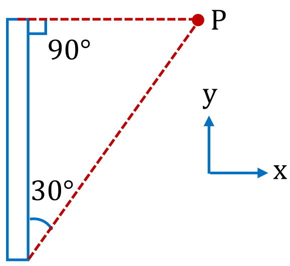


(A) $\dfrac{2\lambda^2}{(4\pi\varepsilon_0 r)^2}$ at 45° with AB (B) $\dfrac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r^2}$ at 45° with AB

(C) $\dfrac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at 45° with AB (D) $\dfrac{\sqrt{2}\lambda}{4\pi\varepsilon_0 r}$ at perpendicular to AB

PES118

33. The direction (θ) of $\vec{E}$ at point P due to uniformly charged finite rod will be :-



(A) At angle 30° from x-axis

(B) 45° from x-axis

(C) 60° from x-axis

(D) None of these

PES119

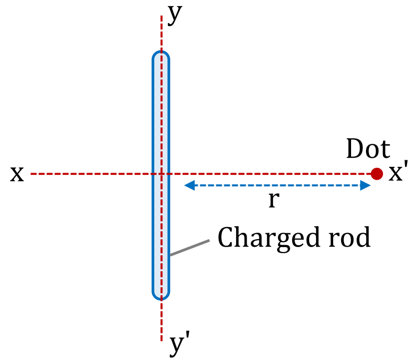
34. A uniformly charged rod is kept on y-axis with centre at origin, as shown. Which of the following actions will increase the electric field strength at the position of the dot ?

(A) Make the rod longer without changing the charge.

(B) Make the rod shorter without changing the charge.

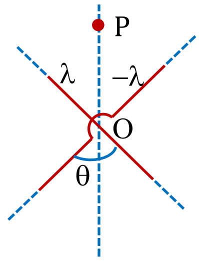
(C) Make the rod shorter without changing the linear charge density.

(D) Rotate the rod about yy'.



PES123

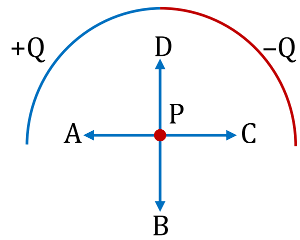
35. If the line charge densities are λ and $-\lambda$. as shown in figure. Find the electric field at P.



(A) $\frac{2k\lambda}{x}\cot\frac{\theta}{2}$ (B) $\frac{4k\lambda}{x}\cot\frac{\theta}{2}$ (C) $\frac{2k\lambda}{x}\tan\frac{\theta}{2}$ (D) $\frac{4k\lambda}{x}\tan\frac{\theta}{2}$

PES127

36. As shown in the figure, an insulating rod is set into the shape of a semicircle. The left half of the rod has a charge of $+Q$ uniformly distributed along its length, and the right half of the rod has a charge of $-Q$ uniformly distributed along its length. Which vector shows the correct direction of the electric field at point P, the centre of the semicircle ?



(A) A (B) B

(C) C (D) D

PES120

37. A nonconducting ring of radius R has uniformly distributed positive charge Q. A small part of the ring, of length d, is removed ($d << R$). The electric field at the centre of the ring will now be

(A) directed towards the gap, inversely proportional to R^3.

(B) directed towards the gap, inversely proportional to R^2.

(C) directed away from the gap, inversely proportional to R^3.

(D) directed away from the gap, inversely proportional to R^2.

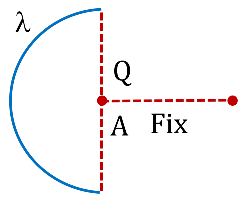
PES121

38. The maximum electric field at a point on the axis a uniformly charged ring is E_0. At how many points on the axis will the magnitude of electric field be $E_0/2$:-

(A) 1 (B) 2 (C) 3 (D) 4

PES122

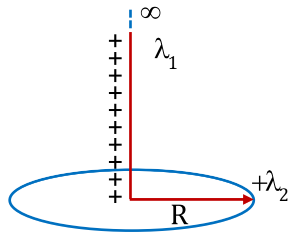
39. A charge is kept fixed at point A as shown in the figure in a gravity free space. A semicircular ring of linear charge density λ, mass m and radius R is released from rest. Initially centre of semicircular ring coincides with the fixed charge. The initial acceleration of the semicircular ring is :-



(A) $\frac{2K\lambda Q}{mR}$ (B) $\frac{K\lambda Q}{2mR}$ (C) $\frac{K\lambda Q}{mR}$ (D) 0

PES125

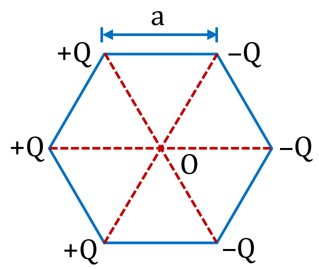
40. A semi-infinite charged wire with charge density $+\lambda_1$ is placed along the axis of a uniformly charged ring of charge density $+\lambda_2$. Find the force exerted on the wire due to the ring. The radius of ring is R.



(A) $(k\lambda_1\lambda_2)\ 2\pi R$ (B) $\frac{\lambda_1\lambda_2}{2\epsilon_0}$ (C) $k\lambda_1^2 2\pi R$ (D) None of these

PES126

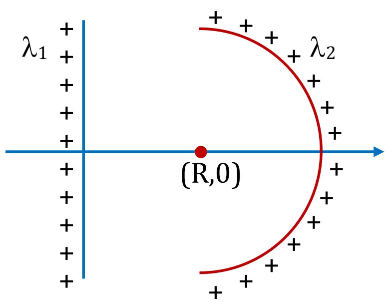
41. Six charges are placed at the vertices of a regular hexagon as shown in the figure. The vertical component of the electric field along the line passing through point O and perpendicular to the plane of the figure at a distance of x ($>>a$) from O is



(A) $\frac{Qa}{\pi\varepsilon_0 x^3}$ (B) $\frac{2Qa}{\pi\varepsilon_0 x^3}$ (C) $\frac{\sqrt{3}Qa}{\pi\varepsilon_0 x^3}$ (D) zero

PES271

42. A uniformly charged infinite wire is placed along 'y' axis having linear charge density 'λ_1'. A semicircle wire having linear charge density 'λ_2' centred at (R, 0) is placed as shown. Find the ratio of $\frac{\lambda_1}{\lambda_2}$. If electric field at ($R$, 0) is zero.



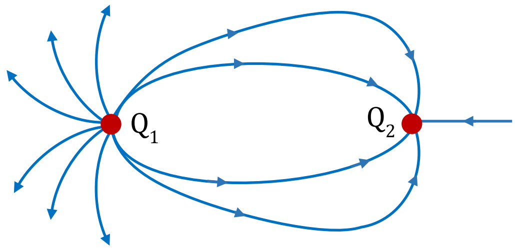
(A) $\frac{\lambda_1}{\lambda_2} = 1$ (B) $\frac{\lambda_2}{\lambda_1} = 2$

(C) $\frac{\lambda_2}{\lambda_1} = \frac{1}{2}$ (D) $\frac{\lambda_1}{\lambda_2} = \sqrt{2}$

PES272

Properties of Electric Line of Force and Gauss Law

43. From the field pattern shown in figure, identify the correct statement related to the charges Q_1 and Q_2.



(A) $\dfrac{Q_1}{Q_2} = +2.5$

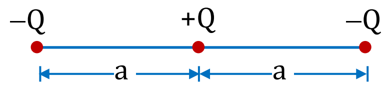
(B) $\dfrac{Q_1}{Q_2} = +2$

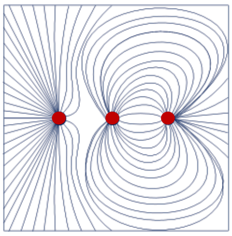
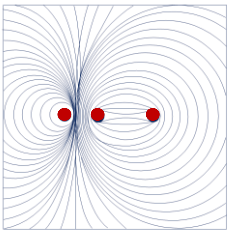
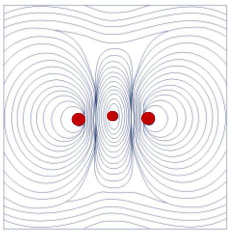
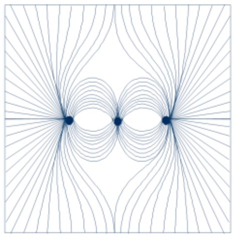
(C) $\dfrac{Q_1}{Q_2} = -2$

(D) There is no relation exist between Q_1 and Q_2

PES137

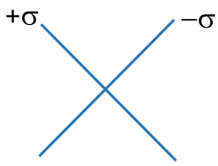
44. The fig. shows the distribution of three charges $-Q$, $+Q$ and $-Q$ on the X-axis. Which of the following figures shows the possible electric field lines for the distribution?

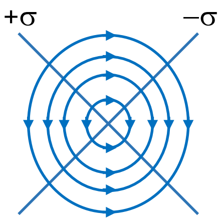


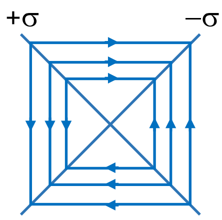
(A)  (B)  (C)  (D) 

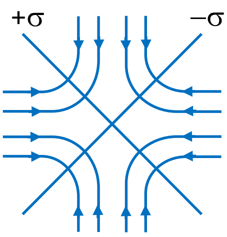
PES138

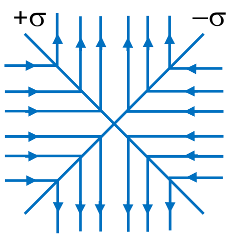
45. Two infinite sheets carrying charge density $+\sigma$ and $-\sigma$ are arranged perpendicularly as shown in the figure. Select the approximate electric field lines for the charge system near the intersection.



(A) 

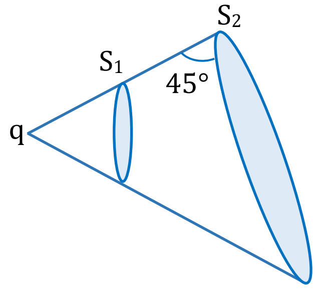
(B) 

(C) 

(D) 

PES140

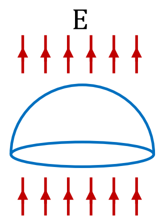
46. In the given figure flux through surface S_1 is f_1 and through S_2 is f_2. Which is correct ?



(A) $f_1 = f_2$ (B) $f_1 > f_2$ (C) $f_1 < f_2$ (D) None of these

PES135

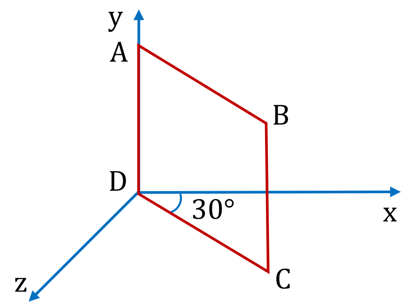
47. A hemispherical surface (half of a spherical surface) of radius R is located in a uniform electric field E that is parallel to the axis of the hemisphere. What is the magnitude of the electric flux through the hemisphere surface?



(A) 0 (B) $4\pi R^2E/3$ (C) $2\pi R^2E$ (D) πR^2E

PES136

48. A square cross-section $ABCD$ of side a is kept in the direction shown in the diagram. An electric field $E_0\hat{i} + E_0\hat{j}$ exists in the region. The flux of this field through the area cross-section is :



(A) E_0a^2 (B) $\frac{E_0a^2}{3}$ (C) $\frac{E_0a^2}{2}$ (D) $\frac{\sqrt{3}}{2}E_0a^2$

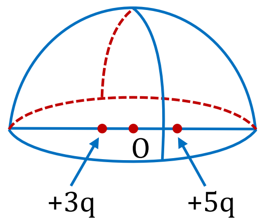
PES141

49. An electric field $\vec{E} = E_0\hat{i} + E_0\hat{j}$ exists in a space. Find the flux through a triangular loop with vertices at $\left(\frac{a}{2},0,0\right)$, $\left(\frac{a}{2},0,a\right)$ and $\left(\frac{a}{2},a,\frac{a}{2}\right)$.

(A) $\sqrt{2}\,E_0a^2$ (B) $\frac{E_0a^2}{2}$ (C) $\frac{\sqrt{3}}{2}E_0a^2$ (D) $\frac{\sqrt{3}}{4}E_0a^2$

PES273

50. The figure shows a hollow hemisphere of radius R in which two charges $3q$ and $5q$ are placed symmetrically about the centre O on the planar surface. The electric flux over the curved surface is:



(A) $\frac{15}{2}\frac{q}{\varepsilon_0}$ (B) $\frac{4q}{\varepsilon_0}$

(C) $\frac{q}{\varepsilon_0}$ (D) $\frac{2q}{\varepsilon_0}$

PES274

51. Find out the electric flux through an area 10 m^2 lying in XY plane due to an electric field $\vec{E} = 2\hat{\imath} - 10\hat{\jmath} + 5\hat{k}$.

(A) 40 $N\,m^2/C$ (B) 20 $N\,m^2/C$ (C) 50 $N\,m^2/C$ (D) 60 $N\,m^2/C$

PES142

52. A square of side 'a' is lying in xy plane such that two of its sides are lying on the axis. If an electric field $\vec{E} = E_0 x\,\hat{k}$ is applied on the square. The flux passing through the square is :–

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

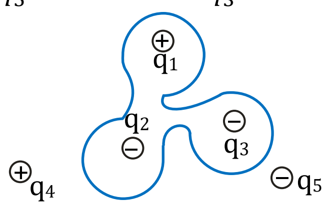
PES143

53. A very long uniformly charged thread oriented along the axis of a circle of radius R = 1m, rests on its centre with one of the ends. The charge per unit length on the thread is $\lambda = 16\,\varepsilon_0$. Find the flux of the vector E through the circle area in (Vm).

(A) 4 (B) 8 (C) 16 (D) 32

PES144

54. Figure shows five charged lumps of non-conducting material.
The cross-section of a gaussian surface S is indicated. What is the net electric flux through the surface if q_1 = q_4 = 10 nC q_2 = q_5 = –10 nC and q_3 = – 5 nC



(A) – 565 (B) – 400 (C) – 800 (D) – 500

PES150

55. A square of side 20 cm is enclosed by a surface of sphere of 80 cm radius. Square and sphere have the same centre. Four charges $+2 \times 10^{-6}$ C, -5×10^{-6} C, -3×10^{-6} C, $+6 \times 10^{-6}$ C are located at the four corners of a square, then out going total flux from spherical surface in $N - m^2/C$ will be

(A) Zero (B) $(16\pi) \times 10^{-6}$ (C) $(8\pi) \times 10^{-6}$ (D) $36\pi \times 10^{-6}$

PES151

56. The inward and outward electric flux from a closed surface are respectively 8×10^3 and 4×10^3 units. Then the net charge inside the closed surface is -

(A) -4×10^3 coulomb (B) 4×10^3 coulomb

(C) $\frac{-4\times10^3}{\varepsilon_0}$ coulomb (D) $-4 \times 10^3\,\varepsilon_0$ coulomb

PES149

57. Gauss's law is given by $\oint_s \vec{E}.d\vec{s} = \frac{q}{\epsilon_0}$, if net charge enclosed by a Gaussian surface is zero then:

(A) E must be zero on the surface

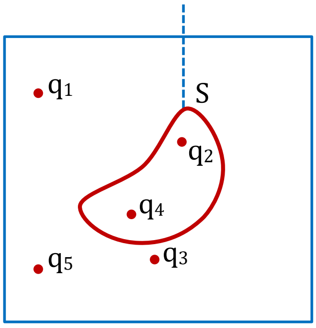
(B) Number of incoming and outgoing electric lines are equal

(C) There is a net incoming of electric lines

(D) None

PES147

58. Five charges $q_1, q_2, q_3, q_4,$ and q_5 are fixed at their positions as shown in Fig. (S is a Gaussian surface). The Gauss's law is given by $\oint E.ds = \frac{q}{\varepsilon_0}$. Which of the following statements is correct?



(A) E on the LHS of the above equation will have a contribution from q_1, q_3 and q_5 while q on the RHS will have a contribution from q_2 and q_4 only.

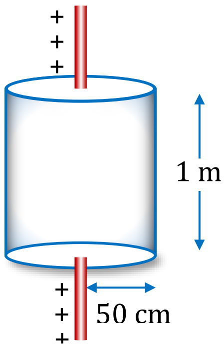
(B) E on the LHS of the above equation will have a contribution from all charges while q on the RHS will have a contribution from q_2 and q_4 only.

(C) E on the LHS of the above equation will have a contribution from all charges while q on the RHS will have a contribution from q_1, q_3 and q_5 only.

(D) Both E on the LHS and q on the RHS will have contributions from q_2 and q_4 only.

PES148

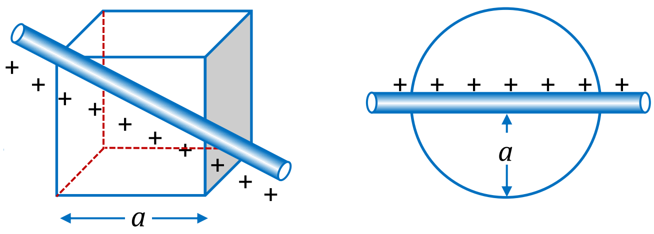
59. Electric charge is uniformly distributed along a long straight wire of radius 1 *mm*. The charge per *cm* length of the wire is Q coulomb. Another cylindrical surface of radius 50 *cm* and length 1 *m* symmetrically encloses the wire as shown in the figure. The total electric flux passing through the cylindrical surface is



(A) $\frac{Q}{\varepsilon_0}$ (B) $\frac{100Q}{\varepsilon_0}$ (C) $\frac{10Q}{(\pi\varepsilon_0)}$ (D) $\frac{100Q}{(\pi\varepsilon_0)}$

PES152

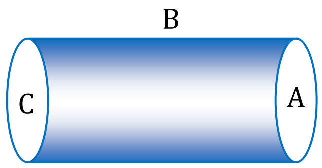
60. A linear charge having linear charge density λ, penetrates a cube diagonally and then it penetrate a sphere diametrically as shown. What will be the ratio of flux coming out of cube and sphere



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

PES153

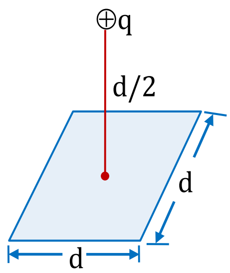
61. A hollow cylinder has a charge q coulomb symmetrically within it. If ϕ is the electric flux in units of Vm associated with the curved surface B, the flux linked with the plane surface A in units of Vm will be-



(A) $\frac{q}{2\varepsilon_0}$ (B) $\frac{\phi}{3}$ (C) $\frac{q}{\varepsilon_0} - \phi$ (D) $\frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$

PES154

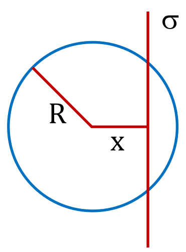
62. A point charge $+q$ is kept at a distance $d/2$ from a square surface of side d and is directly above the centre of the square, as shown above. Find the electric flux through the square.



(A) $\frac{q}{\epsilon_0}$ (B) $\frac{q}{2\epsilon_0}$ (C) $\frac{q}{3\epsilon_0}$ (D) $\frac{q}{6\epsilon_0}$

PES155

63. An infinite uniformly charged sheet with surface charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure. The electric flux ϕ through the Gaussian surface is :-

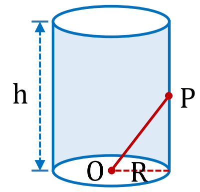


(A) $\frac{\pi R^2 \sigma}{\varepsilon_0}$ (B) $\frac{2\pi\left(R^2 - x^2\right)\sigma}{\varepsilon_0}$

(C) $\frac{\pi(R-x)^2\sigma}{\varepsilon_0}$ (D) $\frac{\pi\left(R^2 - x^2\right)\sigma}{\varepsilon_0}$

PES146

64. Electric field at point P is given by $\vec{E} = E_0\vec{r}$. The total flux through the given cylinder of radius R and height h is:



(A) $E_0\pi R^2h$ (B) $2E_0\pi R^2h$ (C) $3E_0\pi R^2h$ (D) $4E_0\pi R^2h$

PES163

65. A solid non conducting sphere having variable volume charge density $d = \frac{Ar}{R}$. If electric field at distance $\frac{R}{2}$ from the centre of charged sphere is $E = \frac{2R}{\epsilon_0}\ N/C$. Value of $\frac{A}{16}$ will be

(A) 2 (B) 4 (C) 6 (D) 8

PES164

66. Let $P(r) = \frac{Q}{\pi R^4}r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point 'p' inside the sphere at distance r_1 from the centre of the sphere, the magnitude of electric field is –

(A) 0 (B) $\frac{Q}{4\pi\epsilon_0 r_1^2}$ (C) $\frac{Qr_1^2}{4\pi\epsilon_0 R^4}$ (D) $\frac{Qr_1^2}{3\pi\epsilon_0 R^4}$

PES167

67. A ball of radius R carries a positive charge whose volume charge density depends only on the distance r form the ball's centre as :

$$\rho = \rho_0\left(1 - \frac{r}{R}\right)$$

where ρ_0 is a constant. Assume ε as the permittivity of the ball.

The magnitude of the electric field as a function of the distance r outside the ball is given by :

(A) $E = \frac{\rho_0 R^3}{8\varepsilon r^2}$ (B) $E = \frac{\rho_0 R^3}{12\varepsilon r^2}$ (C) $E = \frac{\rho_0 R^2}{8\varepsilon r^3}$ (D) $E = \frac{\rho_0 R^2}{12\varepsilon r^3}$

PES168

68. A system consists of uniformly charged sphere of radius R and a surrounding medium filled by a charge with the volume density $\rho = \frac{\alpha}{r}$, where a is a positive constant and r is the distance from the centre of the sphere. The charge of the sphere for which electric field intensity E outside the sphere is independent of r is

(A) $\frac{\alpha}{2\epsilon_0}$ (B) $\frac{2}{\alpha\,\epsilon_0}$ (C) $2\,paR^2$ (D) aR^2

PES171

69. The electric field inside a sphere which carries a charge density proportional to the distance from the origin $\rho = \propto r$ ($\propto$ is a constant) is:

(A) $\frac{\propto r^3}{4\varepsilon_0}$ (B) $\frac{\propto r^2}{4\varepsilon_0}$ (C) $\frac{\propto r^2}{3\varepsilon_0}$ (D) None of these

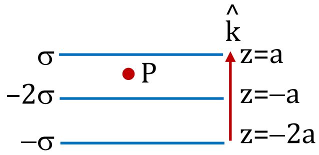
PES166

70. For a spherically symmetrical charge distribution, electric field at a distance r from the centre of sphere is $\vec{E} = kr^7\hat{r}$. Where k is a constant. What will be the volume charge density at a distance r from the centre of sphere?

(A) $\rho = 9k\varepsilon_0 r^6$ (B) $\rho = 5k\varepsilon_0 r^3$ (C) $\rho = 3k\varepsilon_0 r^4$ (D) $\rho = 9k\varepsilon_0 r^0$

PES165

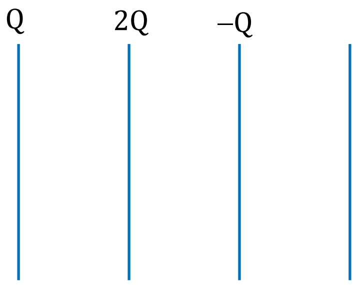
71. Three large parallel plates have uniform surface charge densities as shown in the figure. What is the electric field at P?



(A) $-\frac{4\sigma}{\epsilon_0}\hat{k}$ (B) $\frac{4\sigma}{\epsilon_0}\hat{k}$ (C) $-\frac{2\sigma}{\epsilon_0}\hat{k}$ (D) $\frac{2\sigma}{\epsilon_0}\hat{k}$

PES175

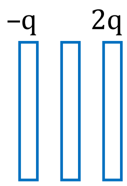
72. Find charge on left surface of the third plate.



(A) Q (B) 2Q (C) –Q (D) –2Q

PES178

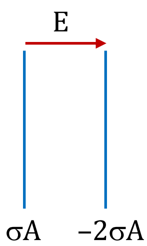
73. Three identical metal plates with large equal surface areas are kept parallel to each other as shown in figure. The leftmost plate is given a charge $-q$, the rightmost a charge $2q$ and the middle one remains neutral. Find the charge appearing on the outer surface of the leftmost plate.



