CPP-01
SS JEE(M) &
ADVANCED

Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - Electric Charges and Fields

Level-1

SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. Charge is distributed inside a long cylindrical volume of radius R such that charge density inside the volume varies as $\rho = \alpha r^n$ where α is a constant and r the distance from the axis of the cylinder. If the magnitude of electric field inside the cylinder is independent of r, the value of n is

(A) 1 (B) 2
(C) –2 (D) –1

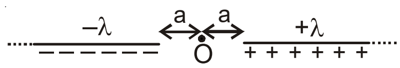
2. A particle of mass m and charge q is projected in a region where an electric field by $\vec{E} = E_0\hat{i}$ exists, with a velocity $v_0\hat{j}$ from the origin. Given $m^2v_0^2 = 2qE_0mx_0$. The radius of curvature of the path of the particle when its x-coordinate becomes x_0, is

(A) $4\sqrt{2}x_0$ (B) $2\sqrt{2}x_0$
(C) $\sqrt{2}x_0$ (D) $\frac{x_0}{2\sqrt{2}}$

3. A point charge q is paced at a point on the axis of a non-conducting circular plate of radius r at a distance R (>>r) from its center. The electric flux associated with the plate is

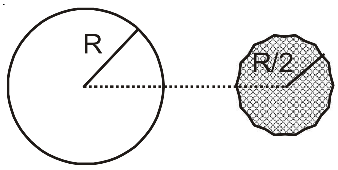
(A) $\frac{qr^2}{4\pi\varepsilon_0 R^2}$ (B) $\frac{qr^2}{4\varepsilon_0 R^2}$
(C) $\frac{qr^2}{4\varepsilon_0 r^2}$ (D) $\frac{q}{4\varepsilon_0}$

4. Two very long line charges of uniform linear charge density +λ and –λ are placed along same line with the separation between the nearest ends being 2a, as shown in figure. The electric field intensity at point O is



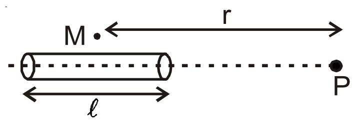
(A) 0 (B) $\frac{\lambda}{\pi \epsilon_0 a}$
(C) $\frac{\lambda}{2\pi \epsilon_0 a}$ (D) $\frac{\lambda}{4\pi \epsilon_0 a}$

5. A thin ring of radius R having a linear charge density λ moves towards an imaginary sphere of radius R/2, so that the centre of ring passes through the centre of sphere. The axis of the ring is perpendicular to the line joining the centres of the ring and the sphere. The maximum flux through the sphere in this process is



(A) $\frac{\lambda R}{\epsilon_0}$ (B) $\frac{\lambda R}{2\epsilon_0}$
(C) $\frac{\lambda\pi R}{4\epsilon_0}$ (D) $\frac{\lambda\pi R}{3\epsilon_0}$

6. A non-conducting cylindrical rod of diameter d and length ℓ (ℓ >>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. Find the electric field due to charge distribution at point P (r >>ℓ).



(A) $E_0\frac{\ell d}{2r^2}$ (B) $E_0\frac{\ell d}{4r^2}$
(C) $E_0\frac{\ell d}{3r^2}$ (D) $E_0\frac{2\ell d}{r^2}$

7. If an electron enters a space between the plates of a parallel plate capacitor at an angle θ_1 with the plates and leaves at an angle θ_2 to the plates, the ratio of its kinetic energy while entering the capacitor to that while leaving will be

(A) $\frac{\text{Cos}^2\theta_2}{\text{Cos}^2\theta_1}$ (B) $\frac{\text{Cos}^2\theta_1}{\text{Cos}^2\theta_2}$

(C) $\frac{\text{Sin}^2\theta_2}{\text{Sin}^2\theta_1}$ (D) $\frac{\text{Sin}^2\theta_1}{\text{Sin}^2\theta_2}$

8. A tiny electric dipole of dipole moment p is placed at a distance r from an infinitely long wire, with its $\vec{p}$ normal to the wire. If the linear charge density of the wire is λ, the electrostatic force acting on the dipole is equal to

(A) $\frac{\lambda P}{4\pi\varepsilon_0 r}$ (B) $\frac{\lambda P}{\pi\varepsilon_0 r}$

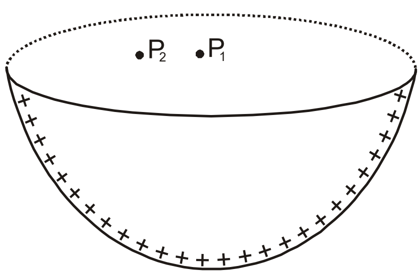
(C) $\frac{2\lambda P}{\pi\varepsilon_0 r}$ (D) $\frac{\lambda P}{2\pi\varepsilon_0 r^2}$

9. A thin ring of radius R having total charge Q uniformly distributed over the ring has a charge particle q kept at its centre. If a transverse pulse is created on the ring, then find the time when pulse completes one revolution. (Total mass of ring is m) (Tension in ring due to its own charge, is negligible)

(A) $3\pi R\sqrt{\frac{QqmR}{\pi\varepsilon_0}}$ (B) $4\pi R\sqrt{\frac{QqmR}{\pi\varepsilon_0}}$

(C) $3\pi R\sqrt{\frac{\pi\varepsilon_0 mR}{Qq}}$ (D) $4\pi R\sqrt{\frac{\pi\varepsilon_0 mR}{Qq}}$

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



(A) ↑; ↖ (B) ↑; ↗

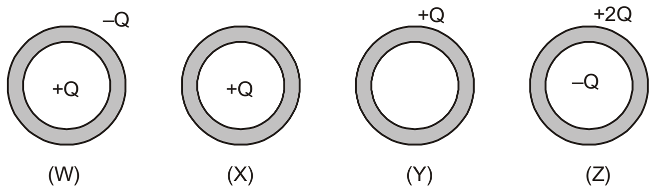
(C) ↑; ↑ (D) ↑; ←

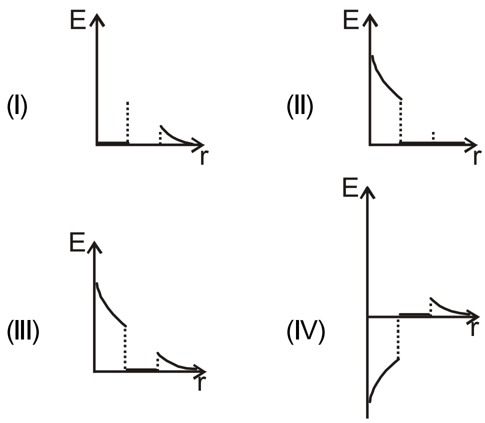
11. The magnitude of electric field intensity at point B (2, 0, 0) due to small dipole of dipole moment, $\vec{P} = \hat{i} + \sqrt{3}\hat{j}$ kept at origin is (assume that the point B is at large distance from the dipole and $k = \frac{1}{4\pi\varepsilon_0}$)