(A) $4q$ (B) $q/4$ (C) $q/2$ (D) $2q$

PES179

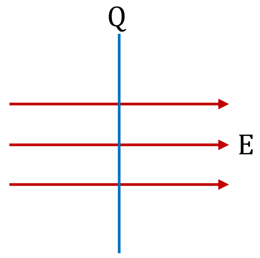
74. Two thin conducting plates (very large) parallel to each other carrying total charges σA and –2σ A respectively (where A is the area of each plate), are placed in a uniform external electric field E as shown. Find the charge on inner surface of first plate.



(A) $\left[\frac{3\sigma+2\varepsilon_0 E}{2}\right] A$ (B) $\left[\frac{2\sigma+2\varepsilon_0 E}{3}\right] A$ (C) $\left[\frac{2\sigma+3\varepsilon_0 E}{3}\right] A$ (D) $\left[\frac{2\sigma+3\varepsilon_0 E}{4}\right] A$

PES180

75. An isolated conducting sheet of area A and carrying a charge Q is placed in a uniform electric field E, such that electric field is perpendicular to sheet and covers all the sheet. Find out charges appearing on right surface of plate.



(A) $\frac{Q}{2} - EA\varepsilon_0$ (B) $\frac{Q}{2} - 2EA\varepsilon_0$

(C) $\frac{Q}{2} + EA\varepsilon_0$ (D) $\frac{Q}{2} + 2EA\varepsilon_0$

PES181

Electric Potential Energy and Electric Potential

76. Two positively charged particles X and Y are initially far away from each other and at rest. X begins to move towards Y with some initial velocity. The total momentum and energy of the system are p and E.

(A) If Y is fixed, both p and E are conserved.

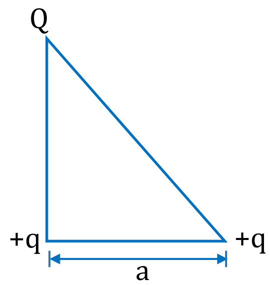
(B) If Y is fixed, E is conserved, but not p.

(C) If both are free to move, p is conserved but not E.

(D) If both are free, E is conserved, but not p.

PES183

77. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right-angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero if Q is equal to :



(A) $\frac{-q}{1+\sqrt{2}}$ (B) $\frac{-2q}{2+\sqrt{2}}$

(C) $-2q$ (D) $+q$

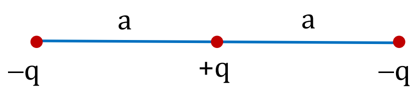
PES185

78. Potential energy of a system comprising of point charges is U_1. When a charge q is added in the system without disturbing other charges, the potential energy becomes U_2. The potential of the point where the charge q is placed in the system is

(A) $\frac{U_2 - U_1}{q}$ (B) $\frac{U_1 - U_2}{q}$ (C) $\frac{U_1 + U_2}{2q}$ (D) $\frac{U_2 - U_1}{2q}$

PES184

79. Three point charges shown in the figure be along a straight line. The work done against electrostatic forces to exchange the position of the central $+ve$ charge with one of the negative charge is



(A) $\frac{q^2}{4\pi\epsilon_0 a}$ (B) $\frac{q^2}{8\pi\epsilon_0 a}$ (C) $\frac{-q^2}{8\pi\epsilon_0 a}$ (D) $\frac{-q^2}{4\pi\epsilon_0 a}$

PES187

80. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge

(A) remains a constant because the electric field is uniform.

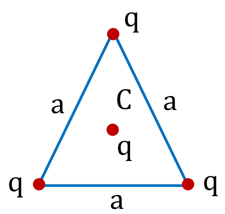
(B) increases because the charge moves along the electric field.

(C) decreases because the charge moves along the electric field.

(D) decreases because the charge moves opposite to the electric field.

PES186

81. Four equal charges of magnitude q are as shown in fig. Now the charge at center C is taken to infinity slowly, then work done by external force will be -



(A) $\frac{-3Kq^2}{a}$ (B) $\frac{-3\sqrt{3}Kq^2}{a}$ (C) $\frac{-3Kq^2}{a}(\sqrt{3}+1)$ (D) $\frac{3Kq^2}{a}(\sqrt{3}+1)$

PES188

82. Two identical particles of mass m carry a charge Q each. Initially one is at rest on a smooth horizontal plane and the other is projected along the plane directly towards first particle from a large distance with speed ν. The closest distance of approach will be

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{mv}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{4Q^2}{mv^2}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{mv^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{3Q^2}{mv^2}$

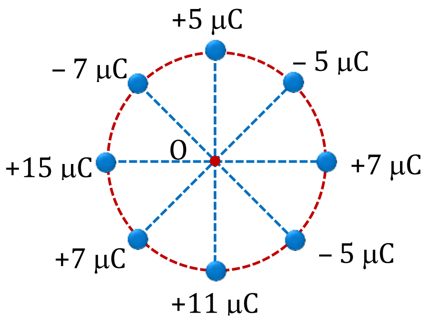
PES189

83. A charge $+q$ is placed at each of the points $x = x_0, x = 3x_0, x = 5x_0$,...., and infinitum on the x-axis, and a charge $-q$ is placed at each of the points $x = 2x_0, x = 4x_0, x = 6x_0$.... and infinitum. Here x_0 is a positive constant. Take the electric potential at a point due to a charge q at a distance r from it to be $Q/(4\pi\varepsilon_0 r)$. Then the potential at the origin due to the above system of charge is -

(A) 0 (B) $\frac{q}{8\pi\varepsilon_0 \log_e 2}$ (C) ∞ (D) $\frac{q \log_e 2}{4\pi\varepsilon_0 x_0}$

PES196

84. Eight charges having the values as shown are arranged symmetrically on a circle of radius 0.4m in air. Potential at centre O will be



(A) 63×10^4volt (B) 63×10^{10}volt (C) 63×10^6volt (D) Zero

PES195

85. Eight charges, each of the magnitude q are placed at the vertices of a cube placed in vacuum. Electric potential at the centre of the cube due to this system of charges is -
(ε_0 is permittivity of vacuum and a is length of the each side of the cube)

(A) $\frac{2q}{\pi\varepsilon_0 a}$ (B) $\frac{4q}{\sqrt{3}\pi\varepsilon_0 a}$ (C) zero (D) $\frac{\sqrt{3}q}{\pi\varepsilon_0 a}$

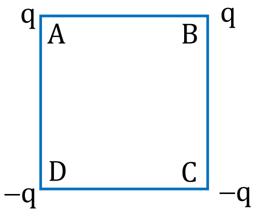
PES194

86. Four charges of $6\mu C$, $2\mu C$, $-12\mu C$ and $4\mu C$ are placed at the corners of a square of side $1m$. The square is in x-y plane and its center at its origin. Electric potential due to these charges is zero everywhere on the line -

(A) $x = y, z = 0$ (B) $x = 0 = z$ (C) $x = 0 = y$ (D) None of these

PES193

87. Charges are placed on the vertices of a square as shown. Let $\vec{E}$ be the electric field and V the potential at the centre. If the charges on A and B are interchanged with those on D and C respectively, then –



(A) $\vec{E}$ remains unchanged, V changes

(B) Both $\vec{E}$ and V changes

(C) $\vec{E}$ and V remains unchanged

(D) $\vec{E}$ changes, V remains unchanged

PES192

88. Two fixed charges A and B of 5 μC each are separated by a distance of $6m$. C is the mid-point of the line joining A and B. A charge 'Q' of $-5\mu C$ is shot perpendicular to the line joining A and B through C with a kinetic energy of $0.06J$. The charge 'Q' comes to rest at a point D. The distance CD is:-

(A) 3 m (B) $\sqrt{3}$ m (C) $3\sqrt{3}$ m (D) 4 m

PES221

89. Two positive charges of magnitude 'q' are placed at the ends of a side (side 1) of a square of side '$2a$'. Two negative charges of the same magnitude are kept at the other corners. Starting from rest, if a charge Q moves from the middle of side 1 to the centre of square, its kinetic energy at the centre of square is :-

(A) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1-\frac{1}{\sqrt{5}}\right)$ (B) zero

(C) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1+\frac{1}{\sqrt{5}}\right)$ (D) $\frac{1}{4\pi\epsilon_0}\frac{2qQ}{a}\left(1-\frac{2}{\sqrt{5}}\right)$

PES223

90. At any point $(x, 0, 0)$ the electric potential V is $\left(\frac{1000}{x}+\frac{1500}{x^2}+\frac{500}{x^3}\right)$ volt, then electric field at $x = 1$ m will be :-

(A) $5500(\hat{j}+\hat{k})V/m$ (B) $5500\hat{i}V/m$ (C) $\frac{5500}{\sqrt{2}}(\hat{j}+\hat{k})V/m$ (D) $\frac{5500}{\sqrt{2}}(\hat{i}+\hat{k})V/m$

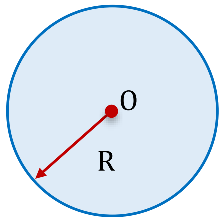
PES199

91. In an electric field the potential at a point is given by the following relation $V = \frac{343}{r}$. The electric field at $\vec{r} = 3\hat{\imath} + 2\hat{\jmath} + 6\hat{k}$ is :

(A) $21\hat{\imath} + 14\hat{\jmath} + 42\hat{k}$ (B) $3\hat{\imath} + 2\hat{\jmath} + 6\hat{k}$ (C) $\frac{1}{7}\left(3\hat{\imath} + 2\hat{\jmath} + 6\hat{k}\right)$ (D) $-\left(3\hat{\imath} + 2\hat{\jmath} + 6\hat{k}\right)$

PES200

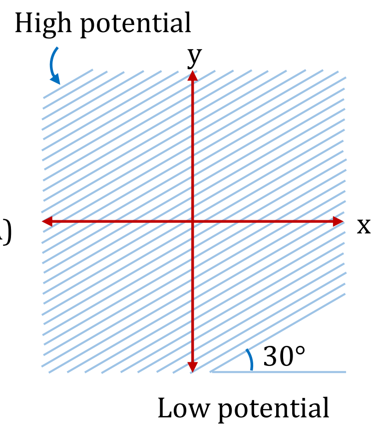
92. Volume charge density of a non–conducting sphere is varying as $\rho = \rho_0 r$ where ρ_0 is a constant and r is the distance from centre of sphere. If potential at $r = 2R$ is zero then potential at infinity will be

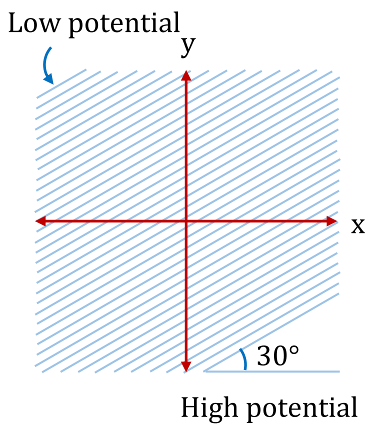


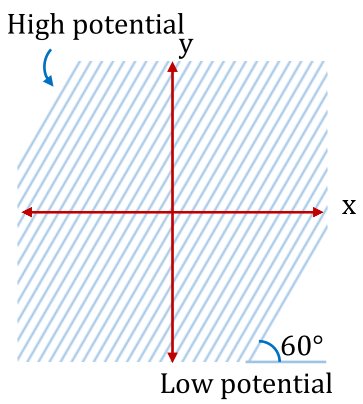
(A) $\frac{\rho_0 R^3}{8\epsilon_0}$ (B) $-\frac{\rho_0 R^3}{8\epsilon_0}$ (C) $-\frac{\rho_0 R^3}{4\epsilon_0}$ (D) Data insufficient

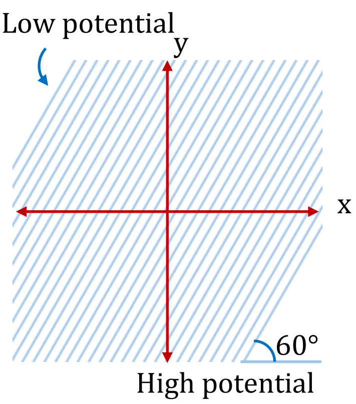
PES212

93. The electric field intensity at all points in space is given by $\vec{E} = \sqrt{3}\hat{\imath} - \hat{\jmath}$ volts/metre. The nature of equipotential lines in x-y plane is given by :-

(A)


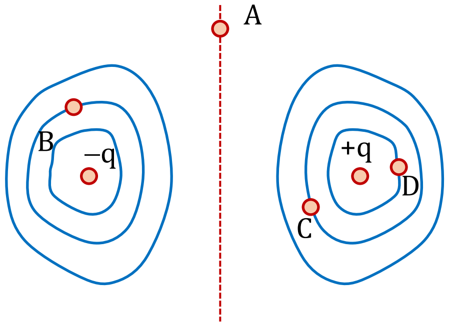
(B)


(C)


(D)


PES213

94. Figure shows equi-potential surfaces for a two charges system. At which of the labeled points point will an electron have the highest potential energy?



(A) Point A (B) Point B (C) Point C (D) Point D

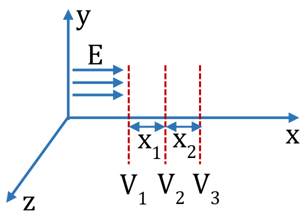
PES191

95. Equipotential at a great distance from a collection of charges whose total sum is not zero are approximately

(A) spheres (B) planes (C) paraboloids (D) ellipsoids

PES214

96. In an electric field shown in figure three equipotential surfaces are shown. If function of electric field is $E = 2x^2 V/m$, and given that $V_1 - V_2 = V_2 - V_3$, then we have



(A) $x_1 = x_2$ (B) $x_1 > x_2$ (C) $x_2 > x_1$ (D) Data insufficient

PES215

97. Consider the following conclusions regarding the components of an electric field at a certain point in space given by

$E_x = -Ky$ $\quad E_y = Kx$ $\quad E_z = 0$

(I) The field is conservative. (II) The field is non-conservative.

(III) The lines of force are straight lines (IV) The lines of force are circles.

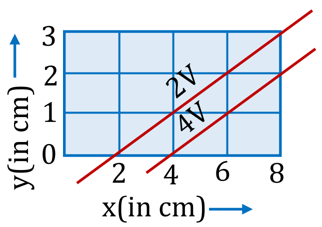
Of these conclusions

(A) II and IV are valid (B) I and III are valid

(C) I and IV are valid (D) II and III are valid

PES216

98. Figure shows two equipotential lines in xy-plane for an electric field. The x-component E_x and y-component E_y of the field in the electric space between these equipotential lines are, respectively-



(A) + 100 V/m, −200 V/m

(B) −100 V/m, + 200 V/m

(C) + 200 V/m, 100 V/m

(D) −200 V/m, −100 V/m

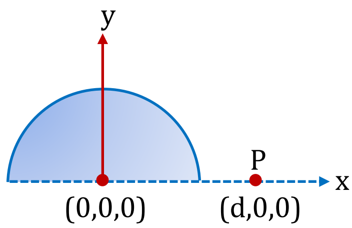
PES198

99. Magnitude of electric field depends only on the x-coordinate given by $\vec{E} = \frac{20}{x^2}\hat{\imath}\ V/m$. Find the potential difference between two points A $(5m, 0)$ and B $(10m, 0)$.

(A) $-5\ V$ (B) $5\ V$ (C) $-2\ V$ (D) $5\ V$

PES224

100. A solid hemispherical uniform charged body having charge Q is kept symmetrically along the y-axis as shown in figure. The electric potential at a distance d from the origin along the x-axis at point P will be



(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$

(B) less than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$

(C) more than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$ and less then $\frac{2}{4\pi\varepsilon_0}\frac{Q}{d}$

(D) more than $\frac{2}{4\pi\varepsilon_0}\frac{Q}{d}$

PES275

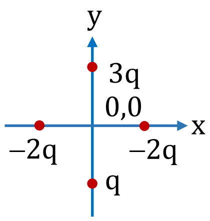
101. A conducting bubble of radius a, thickness t $(<< a)$ has potential V. Now the bubble collapses into a droplet. The potential of the surface of droplet will be :-

(A) V (B) $\frac{V}{2}\left(\frac{2a}{3t}\right)^{1/3}$ (C) $V\left(\frac{a}{3t}\right)^{1/3}$ (D) $V\left(\frac{a}{3t}\right)^{2/3}$

PES276

Dipole

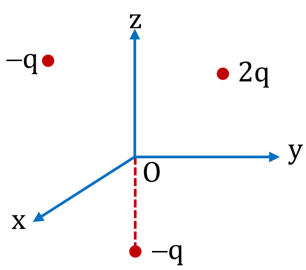
102. 4 charges are placed each at a distance 'a' from origin. The dipole moment of configuration is-



(A) $2qa\hat{\jmath}$ (B) $3qa\hat{\jmath}$ (C) $2aq[\hat{\imath}+\hat{\jmath}]$ (D) None of these

PES230

103. Three point charges $2q$, $-q$ and $-q$ are located respectively at $(0, a, a)$, $(0, a, -a)$ and $(0, 0, -a)$ as shown. The dipole moment of this distribution is :-



(A) $2qa$ in the y–z plane at $\tan^{-1}\left(\frac{1}{4}\right)$ with z-axis

(B) $\sqrt{17}qa$ in the y–z plane at $\tan^{-1}\left(\frac{1}{4}\right)$ with z-axis

(C) $\sqrt{5}qa$ in the x–y plane at $\tan^{-1}(4)$ with y-axis

(D) $4qa$ in the x–y plane at $\tan^{-1}(4)$ with y-axis

PES231

104. Three point charges $+q$, $-2q$ and $+q$ are placed at points ($x = 0, y = a, z = 0$), ($x = 0, y = 0, z = 0$) and ($x = a, y = 0, z = 0$) respectively. The direction of the electric dipole moment vector of this charge assembly is :–

(A) along + x direction

(B) along + y direction

(C) along the line joining points ($x = 0, y = 0, z = 0$) and ($x = a, y = a, z = 0$)

(D) along the line joining points ($x = 0, y = 0, z = 0$) and ($x = a, y = 0, z = 0$)

PES229

105. Point P lies on the axis of a dipole. If the dipole is rotated by 90° anticlock wise, the electric field vector $\vec{E}$ at P will rotate by

(A) 90° clock wise (B) 180° clock wise (C) 90° anti clock wise (D) none

PES228

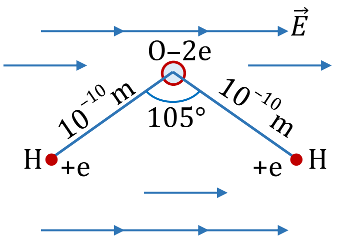
106. An electric dipole of dipole moment $\vec{p}$ is placed at the origin along the x-axis. The angle made by electric field with x-axis at a point P, whose position vector makes an angle θ with x-axis, is :

(Where, $\tan \alpha = \frac{1}{2} \tan \theta$)

(A) α (B) θ (C) $\theta + \alpha$ (D) $\theta + 2\alpha$

PES234

107. A water molecule as shown is in a region of uniform electric field $\vec{E} = 1000\ \hat{i} V/m$. This molecule experiences

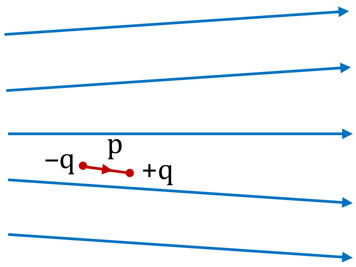


(A) A counter clockwise torque (B) A clockwise torque

(C) A net force to the right (D) A net force to the left

PES242

108. Electric field lines in which an electric dipole p is placed as shown. Which of the following statements is correct ?



(A) The dipole will not experience any force.

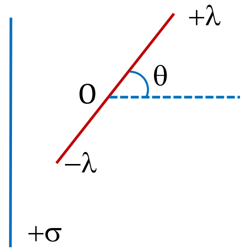
(B) The dipole will experience a force towards right.

(C) The dipole will experience a force towards left.

(D) The dipole will experience a force upwards.

PES243

109. A large sheet carries uniform surface charge density *s*. A rod of length 2ℓ has a linear charge density λ on one half and $-\lambda$ on the other half. The rod is hinged at mid point O and makes angle θ with the normal to the sheet. The torque experienced by the rod is :-



(A) $\dfrac{\sigma\lambda\ell^2}{2\varepsilon_0}\cos\theta$ (B) $\dfrac{\sigma\lambda\ell}{\varepsilon_0}\cos 2\theta$

(C) $\dfrac{\sigma\lambda\ell^2\sin\theta}{2\varepsilon_0}$ (D) $\dfrac{\sigma\lambda\ell\sin^2\theta}{\varepsilon_0}$

PES244

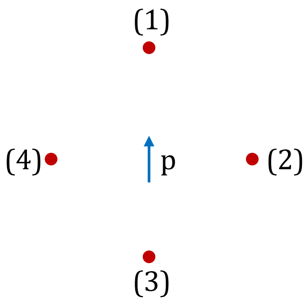
110. An electric dipole (dipole moment p) is placed at a radial distance $r >> a$ (where a is dipole length) from a infinite line of charge having linear charge density $+\lambda$. Dipole moment vector is aligned along radial vector $\vec{r}$ force experienced by dipole is :-

(A) $\dfrac{\lambda p}{2\pi\varepsilon_0 r^2}$, attractive (B) $\dfrac{\lambda p}{2\pi\varepsilon_0 r^3}$, attractive

(C) $\dfrac{\lambda p}{2\pi\varepsilon_0 r^2}$, repulsive (D) $\dfrac{\lambda p}{2\pi\varepsilon_0 r^3}$, repulsive

PES245

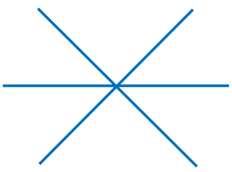
111. The drawing shows four points surrounding an electric dipole. Which one of the following expressions best ranks the electric potential at these four locations?

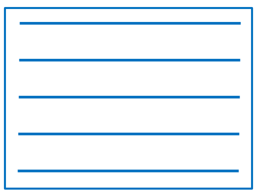


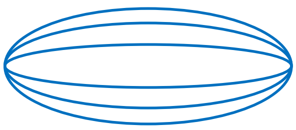
(A) 1 > 2 = 4 > 3 (B) 3 > 2 > 4 > 1 (C) 3 > 2 = 4 > 1 (D) 2 = 4 > 1 = 3

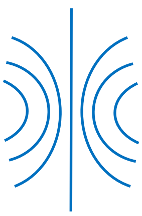
PES227

112. Which of the following represents the equipotential lines of a dipole (two equal and opposite charges placed at small separation)?

(A) 

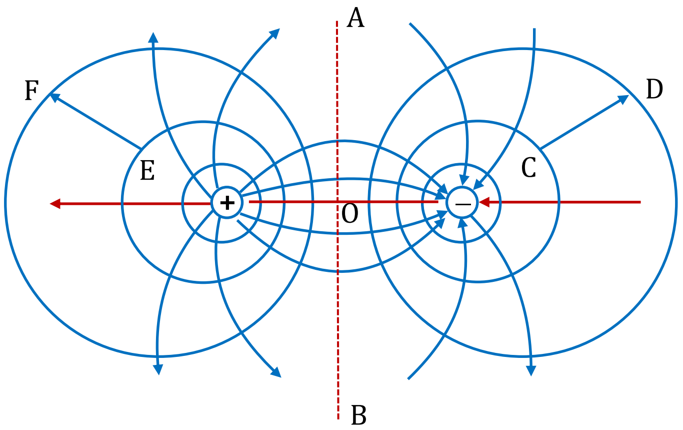
(B) 

(C) 

(D) 

PES246

113. Figure shows a charge configuration with its equipotential surfaces and electric field lines placed in *x*-*y* plane. Mark **INCORRECT** statement :-



(A) Potential gradient is positive along $(\overrightarrow{CD})$

(B) Potential gradient is negative along $(\overrightarrow{EF})$

(C) If a positive charge particle is constrained to move along line AB, it will have constant potential energy.

(D) A positive charge particle released from rest at C will begin to move in direction $(\overrightarrow{DC})$

PES247

Conductors

114. The electrostatic potential on the surface of a charged conducting sphere is $100V$. Two statements are made in this regard:

S_1 : At any point inside the sphere, electric field intensity is zero.

S_2 : At any point inside the sphere, the electrostatic potential is $100V$.

Which of the following is a correct statement?

(A) S_1 is true but S_2 is false.

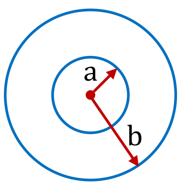
(B) Both S_1 and S_2 are false.

(C) S_1 is true, S_2 is also true and S_1 is the cause of S_2.

(D) S_1 is true, S_2 is also true but the statements are independent.

PES249

115. If the electric potential of the inner metal sphere is 10 volt and that of the outer shell is 5 volt, then the potential at the centre will be :



(A) 10 volt (B) 5 volt (C) 15 volt (D) 0

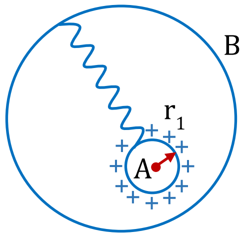
PES251

116. There are two uncharged identical metallic spheres 1 and 2 of radius r separated by a distance d ($d >> r$). A charged metallic sphere of same radius having charge q is touched with one of the sphere. After some time it is moved away from the system. Now the uncharged sphere is earthed. Charge on earthed sphere is

(A) q (B) $-q$ (C) $-qr/2d$ (D) 0

PES252

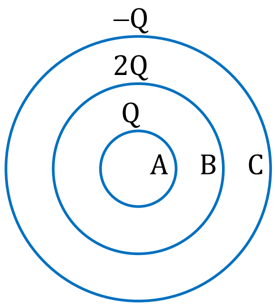
117. A metal sphere A of radius r_1 charged to a potential f_1 is enveloped by a thin walled conducting spherical shell B of radius r_2. Then f_2 of the sphere A after it is connected by a thin wire to the shell B will be :-



(A) $f_1\dfrac{r_1}{r_2}$ (B) $f_1\left(\dfrac{r_2}{r_1}\right)$ (C) $f_1\left(1-\dfrac{r_1}{r_2}\right)$ (D) $f_1\left(\dfrac{r_1 r_2}{r_1+r_2}\right)$

PES253

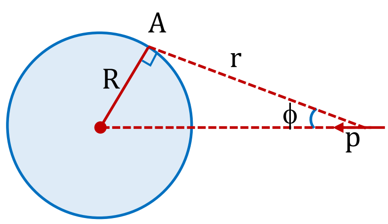
118. Charge Q, $2Q$ and $-Q$ are given to three concentric conducting spherical shells A, B and C respectively. The ratio of charges on the inner and the outer surfaces of the shell 'C' will be :-



(A) $\dfrac{3}{4}$ (B) $-\dfrac{3}{4}$ (C) $\dfrac{3}{2}$ (D) $-\dfrac{3}{2}$

PES250

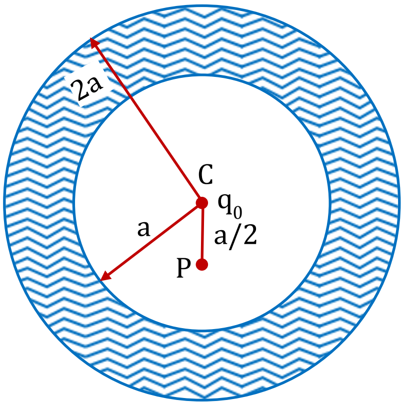
119. A dipole having dipole moment p is placed in front of a solid uncharged conducting sphere as shown in the diagram. The net potential at point A lying on the surface of the sphere is :-



(A) $\dfrac{kp\cos\phi}{r^2}$ (B) $\dfrac{kp\cos^2\phi}{r^2}$ (C) 0 (D) $\dfrac{2kp\cos^2\phi}{r^2}$

PES254

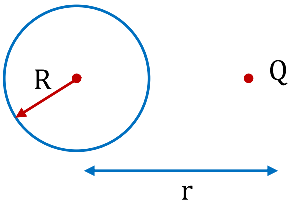
120. A point positive charge q_0 is placed at a point C inside the cavity in a neutral spherical conductor as shown in figure. Find the potential at P :-



(A) $\frac{Kq_0}{2a}$ (B) $\frac{Kq_0}{a}$ (C) $\frac{2Kq_0}{a}$ (D) $\frac{3Kq_0}{2a}$

PES257

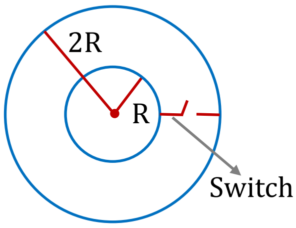
121. A point charge Q is placed near a conducting neutral sphere of radius R. Then electric potential due to induce charges, on the sphere, at the centre of the sphere is
(Given: 'r' is the distance between Centre of sphere and point charge Q).



(A) $\frac{KQ}{r}$ (B) $KQ\left(\frac{1}{R}-\frac{1}{r}\right)$ (C) Zero (D) $\frac{KQ}{R}$

PES277

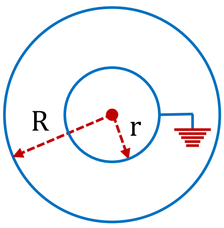
122. Net positive charge on inner spherical conductor is $3Q$ and on outer spherical conductor is Q. Switch is closed.



(A) Charge will flow from inner shell to outer shell
(B) Charge will flow from outer shell to inner shell
(C) Charge will not flow
(D) None of these

PES259

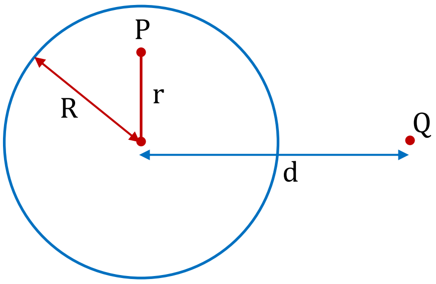
123. If bigger hollow sphere has charge Q then the charge on inner earthed sphere, is :-



(A) $\frac{R}{r}Q$ (B) $-\frac{R}{r}Q$ (C) $\frac{r}{R}Q$ (D) $-\frac{r}{R}Q$

PES258

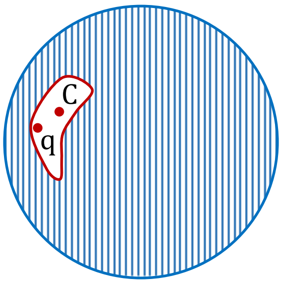
124. An uncharged spherical conductor having radius R is as shown. Find potential at a point P :-



(A) $\frac{kQ}{d}$ (B) $\frac{kQ}{r}$ (C) $\frac{kQ}{R}$ (D) $\frac{kQ}{\sqrt{r^2+d^2}}$

PES265

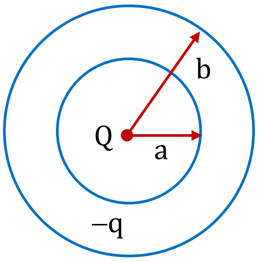
125. The figure shows a charge q placed inside a cavity in an uncharged conductor. Now if an external electric field is switched on then :



(A) only induced charge on outer surface will redistribute
(B) only induced charge on inner surface will redistribute
(C) both induced charge on outer and inner surface will redistribute
(D) force on charge q placed inside the cavity will change

PES266

126. A spherical shell with an inner radius 'a' and an outer radius 'b' is made of conducting material. A point charge $+Q$ is placed at the centre of the spherical shell and a total charge $-q$ is placed on the shell. Charge $-q$ is distributed on the surfaces as



(A) $-Q$ on the inner surface, $-q$ on outer surface
(B) $-Q$ on the inner surface, $-q+Q$ on the outer surface
(C) $+Q$ on the inner surface, $-q-Q$ on the outer surface
(D) the charge $-q$ is spread uniformly between the inner and outer surface.

PES248

127. The intensity of an electric field depends only on the coordinates x, y and z as follows :

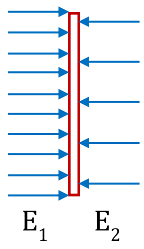
$$\vec{E} = a\frac{(x\hat{i}+y\hat{j}+z\hat{k})}{(x^2+y^2+z^2)^{3/2}}\text{unit}$$

The electrostatic energy stored between two imaginary concentric spherical shells of radii R and $2R$ with centre at origin is :-

(A) $\frac{4\pi\varepsilon_0 a^2}{R}$ (B) $\frac{2\pi\varepsilon_0 a^2}{R}$ (C) $\frac{\pi\varepsilon_0 a^2}{R}$ (D) $\frac{\pi\varepsilon_0 a^2}{2R}$

PES255

128. A charged large metal sheet is placed into uniform electric field, perpendicularly to the electric field lines. After placing the sheet into the field, the electric field on the left side of the sheet is $E_1 = 5 \times 10^5\ V/m$ and on the right it is $E_2 = 3 \times 10^5\ V/m$. The sheet experiences a net electric force of 0.08 N. Find the area of one face of the sheet. Assume external field to remain constant after introducing the large sheet. Use $\left(\frac{1}{4\pi\varepsilon_0}\right) = 9 \times 10^9\ Nm^2/C^2$



(A) $3.6\ \pi \times 10^{-2}\ m^2$ (B) $0.9\ \pi \times 10^{-2}\ m^2$ (C) $1.8\ \pi \times 10^{-2}\ m^2$ (D) None

PES256

Gravitational Force

129. If the distance between two masses is doubled, the gravitational attraction between them

(A) is doubled (B) becomes four times
(C) is reduced to half (D) is reduced to a quarter

PGR033

130. The earth (mass = $6 \times 10^{24}\ kg$) revolves round the sun with angular velocity $2 \times 10^{-7}\ rad/s$ in a circular orbit of radius $1.5 \times 10^8\ km$. The force exerted by the sun on the earth, in newtons is :-

(A) 18×10^{25} (B) zero (C) 27×10^{39} (D) 36×10^{21}

PGR034

131. The distance of the centres of moon and earth is D. The mass of earth is 81 times the mass of the moon. At what distance from the centre of the earth, the gravitational force will be zero

(A) $\frac{D}{2}$ (B) $\frac{2D}{3}$ (C) $\frac{4D}{3}$ (D) $\frac{9D}{10}$

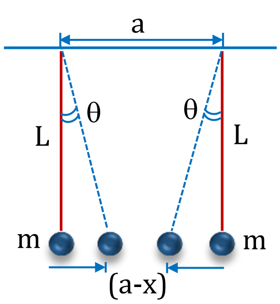
PGR035

132. Four particles of equal mass M move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is -

(A) $\frac{GM}{R}$ (B) $\sqrt{\left[2\sqrt{2}\frac{GM}{R}\right]}$ (C) $\sqrt{\left[\frac{GM}{R}(2\sqrt{2}+1)\right]}$ (D) $\sqrt{\left[\frac{GM}{R}\left(\frac{2\sqrt{2}+1}{4}\right)\right]}$

PGR038

133. Two small balls of mass m each are suspended side by side by two equal threads of length L as shown in the figure. If the distance between the upper ends of the threads be a, the angle θ that the threads will make with the vertical due to attraction between the balls is



(A) $\tan^{-1}\frac{(a-x)g}{mG}$ (B) $\tan^{-1}\frac{mG}{(a-x)^2 g}$ (C) $\tan^{-1}\frac{(a-x)^2 g}{mG}$ (D) $\tan^{-1}\frac{(a^2-x^2)g}{mG}$

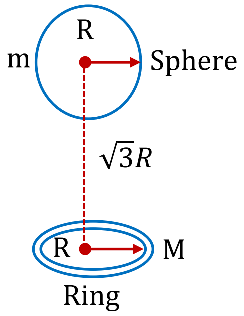
PGR039

134. The masses and radii of the earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centres are distance d apart. The minimum velocity with which a particle of mass m should be projected from a point midway between their centres so that it escapes to infinity is

(A) $2\sqrt{\frac{G}{d}(M_1+M_2)}$ (B) $2\sqrt{\frac{2G}{d}(M_1+M_2)}$ (C) $2\sqrt{\frac{Gm}{d}(M_1+M_2)}$ (D) $2\sqrt{\frac{Gm(M_1+M_2)}{d(R_1+R_2)}}$

PGR043

135. A uniform ring of mass M is lying at a distance $\sqrt{3}R$ from the centre of a uniform sphere of mass m just below the sphere as shown in the figure where R is the radius of the ring as well as that of the sphere. Then gravitational force exerted by the ring on the sphere is:

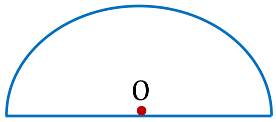


(A) $\frac{GMm}{8R^2}$ (B) $\frac{GMm}{3R^2}$ (C) $\sqrt{3}\frac{GMm}{R^2}$ (D) $\sqrt{3}\frac{GMm}{8R^2}$

PGR044

Gravitation Intensity, Potential and Potential Energy

136. Find the field strength at the centre of a thin semicircular ring of radius R and mass M as shown in figure. Take the linear mass density $\lambda\ kg/m$ -



(A) $\frac{G\lambda}{R}$ (B) $\frac{4G\lambda}{R}$ (C) $\frac{2G\lambda}{R}$ (D) $\frac{G\lambda}{2R}$

PGR036

137. A spherical cavity of radius $\frac{R}{2}$ is made in a sphere of radius R and mass M. The centre of the cavity is at a distance $\frac{R}{2}$ from the centre of the sphere. The intensity of gravitational field at the centre of cavity is :-

(A) 0 (B) $\frac{GM}{R^2}$ (C) $\frac{GM}{2R^2}$ (D) $\frac{3GM}{2R^2}$

PGR040

138. Let E_1 and E_2 denotes gravitational field at distance 'r_1' and 'r_2' from axis of infinitely long solid cylinder of radius 'R'. Which of the following must hold true.

(A) $E_1 < E_2$ if $r_1 < r_2 < R$

(B) $E_1 > E_2$ if $R < r_1 < r_2$

(C) $E_1 > E_2$ if $r_1 = R - E$, $r_2 = R + E$ (E is positive constant $< R$)

(D) All of the above

PGR041

139. If the radius of the earth be increased by a factor of 5, by what factor its density be changed to keep the value of g the same?

(A) 1/25 (B) 1/5 (C) $1/\sqrt{5}$ (D) 5

PGR037

Kepler's Law and Satellite Motion

140. The escape velocity from earth is V_{es}. A body is projected with velocity $2V_{es}$ with what constant velocity will it move in the inter planetary space

(A) v_{es} (B) $3v_{es}$ (C) $\sqrt{3}v_{es}$ (D) $\sqrt{5}v_{es}$

PGR046

141. V_e and V_p denotes the escape velocity from the earth and another planet having twice the radius and the same mean density as the earth. Then

(A) $v_e = v_p$ (B) $v_e = v_p/2$ (C) $v_e = 2v_p$ (D) $v_e = v_p/4$

PGR047

142. A particle is fired vertically from the surface of the earth with a velocity kv_e, where v_e is the escape velocity and $k < 1$. Neglecting air resistance and assuming earth's radius as R_e. Calculate the height to which it will rise from the surface of the earth.

(A) $\left(\frac{R_e k^2}{1-k^2}\right)$ (B) $\left(\frac{R_e k}{1-k^2}\right)$ (C) $\left(\frac{R_e k^2}{1-k}\right)$ (D) None

PGR048

143. A satellite can be in a geostationary orbit around earth at a distance r from the centre. If the angular velocity of earth about its axis doubles, a satellite can now be in a geostationary orbit around earth if its distance from the centre is :-

(A) $\frac{r}{2}$ (B) $\frac{r}{2\sqrt{2}}$ (C) $\frac{r}{(4)^{1/3}}$ (D) $\frac{r}{(2)^{1/3}}$

PGR054

144. A satellite of mass $5M$ orbits the earth in a circular orbit. At one point in its orbit, the satellite explodes into two pieces, one of mass M and the other of mass $4M$. After the explosion the mass M ends up travelling in the same circular orbit, but in opposite direction. After explosion the mass $4M$ is

(A) in a circular orbit

(B) unbound

(C) elliptical orbit

(D) data is insufficient to determine the nature of the orbit.

PGR055

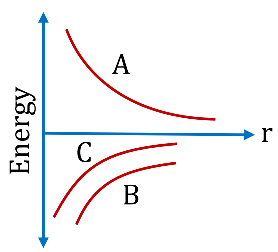
145. The figure shows the variation of energy with the orbit radius of a body in circular planetary motion. Find the correct statement about the curves A, B and C

(A) A shows the kinetic energy, B the total energy and C the potential energy of the system.

(B) C shows the total energy, B the kinetic energy and A the potential energy of the system.

(C) C and A are kinetic and potential energies respectively and B is the total energy of the system.

(D) A and B are kinetic and potential energies and C is the total energy of the system.



PGR050

146. A satellite of mass m, initially at rest on the earth, is launched into a circular orbit at a height equal to the radius of the earth. The minimum energy required is

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

PGR051

147. A space ship of mass m is in circular orbit of radius $2R_e$ about the earth of mass M and radius R_e. Energy required to transfer the space ship to circular orbit of radius $3R_e$ is :

(A) $\frac{GMm}{8R_e}$ (B) $\frac{GMm}{4R_e}$ (C) $\frac{GMm}{24R_e}$ (D) $\frac{GMm}{12R_e}$

PGR052

148. An earth satellite is moved from one stable circular orbit to another larger and stable circular orbit. The following quantities increase for the satellite as a result of this change:-

(A) gravitational potential energy (B) angular velocity
(C) linear orbital velocity (D) centripetal acceleration

PGR053

149. Two identical satellites are at R and $7R$ away from earth surface, the wrong statement is (R = Radius of earth)

(A) Ratio of total energy will be 4
(B) Ratio of kinetic energies will be 4
(C) Ratio of potential energies will be 4
(D) Ratio of total energy will be 4 but ratio of potential and kinetic energies will be 2

PGR057

150. A planet of mass m is in an elliptical orbit about the sun ($m << M_{sun}$) with an orbital period T. If A be the area of orbit, then its angular momentum would be :

(A) $\frac{2mA}{T}$ (B) mAT (C) $\frac{mA}{2T}$ (D) $2mAT$

PGR063

151. A planet revolves about the sun in elliptical orbit. The areal velocity $\left(\frac{dA}{dt}\right)$ of the planet is $4.0 \times 10^{16}\ m^2/s$. The least distance between planet and the sun is $2 \times 10^{12}\ m$. Then the maximum speed of the planet in km/s is :

(A) 10 (B) 20 (C) 40 (D) None of these

PGR066

152. Satellites A and B are orbiting around the earth in orbits of ratio R and $4R$ respectively. The ratio of their areal velocities is :

(A) 1 : 2 (B) 1 : 4 (C) 1 : 8 (D) 1 : 16

PGR067

153. The time period of a satellite of earth is 5 hours. If the separation between the centre of earth and the satellite is increased to 4 times the previous value, the new period will become-

(A) 10 h (B) 80 h (C) 40 h (D) 20 h

PGR070

154. The Sun travels in approximately circular orbit of radius R around the center of the galaxy and completes one revolution in time T. The Earth also revolves around the Sun in time t. Assume orbit of the Earth to be a circle of radius r ($r << R$) and whole mass of the galaxy centered on its center. By using only these given information's, find an expression for the ratio of the mass of the galaxy to that of the Sun.

(A) $\left(\frac{R}{r}\right)^3\left(\frac{t}{T}\right)^2$ (B) $\left(\frac{R}{r}\right)^3\left(\frac{T}{t}\right)^2$ (C) $\left(\frac{R}{r}\right)^2\left(\frac{t}{T}\right)^3$ (D) $\left(\frac{R}{r}\right)^2\left(\frac{T}{t}\right)^3$

PGR071

155. In the following four periods

(i) Time of revolution of a satellite just above the earth's surface (T_{st})

(ii) Period of oscillation of mass inside the tunnel bored along the diameter of the earth (T_{ma})

(iii) Period of simple pendulum having a length equal to the earth's radius in a uniform field of $9.8\ N/kg$ (T_{sp})

(iv) Period of an infinite length simple pendulum in the earth's real gravitational field (T_{is})

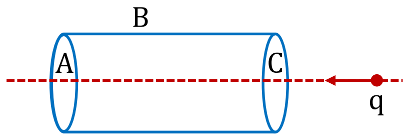
(A) $T_{st} > T_{ma}$ (B) $T_{ma} > T_{st}$ (C) $T_{sp} < T_{is}$ (D) $T_{st} = T_{ma} = T_{sp} = T_{is}$

PGR072

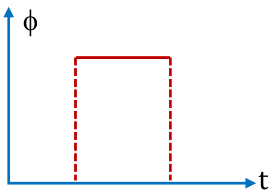
MULTIPLE CORRECT TYPE QUESTIONS

Properties of Electric Line of Force and Gauss Law

156. Consider a Gaussian surface as shown. A and C are the circular faces while B is the curved surface. A charge q is moved along the axis of cylinder with constant velocity v. Choose the correct variation of flux through the surface / cylinder.

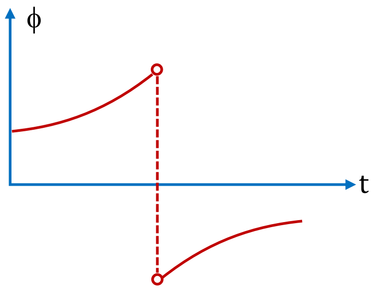


(A)



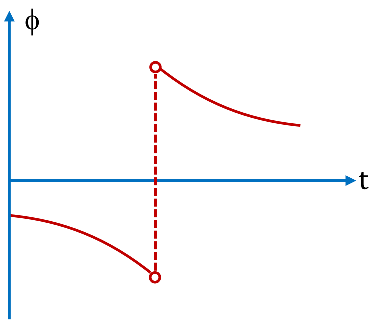
Flux through the cylinder

(B)



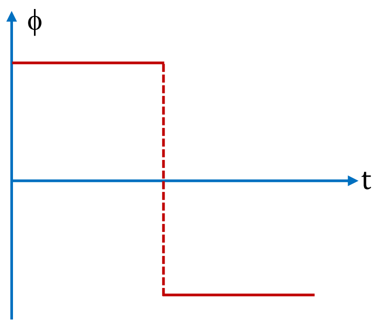
Through surface A

(C)



Through surface C

(D)



Through surface B

PES278

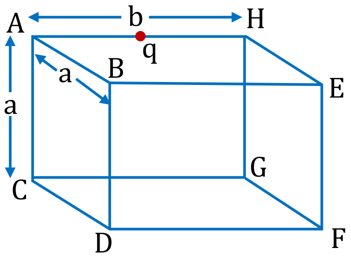
157. A cuboid of dimension [$a \times a \times b$]. Charge q is placed at the centre of edge having length 'b'. If flux through face 'ABCD' is $\frac{q}{32\epsilon_0}$ then select the correct statement(s) :-

(A) Flux through the entire cuboid is $\frac{q}{4\epsilon_0}$

(B) Flux through the face 'ABEH is zero.

(C) Flux through the face 'BEFD' is $\frac{3q}{32\epsilon_0}$

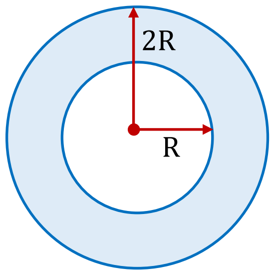
(D) Flux through the face 'BEFD' is $\frac{q}{16\epsilon_0}$



PES279

Electric Potential Energy and Electric Potential

158. Consider a spherical volume which has uniform charge density ρ from $x = R$ to $x = 2R$. There is no charge from $x = 0$ to $x = R$ and from $x = 2R$ to infinity. The electric potential due to this charge.



(A) at $x = 0$ is 0

(B) at $x = \frac{R}{2}$ is $\frac{3\rho R^2}{2\epsilon_0}$

(C) at $x = 2R$ is $\frac{7\rho R^2}{6\epsilon_0}$

(D) at $x = \frac{3R}{2}$ is $\frac{8\rho R^2}{3\epsilon_0}$

PES210

159. The electric field in x-y plane is given by $\vec{E} = x^2\hat{i} + y^2\hat{j}$. Potential at point (3, 3) is taken as zero. Then :-

(A) Work done in moving a test charge q slowly from a point (a, b) to a point (b, a) is zero.