(A) $\frac{\sqrt{13}k}{8}$ (B) $\frac{\sqrt{13}k}{4}$

(C) $\frac{\sqrt{7}k}{8}$ (D) $\frac{\sqrt{7}k}{4}$

12. Figure shows charged hollow metal spheres (except X) each with internal radius a and external radius b. Match each charge distribution with the corresponding E-field graph.





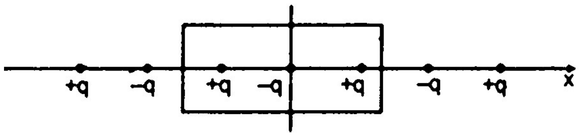
(A) W – II; X – I; Y – III; Z – IV

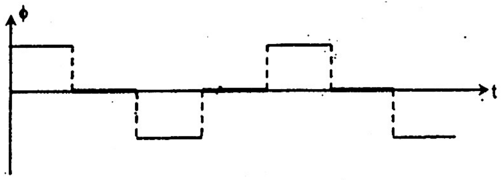
(B) W – III; X – I; Y – II; Z – IV

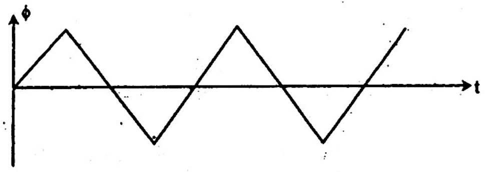
(C) W – I; X – II; Y – III; Z – IV

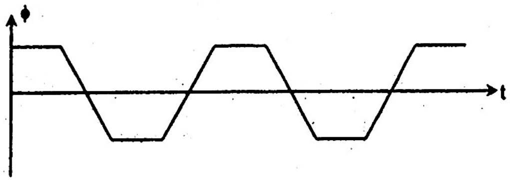
(D) W – II; X – III; Y – I; Z – IV

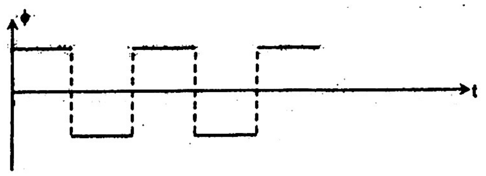
13. Infinite point charges +q and –q are placed alternatively on x-axis as shown in the figure. The distance between two consecutive charges is 'a'. Consider a cuboid of dimensions 3a × a × a centred at origin. The longest side of the cuboid is parallel to x-axis. The cuboid starts moving with constant velocity $v\hat{i}$. The correct graph to show the variation of net electric flux linked with cuboid with time is



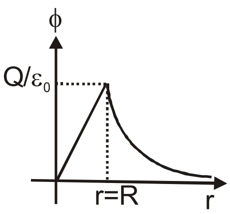
(A) 

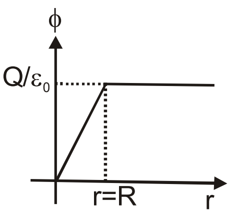
(B) 

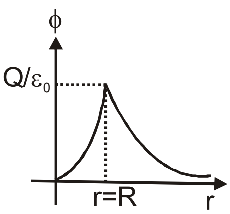
(C) 

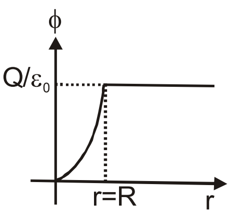
(D) 

14. Electric flux (ϕ) as a function of distance (r) from centre of uniformly charged solid sphere of charge Q and radius R, is best represented by

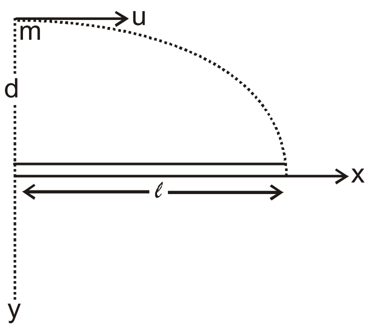
(A) 

(B) 

(C) 

(D) 

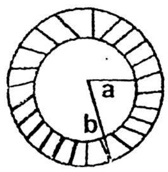
15. An electron is projected from a distance d and with initial velocity u parallel to a uniformly chaged flat infinite conducting plate as shown. It strikes the plate after travelling a distance ℓ along the direction of projection. The surface charge density of the conducting plate is equal to (neglect gravity)

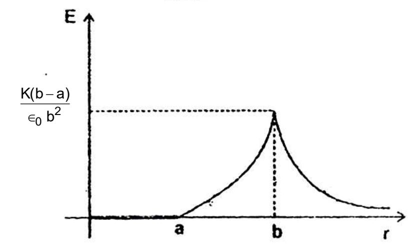


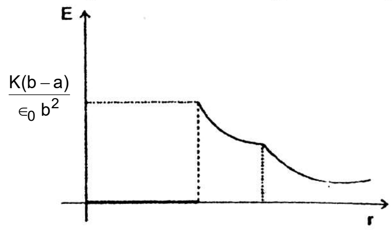
(A) $\frac{2d\varepsilon_0 mu^2}{e\ell^2}$ (B) $\frac{2d\varepsilon_0 mu}{e\ell}$

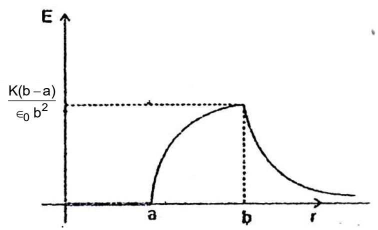
(C) $\frac{d\varepsilon_0 mu^2}{e\ell}$ (D) $\frac{d\varepsilon_0 mu}{e\ell}$

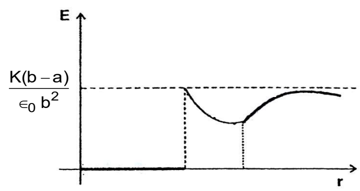
16. A hollow thick spherical shell of inner radius a and outer radius b carries volume charge density $\rho = \frac{k}{r^2}$ where k is some positive constant r is distance from centre. Select correct variation of magnitude of electric field with distance r. ($b \le 2a$)



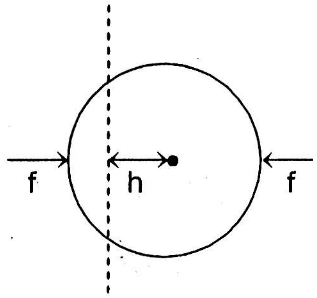
(A) 

(B) 

(C) 

(D) 

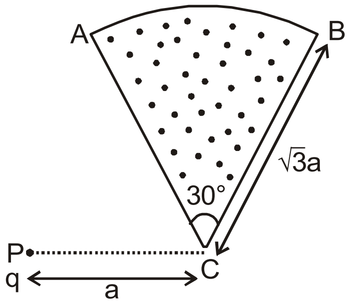
17. A charged conducting sphere of radius R is cut into two parts along a plane whose perpendicular distance from centre of sphere is h. The total charge on sphere is Q. If the force required to hold two parts of the sphere together is f and the force required to hold two parts is f_0 when h = 0, then $\frac{f}{f_0}$ is



(A) $\frac{R^2 - h^2}{R^2}$ (B) 1

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

18. A charged particle 'q' lies at 'P' and the line PC is perpendicular to the surface of ABC (part of disc). Find the flux passing through the surface ABC.



(A) $\frac{q}{4\varepsilon_0}$ (B) $\frac{q}{16\varepsilon_0}$

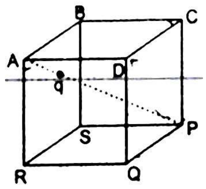
(C) $\frac{q}{32\varepsilon_0}$ (D) $\frac{q}{48\varepsilon_0}$

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

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



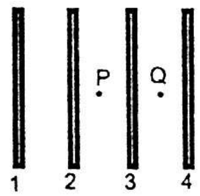
(A) the flux through both the surfaces ABCD and PQRS are same

(B) the flux through the surfaces ABCD is larger than the flux through surfaces PQRS

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

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

20. There are four parallel large conducting plates placed parallel to one another. Plate no. 1,2,3,4 are given charges equal to q_1,q_2,q_3 and q_4 respectively. (area of each plate is A). Select correct option.



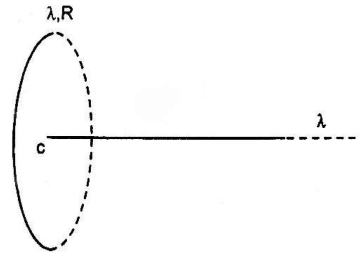
(A) Charges appearing on the left hand side of plate 1 will be $\frac{q_1 + q_2 + q_3 + q_4}{2}$

(B) Electric field intensity at the point P, will be $\frac{q_1 + q_2 - q_3 - q_4}{2A \in_0}$ towards right

(C) Electric field intensity at the point Q, will be $\frac{q_1 - q_2 + q_3 + q_4}{2A \in_0}$ towards right

(D) Charge appearing on the left hand side of plate 1 will be equal to charge appearing on the right hand side of plate 4

21. A semi-Infinite thin wire of charge per unit length λ is placed along axis of uniformly charged thin ring of same charge density. One end of semi-infinite wire is at centre of the ring of radius R. Select the correct statements



(A) Tension in ring due to wire is $\frac{\lambda^2}{4\pi \epsilon_0}$

(B) Tension in ring due to wire is zero

(C) Force on ring due to wire is $\frac{\lambda^2}{\epsilon_0}$

(D) Force on ring due to wire is $\frac{\lambda^2}{2 \epsilon_0}$

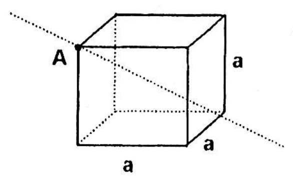
SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

Paragraph for Question Nos. 22 and 23

A point charge q (of negligible dimension) is kept near (not touching any face) the corner A of a cube (having faces of negligible thickness) as shown in the figure. Under the appropriate assumption (considering the size of the charge). Answer the following questions.



22. The flux crossing three faces close to the charge if charge is just inside the cube will be

(A) $\frac{q}{8\varepsilon_0}$ (B) $\frac{q}{\varepsilon_0}$

(C) $\frac{7q}{8\varepsilon_0}$ (D) $\frac{q}{6\varepsilon_0}$

23. The flux crossing the three symmetric faces which are close to the point charge will be if point charge is just outside of the cube

(A) $\frac{q}{8\varepsilon_0}$ (B) $\frac{q}{\varepsilon_0}$

(C) $\frac{7q}{8\varepsilon_0}$ (D) $\frac{q}{6\varepsilon_0}$

Paragraph for Question Nos. 24 to 26

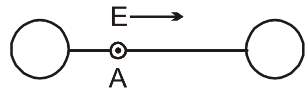
There is an insulator rod of length L and of negligible mass with two small balls of mass m and electric charge Q attached to its ends. The rod can rotate in the horizontal plane around a vertical axis crossing it at a L/4 distance from one of its ends

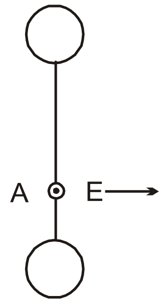
24. At first the rod is in unstable equilibrium in a horizontal uniform electric field of field strength E. Then we gently displace it from this position. Determine the maximum velocity attained by the ball which is closer to the axis in the subsequent motion

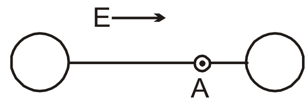
(A) $\sqrt{\frac{2QEL}{m}}$ (B) $\sqrt{\frac{2QEL}{5m}}$

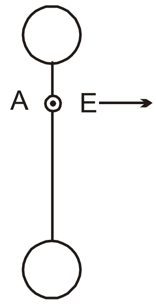
(C) $\sqrt{\frac{QEL}{5m}}$ (D) $\sqrt{\frac{4QEL}{5m}}$

25. In what position is the rod to be set that if displaced a little from that position it begins a harmonic oscillation about the axis A?