(B) Potential at any point on x-y plane can't exceed 18 unit for x and y in 1st quadrant.

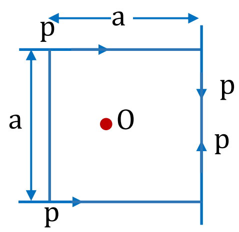
(C) Potential can't be defined as field is non- conservative in nature.

(D) Equipotential curve are concentric circles with centre (3, 3).

PES280

Dipole

160. Four short dipoles each of dipole moment 'p' are placed at the vertices of a square of side a. The direction of the dipole moments are shown in the figure.



(A) Electric field at O is $\frac{\sqrt{2}p}{2\pi\epsilon_0 a^3}$

(B) Electric field at O is $\frac{\sqrt{2}p}{\pi\epsilon_0 a^3}$

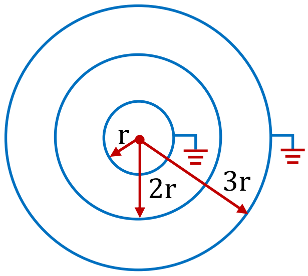
(C) Electrostatic potential at O is zero

(D) Net dipole moment is $2p$

PES235

Conductors

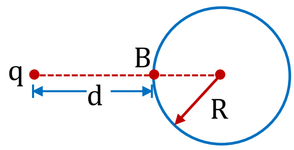
161. Three concentric conducting spherical shells have radii r, $2r$ and $3r$ respectively. In the state shown charges are q_1, q_2 and q_3 are present on innermost, middle and outermost shells respectively. Then select correct alternative(s).



(A) $q_1 + q_3 = -q_2$ (B) $q_1 = -\frac{q_2}{4}$ (C) $\frac{q_3}{q_1} = 3$ (D) $\frac{q_3}{q_2} = -\frac{1}{3}$

PES260

162. For the situation shown in the figure below, mark out the correct statement(s)



Hollow neutral conductor

(A) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0(d+R)}$

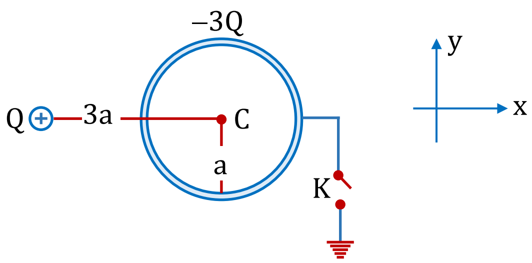
(B) Potential of the conductor is $\frac{q}{4\pi\varepsilon_0 d}$

(C) Potential of the conductor can't be determined as nature of distribution of induced charges is not known

(D) Potential at point B due to induced charges is $\frac{-qR}{4\pi\varepsilon_0(d+R)d}$

PES261

163. A point charge $+Q$ is kept at a distance $3a$ from the centre of a spherical conducting shell of charge $-3Q$ and radius a. Assuming $K = \frac{1}{4\pi\varepsilon_0}$, mark the **CORRECT** statement(s) :-



(A) Before closing switch, the electric field at C due to the spherical shell is $\left(-\frac{KQ}{9a^2}\hat{i}\right)$

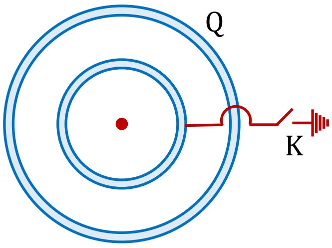
(B) Before closing switch, the potential of the shell is $\left(-\frac{8KQ}{3a}\right)$

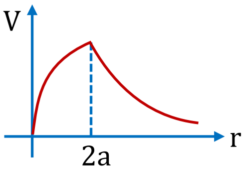
(C) After closing the key, the charge on the shell is $\left(-\frac{Q}{3}\right)$

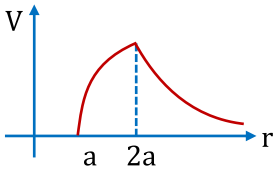
(D) After closing the key, the charge of the shell is zero

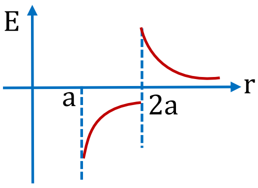
PES262

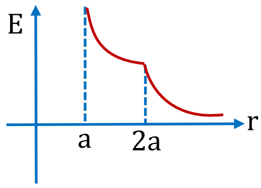
164. In the given figure two concentric conducting spherical shells of radii a and $2a$ have charges zero and Q respectively. When the key K is closed :-



(A)


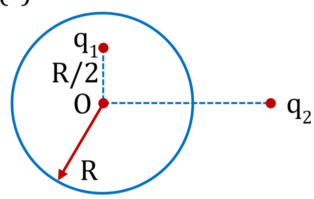
(B)


(C)


(D)


PES263

165. As shown in figure a point charge q_1 is placed inside a neutral conducting shell at a distance $\frac{R}{2}$ from the centre of shell. Another point charge q_2 is placed at a distance $\frac{\sqrt{7}}{2}R$ from the centre of shell. Choose the correct option(s).



(A) The magnitude of force on q_1 due to induced charges at the inner surface of the conducting shell is zero.

(B) The magnitude of force on q_1 due to induced charges at the outer surface of the conducting shell is $\frac{q_1 q_2}{8\pi\varepsilon_0 R^2}$

(C) The magnitude of force on q_2 due to induced charges at the inner surface of the shell is zero.

(D) The magnitude of force on q_2 due to induced charges at the inner surface of the shell is $\frac{q_1 q_2}{8\pi\varepsilon_0 R^2}$

PES264

Gravitational Force

166. Two tunnels are dug from one side of the Earth's surface to the other side, one along a diameter and the other along a chord. Now two particle are dropped from one end of each of the tunnels. Both the particles oscillate simple harmonically along the tunnels. Let T_1 and T_2 be the time period, v_1 and v_2 be the maximum speed of the particle in the two tunnels. Then :-

(A) $T_1 = T_2$ (B) $T_1 > T_2$ (C) $v_1 = v_2$ (D) $v_1 > v_2$

PGR042

Kepler's Law and Satellite Motion

167. If a satellite orbits as close to the earth's surface as possible,

(A) its speed is maximum

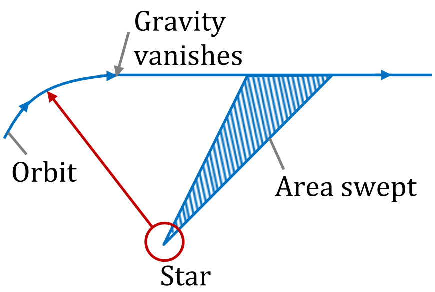
(B) time period of its rotation is minimum

(C) the total energy of the 'earth plus satellite' system is minimum

(D) the total energy of the 'earth plus satellite' system is maximum

PGR049

168. A planet is orbiting a star when for no apparent reason the star's gravity suddenly vanishes. After which planet moves in a straight line. Mark the **CORRECT** statement(s) :



(A) Newton's first law is obeyed on planet after gravity vanishes.

(B) Kepler's law of areas is obeyed only till the planet is in gravity of star.

(C) Kepler's law of areas is obeyed even after gravity vanishes.

(D) Angular momentum of planet about centre of star is conserved through out its motion.

PGR065

COMPREHENSION TYPE QUESTIONS

Properties of Electric Line of Force and Gauss Law

PARAGRAPH FOR QUESTION NO. 169 AND 170

A long cylinder of radius a is charged with a volume charge density

$\rho = \rho_0 r^3$ for $r \leq a$

$= 0$ for $r > a$

Where ρ_0 is constant and r is the distance measured from the axis of the cylinder.

169. The charge contained in ℓ length of the cylinder for $r > a$ is :

(A) $\frac{2\pi\rho_0 a^3 \ell}{3}$ (B) $\frac{2\pi\rho_0 a^5 \ell}{5}$ (C) $\frac{4\pi\rho_0 a^3 \ell}{3}$ (D) zero

PES169

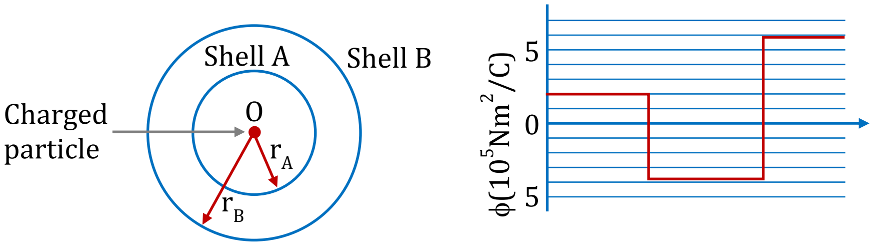
170. The electric field at $r < a$.

(A) $\frac{\rho_0 r^4}{5\epsilon_0}$ (B) $\frac{\rho_0 r^3}{3\epsilon_0}$ (C) $\frac{\rho_0 r^5}{5\epsilon_0}$ (D) zero

PES170

PARAGRAPH FOR QUESTION NO. 171 TO 173

A charged particle is suspended at the centre of two thin concentric spherical charged shells, made of non conducting material. Figure *A* shows cross section of the arrangement. Figure *B* gives the net flux ϕ through a Gaussian sphere centered on the particle, as a function of the radius *r* of the sphere.



171. What is the charge on the central particle?

(A) 0.2 μC (B) 2μC (C) 1.77 μC (D) 3.4 μC

PES172

172. What is the charge on shell *A*?

(A) $5.31 \times 10^{-6} C$ (B) $-5.31 \times 10^{-6} C$ (C) $-3.54 \times 10^{-6} C$ (D) $-1.77 \times 10^{-6} C$

PES173

173. In which range of the values of *r* is the electric field zero?

(A) 0 to r_A (B) r_A to r_B

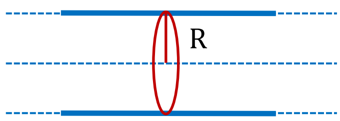
(C) for $r > r_B$ (D) for no range of *r*, electric field is zero

PES174

Kepler's Law and Satellite Motion

PARAGRAPH FOR QUESTION NO. 174 TO 176

Consider a hypothetical planet which is very long and cylindrical. The density of the planet is ρ and its radius is *R*.



174. What is the possible orbital speed of the satellite in moving around the planet in circular orbit in a plane which is perpendicular to the axis of planet?

(A) $R\sqrt{\pi G\rho}$ (B) $2R\sqrt{\pi G\rho}$ (C) $R\sqrt{2\pi G\rho}$ (D) $R\sqrt{\frac{G\rho}{2\pi}}$

PGR059

175. If an object is projected radially outwards from the surface such that it reaches upto a maximum distance of 3*R* from the axis then what should be the speed of projection?

(A) $R\sqrt{\frac{2}{3}\pi\rho G}$ (B) $2R\sqrt{\pi\rho G\ell n3}$ (C) $R\sqrt{\frac{4}{3}\pi\rho G}$ (D) $R\sqrt{\frac{2}{3}\pi\rho G\ell n3}$

PGR060

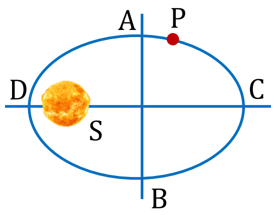
176. Assume that the planet is rotating about its axis with time period *T*. How far from the axis of the planet do the **geo synchronous telecommunication satellites** orbit are?

(A) $RT\sqrt{\pi G\rho}$ (B) $2RT\sqrt{\pi G\rho}$ (C) $RT\sqrt{2\pi G\rho}$ (D) $RT\sqrt{\frac{G\rho}{2\pi}}$

PGR061

PARAGRAPH FOR QUESTION NO. 177 AND 178

Figure shows the orbit of a planet *P* around the sun *S*. *AB* and *CD* are the minor and major axes of the ellipse.



177. If t_1 is the time taken by the planet to travel along *ACB* and t_2 the time along *BDA*, then

(A) $t_1 = t_2$
(B) $t_1 > t_2$
(C) $t_1 < t_2$
(D) nothing can be concluded

PGR068

178. If *U* is the potential energy and *K* is the kinetic energy then $|U| > |K|$ at

(A) Only *D*
(B) Only *C*
(C) Both *D* and *C*
(D) Neither *D* nor *C*

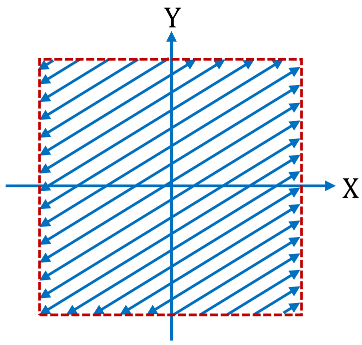
PGR069

MATRIX MATCH TYPE QUESTION

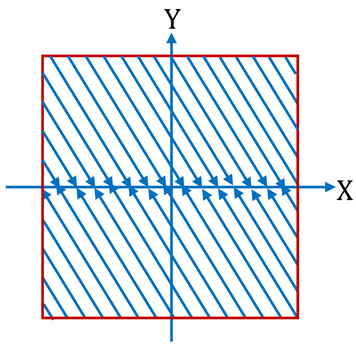
179. In the following question List-I shows various electric field and List-II shows its plot in *XY* plane. Match the Lists appropriately.

List-I | **List-II**

(P) $\vec{E} = y\hat{i} - x\hat{j}$

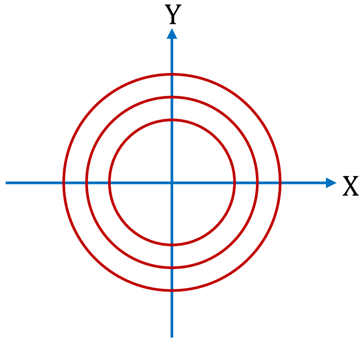
(1) 

(Q) $\vec{E} = y\hat{i} + y\hat{j}$

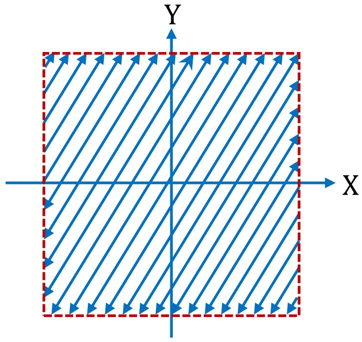
(2) 

List-I | **List-II**

(R) $\vec{E} = x\hat{i} + x\hat{j}$

(3) 

(S) $\vec{E} = y\hat{i} - y\hat{j}$

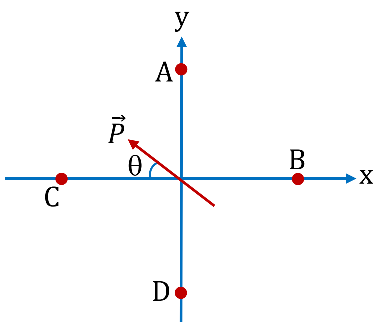
(4) 

Code :-

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

PES281

180. Electric dipole is placed at origin as shown. Point *A, B, C* and *D* are at distance *r* from origin, then match the List-I with List-II.



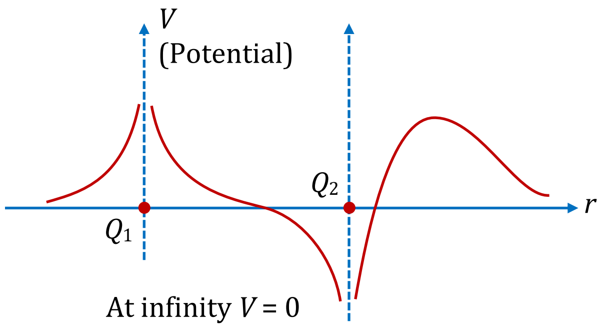
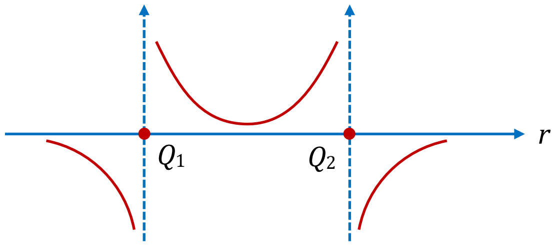
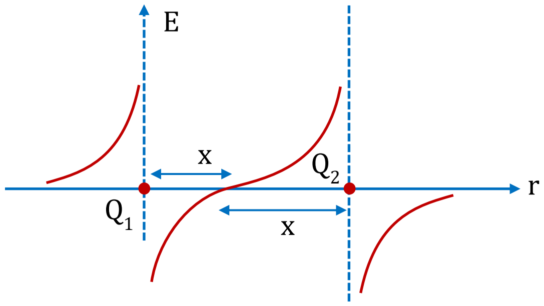
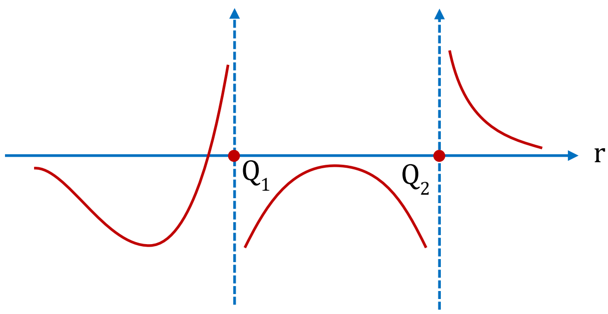
List-I	**List-II**
(P) Electric potential at *A*	(1) $\frac{-kP\sin\theta}{r^2}$
(Q) Electric potential at *B*	(2) $\frac{kP\cos\theta}{r^2}$
(R) Electric potential at *C*	(3) $\frac{kP\sin\theta}{r^2}$
(S) Electric potential at *D*	(4) $\frac{-kP\cos\theta}{r^2}$

Code:

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

PES236

181. As shown in column I their are graphs of electric field (E) and potential (V) along the line joining charges Q_1 and Q_2 are drawn against distance (r) on x-axis for charges Q_1 and Q_2. Take potential at infinity equal to zero. [Take direction of E in rightward direction as positive]

Column-I		Column-II	
(A)		(P)	$Q_1 < 0, Q_2 > 0$
(B)		(Q)	$Q_1 > 0, Q_2 < 0$
(C)		(R)	$\lvert Q_1\rvert > \lvert Q_2\rvert$
(D)		(S)	$Q_1 < 0, Q_2 < 0$
		(T)	$\lvert Q_1\rvert = \lvert Q_2\rvert$

PES197

182. In elliptical orbit of a planet, as the planet moves from apogee position to perigee position,

Column-I		Column-II	
(A)	Speed of planet	(P)	Remains same
(B)	Distance of planet from centre of Sun	(Q)	Decreases
(C)	Potential energy	(R)	Increases
(D)	Angular momentum about centre of Sun	(S)	Can not say

PGR064

EXERCISE - S

Properties of Charge and Coulomb's Law

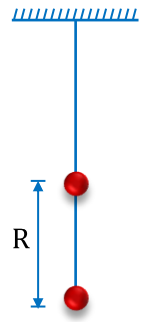
1. What is the excess number of electrons that must be placed on each of two small spheres spaced 3 *cm* apart so that a force of repulsion that acts between them becomes 10^{-19} *N*?

PES080

2. If charge on each of two point charges is tripled and separation between them is doubled, by what factor will the mutual force between them change?

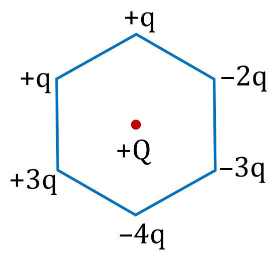
PES081

3. Two identical balls of mass $m = 0.9$ *g* each are charged by the same charges, joined by a thread and suspended from the ceiling (figure). Find the charge (in μC) that each ball should have so that the tension in both the threads are same? The distance between the centers of balls is $R = 3m$.



PES087

4. Six charges are kept at the vertices of a regular hexagon as shown in the figure. If magnitude of force applied by $+Q$ on $+q$ charge is F, then net electric force on the $+Q$ is nF. Find the value of n.



PES088

5. Two charged balls are connected by an inextensible thread of length 3 *m*. Masses of balls are 2*kg* and 1 *kg*, the charges are +20 μC and –100 μC. What minimum constant external force *F* (in *N*) must be applied to the ball of mass 1 *kg* so that the thread does not slack? Neglect gravity and friction.

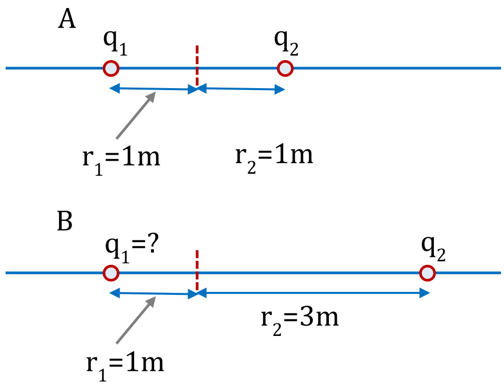
PES089

6. A thin conducting ring of radius *r* has an electric charge $+Q$. If a point charge *q* is placed at the center of the ring, the increment in tension in the ring will be $\dfrac{Qq}{n\pi^2\varepsilon_o r^2}$. Find *n*.

PES282

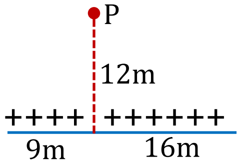
Electric Field

7. Two charges are separated as shown in the diagram A below. Each charge has a magnitude of $50nC$ in diagram A. If the charge on the right is moved further to the right as depicted in diagram B, additional charge that must be removed from the left in order to maintain the initial electric field magnitude at the center (in nC) is given by $\frac{\alpha}{9}\,nC$. Fill the value of α in OMR sheet.



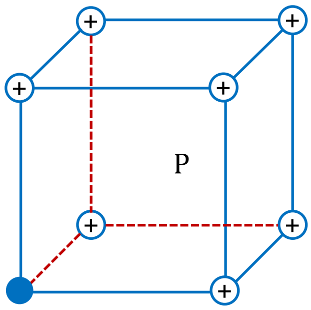
PES102

8. Find the magnitude of electric field (in N/C) due to a line charge of $\lambda = (2\sqrt{2})\,nC/m$ at a point P as shown.



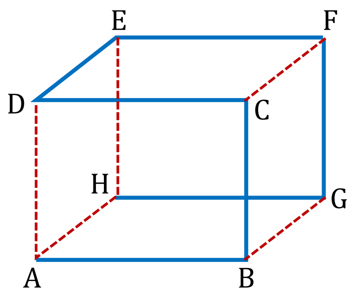
PES124

9. Consider a regular cube with positive point charge $+Q$ in all corners except for one which has a negative point charge $-Q$. Let the distance from any corner to the center of the cube be r. The magnitude of electric field at point P, the center of the cube is $\frac{nkQ}{r^2}$. Find n?



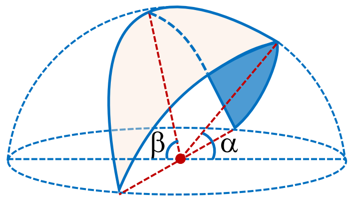
PES283

10. 7 rods, AB, BC, CD, DE, EF, FG and GH are uniformly charged. Electric field due to each one is E at the centre of cube. Net electric field due to the entire combination is $\sqrt{n}E$. Find n.



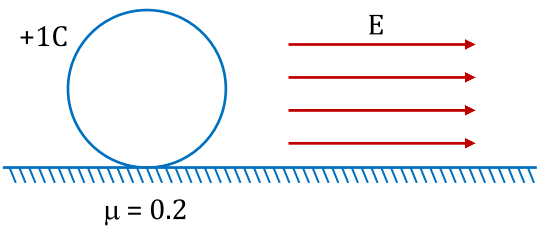
PES284

11. The electric field intensity 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 $\alpha = \beta = \pi/3$, then electric field intensity at centre due to remaining portion is $\frac{E_0}{n}$. Find n.



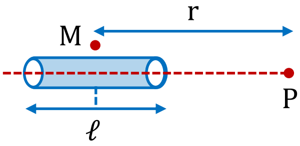
PES285

12. A non-conducting disc of mass = 2kg, total charge = +1C uniformly distributed, is placed on a rough horizontal non-conducting surface with its cross-section in vertical plane as shown. A uniform horizontal electric field E is now switched on. Find maximum magnitude of electric field E in (N/C) so that the disc rolls purely. [g = 10 ms^{-2}]



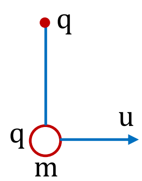
PES286

13. A insulating cylindrical rod of diameter d and length ℓ ($\ell >> d$) has a uniform surface charge density such that the electric field just outside the curved surface of the cylinder at point M is E_0. The electric field due to charge distribution at point P ($r >> \ell$) is $E_0\frac{\ell d}{nr^2}$. Find n.