(A) 

(B) 

(C) 

(D) 

26. What is the time period of the SHM as mentioned in previous question?

(A) $2\pi\sqrt{\frac{mL}{QE}}$ (B) $2\pi\sqrt{\frac{2mL}{3QE}}$

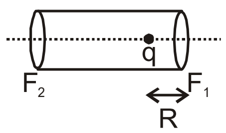
(C) $2\pi\sqrt{\frac{5mL}{QE}}$ (D) $2\pi\sqrt{\frac{5mL}{4QE}}$

SECTION-D

Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

27. Consider an imaginary cylindrical surface of length 3R and radius R. A point charge q is placed on the axis of cylinder at a distance of 2R from plane circular face F_2 and at R from plane circular face F_1



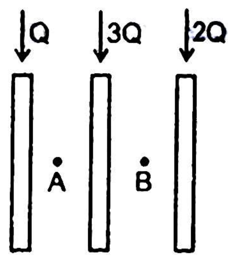
Column I	**Column II**
(A) Electric flux through face F_1 is	(p) $\frac{q}{\varepsilon_0}\left[\frac{1}{2\sqrt{2}}+\frac{1}{\sqrt{5}}\right]$
(B) Electric flux through face F_2 is	(q) $\frac{q}{2\varepsilon_0}\left[1+\frac{2}{\sqrt{5}}\right]$
(C) Electric flux through curved surface of cylinder is	(r) $\frac{q}{2\varepsilon_0}\left[1-\frac{1}{\sqrt{2}}\right]$
(D) Total flux through the cylinder is	(s) $\frac{q}{2\varepsilon_0}\left[1-\frac{2}{\sqrt{5}}\right]$
	(t) $\frac{q}{\varepsilon_0}$

SECTION-E

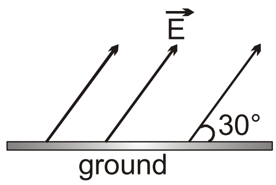
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

28. Three identical infinite conducting plates are placed very close to each other they are given charge Q, 3Q and 2Q respectively. Determine the ratio of magnitude of electric field intensity at point A and B.



29. In a region an electric field E = 15 N/C making an angle of 30° with the horizontal plane is present. A ball having charge 2C, mass 3 kg and coefficient of restitution with ground 1/2 is projected at an angle of 30° with the horizontal from the ground in the direction electric field with speed 20 m/s. Find the time (in sec) after projection when ball hits the ground second time



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SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. A point charge $\left(5\sqrt{2}+2\sqrt{5}\right)$ coulomb is placed on the axis of an infinite disc at a distance a from the centre of disc. The flux of this charge on the part of the disc having inner and outer radius of a and 2a will be

(A) $\frac{3}{2\varepsilon_0}$ (B) $\frac{1}{2\varepsilon_0}$

(C) $\frac{2\left[\sqrt{5}+\sqrt{2}\right]}{\varepsilon_0}$ (D) $\frac{2\sqrt{5}+5\sqrt{2}}{2\varepsilon_0}$

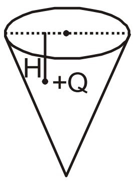
2. The electric field strength depends upon x, y and z coordinates according to law $\vec{E}=\frac{ax^2\hat{i}+by^2\hat{j}+cz^2\hat{k}}{ax^3+by^3+cz^3}$, where a, b and c are non-zero constants and $\hat{i}$, $\hat{j}$ and $\hat{k}$ are the unit vectors of x, y and z-axes. The flux of $\vec{E}$ through the sphere of radius R with its centre at the origin of the coordinates is

(A) $4\pi R$

(B) $2\pi R$

(C) $4\pi\varepsilon_0 R$

(D) $2\pi\varepsilon_0 R$



3. A charge +Q is located somewhere inside a vertical cone such that the depth of the charge from the free surface of the cone is H. It is found that the flux through the curved surface of the cone is $\frac{3Q}{5\varepsilon_0}$. If the charge is raised vertically through a height 2H, find flux through the cone's curved surface now.

(A) $\frac{3Q}{5\varepsilon_0}$ (B) $\frac{2Q}{5\varepsilon_0}$

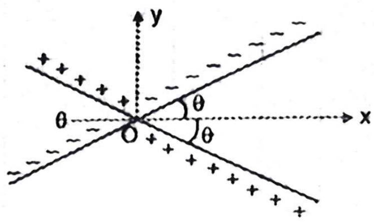
(C) $\frac{Q}{5\varepsilon_0}$ (D) $\frac{Q}{\varepsilon_0}$

4. A long thin cylindrical shell of radius R is charged uniformly on its surface with charge per unit length λ. Find magnitude of electric field at the centre of its one of the ends.

(A) $\frac{K\lambda}{R}$ (B) $\frac{2K\lambda}{R}$

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

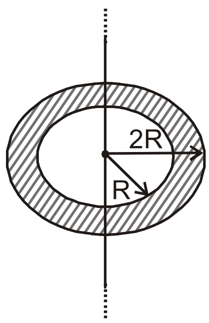
5. The given diagram shows two infinite line of charges having equal (in magnitude) linear charge density but with opposite sign. The electric field at any point on x axis for (x > 0) is along the unit vector



(A) $\cos\theta\hat{i}+\sin\theta\hat{j}$ (B) $\hat{i}$

(C) $\hat{j}$ (D) $-\sin\theta\hat{i}+\sin\theta\hat{j}$

6. A non conducting infinite rod is placed along the z-axis: the upper half of the rod (lying along $z \geq 0$) is charged positively with a uniform linear charge density $+\lambda$ while the lower half ($z < 0$) is charged negatively with a uniform linear charge density $-\lambda$. The origin is located at the junction of the positive and negative halves of the rod. A uniformly charged annular disc (surface charge density : σ_0) of inner radius R and outer radius 2R is placed in the x-y plane with its centre at the origin. Find the force on the rod due to the disc.



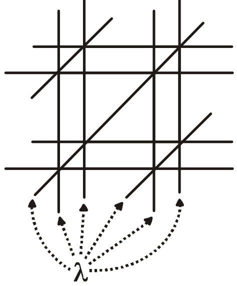
(A) $\frac{2\sigma_0\lambda R}{\varepsilon_0}$

(B) $\frac{\sigma_0\lambda R}{2\varepsilon_0}$

(C) $\frac{\sigma_0\lambda R}{\varepsilon_0}$

(D) $\frac{\sigma_0\lambda R}{3\varepsilon_0}$

7. Twelve infinite long wire of uniform linear charge density (λ) are passing along the twelve edges of a cube of side 'ℓ'. Find electric flux through any face of cube.



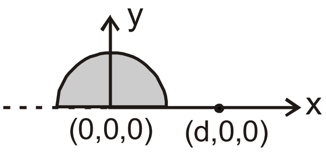
(A) $\left(\frac{\lambda\ell}{2\varepsilon_0}\right)$

(B) $\left(\frac{\lambda\ell}{\varepsilon_0}\right)$

(C) $\left(\frac{\lambda\ell}{3\varepsilon_0}\right)$

(D) $\left(\frac{3\lambda\ell}{\varepsilon_0}\right)$

8. A solid hemispherical uniformly charged body having charge Q is kept symmetrically with respect to the y-axis as shown in the figure. The net electric field at (d, 0, 0) is



(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}$ (B)less than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}$

(C) greater than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{2Q}{d^2}$

9. A non conducting ring of radius R_1 is charged such that the linear charge density is $\lambda_1 \cos^2\theta$ where θ is the polar angle. If the radius is increased to R_2 keeping the charge constant, the linear charge density is changed to $\lambda_2 \cos^2\theta$. The relation connecting R_1, R_2 λ_1 and λ_2 will be

(A) $\lambda_1/R_1 = \lambda_2/R_2$ (B) $\lambda_1/R_2 = \lambda_2/R_1$

(C) $\lambda_1\lambda_2 = R_1R_2$ (D) $\lambda_1^2 R_1 = \lambda_2^2 R_2$

10. If the radius and surface tension of a spherical soap bubble be r and T respectively. Find the charge uniformly distributed over the outer surface of the bubble which needs to be sprayed on bubble to double its radius. (Given that atmospheric pressure is P_0 and inside temperature of the bubble during expansion remains constant.)

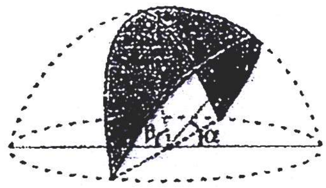
(A) $8\pi r[\varepsilon_0 r\ (7P_0 r + 12T)]1/2$

(B) $4\pi r[\varepsilon_0 r\ (7P_0 r + 12T)]1/2$

(C) $\pi r[\varepsilon_0 r\ (7P_0 r + 12T)]1/2$

(D) $8\pi r[\varepsilon_0 r\ (7P_0 r + 12T)]1/3$

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



(A) $E_0/3$

(B) $E_0/6$

(C) $E_0/2$

(D) Information insufficient

12. Two short dipoles $p\hat{k}$ and $\frac{p}{2}\hat{k}$ are located at (0, 0, 0) and (1m, 0, 2m) respectively. The resultant electric field due to two dipoles at the point (1m, 0, 0) is

(A) $\frac{9p}{32\pi\epsilon_0}\hat{k}$ (B) $\frac{-7p}{32\pi\epsilon_0}\hat{k}$

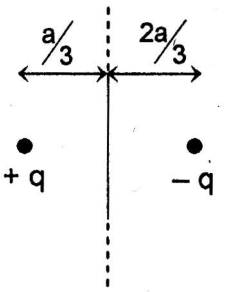
(C) $\frac{7p}{32\pi\epsilon_0}\hat{k}$ (D) None of these

13. Three charges q, q and –2q are fixed on the vertices of an equilateral triangular plate A of edge length a. This plate is in equilibrium between two very large parallel plates B and C having surface charge density σ_1 and σ_2 respectively. Find the period of small angular oscillation about axis passing through its centroid and perpendicular to plate A an parallel to plates B and C. Moment of inertia of the system about this axis I

(A) $2\pi\sqrt{\frac{\varepsilon_0 I}{qa|\sigma_1-\sigma_2|}}$ (B) $2\pi\sqrt{\frac{\varepsilon_0 I}{2qa|\sigma_1-\sigma_2|}}$

(C) $2\pi\sqrt{\frac{2\varepsilon_0 I}{\sqrt{3}qa|\sigma_1-\sigma_2|}}$ (D) $2\pi\sqrt{\frac{2\varepsilon_0 I}{qa|\sigma_1-\sigma_2|}}$

14. Two point charges q and –q are fixed in space at separation a. The flux through infinite plane perpendicular to line joining the charges and at a distance a/3 from +q will be



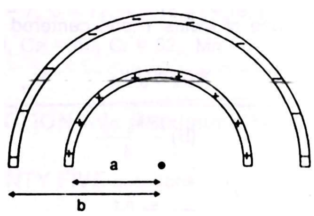
(A) $\frac{q}{3\epsilon_0}$

(B) $\frac{q}{2\epsilon_0}$

(C) $\frac{q}{\epsilon_0}$

(D) $\frac{2q}{\epsilon_0}$

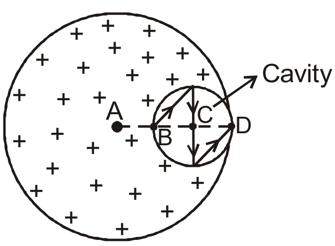
15. Figure shows two half coplanar rings of radii a and b. Both have same magnitude of charge but of opposite nature. Magnitude of charge on each ring is Q. What is electric dipole moment of the system ?



(A) $\frac{2Q(b-a)}{\pi}$ (B) $\frac{Q(b-a)}{2\pi}$

(C) $\frac{Q(b+a)}{2\pi}$ (D) $\frac{4Q(b-a)}{3\pi}$

16. The figure shows a non-conducting ball of radius 3R (of volumetric charge density ρ) having a spherical cavity of radius R. Work done in slowly moving an electron from B to D, via the path shown, is (A is centre of dielectric ball, C is centre of spherical cavity, B is point inside cavity nearest to A, D is point inside cavity farthest from A, e stands for magnitude of electronic charge).