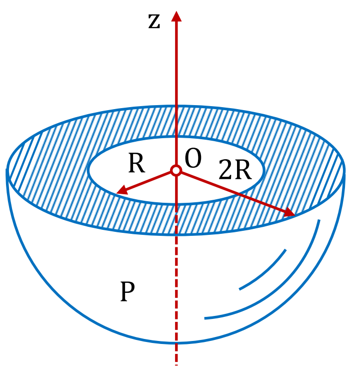
PES287

14. The bob of a pendulum has mass m = 1 kg and charge q = +40 μC. Length of pendulum is ℓ = 0.9 m. The point of suspension also has the same charge +40 μC. What the minimum speed u (in m/s) should be imparted to the bob so that it can complete vertical circle ?



PES288

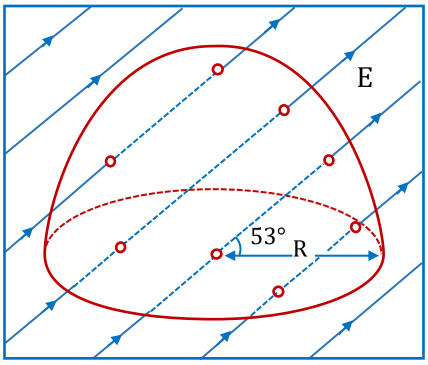
15. A hemispherical bowl of inner radii R and outer radii 2R is charged with density $\rho = \rho_o \frac{r}{R}$. The electric field at point O *is* $\frac{n\rho_o R}{4\varepsilon_o}$. Find *n.*



PES289

Properties of Electric Line of Force and Gauss Law

16. A uniform electric field E = 500 N/C passes through a hemispherical surface of radius R = 1.2 m as shown in figure. The net electric flux (in S.I. units) through the hemispherical surface only is $N\pi$. Then find the value of N.

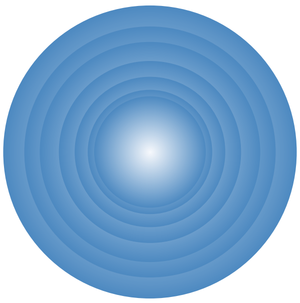


PES139

17. A spherical cavity of radius 2m is made whose centre is at a distance of 2m from centre of a uniformly charged solid sphere of density $\rho = 8.85 \times 10^{-12}$ C/m^3 and radius 5m. If electric field inside cavity is given by x/y N/C, fill value of (y-x). (y and x are minimum possible integers).

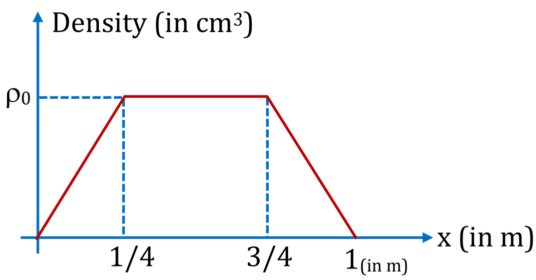
PES176

18. In space of a spherical charge distribution with radial charge density $\rho(r) = \rho_0 \dfrac{e^{-r/2a}}{r^2}$. Total charge in the distribution is Q. The value of $\dfrac{Q}{\rho_0 \pi a}$ is :



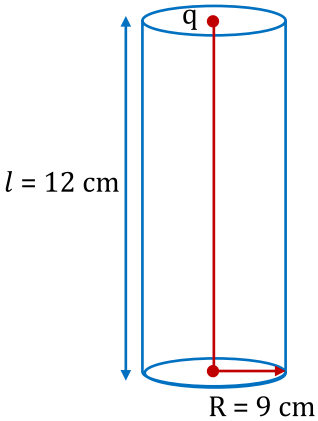
PES290

19. The volume charge density as a function of distance X from one face inside a unit cube is varying as shown in the figure. The total flux (in S.I. units) through the cube if ($\rho_0 = 8.85 \times 10^{-12}$ C/m^3) is $\dfrac{n}{4}$, Find n?



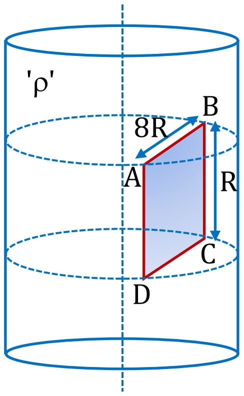
PES291

20. A point charge is placed at the centre of top circular end of a cylinder of length l = 12*cm* and radius R = 9 *cm* as shown. Electric flux through the curved surface of the cylinder is $\frac{nq}{5\varepsilon_0}$: Find n ?



PES292

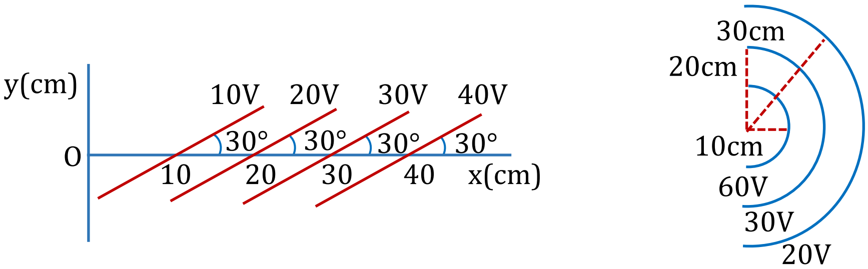
21. A non-conducting solid cylinder of infinite length having charge density ρ and radius of cylinder is 5R. If the flux passing through the surface *ABCD* as shown in figure is $\frac{2\theta\rho R^3}{\varepsilon_0}$. Find the value of θ.



PES293

Electric Potential Energy and Electric Potential

22. Some equipotential surfaces are shown in figure. What can you say about the magnitude and the direction of the electric field?



(a) **(b)**

PES217

23. A particle of mass m carrying charge 'q' is projected with velocity (v) from point P towards an infinite line charge from a distance 'a'. Its speed reduces to zero momentarily at point Q which is at a distance $a/2$ from the line charge. If another particle with mass m and charge $-q$ is projected with the same velocity v from point P towards the line charge. Its speed is found to be $\frac{Nv}{\sqrt{2}}$ at point 'Q'. Find the value of N.

PES218

24. Consider the configuration of a system of four charges each of value $+q$. Find the work done by external agent in changing the configuration of the system from figure (i) to fig (ii).

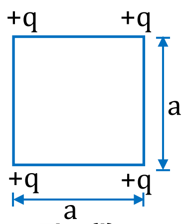


Fig. (i)

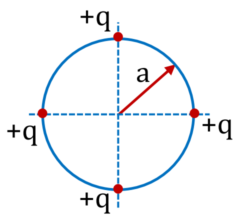
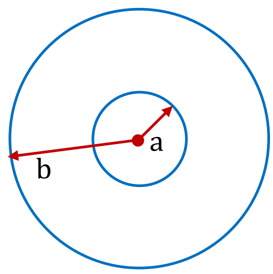


Fig. (ii)

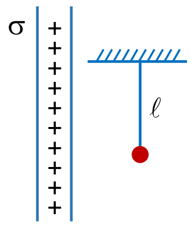
PES190

25. Outer cylinder of the coaxial non-conductor of radius 'b' is given a positive potential V relative to the inner cylinder of radius 'a' as shown in the figure (charge distribution is uniform). A charge q (mass = m) is set free with negligible velocity at the surface of the inner cylinder. Find the velocity (in m/s), when it hits the outer cylinder. [Consider $V = 10$, $q = -20$, $m = 1$ all in S.I. Units]



PES219

26. A simple pendulum of length ℓ and bob mass m is hanging in front of a large nonconducting sheet of surface charge density σ. If suddenly a charge $+q$ is given to the bob in the position shown in figure. Find the maximum angle through which the string is deflected from vertical.

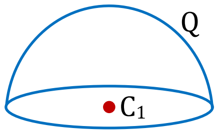


PES225

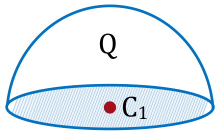
27. A positive charge Q is uniformly distributed throughout the volume of a nonconducting sphere of radius R. A point mass having charge $+q$ and mass m is fired towards the centre of the sphere with velocity v from a point at distance $r(r > R)$ from the centre of the sphere. Find the minimum velocity v so that it can penetrate $R/2$ distance of the sphere. Neglect any resistance other than electric interaction. Charge on the small mass remains constant throughout the motion.

PES226

28. Charges Q each are distributed uniformly on a nonconducting hemispherical shell (on the surface) and in the volume of a nonconducting solid hemisphere. A point charge is brought at the centre C_1 of shell and at the centre C_2 of solid hemisphere from infinity. If work done in these process are W_1 and W_2 the W_1/W_2 is equal $n/3$. Find n?



Hollow (without base)

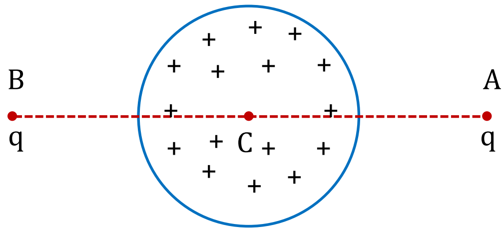


Solid hemisphere

PES294

29. A uniformly charged non-conducting sphere having charge Q and radius R is kept in gravity free space. Two identical charge particles are released from rest from 'A' and 'B' simultaneously. The speed of one of the charge particle when separation between them is very large, is $\sqrt{\frac{Kq}{nmR}\left(\frac{q}{2}+2Q\right)}$ (mass of one of the particle is m), Find n.

[$C \rightarrow$ centre of sphere and A, B and C in same line. $AC = BC = 2R$, $K = \frac{1}{4\pi\varepsilon_0}$]



PES295

30. Consider the potential at the corner of a uniformly charged cube of dimension L to be directly proportional to ρL^2, where ρ is volume charge density. The value of the ratio of the potential at the centre to the potential at the corner of the cube is n:1. Find n?

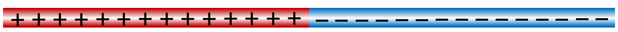
PES296

31. A charge q is uniformly distributed on the surface of a disc of radius R. Then a circular hole of radius $R/2$ is punched taking one of the radii as the diameter of the hole. The potential due to remaining portion of the disc at the center of the disc is nV_0. $\left[V_0 = \frac{q}{2\pi\varepsilon_0 R}\left(1-\frac{1}{\pi}\right)\right]$. Find n.

PES297

Dipole

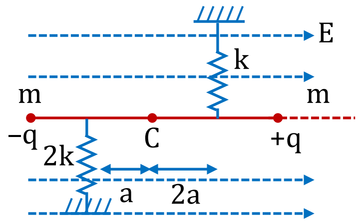
32. A plastic rod of length 1.0 m carries uniform positive charge +4.0 μC on half of its length and uniform negative charge –4.0 μC on the remaining half of its length. Find magnitude of it's net dipole moment in $\mu C\text{–}m$.



PES232

33. Two particles of mass 'm' each and having charge $+q$ and $-q$ respectively joined by a light rod of length $6a$ as shown in the figure. The whole system is kept on a horizontal frictionless surface and two spring are connected to the rod. Rod is hinged at centre and assume no energy loss takes place in form of electromagnetic wave during the motion of particles. A uniform electric field exists in the region as shown in the figure in entire region. The rod is given a small angular displacement from equilibrium, then the frequency of small oscillation is v then fill value of $4v$.

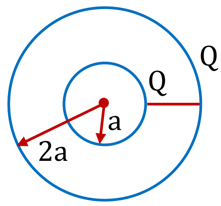
$\left[\text{Given } m = \dfrac{k}{3\pi^2} kg \text{ and } Eq = 8ka\right]$



PES298

Conductors

34. Figure shows a solid metal sphere of radius a surrounded by a concentric thin metal shell of radius $2a$. Initially both are having charges Q each. When the two are connected by a conducting wire as shown in figure, then amount of heat produced in this process will be $\dfrac{KQ^2}{\lambda a}$. Find the value of λ.



PES267

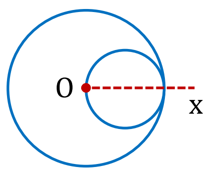
Gravitational Force

35. Two small balls of the same size and of mass m_1 and m_2 ($m_1 > m_2$) are tied by a thin light thread and dropped from a large height. Determine the tension T of the thread during the flight after the motion of the balls has become steady. (Air resistance force is same on two balls)
[Take $m_1 = 2kg$. $m_2 = 1\ kg$, $g = 10\ m/s^2$]

PGR076

Gravitation Intensity, Potential and Potential Energy

36. A sphere of radius R has its centre at the origin. It has a uniform mass density r_o except that there is a spherical hole of radius $r = R/2$ whose centre is at $x = R/2$ as in fig.

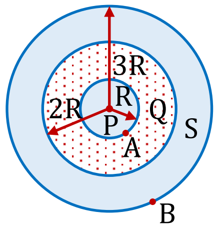


(a) Find gravitational field at points on the axis for $|x| > R$.

(b) Show that the gravitational field inside the hole is uniform, find its magnitude and direction.

PGR045

37. A solid sphere P and two hollow sphere Q and S are concentrically placed as shown in the figure. The radius of P. Q and S are R, $2R$ and $3R$ respectively. The density of P, Q and S are ρ_1, ρ_2 and ρ_3 respectively. It is given that the density of middle sphere is the arithmetic mean of the densities of other two spheres. If the gravitational fields at points A and B are equal then find the ratio of $\frac{\rho_3}{\rho_1}$ and fill the value of $10\frac{\rho_3}{\rho_1}$.

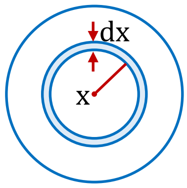


PGR077

38. A hypothetical spherical planet of radius R and its density varies as $\rho = Kr$, where K is constant and r is the distance from the center. The pressure caused by gravitational pull inside ($r < R$) the planet at a distance r measured from its center is $\frac{K^2}{n^2}G\pi(R^4 - r^4)$. Find n^2.

PGR078

39. The density of a solid spherical planet of radius R is given as $\rho = \rho_0 r$, where ρ_0 = constant and r is distance measured from centre of planet. The acceleration due to gravity of this planet is half of maximum value at distance x from centre and also at a distance y from the centre. The value of $x + y$ is $R\sqrt{\frac{\alpha}{\beta}}$. Here α and β are single digit integer. Find the value of α-β?



(Where the fraction is in lowest form)

PGR079

Kepler's Law and Satellite Motion

40. A satellite close to the earth is in orbit above the equator with a period of rotation of 1.5 hours. If it is above a point P on the equator at some time, it will be above P again after time_______.

PGR058

41. A satellite is moving in a circular orbit around the earth. The total energy of the satellite is $E = -2\times10^5 J$. The amount of energy to be imparted to the satellite to transfer it to a circular orbit where its potential energy is $U = -2\times10^5 J$ is equal to _______.

PGR056

42. A pair of stars rotates about a common center of mass. One of the stars has a mass M which is twice as large as the mass m of the other. Their centres are at a distance d apart, d being large compared to the size of either star.

(a) Derive an expression for the period of rotation of the stars about their common centre of mass in terms of d, m, G.

(b) Compare the angular momentum of the two stars about their common centre of mass by calculating the ratio L_m/L_M.

(c) Compare the kinetic energies of the two stars by calculating the ratio K_m/K_M.

PGR062

43. A comet is in elliptical orbit around the sun. In this orbit the comet's smallest distance from the sun is 72×10^6 m and its largest distance from the sun is 144×10^6 m. The ratio of comet's maximum speed to the minimum speed in the orbit is : (Neglect the presence of all bodies other than the sun and comet).

PGR080

44. The distance between two stars of masses 3 M_S and 6 M_S is 9 R. Here R is the mean distance between the centers of the Earth and the Sun, and M_S is the mass of the Sun. The two stars orbit around their common center of mass in circular orbits with period nT, where T is the period of Earth's revolution around the Sun. The value of n is ________.

PGR081

45. A binary star consists of two stars A (mass 2.2 M_S) and B (mass 11 M_S), where M_S is the mass of the sun. They are separated by distance d and are rotating about their centre of mass, which is stationary. The ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass is :

PGR082

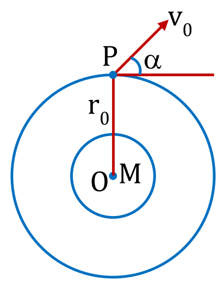
46. A satellite is launched in the equatorial plane in such a way that it can transmit signals upto 60° latitude on the earth. The orbital velocity of the satellite is found to be $\sqrt{\frac{GM}{\alpha R}}$. Find the value of α.

PGR083

47. A satellite of mass m is orbiting the Earth in a circular orbit of radius r. It starts losing energy due to small air resistance at the rate of $C\ J/s$. Then the time taken for the satellite to reach the Earth is $t = \frac{GMm}{nC}\left(\frac{1}{R_e} - \frac{1}{r}\right)$. Find n.

PGR084

48. A satellite is projected into space from a point 'P' at a distance 'r_0' from the centre of the earth with an initial velocity $v_0 = \sqrt{\frac{GM}{r_0}}$ at an angle α = 37° with the horizontal at point 'P' as shown in the figure. It is found that the satellite is propelled into an elliptical orbit. If the eccentricity of the elliptical orbit is e, then value of 5e is ?

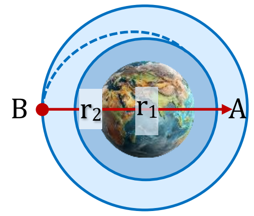


PGR085

49. A spacecraft of mass m describes a circular orbit or radius r_1 around the earth.

(a) Find the additional energy ΔE which must be imparted to the spacecraft to transfer it to a circular orbit of larger radius r^2.

(b) If the transfer from one circular orbit to the other is executed by placing the spacecraft on a transitional semi elliptical path AB then find the amounts of energy ΔE_A and ΔE_B which must be imparted at A and B respectively.



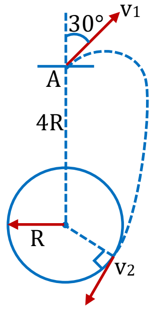
PGR086

50. An astronaut in a circular orbit around earth observes a celestial body moving in a lower circular orbit around earth in same plane as his orbit and in the same sense. He observes that the body moves at a speed of 5 m/s relative to himself when it is closest to him. The minimum distance between him and the body if he is moving at a speed of 5000 m/s is α km. Fill the value of $\frac{\alpha}{4}$ in OMR sheet. (Mass of earth = 6 × 10^{24} kg and round off the value of α to the nearest integer).

PGR087

51. A particle is projected from point A, that is at a distance $4R$ from the centre of the earth, with speed v_1 in a direction making 30° with the line joining the centre of the earth and point A, as shown. Find v_1 if the particle passes grazing the surface of the earth. Consider gravitational interaction only between these two. Express your answer in the form $\frac{1000X}{\sqrt{2}} m/s$ and fill value of X.

(Use $\frac{GM}{R}$ = $6.4 \times 10^7\ m^2/s^2$)



PGR088

52. Gravitational acceleration on the surface of a planet is $\frac{g}{11}$, where g is the gravitational acceleration on the surface of the earth. The average mass density of the planet is $\frac{1}{4}$ times that of the Earth. If the escape speed on the surface of the earth is taken to be 11 kms^{-1}, the escape speed on the surface of the planet in kms^{-1} will be

PGR089

EXERCISE - JEE (Main) PYQ

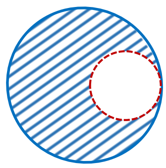
1. Four particles, each of mass M and equidistant from each other, move along a circle of radius R under the action of their mutual gravitational attraction. The speed of each particle is :

[JEE (Main) 2014]

(1) $\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$ (2) $\frac{1}{2}\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$ (3) $\sqrt{\frac{GM}{R}}$ (4) $\sqrt{2\sqrt{2}\frac{GM}{R}}$

PGR008

2. From a solid sphere of mass M and radius R, a spherical portion of radius $\frac{R}{2}$ is removed, as shown in the figure. Taking gravitational potential $V = 0$ at $r \to \infty$, the potential at the centre of the cavity thus formed is : (G = Gravitational constant) **[JEE (Main) 2015]**



(1) $\frac{-2GM}{3R}$ (2) $\frac{-2GM}{R}$ (3) $\frac{-GM}{2R}$ (4) $\frac{-GM}{R}$

PGR009

3. An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences torque $\vec{T}_2 = -\vec{T}_1$. The angle θ is : **[JEE (Main) 2017]**

(1) 60° (2) 90° (3) 30° (4) 45°

PES024

4. Three concentric metal shells A, B and C of respective radii a, b and c ($a < b < c$) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively. The potential of shell B is **[JEE (Main) 2018]**

(1) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{b}+c\right]$ (2) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{b}+a\right]$ (3) $\frac{\sigma}{\varepsilon_0}\left[\frac{b^2-c^2}{c}+a\right]$ (4) $\frac{\sigma}{\varepsilon_0}\left[\frac{a^2-b^2}{a}+c\right]$

PES025

5. Charge is distributed within a sphere of radius R with a volume charge density $\rho(r) = \frac{A}{r^2}e^{-2r/a}$, where A and a are constants. If Q is the total charge of this charge distribution, the radius R is :

[JEE (Main) 2019]

(1) $\frac{a}{2}\log\left(1-\frac{Q}{2\pi aA}\right)$ (2) $a\log\left(1-\frac{Q}{2\pi aA}\right)$ (3) $a\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$ (4) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$

PES026

6. A solid conducting sphere, having a charge Q, is surrounded by an uncharged conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is now given a charge of $-4\ Q$, the new potential difference between the same two surfaces is: **[JEE (Main) 2019]**

(1) V (2) $2V$ (3) $-2V$ (4) $4V$

PES027

7. A uniformly charged ring of radius $3a$ and total charge q is placed in xy-plane centred at origin. A point charge q is moving towards the ring along the z-axis and has speed u at $z = 4a$. The minimum value of u such that it crosses the origin is : **[JEE (Main) 2019]**

(1) $\sqrt{\frac{2}{m}}\left(\frac{1}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$ (2) $\sqrt{\frac{2}{m}}\left(\frac{2}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$ (3) $\sqrt{\frac{2}{m}}\left(\frac{4}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$ (4) $\sqrt{\frac{2}{m}}\left(\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

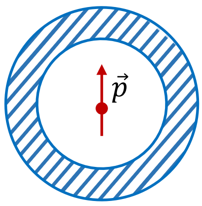
PES028

8. Let a total charge $2Q$ be distributed in a sphere of radius R, with the charge density given by $\rho(r) = kr$, where r is the distance from the centre. Two charges A and B, of $-Q$ each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any force, then : **[JEE (Main) 2019]**

(1) $a = \frac{3R}{2^{1/4}}$ (2) $\frac{\int_0^a kr\,4\pi r^2\,dr}{\varepsilon_0}$ (3) $a = 8^{-1/4}R$ (4) $a = 2^{-1/4}R$

PES029

9. Shown in the figure is a shell made of a conductor. It has inner radius a and outer radius b, and carries charge Q. At its centre is a dipole $\vec{p}$ as shown. In this case **[JEE (Main) 2019]**



(1) Electric field outside the shell is the same as that of a point charge at the centre of the shell.

(2) Surface charge density on the inner surface of the shell is zero everywhere

(3) Surface charge density on the inner surface is uniform and equal to $\frac{(Q/2)}{4\pi a^2}$

(4) Surface charge density on the outer surface depends on $|\vec{p}|$

PES030

10. A rocket has to be launched from Earth in such a way that it never returns. If E is the minimum energy delivered by the rocket launcher, what should be the minimum energy that the launcher should have if the same rocket is to be launched from the surface of the moon ?
Assume that the density of the Earth and the moon are equal and that the Earth's volume is 64 times the volume of the moon : **[JEE (Main) 2019]**

(1) $\frac{E}{4}$ (2) $\frac{E}{16}$ (3) $\frac{E}{32}$ (4) $\frac{E}{64}$

PGR010

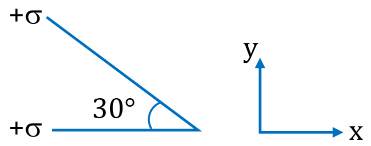
11. A satellite is moving in a low nearly circular orbit around the earth. Its radius is roughly equal to that of the Earth's radius R_e. By firing rockets attached to it, its speed is instantaneously increased in the direction of its motion so that is become $\sqrt{\frac{3}{2}}$ times larger. Due to this the farthest distance from the centre of the Earth that the satellite reaches is R, value of R is : **[JEE (Main) 2020]**

(1) $4R_e$ (2) $3R_e$ (3) $2R_e$ (4) $2.5R_e$

PGR011

12. Two infinite planes each with uniform surface charge density + σ are kept in such a way that the angle between them is 30°. The electric field in the region shown between them is given by:

[JEE (Main) 2020]

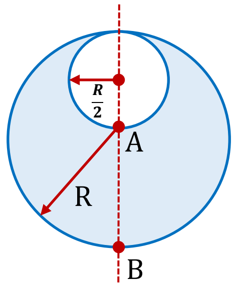


(1) $\frac{\sigma}{\varepsilon_0}\left[\left(1+\frac{\sqrt{3}}{2}\right)\hat{y}+\frac{\hat{x}}{2}\right]$ (2) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y}-\frac{\hat{x}}{2}\right]$

(3) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y}+\frac{\hat{x}}{2}\right]$ (4) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y}-\frac{\hat{x}}{2}\right]$

PES031

13. Consider a sphere of radius R which carries a uniform charge density ρ. If a sphere of radius $\frac{R}{2}$ is carved out of it, as shown, the ratio $\frac{|\vec{E}_A|}{|\vec{E}_B|}$ of magnitude of electric field $\vec{E}_A$ and $\vec{E}_B$, respectively, at points A and B due to the remaining portion is: **[JEE (Main) 2020]**



(1) $\frac{18}{54}$ (2) $\frac{21}{34}$ (3) $\frac{17}{54}$ (4) $\frac{18}{34}$

PES032

14. Two isolated conducting spheres S_1 and S_2 of radius $\frac{2R}{3}$ and $\frac{R}{3}$ have 12 μC and –3 μC charges, respectively, and are at a large distance from each other. They are now connected by a conducting wire. A long time after this is done the charges on S_1 and S_2 are respectively :

[JEE (Main) 2020]

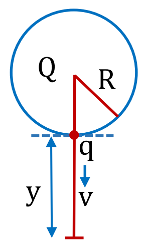
(1) 6 μ*C* and 3 μ*C* (2) +4.5 μ*C* and –4.5 μ*C*

(3) 3 μ*C* and 6 μ*C* (4) 4.5 μ*C* on both

PES033

15. A solid sphere of radius R carries a charge $(Q + q)$ distributed uniformly over its volume. A very small point like piece of it of mass m gets detached from the bottom of the sphere and falls down vertically under gravity. This piece carries charge q. If it acquires a speed v when it has fallen through a vertical height y (see figure), then :

(Assume the remaining portion to be spherical). **[JEE (Main) 2020]**



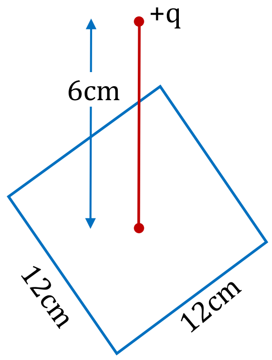
(1) $v^2=2y\left[\frac{qQ}{4\pi\epsilon_0 R(R+y)m}+g\right]$ (2) $v^2=y\left[\frac{qQ}{4\pi\epsilon_0 R^2 ym}+g\right]$

(3) $v^2=2y\left[\frac{qQR}{4\pi\epsilon_0 (R+y)^3 m}+g\right]$ (4) $v^2=y\left[\frac{qQ}{4\pi\epsilon_0 R(R+y)m}+g\right]$

PES034

16. A point charge of +12 μC is at a distance 6 cm vertically above the centre of a square of side 12 cm as shown in figure. The magnitude of the electric flux through the square will be _____ $\times 10^3$ Nm^2/C.

[JEE (Main) 2021]



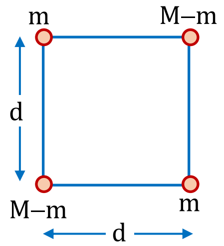
PES035

17. The electric field in a region is given by $\vec{E} = \frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}$ with $E_0 = 4.0 \times 10^3 \frac{N}{C}$. The flux of this field through a rectangular surface area 0.4 m^2 parallel to the $Y - Z$ plane is ________Nm^2C^{-1}.

[JEE (Main) 2021]

PES036

18. A body of mass $(2M)$ splits into four masses $\{m, M - m, m, M - m\}$, which are rearranged to form a square as shown in the figure. The ratio of $\frac{M}{m}$ for which, the gravitational potential energy of the system becomes maximum is x : 1. The value of x is .... **[JEE (Main) 2021]**



PGR012

19. The distance between Sun and Earth is R. The duration of year if the distance between Sun and Earth becomes $3R$ will be : **[JEE (Main) 2022]**

(1) $\sqrt{3}$ years (2) 3 years (3) 9 years (4) $3\sqrt{3}$ years

PGR013

20. Two identical charged particles each having a mass 10 g and charge 2.0×10^{-7} C area placed on a horizontal table with a separation of L between then such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is 0.25, find the value of L.

[Use $g = 10$ ms^{-2}] **[JEE (Main) 2022]**

(1) 12 cm (2) 10 cm (3) 8 cm (4) 5 cm

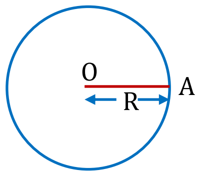
PES037

21. A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass 'm' of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance 'l'. If the dipole is placed in a uniform electric field '$\vec{E}$'; such a way that dipole axis makes a very small angle with the electric field, '$\vec{E}$'. The angular frequency of the oscillations of the dipole when released is given by: **[JEE (Main) 2023]**

(1) $\sqrt{\frac{8qE}{3ml}}$ (2) $\sqrt{\frac{4qE}{ml}}$ (3) $\sqrt{\frac{4qE}{3ml}}$ (4) $\sqrt{\frac{8qE}{ml}}$

PES268

22. For a uniformly charged thin spherical shell, the electric potential (V) radially away from the center (O) of shell can be graphically represented as **[JEE (Main) 2023]**



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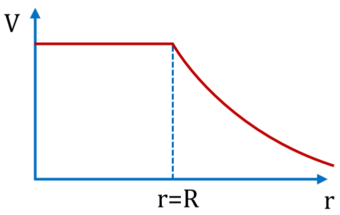

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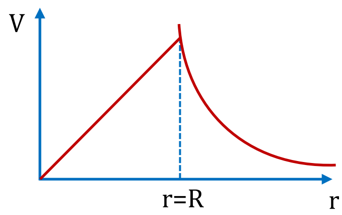
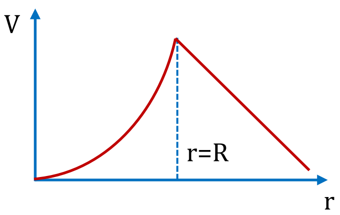


(3)


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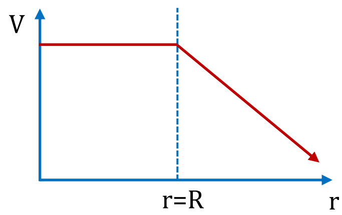


PES269

23. Choose the incorrect statement from the following: **[JEE (Main) 2023]**

(1) The speed of satellite in a given circular orbit remains constant.

(2) For a planet revolving around the sun in an elliptical orbit, the total energy of the planet remains constant.

(3) When a body fall towards earth, the displacement of earth towards the body is negligible.

(4) The linear speed of a planet revolving around the sun remains constant.

PGR073

24. The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth, equal to one-fourth the radius of the earth is:

[JEE (Main) 2023]

(1) 100 N (2) 64 N (3) 50 N (4) 25 N

PGR074

EXERCISE - JEE (Advanced) PYQ

1. A planet of radius $R = \frac{1}{10} \times \text{(radius of Earth)}$ has the same mass density as Earth. Scientists dig a well of depth $\frac{R}{5}$ on it and lower a wire of the same length and of linear mass density 10^{-3} kgm^{-1} into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it in place is (take the radius of Earth = 6×10^6 m and the acceleration due to gravity on Earth is 10 ms^{-2}) **[JEE (Advanced) 2014]**

(A) 96 N (B) 108 N (C) 120 N (D) 150 N

PGR024

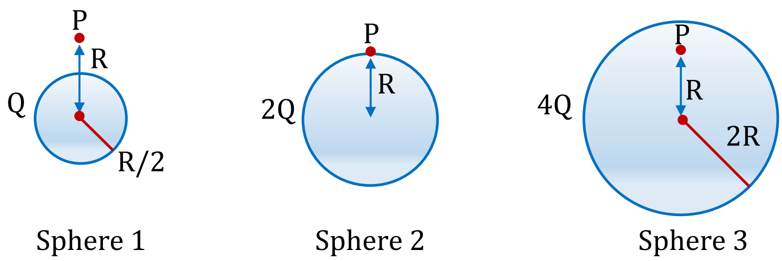
2. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respective electric fields at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. If $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then :- **[JEE (Advanced) 2014]**

(A) $Q = 4\sigma\pi r_0^2$ (B) $r_0 = \frac{\lambda}{2\pi\sigma}$

(C) $E_1(r_0/2) = 2E_2(r_0/2)$ (D) $E_2(r_0/2) = 4E_3(r_0/2)$

PES051

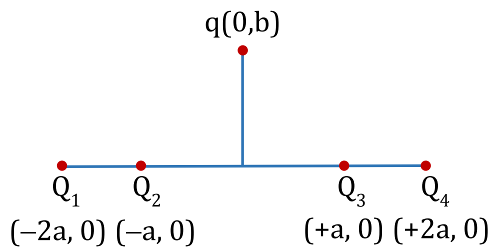
3. Charges Q, $2Q$ and $4Q$ are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii $R/2$, R and $2R$ respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_2 respectively, then **[JEE (Advanced) 2014]**



(A) $E_1 > E_2 > E_3$ (B) $E_3 > E_1 > E_2$ (C) $E_2 > E_1 > E_3$ (D) $E_3 > E_2 > E_1$

PES052

4. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis at $x = -2a, -a, +a$ and $+2a$, respectively. A positive charge q is placed on the positive y axis at a distance $b > 0$. Four options of the signs of these charges are given in List I. The direction of the forces on the charge q is given in List II. Match List I with List II and select the correct answer using the code given below the lists. **[JEE (Advanced) 2014]**



	List-I		List-II
(P)	Q_1, Q_2, Q_3, Q_4 all positive	(1)	$+x$
(Q)	Q_1, Q_2 positive ; Q_3, Q_4 negative	(2)	$-x$
(R)	Q_1, Q_4 positive ; Q_2, Q_3 negative	(3)	$+y$
(S)	Q_1, Q_3 positive ; Q_2, Q_4 negative	(4)	$-y$

Code :

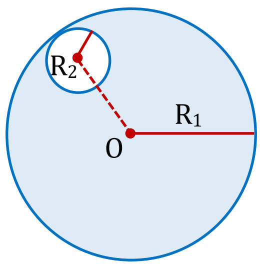
(A) P-3, Q-1, R-4, S-2 (B) P-4, Q-2, R-3, S-1

(C) P-3, Q-1, R-2, S-4 (D) P-4, Q-2, R-1, S-3

PES053

5. Consider a uniform spherical distribution of radius R_1 centred at the origin O. In this distribution, a spherical cavity of radius R_2, centred at P with distance $OP = a = R_1 - R_2$ (see figure) is made. If the electric field inside the cavity at position $\vec{r}$ is $\vec{E}(\vec{r})$, then the correct statement(s) is(are) :

[JEE (Advanced) 2015]



(A) $\vec{E}$ is uniform, its magnitude is independent of R_2 but its direction depends on $\vec{r}$

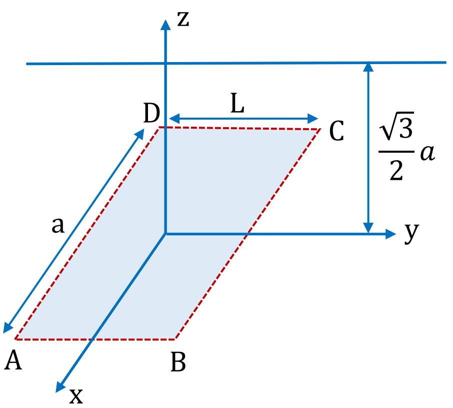
(B) $\vec{E}$ is uniform, its magnitude depends on R_2 and its direction depends on $\vec{r}$

(C) $\vec{E}$ is uniform, its magnitude is independent of a but its direction depends on $\vec{a}$

(D) $\vec{E}$ is uniform and both its magnitude and direction depend on $\vec{a}$

PES054

6. An infinitely long uniform line charge distribution of charge per unit length λ lies parallel to the y-axis in the y-z plane at $z = \frac{\sqrt{3}}{2}a$ (see figure). If the magnitude of the flux of the electric field through the rectangular surface $ABCD$ lying in the x-y plane with its centre at the origin is $\frac{\lambda L}{n\varepsilon_0}$ (ε_0 = perimittivity of free space) then the value of n is **[JEE (Advanced) 2015]**



PES055

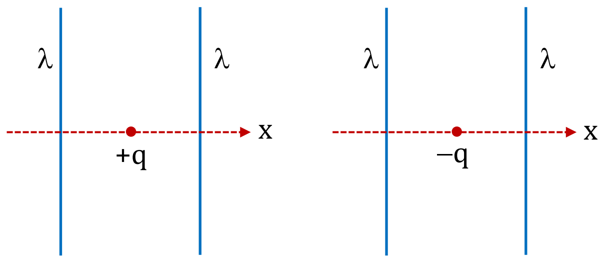
7. The figures below depict two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charges q and $-q$ are kept in equilibrium between them. The point charges are confined to move in the x direction only. If they are given a small displacement about their equlibrium positions, then the correct statement(s) is (are) : **[JEE (Advanced) 2015]**

(A) Both charges execute simple harmonic motion.

(B) Both charges will continue moving in the direction of their displacement.

(C) Charge $+q$ executes simple harmonic motion while charge $-q$ continues moving in the direction of its displacement.

(D) Charge $-q$ executes simple harmonic motion while charge $+q$ continues moving in the direction of its displacement.

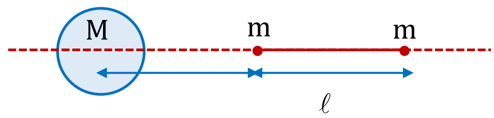


PES056

8. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $1/4^{th}$ of its value at the surface of the planet. If the escape velocity from the planet is $v_{esc} = v\sqrt{N}$, then the value of N is (Ignore energy loss due to atmosphere) **[JEE (Advanced) 2015]**

PGR025

9. A large spherical mass M is fixed at one position and two identical point masses m are kept on a line passing through the centre of M (see figure). The point masses are connected by a rigid massless rod of length ℓ and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass nearer to M is at a distance $r = 3\ell$ from M, the tension in the rod is zero for $m = K\left(\dfrac{M}{288}\right)$. The value of k is: **[JEE (Advanced) 2015]**



PGR026

10. A spherical body of radius R consists of a fluid of constant density and is in equilibrium under its own gravity. If $P(r)$ is the pressure at $r(r < R)$, then the correct option(s) is(are) **[JEE (Advanced) 2015]**

(A) $P(r = 0) = 0$ (B) $\dfrac{P(r=3R/4)}{P(r=2R/3)}=\dfrac{63}{80}$ (C) $\dfrac{P(r=3R/5)}{P(r=2R/5)}=\dfrac{16}{21}$ (D) $\dfrac{P(r=R/2)}{P(r=R/3)}=\dfrac{20}{27}$

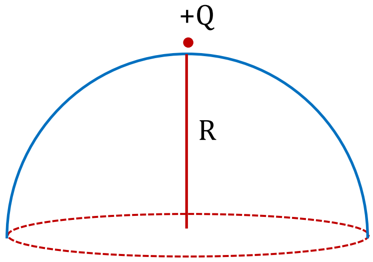
PGR027

11. A length-scale (ℓ) depends on the permittivity (ε) of a dielectric material, Boltzmann constant k_B, the absolute temperature T, the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the particles. Which of the following expressions(s) for ℓ is(are) dimensionally correct? **[JEE (Advanced) 2016]**

(A) $\ell = \sqrt{\left(\dfrac{nq^2}{\varepsilon k_B T}\right)}$ (B) $\ell = \sqrt{\left(\dfrac{\varepsilon k_B T}{nq^2}\right)}$ (C) $\ell = \sqrt{\left(\dfrac{q^2}{\varepsilon n^{2/3} k_B T}\right)}$ (D) $\ell = \sqrt{\left(\dfrac{q^2}{\varepsilon n^{1/3} k_B T}\right)}$

PES057

12. A point charge $+Q$ is placed just outside an imaginary hemispherical surface of radius R as shown in the figure. Which of the following statements is/are correct ? **[JEE (Advanced) 2017]**



(A) The circumference of the flat surface is an equipotential

(B) The electric flux passing through the curved surface of the hemisphere is $-\frac{Q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$

(C) Total flux through the curved and the flat surfaces is $\frac{Q}{\varepsilon_0}$

(D) The component of the electric field normal to the flat surface is constant over the surface.

PES058

13. A rocket is launched normal to the surface of the Earth, away from the Sun, along the line joining the sun and the Earth. The Sun is 3×10^5 times heavier than the Earth and is at a distance 2.5×10^4 times larger than the radius of the Earth. The escape velocity from Earth's gravitational field is $v_e = 11.2\ km\ s^{-1}$. The minimum initial velocity (v_s) required for the rocket to be able to leave the Sun-Earth system is closest to (Ignore the rotation and revolution of the Earth and the presence of any other planet) **[JEE (Advanced) 2017]**

(A) $v_s = 22\ km\ s^{-1}$ (B) $v_s = 72\ km\ s^{-1}$ (C) $v_s = 42\ km\ s^{-1}$ (D) $v_s = 62\ km\ s^{-1}$

PGR028

14. A planet of mass M, has two natural satellites with masses m_1 and m_2. The radii of their circular orbits are R_1 and R_2 respectively. Ignore the gravitational force between the satellites. Define v_1, L_1, K_1 and T_1 to be, respectively, the orbital speed, angular momentum, kinetic energy and time period of revolution of satellite 1 ; and v_2, L_2, K_2 and T_2 to be the corresponding quantities of satellite 2. Given $m_1/m_2 = 2$ and $R_1/R_2 = 1/4$, match the ratios in List-I to the numbers in List-II.

[JEE (Advanced) 2018]

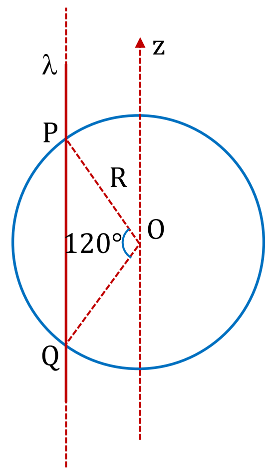
	List–I		**List–II**
P.	$\frac{v_1}{v_2}$	1.	$\frac{1}{8}$
Q.	$\frac{L_1}{L_2}$	2.	1
R.	$\frac{K_1}{K_2}$	3.	2
S.	$\frac{T_1}{T_2}$	4.	8

(A) $P \to 4$; $Q \to 2$; $R \to 1$; $S \to 3$ (B) $P \to 3$; $Q \to 2$; $R \to 4$; $S \to 1$

(C) $P \to 2$; $Q \to 3$; $R \to 1$; $S \to 4$ (D) $P \to 2$; $Q \to 3$; $R \to 4$; $S \to 1$

PGR029

15. An infinitely long thin non-conducting wire is parallel to the z-axis and carries a uniform line charge density λ. It pierces a thin non-conducting spherical shell of radius R in such a way that the arc PQ subtends an angle 120° at the centre O of the spherical shell, as shown in the figure. The permittivity of free space is ε_0. Which of the following statements is (are) true ? **[JEE (Advanced) 2018]**



(A) The electric flux through the shell is $\sqrt{3}R\lambda/\varepsilon_0$

(B) The z-component of the electric field is zero at all the points on the surface of the shell

(C) The electric flux through the shell is $\sqrt{2}R\lambda/\varepsilon_0$

(D) The electric field is normal to the surface of the shell at all points

PES059

16. A particle, of mass 10^{-3} *kg* and charge 1.0 *C*, is initially at rest. At time $t = 0$, the particle comes under the influence of an electric field $\vec{E}(t) = E_0 \sin \omega t \hat{i}$ where $E_0 = 1.0\ N\,C^{-1}$ and $\omega = 10^3$ rad s^{-1}. Consider the effect of only the electrical force on the particle. Then the maximum speed, in ms^{-1}, attained by the particle at subsequent times is **[JEE (Advanced) 2018]**

PES060

17. The electric field E is measured at a point $P(0, 0, d)$ generated due to various charge distributions and the dependence of E on d is found to be different for different charge distributions. List-I contains different relations between E and d. List-II describes different electric charge distributions, along with their locations. Match the functions in List-I with the related charge distributions in List-II. **[JEE (Advanced) 2018]**

List–I		**List–II**	
P.	E is independent of d	1.	A point charge Q at the origin
Q.	$E \propto \frac{1}{d}$	2.	A small dipole with point charges Q at $(0,0,\ell)$ and $-Q$ at $(0,0,-\ell)$. Take $2\ell << d$
R.	$E \propto \frac{1}{d^2}$	3.	An infinite line charge coincident with the x-axis, with uniform linear charge density λ.
S.	$E \propto \frac{1}{d^3}$	4.	Two infinite wires carrying uniform linear Charge density parallel to the x-axis. The one along $(y = 0, z = \ell)$ has a charge density $+\lambda$ and the one along $(y = 0, z = -\ell)$ has a charge density $-\lambda$. Take $2\ell << d$
		5.	Infinite plane charge coincident with the xy-plane with uniform surface charge density

(A) $P \to 5$; $Q \to 3, 4$; $R \to 1$; $S \to 2$
(B) $P \to 5$; $Q \to 3,$; $R \to 1,4$; $S \to 2$
(C) $P \to 5$; $Q \to 3,$; $R \to 1,2$; $S \to 4$
(D) $P \to 4$; $Q \to 2, 3$; $R \to 1$; $S \to 5$

PES061

18. A thin spherical insulating shell of radius R carries a uniformly distributed charge such that the potential at its surface is V_0. A hole with a small area $\alpha 4\pi R^2$ ($\alpha << 1$) is made on the shell without affecting the rest of the shell. Which one of the following statements is correct ?

[JEE (Advanced) 2019]

(A) The ratio of the potential at the centre of the shell to that of the point at $\frac{1}{2}R$ from centre towards the hole will be $\frac{1-\alpha}{1-2\alpha}$

(B) The magnitude of electric field at the center of the shell is reduced by $\frac{\alpha V_0}{2R}$

(C) The magnitude of electric field at a point, located on a line passing through the hole and shell's center on a distance $2R$ from the center of the spherical shell will be reduced by $\frac{\alpha V_0}{2R}$

(D) The potential at the center of the shell is reduced by $2\alpha V_0$

PES062

19. A charged shell of radius R carries a total charge Q. Given Φ as the flux of electric field through a closed cylindrical surface of height h, radius r and with its center same as that of the shell. Here, center of the cylinder is a point on the axis of the cylinder which is equidistant from its top and bottom surfaces. Which of the following option(s) is/are correct ?