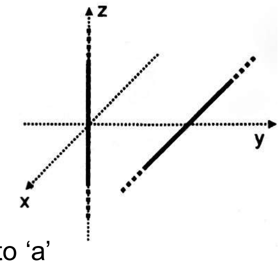
(A) $\frac{4\rho eR^2}{3\epsilon_0}$

(B) $\frac{2\rho eR^2}{\epsilon_0}$

(C) Zero

(D) Intermediate but more than that required to move electron straight from B to D.

17. Two mutually perpendicular infinitely long thin straight wires carrying uniformly distributed charges with charge per unit length λ_1 and λ_2 are in xy-plane and xz-plane respectively. The minimum distance between wires is 'a'. Force between them is



(A) Independent of 'a'

(B) Proportional to $\frac{1}{a^2}$

(C) Proportional to $\frac{1}{a^3}$

(D) Inversely proportional to 'a'

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

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18. Consider a spherically symmetric charge distribution centred at origin. Variation of electric flux with an imaginary Gaussian surface of radius r centre at origin is given by $\phi = \phi_0 r^3$.

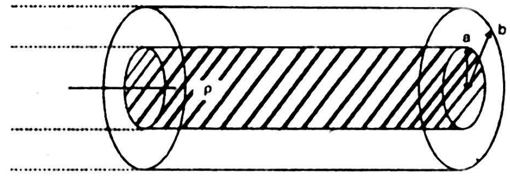
(A) Electric field in space lying in Gaussian surface is uniform

(B) The volume charge density in space lying in Gaussian surface is uniform

(C) For a given radius of spherical Gaussian surface the electric flux does not depend on position of centre of Gaussian surface

(D) For a given radius of spherical Gaussian surface the electric flux depends on position of centre of Gaussian surface

19. A long co-axial cable carries a uniform volume charge density ρ on inner cylinder and uniform surface charge density σ on outer cylinder. If radius of inner cylinder is 'a' and radius of outer cylinder is 'b'. It is found that this infinite cable is electrically neutral then which of the following is/are correct



(A) Electric field outside the cable increase linearly with radial distance

(B) Electric field will be zero outside the cable

(C) $\frac{\sigma}{b^2}+\frac{\rho}{2a}=0$

(D) $\frac{\sigma}{a^2}+\frac{\rho}{2b}=0$

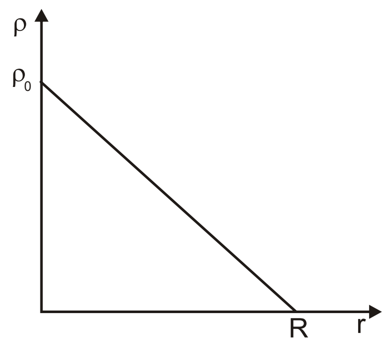
SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

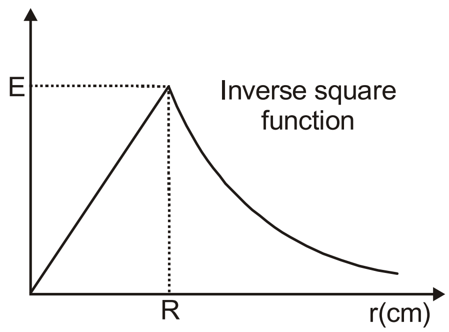
Paragraph for Question Nos. 20 and 21

A non conducting charged sphere A of relative permitivity (ε_r) equal to 1 and radius R is having non uniform charge. Volume charge density $\rho(r)$ as shown in the given graph (a). Here ρ_0 is a constant and r is the radial distance



Graph-(a)

20. For a charged non-conducting sphere B of radius R and relative permitivity ε_r=1, the variation of electric field E on r is observed as shown in the figure graph(b), such that E at the surface of sphere. A and sphere B are equal. If volume charge density of the sphere B is ρ, then



Graph-(b)

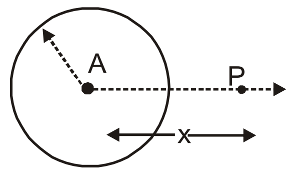
(A) $\rho = \rho_0$

(B) $\rho = \dfrac{\rho_0}{2}$

(C) $\rho = \dfrac{\rho_0}{4}$

(D) $\rho = \dfrac{\rho_0 r}{3R}$

21. A small dipole of dipole moment P is placed at large distance x from the centre of the sphere A as shown in the figure. What is the force exerted on the dipole by the sphere A



(A) $\dfrac{\rho_0 R^3 P}{6\varepsilon_0 x^3}$

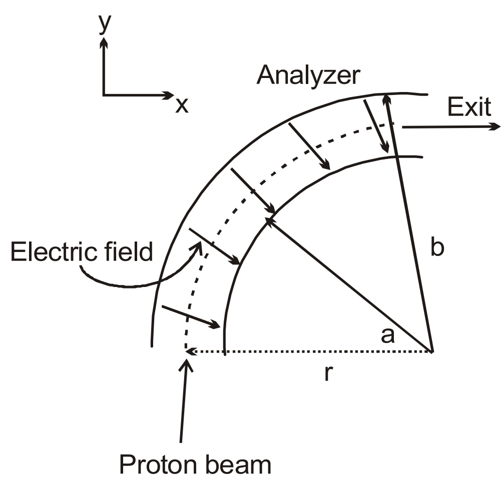
(B) $\dfrac{\rho_0 R^3 P}{2\varepsilon_0 x^3}$

(C) $\dfrac{2\rho_0 R^3 P}{3\varepsilon_0 x^3}$

(D) $\dfrac{4\rho_0 R^3 P}{3\varepsilon_0 x^3}$

Paragraph for Question Nos. 22 to 24

Figure shows a schematic view of an electrostatic analyzer. It can sort out charged particles by speed and charge to mass ratio. Spacecraft use such analyzers to characterize charged particles in interplanetary space. Two curved metal plates establish an electric field given by $E = E_0\left(\dfrac{b}{r}\right)$ where E_0 and b are positive constants with unit of electric field and length. The field points toward the centre of curvature and r is distance from centre. There is no influence of gravity. Proton (charge +e mass 'm') enters along y-axis and exits along x-axis while moving along a circular path



22. Speed with which proton is to be projected is 'v' and centripetal acceleration of proton is 'a_c' is given by respectively. Mark the correct statement

(A) $v=\sqrt{\dfrac{eE_0 b}{m}}; a_c=\dfrac{2e}{m}E_0\left(\dfrac{b}{r}\right)$

(B) $v=\sqrt{\dfrac{2eE_0 b}{m}}; a_c=\dfrac{e}{2m}E_0\left(\dfrac{b}{r}\right)$

(C) $v=\sqrt{\dfrac{eE_0 b}{2m}}; a_c=\dfrac{2e}{m}E_0\left(\dfrac{b}{r}\right)$

(D) $v=\sqrt{\dfrac{eE_0 b}{m}}; a_c=\dfrac{e}{m}E_0\left(\dfrac{b}{r}\right)$

23. Mark the **incorrect** option

(A) Work done by electric field on proton is zero

(B) If $v=\sqrt{\dfrac{2eE_0 b}{m}}$ proton may strike outer surface of analyzer

(C) If $v=\sqrt{\dfrac{2eE_0 b}{m}}$ proton may strike inner surface of analyzer

(D) If an electron is released with zero initial velocity from inner surface of analyzer it will strike outer surface with velocity $v=\sqrt{\dfrac{2eE_0 b}{m_e}\ln\left(\dfrac{b}{a}\right)}$, where m_e is mass of electron

24. Mark the correct option

(A) If E_0 is made larger then in order to maintain same trajectory initial speed has to be decreased

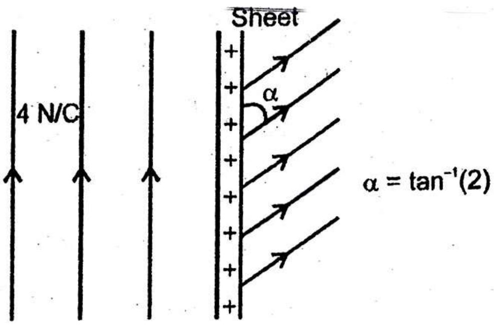
(B) If proton enters closer to the inner surface it will require smaller speed to follow circular trajectory

(C) It does not matter where the protons enter the device it requires same speed to follow circular trajectory

(D) A deuteron (charge +e, mass 2m) will require greater speed as compared to proton to follow circular trajectory

Paragraph for Question Nos. 25 and 26

An infinite large uniform charged non-conducting sheet having surface charge density σ is placed in an external uniform electric field $\vec{E}$. Figure shows electric field lines near the sheet. Magnitude of electric field in left side of sheet is 4N/C and electric field in right side of the sheet is at angle $\tan^{-1}(2)$ from sheet



25. What is magnitude of uniform external electric field ?

(A) 4 N/C (B) 5 N/C

(C) $2\sqrt{2}$ N/C (D) $4\sqrt{2}$ N/C

26. If $\vec{E}_L$ is electric field in region left side of the sheet and $\vec{E}_R$ is electric field in region right side of the sheet then which of the following is correct statement

(A) $\left|\vec{E}_L-\vec{E}_R\right|=\dfrac{\sigma}{2\varepsilon_0}$

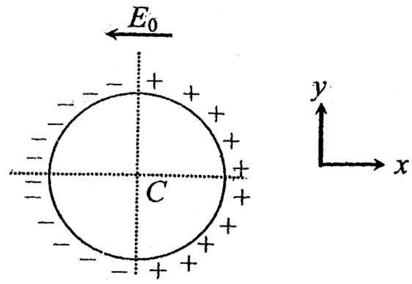
(B) $\left|\vec{E}_L-\vec{E}_R\right|=\dfrac{\sigma}{\varepsilon_0}$

(C) $\left|\vec{E}_L-\vec{E}_R\right|=\dfrac{2\sigma}{\varepsilon_0}$

(D) $\left|\vec{E}_L-\vec{E}_R\right|=\dfrac{\sigma^2}{2\varepsilon_0}$

Paragraph for Question Nos. 27 and 28

A uniform ring of mass m and radius R can rotate freely about an axis passing through centre C and perpendicular to plane of paper. Half of ring is positively charge and other half is negatively charge. Uniform electric field E_0 is switched on along –ve x-axis (Axis are shown in figure). [magnitude of charge density λ]



27. The dipole moment of ring is

(A) $2\lambda R^2$ (B) $4\lambda R^2$

(C) $2\pi\lambda R^2$ (D) $4\pi\lambda R^2$

28. If ring is slightly disturbed in anticlockwise sense from given position, find the angular speed of ring when it rotates by $\pi/2$.

(A) $2\sqrt{\frac{\lambda E_0}{m}}$ (B) $\sqrt{\frac{\lambda E_0}{m}}$

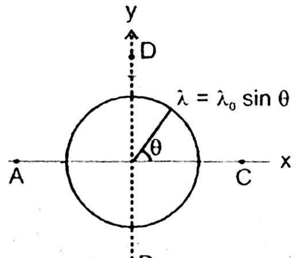
(C) $\sqrt{\frac{8\lambda E_0}{m}}$ (D) None of these

SECTION-D

Matrix-Match Type

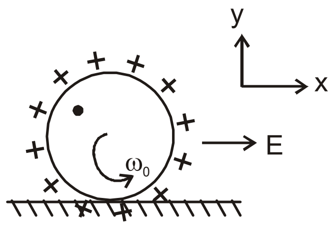
This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

29. A circular wire lying in the X – Y plane has charge density $\lambda = \lambda_0 \sin\theta$ (λ_0 is positive). Points A, B, C and D are shown in the figure. Match the description in Column I with the points in Column II



Column I	Column II
(A) Direction of electric field is along $\hat{j}$	(p) A
(B) Direction of electric field is along $-\hat{j}$	(q) B
(C) Potential is zero (taking infinity as reference)	(r) C
(D) Potential is positive (taking infinity as reference)	(s) D