[ϵ_0 is the permittivity of free space] **[JEE (Advanced) 2019]**

(A) If $h > 2R$ and $r > R$ then $\Phi = \frac{Q}{\epsilon_0}$

(B) If $h < \frac{8R}{5}$ and $r = \frac{3R}{5}$ then $\Phi = 0$

(C) If $h > 2R$ and $r = \frac{4R}{5}$ then $\Phi = \frac{Q}{5\epsilon_0}$

(D) If $h > 2R$ and $r = \frac{3R}{5}$ then $\Phi = \frac{Q}{5\epsilon_0}$

PES063

20. An electric dipole with dipole moment $\frac{p_0}{\sqrt{2}}(\hat{i}+\hat{j})$ is held fixed at the origin O in the presence of an uniform electric field of magnitude E_0. If the potential is constant on a circle of radius R centered at the origin as shown in figure, then the correct statement(s) is/are:

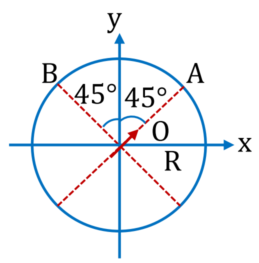
(ε_0 is permittivity of free space, $R >>$ dipole size) **[JEE (Advanced) 2019]**

(A) $R = \left(\frac{p_0}{4\pi\varepsilon_0 E_0}\right)^{1/3}$

(B) The magnitude of total electric field on any two points of the circle will be same

(C) Total electric field at point A is $\vec{E}_A = \sqrt{2}E_0(\hat{\imath}+\hat{\jmath})$

(D) Total electric field at point B is $\vec{E}_B = 0$



PES064

21. Consider a spherical gaseous cloud of mass density $\rho(r)$ in free space where r is the radial distance from its center. The gaseous cloud is made of particles of equal mass m moving in circular orbits about the common center with the same kinetic energy K. The force acting on the particles is their mutual gravitational force. If $\rho(r)$ is constant in time, the particle number density $n(r) = \rho(r)/m$ is :
[G is universal gravitational constant] **[JEE (Advanced) 2019]**

(A) $\frac{K}{\pi r^2 m^2 G}$ (B) $\frac{K}{6\pi r^2 m^2 G}$ (C) $\frac{3K}{\pi r^2 m^2 G}$ (D) $\frac{K}{2\pi r^2 m^2 G}$

PGR030

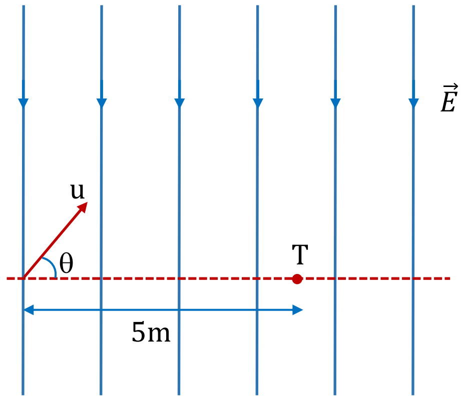
22. A uniform electric field, $\vec{E} = -400\sqrt{3}\hat{y}\ NC^{-1}$ is applied in a region. A charged particle of mass m carrying positive charge q is projected in this region with an initial speed of $2\sqrt{10} \times 10^6\ ms^{-1}$. This particle is aimed to hit a target T, which is $5m$ away from its entry point into the field as shown schematically in the figure. Take $\frac{q}{m} = 10^{10}\ Ckg^{-1}$. Then: **[JEE (Advanced) 2020]**

(A) the particle will hit T if projected at an angle 45° from the horizontal

(B) the particle will hit T if projected either at an angle 30° or 60° from the horizontal

(C) time taken by the particle to hit T could be $\sqrt{\frac{5}{6}}$ μs as well as $\sqrt{\frac{5}{2}}$ μs

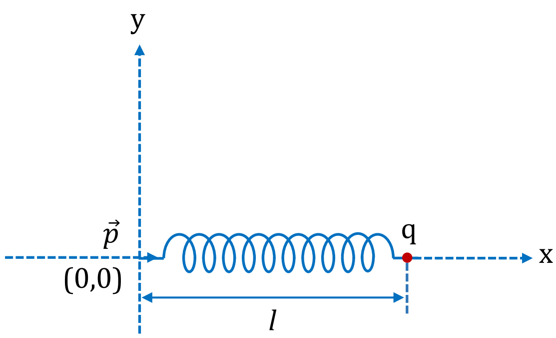
(D) time taken by the particle to hit T is $\sqrt{\frac{5}{3}}$ μs



PES065

23. One end of a spring of negligible unstretched length and spring constant k is fixed at the origin (0, 0). A point particle of mass m carrying a positive charge q is attached at its other end. The entire system is kept on a smooth horizontal surface. When a point dipole $\vec{p}$ pointing towards the charge q is fixed at the origin, the spring gets stretched to a length ℓ and attains a new equilibrium position (see figure below). If the point mass is now displaced slightly by $\Delta\ell << \ell$ from its equilibrium position and released, it is found to oscillate at frequency $\frac{1}{\delta}\sqrt{\frac{k}{m}}$. The value of δ is.

[JEE (Advanced) 2020]



PES066

24. A circular disc of radius R carries surface charge density $\sigma(r) = \sigma_0 \left(1 - \frac{r}{R}\right)$, where σ_0 is a constant and r is the distance from the center of the disc. Electric flux through a large spherical surface that encloses the charged disc completely is ϕ_0. Electric flux through another spherical surface of radius $\frac{R}{4}$ and concentric with the disc is ϕ. Then the ratio $\frac{\phi_0}{\phi}$ is________.

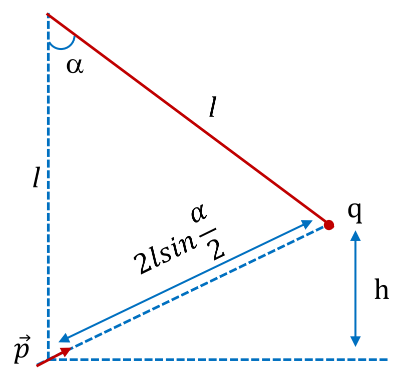
[JEE (Advanced) 2020]

PES067

25. A point charge q of mass m is suspended vertically by a string of length ℓ. A point dipole of dipole moment $\vec{p}$ is now brought towards q from infinity so that the charge moves away. The final equilibrium position of the system including the direction of the dipole, the angles and distances is shown in the figure below. If the work done in bringing the dipole to this position is $N \times (mgh)$, where g is the acceleration due to gravity, then the value of N is ________.

(Note that for three coplanar forces keeping a point mass in equilibrium, $\frac{F}{\sin\theta}$ is the same for all forces, where F is any one of the forces and θ is the angle between the other two forces)

[JEE (Advanced) 2020]



PES068

26. Two identical non-conducting solid spheres of same mass and charge are suspended in air from a common point by two non-conducting, massless strings of same length. At equilibrium, the angle between the strings is α. The spheres are now immersed in a dielectric liquid of density 800 $kg\ m^{-3}$ and dielectric constant 21. If the angle between the strings remains the same after the immersion, then **[JEE (Advanced) 2020]**

(A) electric force between the spheres remains unchanged

(B) electric force between the spheres reduces

(C) mass density of the spheres is 840 $kg\ m^{-3}$

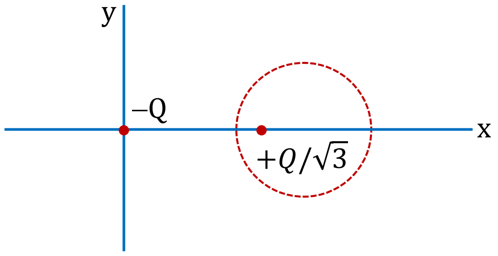
(D) the tension in the strings holding the spheres remains unchanged

PES069

PARAGRAPH FOR QUESTIONS NO. 27 AND 28

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

[JEE (Advanced) 2021]



27. The value of R is ___ meter.

PES070

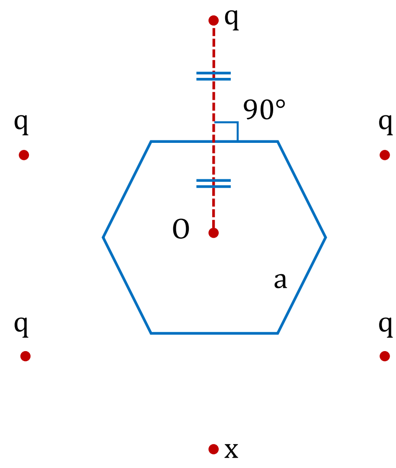
28. The value of b is ___ meter.

PES071

29. The distance between two stars of masses $3M_S$ and $6M_S$ is $9R$. Here R is the mean distance between the centers of the Earth and the Sun, and M_S is the mass of the Sun. The two stars orbit around their common center of mass in circular orbits with period nT, where T is the period of Earth's revolution around the Sun. The value of n is ________. **[JEE (Advanced) 2021]**

PGR031

30. Six charges are placed around a regular hexagon of side length a as shown in the figure. Five of them have charge q, and the remaining one has charge x. The perpendicular from each charge to the nearest hexagon side passes through the center O of the hexagon and is bisected by the side. Which of the following statement(s) is(are) correct in SI units? **[JEE (Advanced) 2022]**



(A) When $x = q$, the magnitude of the electric field at O is zero.

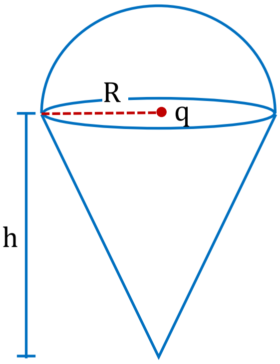
(B) When $x = -q$, the magnitude of the electric field at O is $\dfrac{q}{6\pi \epsilon_0 a^2}$.

(C) When $x = 2q$, the potential at O is $\dfrac{7q}{4\sqrt{3}\pi \epsilon_0 a}$.

(D) When $x = -3q$, the potential at O is $\dfrac{3q}{4\sqrt{3}\pi \epsilon_0 a}$.

PES072

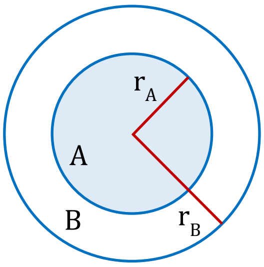
31. A charge q is surrounded by a closed surface consisting of an inverted cone of height h and base radius R, and a hemisphere of radius R as shown in the figure. The electric flux through the conical surface is $\frac{nq}{6\epsilon_0}$ (in SI units). The value of n is _______. **[JEE (Advanced) 2022]**



PES073

32. In the figure, the inner (shaded) region A represents a sphere of radius $r_A = 1$, within which the electrostatic charge density varies with the radial distance r from the center as $\rho_A = kr$, where k is positive. In the spherical shell B of outer radius r_B, the electrostatic charge density varies as $\rho_B = \frac{2k}{r}$. Assume that dimensions are taken care of. All physical quantities are in their SI units. **[JEE (Advanced) 2022]**

Which of the following statement(s) is(are) correct?



(A) If $r_B = \sqrt{\frac{3}{2}}$, then the electric field is zero everywhere outside B.

(B) If $r_B = \frac{3}{2}$, then the electric potential just outside B is $\frac{k}{\epsilon_0}$.

(C) If $r_B = 2$, then the total charge of the configuration is $15\pi k$.

(D) If $r_B = \frac{5}{2}$, then the magnitude of the electric field just outside B is $\frac{13\pi k}{\epsilon_0}$.

PES074

33. A disk of radius R with uniform positive charge density σ is placed on the xy plane with its center at the origin. The Coulomb potential along the z-axis is $V(z) = \frac{\sigma}{2\epsilon_0}\left(\sqrt{R^2+z^2} - z\right)$. A particle of positive charge q is placed initially at rest at a point on the z axis with $z = z_0$ and $z_0 > 0$. In addition to the Coulomb force, the particle experiences a vertical force $\vec{F} = -c\hat{k}$ with $c > 0$. Let $\beta = \frac{2c\epsilon_0}{q\sigma}$. Which of the following statement(s) is(are) correct? **[JEE (Advanced) 2022]**

(A) For $\beta = \frac{1}{4}$ and $z_0 = \frac{25}{7}R$, the particle reaches the origin.

(B) For $\beta = \frac{1}{4}$ and $z_0 = \frac{3}{7}R$, the particle reaches the origin.

(C) For $\beta = \frac{1}{4}$ and $z_0 = \frac{R}{\sqrt{3}}$, the particle returns back to $z = z_0$.

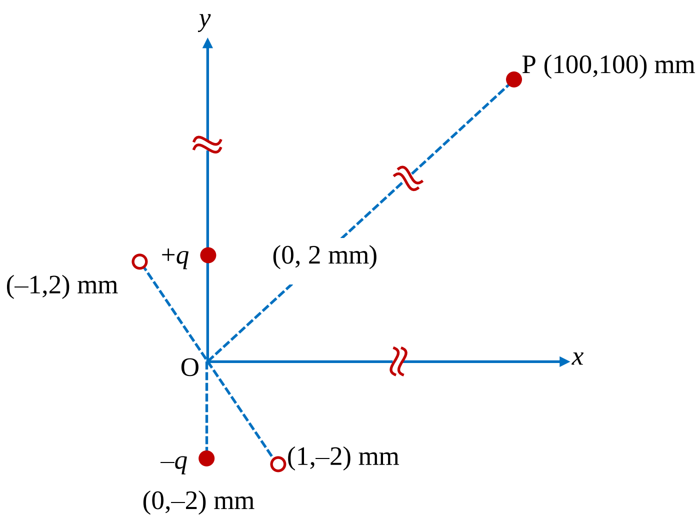
(D) For $\beta > 1$ and $z_0 > 0$, the particle always reaches the origin.

PES075

34. Two spherical stars A and B have densities ρ_A and ρ_B, respectively. A and B have the same radius, and their masses M_A and M_B are related by $M_B = 2M_A$. Due to an interaction process, star A loses some of its mass, so that its radius is halved, while its spherical shape is retained, and its density remains ρ_A. The entire mass lost by A is deposited as a thick spherical shell on B with the density of the shell being ρ_A. If ν_A and ν_B are the escape velocities from A and B after the interaction process, the ratio $\frac{\nu_B}{\nu_A} = \sqrt{\frac{10n}{15^{1/3}}}$. The value of n is ______. **[JEE (Advanced) 2022]**

PGR032

35. An electric dipole is formed by two charges $+q$ and $-q$ located in xy-plane at (0, 2) mm and (0, –2) mm, respectively, as shown in the figure. The electric potential at point P(100, 100) mm due to the dipole is V_0. The charges $+q$ and $-q$ are then moved to the points (–1, 2) mm and (1, –2) mm, respectively. What is the value of electric potential at P due to the new dipole ? **[JEE (Advanced) 2023]**



(A) $V_0/4$ (B) $V_0/2$ (C) $V_o/\sqrt{2}$ (D) $3V_0/4$

PES270

36. Two satellites P and Q are moving in different circular orbits around the Earth (radius R). The heights of P and Q from the Earth surface are h_P and h_Q, respectively, where $h_p = R/3$. The accelerations of P and Q due to Earth's gravity are g_P and g_Q, respectively. If $g_P/g_Q = 36/25$, what is the value of h_Q? **[JEE (Advanced) 2023]**

(A) $3R/5$
(B) $R/6$
(C) $6R/5$
(D) $5R/6$

PGR075

JEE (Main) Practice Paper

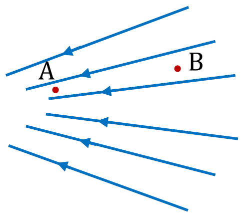
This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

SECTION–A

- This section contains **TWENTY** questions.
- Each question has **FOUR** options (1), (2), (3) and (4). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +4, if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0, if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

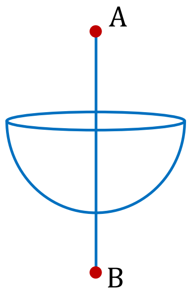
1. Which of the following is true for the figure showing electric lines of force?
(E is electrical field, V is potential)



(1) $E_A > E_B$ (2) $E_B > E_A$ (3) $V_A > V_B$ (4) $V_A = V_B$

PES001

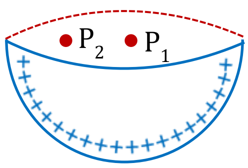
2. The diagram shows a uniformly charged hemisphere of radius R. It has volume charge density r. If the electric field at a point $2R$ distance above its center is E then what is the electric field at the point which is $2R$ below its center?

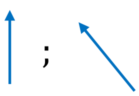


(1) $\rho R/6\varepsilon_0 + E$ (2) $\rho R/12\varepsilon_0 - E$ (3) $-\rho R/6\varepsilon_0 + E$ (4) $\rho R/24\varepsilon_0 + E$

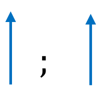
PES002

3. Consider a uniformly charged hemispherical shell shown below. Indicate the directions (not magnitude) of the electric field at the central point P_1 and an off-centre point P_2 on the drumhead of the shell.



(1) 

(2) 

(3) 

(4) 

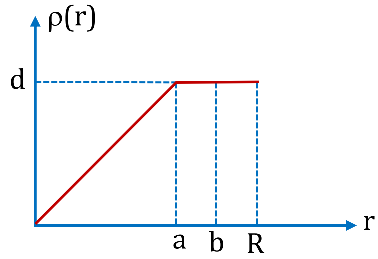
PES003

4. A charged particle of charge Q is held fixed and another charged particle of mass m and charge q (of the same sign) is released from a distance r. The impulse of the force exerted by the external agent on the fixed charge by the time distance between Q and q becomes $2r$ is

(1) $\sqrt{\dfrac{Qq}{4\pi\in_0 mr}}$ (2) $\sqrt{\dfrac{Qqm}{4\pi\in_0 r}}$ (3) $\sqrt{\dfrac{Qqm}{\pi\in_0 r}}$ (4) $\sqrt{\dfrac{Qqm}{2\pi\in_0 r}}$

PES004

5. The nuclear charge (Ze) is non-uniformly distribute within a nucleus of radius R. The charge density $r(r)$ [charge per unit volume] is dependent on the radial distance r from the centre of the nucleus as shown in figure. Select correct alternative/s.



(1) Electric field at $r = R$ is independent of b (2) Electric potential at $r = R$ is proportional to b

(3) Electric field at $r = R$ is proportional to a (4) Electric potential at $r = R$ is proportional to a

PES005

6. Consider a circle of radius R. A point charge lies at a distance $'a'$ from its center and on its axis such that $R = a\sqrt{3}$. If electric flux passing through the circle is ϕ then the magnitude of the point charge is :-

(1) $\sqrt{3}\varepsilon_0\phi$ (2) $2\varepsilon_0\phi$ (3) $4\varepsilon_0\phi/\sqrt{3}$ (4) $4\ \varepsilon_0\phi$

PES006

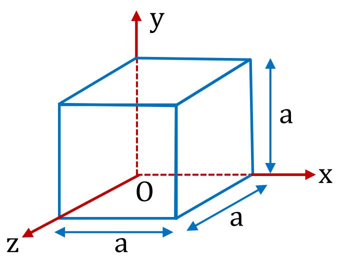
7. The electric field in a region is given by $\vec{E} = 200\hat{i}\ \ N/C$ for $x > 0$ and $-200\hat{i}\ \ N/C$ for $x < 0$. A closed cylinder of length $2m$ and cross-section area $10^2\ m^2$ is kept in such a way that the axis of cylinder is along X-axis and its centre coincides with origin. The total charge inside the cylinder is

[Take : $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2m^2.N$)

(1) zero (2) $1.86 \times 10^{-5} C$ (3) $1.77 \times 10^{-11} C$ (4) $35.4 \times 10^{-8}\ C$

PES007

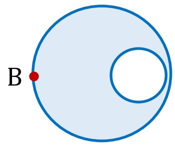
8. Electric field in a region is found to be $E = 3y\hat{j}$. The total energy stored in electric field inside the cube shown will be



(1) $9a^5\in_0$ (2) $3\in_0 a^5$ (3) $\dfrac{3}{2}\in_0 a^5$ (4) 0

PES008

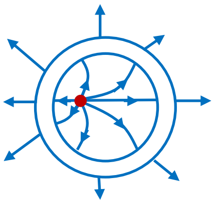
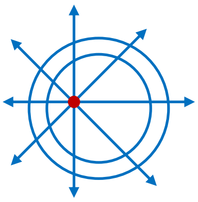
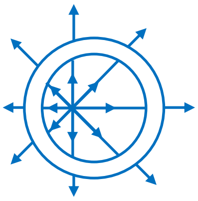
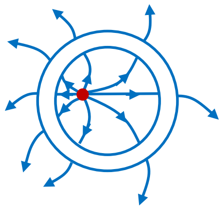
9. A positively charged sphere of radius r_0 carries a volume charge density ρ (Figure). A spherical cavity of radius $r_0/2$ is then scooped out and left empty, as shown. What is the direction and magnitude of the electric field at point B ?



(1) $\dfrac{17\rho r_0}{54\epsilon_0}$ left (2) $\dfrac{\rho r_0}{6\epsilon_0}$ left (3) $\dfrac{17\rho r_0}{54\epsilon_0}$ right (4) $\dfrac{\rho r_0}{6\epsilon_0}$ right

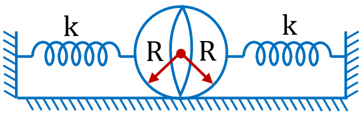
PES009

10. A point charge q is placed at a point inside a hollow conducting sphere. Which of the following electric force pattern is correct ?

(1)  (2)  (3)  (4) 

PES010

11. Two non-conducting hemispherical surfaces, which are having uniform charge density s are placed on smooth horizontal surface as shown in figure. Assuming springs are ideal, calculate compression in each spring if both the hemispherical surface are just touching each other.



(1) $\dfrac{\sigma^2 R^2}{2\varepsilon_0 k}$ (2) R (3) $\dfrac{\sigma^2 \pi R^2}{2\varepsilon_0 k}$ (4) None of these

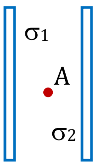
PES011

12. There are two uncharged identical metallic spheres 1 and 2 of radius r separated by a distance d ($d >> r$). A charged metallic sphere of same radius having charge q is touched with one of the sphere. After some time it is moved away from the system. Now the uncharged sphere is earthed. Charge on earthed sphere is

(1) q (2) $-q$ (3) $-qr/2d$ (4) 0

PES012

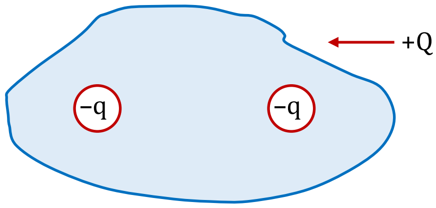
13. Two large conducting sheets are kept parallel to each other as shown. In equilibrium, the charge density on facing surfaces are σ_1 and σ_2. What can not be the value of electric field at A.



(1) $\dfrac{\sigma_1}{\varepsilon_0}\hat{i}$ (2) $-\dfrac{\sigma_2}{\varepsilon_0}\hat{i}$ (3) $\dfrac{\sigma_1+\sigma_2}{2\varepsilon_0}\hat{i}$ (4) $\dfrac{\sigma_1-\sigma_2}{2\varepsilon_0}\hat{i}$

PES013

14. A conducting body is given charge Q and charge $-q$ has been placed in each of the cavity, which of the following statements is false?



(1) If $Q = 2q$, then conducting body will be at zero potential.

(2) If an external electric field is applied then the charge distribution on the outer surface of conductor would change.

(3) The potential of any point inside the cavity is less than that of conducting body.

(4) None of these

PES014

15. The gravitational force between two stones of mass 1 *kg* each separated by a distance of 1 *metre* in vacuum is

(1) Zero (2) 6.675×10^{-5} newton

(3) 6.675×10^{-11} newton (4) 6.675×10^{-8} newton

PES015

16. The fractional change in the value of free–fall acceleration g for a particle when it is lifted from the surface to an elevation h ($h << R$) is

(1) $\frac{h}{R}$ (2) $\frac{2h}{R}$ (3) $-\frac{2h}{R}$ (4) $-\frac{h}{R}$

PES016

17. A body of mass m is projected vertically upwards from Earth's surface with near Earth orbital speed. Find the maximum height from Earth's surface reached by the body. Radius of Earth = R

(1) $\frac{R}{2}$ (2) $2R$ (3) $\frac{4R}{3}$ (4) R

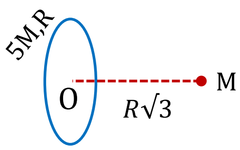
PES017

18. A body weighs 700 *gm wt* on the surface of the earth. How much will it weigh on the surface of a planet whose mass is $\frac{1}{7}$ and radius is half that of the earth?