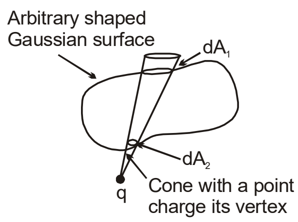
30. A uniformly charged non-conducting uniform hollow sphere of radius 1m and mass 2kg having angular speed ω_0=9 rad/s is gently placed on non-conducting rough horizontal surface with coefficient of friction μ at t = 0. Charge on the sphere is Q_0 and uniform electric field E is present in the region parallel in the region parallel to the horizontal surface (Given Q_0E = 10 N, g = 10 ms^{-2}). Then match the column



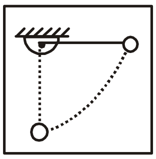
Column I	Column II
(A) If μ = 0.6, then a_{cm} at t = 1 second	(p) Along +ve x-axis
(B) If μ=0.4, then a_{cm} at t = 1 second	(q) Along –ve x-axis
(C) If μ=0.5, then a_{cm} at t = 1 second	(r) Zero
(D) If μ=0.6, then friction force at t = 1 second	(s) Non-zero
	(t) Data insufficient

31. Column-I represents an Event/Setup followed by an explanation or a statement. Column II represent remarks about event as well as explanation.

Note: (A) You have to mark event as possible/ impossible followed by explanation correct/ incorrect. (B) If event turns out to be impossible do not evaluate explanation

Column I	Column II
(A)  **Setup:** A point charge lies outside an arbitrary Gaussian surface as shown in figure. **Event:** Flux through area element dA_1 and dA_2 has same numerical value	(p) Possible

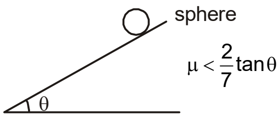
Explanation: Same number of field lines will cross through the two surfaces as field lines due to a point charge are radial

(B)  (q) Impossible

Setup: A pendulum bob is fixed to frame of an elevator at rest. The pendulum bob is released from horizontal position. When it swings and reaches its lowest position, elevator begins to fall freely

Event: Just after beginning of free fall, bob follows parabolic trajectory with respect to ground

Explanation: If string of a pendulum bob get slack pendulum bob becomes an unconstrained object moving under gravity

(C) 

(r)

Correct

Setup: A hollow sphere and a solid sphere of same mass and radius are released simultaneously from an incline

Event: Both the spheres reach the bottom at the same time with same translational kinetic energy

Explanation: Work down by friction and gravity is same on solid as well as hollow sphere

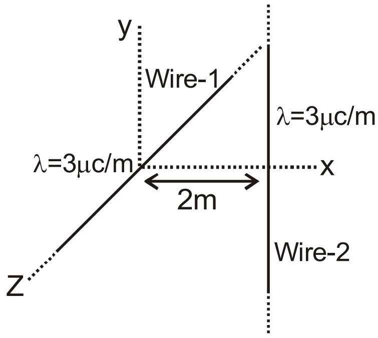
(s) Incorrect

SECTION-E

Integer Answer Type

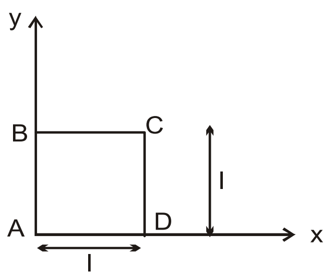
This section contains Integer type questions. The answer to each of the questions is an integer.

32. A long wire has uniform charge density $\lambda = 3\ \mu C/m$ is kept along z-axis Another similar wire 2 is lying on x-y plane such that the minimum separation between them is d = 2m. Calculate the work done (in Joule) in moving the wire-2 upto origin.(approximately)

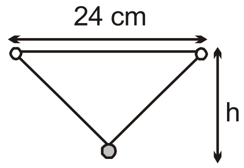


33. A charge q is divided into three equal parts and placed symmetrically on a circle of radius r. The same charge is then divided into four equal parts and placed symmetrically on the same circle. The electric field intensities at the centre of the circle in two situations are zero. If a charge (part charge) is removed from one location in both the situations and the ratio of magnitudes of the electric field intensities at the center is $\left[\frac{n+1}{n}\right]$. Find n.

34. A square loop of side l each side having uniform linear charge density 'λ' is placed in 'xy' plane as shown in the figure. There exists a non uniform electric field $\vec{E} = \frac{a}{l}(x+l)\hat{i}$ where a and l are constants and x is the position of the point from origin along x-axis. Find the resultant electric force on the loop (in Newtons), if l = 10 cm, $\lambda = 20\ \mu C/m$ and $a = 5 \times 10^5$ N/C



35. The two ends of a rubber string of negligible mass and having unstretched length 24 cm are fixed at the same height as shown. A small object is attached to the string in its midpoint, thus the depression (h) of the object in equilibrium is 5 cm. Then the small object is charged and vertical electric field (E_1) is applied. The equilibrium depression of the object increases to 9 cm, then the electric field is changed to E_2 and the depression of object in equilibrium increases to 16 cm. If the ratio of electric fields (E_2/E_1) in the second case to that of in the first case is $\frac{k}{4}$, find the value of k–9. (Assume the rubber string stays withing elastic limit in all cases)



❑ ❑ ❑

ANSWERS

LEVEL-1

1. (D)	2. (A)	3. (B)	4. (C)	5. (D)	6. (B)
7. (A)	8. (D)	9. (D)	10. (C)	11. (C)	12. (D)
13. (D)	14. (D)	15. (A)	16. (C)	17. (A)	18. (D)
19. (B,C)	19. (A,B,D)	21. (A,D)	22. (C)	23. (A)	24. (C)
25. (A)	26. (D)	27. (A-r, B-s ,C-p, D-t)		28. (2)	29. (6)

LEVEL-2

1. (A)	2. (A)	3. (B)	4. (A)	5. (C)	6. (C)
7. (A)	8. (C)	9. (B)	10. (A)	11. (C)	12. (B)
13. (C)	14. (C)	15. (A)	16. (A)	17. (A)	18. (B,C)
19. (B,D)	20. (C)	21. (A)	22. (D)	23. (C)	24. (C)
25. (D)	26. (B)	27. (B)	28. (C)	29. (A-q,s, B-p,r ,C-p,r, D-s)	
30. (A-p,s, B-p,s ,C-r, D-q,s)		31.(A-p,r , B-q , C-p,s)		32. (1)	33. (3)
34. (6)	35. (8)				

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