(1) 200 *gm wt* (2) 400 *gm wt* (3) 50 *gm wt* (4) 300 *gm wt*

PGR001

19. Find speed of M when it crosses 'O', If ring is free to move.



(1) $\sqrt{\frac{25GM}{6R}}$ (2) $\sqrt{\frac{GM}{6R}}$ (3) $\sqrt{\frac{25GM}{R}}$ (4) None

PGR002

20. A geostationary satellite is revolving around the earth. To make it escape from gravitational field of earth, is velocity must be increased

(1) 100% (2) 41.4% (3) 50% (4) 59.6%

PGR003

SECTION–B

- This section contains **TEN** Questions. Attempt any five Questions. First five Questions Attempt will be considered for marking.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4, if ONLY the correct numerical value is entered as answer.

Zero Marks : 0 in all other cases.

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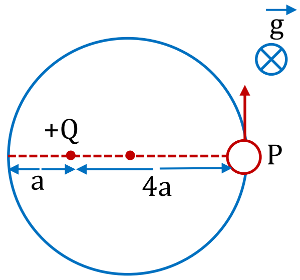
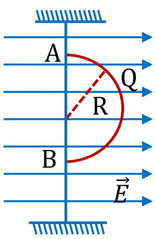
1. The diagram shows a small bead of mass m carrying charge q. The bead can freely move on the smooth fixed ring placed on a smooth horizontal plane. In the same plane a charge $+Q$ has also been fixed as shown. The potential at the point P due to $+Q$ is V. The velocity with which the bead should projected from the point P so that it can complete a circle should be greater than $\sqrt{\frac{nqV}{m}}$ find 'n'.



PES018

2. The charge $Q = \pi C$ is distributed on a thin semicircular ring of radius $R = 2m$. There is a uniform electrostatic field $|\vec{E}| = 2N/C$ directed horizontally. The semicircular ring can rotate freely about a fixed vertical axis AB. Initially the ring is in static equilibrium as shown in figure. If we want to rotate it about the fixed axis by 90° then minimum work required on the ring is $x\,J$. Find the value of x.

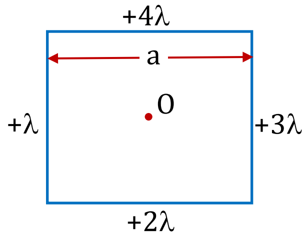


PES019

3. A circular ring of radius a with uniform charge density λ is in the xy plane with centre at origin. A particle of mass m and charge q is projected from P $(0, 0, a\sqrt{3})$ on $+z$-axis towards origin with initial velocity u. The minimum value of the velocity so that the particle does not return to P is $\sqrt{\frac{\lambda q}{x\varepsilon_0 m}}$. Find '$x$' (neglect gravity).

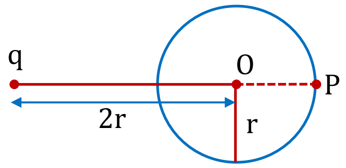
PES020

4. Four uniformly charged wires of length a are arranged to form a square. Linear charge density of each wire is as shown. Electric field intensity at centre of square is $\frac{nk\lambda}{a}$ then value of n



PES021

5. A point charge q is placed at a distance $2r$ from the centre O of a conducting neutral sphere of radius r. Due to the induced charge on the sphere, the electric potential at point P on the surface of sphere is x volt. Then find the value of x. (If $\frac{kq}{r}$ = 18 volt)



PES022

6. A spherical shell has uniform charge density $8.8 \times 10^{-11}\ C/m^2$. If a pin hole is made in the surface of the shell then find the electric field in the hole in N/C.

(Take $\in_0 = 8.8 \times 10^{-12}$ S.I. units)

PES023

7. With what angular velocity the Earth should spin in order that a body lying at 45° latitude may become weightless is $\sqrt{\frac{ng}{R}}$. Find n.

PGR004

8. A comet is in elliptical orbit around the sun. In this orbit the comet's smallest distance from the sun is $72 \times 10^6\ m$ and its largest distance from the sun is $144 \times 10^6\ m$. The ratio of comet's maximum speed to the minimum speed in the orbit is : (Neglect the presence of all bodies other than the sun and comet).

PGR005

9. If the areal velocity of one planet is 2 times the areal velocity of other planet, then find the ratio of their radii of circular motion around the sun.

PGR006

10. A binary star has a period (T) of 2 Earth years while distance L between its components having masses M_1 and M_2 is four astronomical units. If $M_1 = M_S$ where M_S is the mass of sun, find the ratio $M_2/5M_S$.

PGR007

JEE (Advanced) Practice Paper

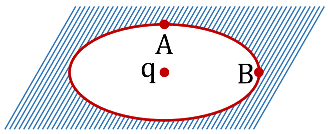
This paper is for yourself practice and assessment the discussion of this paper is optional though you can see PDF solutions or video solutions or solutions in hardcopy whichever is provided.

SECTION–I

- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +3 if only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 if none of the bubbles is darkened.
Negative Marks : –1 in all other cases.

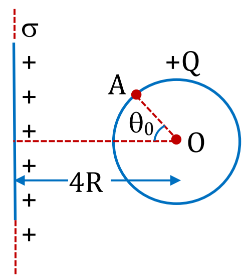
1. An ellipsoidal cavity is carved within a perfect conductor. A positive charge q is placed at the center of the cavity. The points A & B are on the cavity surface as shown in the figure. Then :



(A) electric field near A in the cavity = electric field near B in the cavity
(B) charge density at A = charge density at B
(C) potential at A = potential at B
(D) total electric field flux through the surface of the cavity is q/e_0.

PES038

2. A conducting sphere of radius R and charge Q is placed near a uniformly charged nonconducting infinitely large thin plate having surface charge density s. Then find the potential at point A (on the surface of sphere) due to charge on sphere (Here $K = \frac{1}{4\pi \in_0}$, $q_0 = \frac{\pi}{3}$)



(A) $K\frac{Q}{R} - \frac{\sigma}{4\in_0}R$ (B) $K\frac{Q}{R} - \frac{\sigma}{\in_0}$ (C) $K\frac{Q}{R}$ (D) None of these

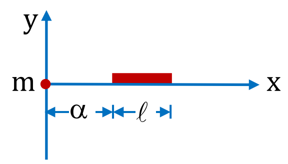
PES039

3. Calculate the distance from the surface of the Earth at which above and below the surface acceleration due to gravity is the same.

(A) $h = R$ (B) $h = \frac{\sqrt{5}-1}{2}R$ (C) $h = \frac{\sqrt{3}-1}{2}R$ (D) None

PGR014

4. A straight rod of length ℓ extends from $x = \alpha$ to $x = \ell + \alpha$. as shown in the figure. If the mass per unit length is $(a + bx^2)$. The gravitational force it exerts on a point mass m placed at $x = 0$ is given by



(A) $Gm\left(a\left(\frac{1}{\alpha}-\frac{1}{\alpha+\ell}\right)+b\ell\right)$

(B) $\frac{Gm(a+bx^2)}{\ell^2}$

(C) $Gm\left(\alpha\left(\frac{1}{a}-\frac{1}{a+\ell}\right)+b\ell\right)$

(D) $Gm\left(a\left(\frac{1}{\alpha+\ell}-\frac{1}{\alpha}\right)+b\ell\right)$

PGR015

SECTION-II

- This section contains **SIX** questions.
- Each question has **FOUR** options for correct answer(*s*). **ONE OR MORE THAN ONE** of these four option(*s*) is (are) correct option(*s*).
- For each question, choose the correct option(*s*) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 if only (all) the correct option(*s*) is (are) chosen.

Partial Marks : +3 if all the four options are correct but ONLY three options are chosen.

Partial Marks : +2 if three or more options are correct but ONLY two options are chosen, both of which are correct options.

Partial Marks : +1 if two or more options are correct but ONLY one option is chosen and it is a correct option.

Zero Marks : 0 if none of the options is chosen (i.e. the question is unanswered).

Negative Marks : –2 in all other cases.

For Example : If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(*s*) (second option in this case), with or without selection of any correct option(*s*) will result in –2 marks.

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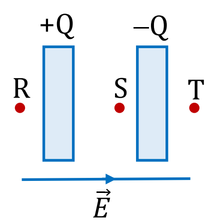
5. Two large thin conducting plates with small gap in between are placed in a uniform electric field E (perpendicular to the plates). Area of each plate is A and charges $+Q$ and $-Q$ are given to these plates as shown in the figure. If points R, S and T as shown in the figure are three points in space, then the



(A) field at point R is E

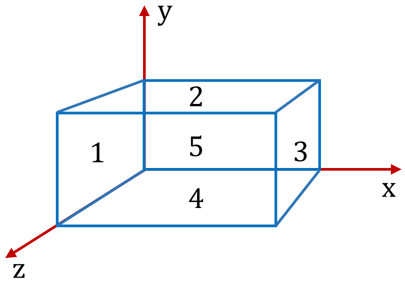
(B) field at point S is E

(C) field at point T is $\left(E+\frac{Q}{\varepsilon_o A}\right)$

(D) field at point S is $\left(E+\frac{Q}{A\varepsilon_o}\right)$

PES040

6. In a region of space, the electric field $\vec{E} = E_0 x\hat{i} + E_0 y\hat{j}$. Consider an imaginary cubical volume of edge 'a' with its edges parallel to the axes of coordinates. Now,



(A) the total electric flux through the faces 1 and 3 is E_0a^3

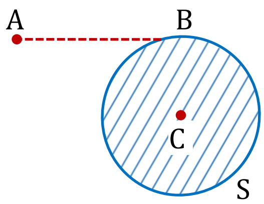
(B) the charge inside the cubical volume is $2\varepsilon_0 E_0 a^3$

(C) the total electric flux through the faces 2 and 4 is $2E_0a^3$

(D) the charge inside the cubical volume is $\varepsilon_0 E_0 a^3$

PES041

7. S is a solid neutral conducting sphere. A point charge q of $1 \times 10^{-6} C$ is placed at point A. C is the centre of sphere and AB is a tangent. $BC = 3m$ and $AB = 4m$.



(A) The electric potential of the conductor is 1.8 kV.

(B) The electric potential of the conductor is 2.25 kV.

(C) The electric potential at B due to induced charges on the sphere is –0.45 kV.

(D) The electric potential at B due to induced charges on the sphere is 0.45 kV.

PES042

8. Four identical particles each having mass m and charge q are placed at the vertices of a square of side ℓ. All the particles are free to move without any friction and released simultaneously from rest. Then

(A) At all instants, the particles remains at vertices of square whose edge length is changing

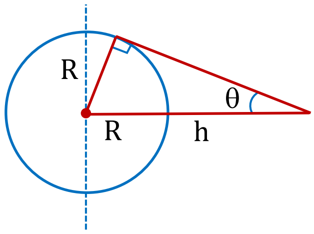
(B) The configuration is changing (not remaining square) as the time passes

(C) The speed of the particles when one of the particles get displaced by $\frac{\ell}{\sqrt{2}}$ is $\sqrt{\frac{q^2}{8\pi\varepsilon_0 m\ell}\left(2+\frac{1}{\sqrt{2}}\right)}$

(D) Speed of the particles can not be found

PES043

9. A geostationary satellite is at a height h above the surface of earth. If Earth radius is R



(A) The minimum colatitude on Earth upto which the satellite can be used for communication is $\sin^{-1}\left(R/R+h\right)$.

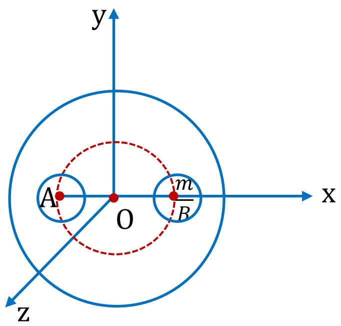
(B) The maximum latitudes on Earth upto which the satellite can be used for communication is $\cos^{-1}\left(R/R+h\right)$.

(C) The area on Earth escaped from this satellite is given as $2\pi R^2$ (1 + sin θ)

(D) The area on Earth escaped from this satellite is given as $2\pi R^2$ (1 + cos θ)

PGR016

10. A solid sphere of uniform density and radius 4 units is located with its centre at the origin O of coordinates. Two spheres of equal radii 1 unit, with their centres at A (–2, 0, 0) and B (2, 0, 0) respectively, are taken out of the solid leaving behind spherical cavities as shown in figure. Then



(A) The gravitational field due to this object at the origin is zero

(B) The gravitational field at the point B (2, 0, 0) is zero

(C) The gravitational potential is the same at all points of circle $y^2 + z^2 = 36$

(D) The gravitational potential is the same at all points on the circle $y^2 + z^2 = 4$

PGR017

SECTION-III

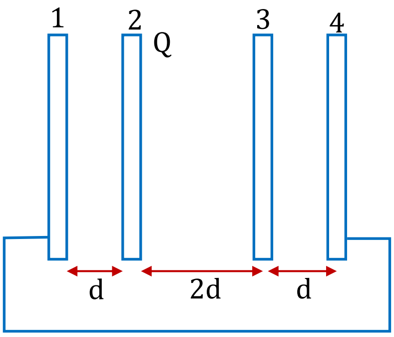
- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO/THREE** questions.
- Each question has **FOUR** options (A), (B), (C) and (D) **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 if only the bubble corresponding to the correct answer is darkened.

Zero Marks : 0 in all other cases.

PARAGRAPH FOR QUESTION NO. 11 TO 13

Four metallic plates are placed as shown in the figure. Plate 2 is given a charge Q whereas all other plates are uncharged. Plates 1 and 4 are joined together. The area of each plate is same.



11. The charge appearing on the right side of plate 3 is

(A) 0 (B) $+Q/4$ (C) $-3Q/4$ (D) $Q/2$

PES044

12. The charge appearing on right side of plate 4 is

(A) 0 (B) $-Q/4$ (C) $-3Q/4$ (D) $+Q/2$

PES045

13. The potential difference between plates 1 and 2 is

(A) $\frac{3}{2}\frac{Qd}{\varepsilon_0 A}$ (B) $\frac{Qd}{\varepsilon_0 A}$ (C) $\frac{3}{4}\frac{Qd}{\varepsilon_0 A}$ (D) $\frac{3Qd}{\varepsilon_0 A}$

PES046

PARAGRAPH FOR QUESTION NO. 14 & 15

Let us assume that angular momentum of a binary star system is quantised and is equal to $n\,J_0$ where n is positive integer. A binary star system consists of two identical stars of mass 'm'.

14. Permissible value of distance between the stars in the system -

(A) zero (B) $\frac{J_0^2}{2Gm^3}$ (C) $\frac{2J_0^2}{Gm^3}$ (D) None

PGR018

15. Lowest energy of the binary star system is -

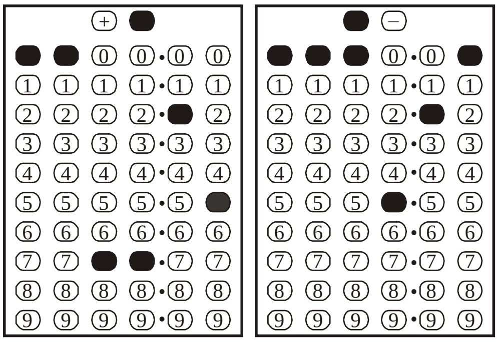
(A) zero (B) $-\frac{3}{16}\frac{m^5a^2}{J_0^2}$ (C) $-\frac{1}{8}\frac{m^5G^2}{J_0^2}$ (D) None

PGR019

SECTION-IV

- This section contains **FOUR** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.

  For Example : If answer is –77.25, 5.2 then fill the bubbles as follows:

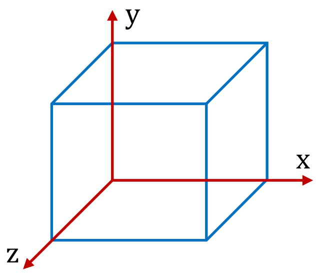


- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 if ONLY the correct numerical value is entered as answer.

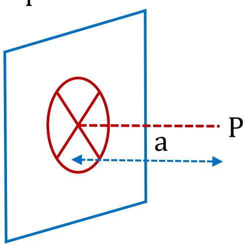
  Zero Marks : 0 in all other cases.

16. An electric field given by $\vec{E} = 4\hat{\imath} - 3(y^2 + 2)\hat{\jmath}$ pierces Gaussian's cube of side $1m$ placed at origin such that its three sides represents x, y and z axes. The net charge enclosed within the cube is given by $-n\varepsilon_0$. Find the value of n.



PES047

17. An infinitely long non-conducting plane of charge density σ has circular aperture of certain radius carved out from it. The electric field at a point which is at a distance 'a' from the centre of the aperture is $\sigma/2\sqrt{2}\epsilon_0$. The radius of aperture is an 'a' find n.



PES048

18. A satellite of mass m is orbiting the Earth in a circular orbit of radius r. It starts losing energy due to small air resistance at the rate of $C\,J/s$. Then the time taken for the satellite to reach the Earth is $t = \dfrac{GMm}{nC}\left(\dfrac{1}{R_e} - \dfrac{1}{r}\right)$. Find n.

PGR020

19. A hypothetical spherical planet of radius R and its density varies as $r = Kr$, where K is constant and r is the distance from the center. The pressure caused by gravitational pull inside ($r < R$) the planet at a distance r measured from its center is $\frac{1}{n}K^2Gp(R^4 - r^4)$. Find n.

PGR021

SECTION–V

- This section contains **ONE** question.
- Each question contains two columns, **Column-I** and **Column-II.**
- **Column-I** has **four** entries (A), (B), (C) and (D).
- **Column-II** has **four** entries (P), (Q), (R) and (S)
- Match the entries in **Column-I** with the entries in **column-II.**
- One or more entries in **Column-I** may match with one or more entries in **Column-II.**
- The ORS contains a 4 × 4 matrix whose layout will be similar to the one shown below:

(A)	(P)	(Q)	(R)	(S)
(B)	(P)	(Q)	(R)	(S)
(C)	(P)	(Q)	(R)	(S)
(D)	(P)	(Q)	(R)	(S)

- For each entry in **column-I,** darken the bubbles of all the matching entries. For example, if entry (A) in **Column-I** matches with entries (Q), (R) and (S), then darken these three bubbles in the ORS. Similarly, for entries (B), (C) and (D).
- For each question, marks will be awarded in one of the following categories :

  For each entry in **Column-I**

  Full Marks : +2 if only the bubble(s) corresponding to all the correct match(es) is (are) darkened.

  Zero Marks : 0 if none of the bubbles is darkened.

  Negative Marks : –1 in all other cases.

20. A particle at a distance r from the centre of a uniform spherical planet of mass M radius R ($< r$) has a velocity v, magnitude of which is given in column I. Match trajectory from column II about possible nature of orbit.

Column-I		**Column-II**	
(A)	$0 < v < \sqrt{\frac{GM}{r}}$	(P)	Straight line
(B)	$\sqrt{\frac{GM}{r}}$	(Q)	Circle
(C)	$\sqrt{\frac{2GM}{r}}$	(R)	Parabola
(D)	$v > \sqrt{\frac{2GM}{r}}$	(S)	Ellipse

PGR022

ANSWER KEY

EXERCISE - O

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.	C	B	C	C	D	A	C	B	C	C
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	B	D	D	B	A	B	D	B	D	B
Que.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Ans.	A	A	C	D	B	D	A	C	A	C
Que.	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	B	C	A	B	B	C	A	D	A	B
Que.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Ans.	D	A	C	D	B	A	D	C	B	B
Que.	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	C	B	B	A	A	D	B	B	B	C
Que.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
Ans.	D	D	D	C	A	C	B	C	B	A
Que.	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	C	D	C	A	C	B	B	A	A	C
Que.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Ans.	B	B	D	A	B	C	D	D	A	B
Que.	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
Ans.	B	B	C	B	A	B	A	B	C	A
Que.	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**
Ans.	C	A	B	C	A	C	A	C	C	A
Que.	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
Ans.	A	D	D	C	A	C	A	D	B	D
Que.	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**
Ans.	C	A	D	A	A	B	C	A	D	D
Que.	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**
Ans.	D	D	B	A	D	C	C	D	B	C
Que.	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**
Ans.	B	A	C	B	D	D	D	A	D	A
Que.	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**	**160**
Ans.	C	A	C	A	C	ABC	ABC	BC	AB	BD
Que.	**161**	**162**	**163**	**164**	**165**	**166**	**167**	**168**	**169**	**170**
Ans.	ABC	AD	ABC	BC	BD	AD	ABC	ACD	B	A
Que.	**171**	**172**	**173**	**174**	**175**	**176**	**177**	**178**	**179**	**180**
Ans.	C	B	D	C	B	D	B	C	A	A
Que.	**181**					**182**				
Ans.	(A-Q,R), (B-Q,T), (C-S,T), (D-P)					(A-R), (B-Q), (C-Q), (D-P)				

EXERCISE - S

1. 625 **2.** $\frac{9F}{4}$ **3.** 3 **4.** 9 **5.** 3

6. 8 **7.** 400 **8.** 3 **9.** 2 **10.** 1

11. 2 **12.** 12 **13.** 4 **14.** 6 **15.** 3

16. 576 **17.** 1 **18.** 8 **19.** 3 **20.** 2

21. 6

22. (a) 200 Vm^{-1} making an angle 120° with the x-axis

(b) Radially outward, decreasing with distance as $E=\frac{6}{r^2}V/m$

23. 2 **24.** $-\frac{kq^2}{a}\left(3-\sqrt{2}\right)$ **25.** 20

26. $2\tan^{-1}\left(\frac{\sigma q}{2\varepsilon_0 mg}\right)$ **27.** $\left[\frac{2KQq}{mR}\left(\frac{r-R}{r}+\frac{3}{8}\right)\right]^{1/2}$ **28.** 2

29. 2 **30.** 2 **31.** 1 **32.** 2 **33.** 6

34. 4 **35.** 5 **36.** $\left(\vec{g}=+\frac{\pi G\rho_0 R^3}{6}\left[\frac{1}{\left(x-(R/2)\right)^2}-\frac{8}{x^2}\right], \vec{g}=-\frac{2\pi G\rho_0 R}{3}\hat{i}\right)$

37. 2 **38.** 4 **39.** 7

40. 1.6 hours if it is rotating from west to east, 24/17 hours if it is rotating from east to west

41. $1\times10^5 J$ **42.** (a) $T=\frac{2\pi d^{3/2}}{\sqrt{3Gm}}$, (b) 2, (c) 2 **43.** 2 **44.** 9

45. 6 **46.** 2 **47.** 2 **48.** 3

49. (a) $\Delta E=\frac{GMm}{2r_1r_2}\left(r_2-r_1\right)$ (b) $\Delta E_A=\frac{r_2\Delta E}{r_1+r_2}$, $\Delta E_B=\frac{r_1}{r_1+r_2}\Delta E$

50. 8 **51.** 8 **52.** 2

EXERCISE - JEE (Main) PYQ

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	2	4	1	1	4	1	2	3	1	2
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	2	2	4	1	1	226	640	2	4	1
Que.	21	22	23	24						
Ans.	3	1	4	2						

EXERCISE - JEE (Advanced) PYQ

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	B	C	C	A	D	6	C	2	7	BC
Que.	11	12	13	14	15	16	17	18	19	20
Ans.	BD	AB	C	B	AB	2	B	A	ABD	AD
Que.	21	22	23	24	25	26	27	28	29	30
Ans.	D	BC	3.14	6.40	2	BC	1.73	3	9	ABC
Que.	31	32	33	34	35	36				
Ans.	3	B	ACD	2.30	B	A				

JEE (Main) Practice Paper

Section-A	Q.	1	2	3	4	5	6	7	8	9	10
	A.	1	2	3	2	1	4	4	3	1	1
	Q.	11	12	13	14	15	16	17	18	19	20
	A.	3	3	3	4	3	3	4	2	1	2
Section-B	Q.	1	2	3	4	5	6	7	8	9	10
	A.	6	8	2	8	3	5	2	2	4	3

JEE (Advanced) Practice Paper

Section-I	Q.	1	2	3	4		
	A.	C	A	D	A		
Section-II	Q.	5	6	7	8	9	10
	A.	AD	AB	AC	AC	ABC	ACD
Section-III	Q.	11	12	13	14	15	
	A.	B	D	C	C	D	
Section-IV	Q.	16	17	18	19		
	A.	3	1	2	4		
Section-V	Q.	20					
	A.	(A-P,S), (B-P,Q,S), (C-P,R), (D-P)					

Important Notes

Important Notes