PHYSICS

NCERT - NCERT PHYSICS(HINGLISH)

ELECTRIC CHARGES AND FIELDS

Solved Examples

1. How can you charge a metal sphere negatively without touching it?

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2. If a body gives out 10^9 electrons every second, how much time required to get a total charge of $1C$ from it ?

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3. How much positive and negative charge is there in a cup of water ?

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4. Coulomb's law for electrostatic force between two point charges and Newton's law for gravitational force between two stationary point masses, both have inverse square dependence on the distance between the charges / masees (a) compare the strength of these forces by determining the ratio of their maagnitudes (i) for an electron and as proton (ii) for two protons (b) estimate the accelerations for election and proton due to electrical force of their mutal attraction when they are 1 A apart.

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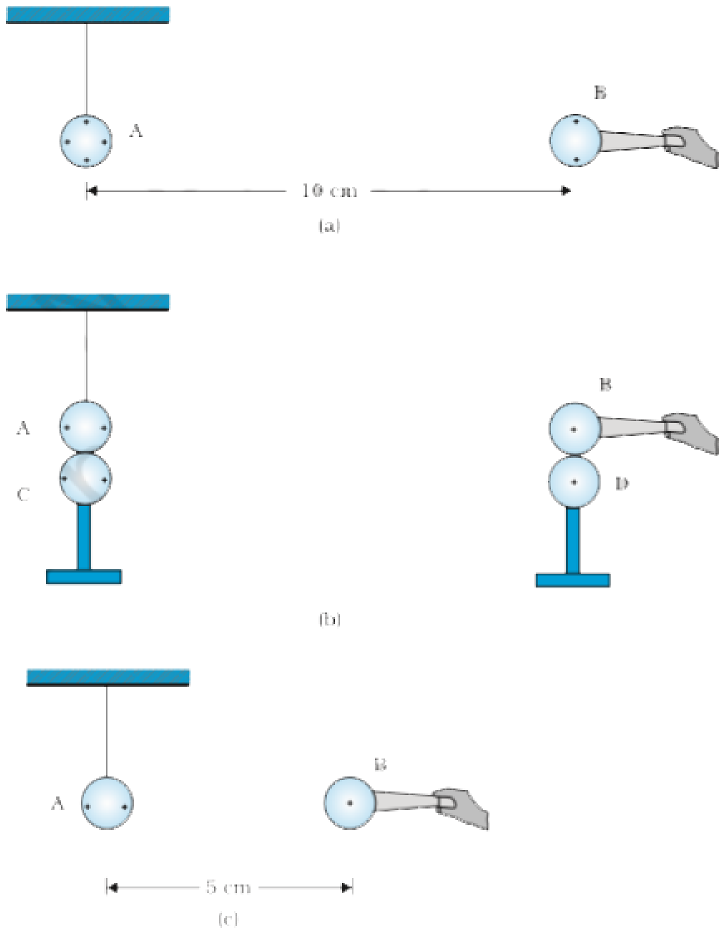
5. A charged metallic sphere A is suspended by a nylon thread. Another charged metallic sphere B held by an insulating handle is brought close to A such that the distance between their centres is 10 cm, as shown in Fig. 1.7(a). The resulting repulsion of A is noted (for example, by shining a beam of light and measuring the deflection of its shadow on a screen). Spheres A and B are touched by uncharged spheres C and D respectively, as shown in Fig. 1.7(b). C and D are then removed and B is brought closer to A to a distance of 5.0 cm between their centres, as shown in Fig. 1.7(c). What is the expected repulsion of A on the basis of Coulomb's law? Spheres A and C and spheres B and D have identical sizes. Ignore the sizes of A and B in comparison to the separation between their centres.



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6. Consider three charges q_1, q_2 and q_3 each equal to q, at the vertices of an equilateral triangle of side l. What is the force on a charge Q placed at the centroid of the triangle?

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7. Consider the charges q,q and -q placed at the vertices of an equilateral triangle of each side l. What is the force on each charge ?

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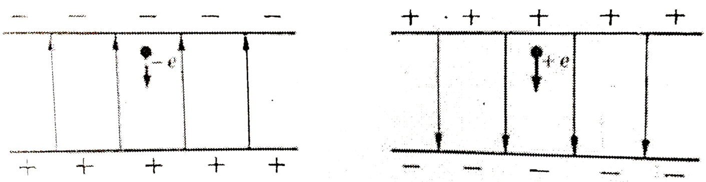
8. An electron falls through a distance of 1.5 cm in a uniform electric field of magnitude $2.4 \times 10^4 NC^{-1}$ [Fig.1.12 (a)]`. The direction of the field is reversed keeping its magnitude unchagned and a proton falls through the same distance [Fig. 1.12 (b)]. Complute the time of fall in each case. Contrast the situation (a) with that of free fall under gravity.



(a) (b)

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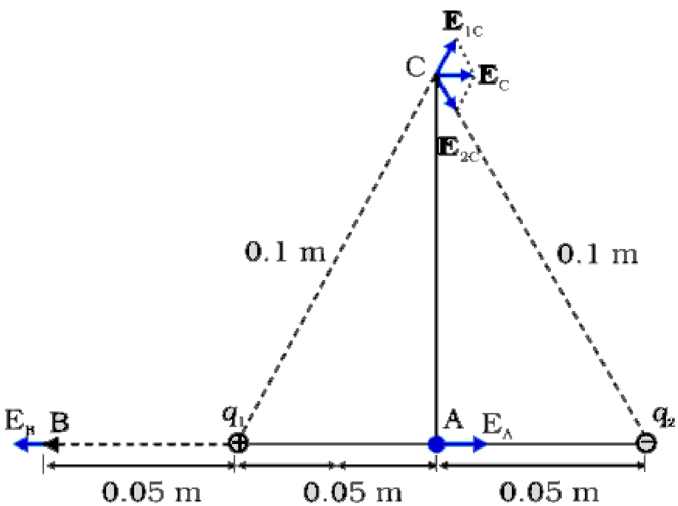
9. Two point charges q_1 and q_2, of magnitude $+10^{-8}C$ and $-10^{-8}C$, respectively, are placed 0.1 m apart. Calculate the electric fields at points A, B and C shown in Fig. 1.14.



A. $E_A = 7.2 \times 10^4 NC^{-1}$

$E_B = 3.2 \times 10^4 NC^{-1}$

E_B is directed towards the RIGHT.`

B. $E_A = 7.2 \times 10^{-4} NC^{-1}$

$E_B = 3.2 \times 10^4 NC^{-1}$

E_B is directed towards the left.`

C. $E_A = 7.2 \times 10^4 NC^{-1}$

$E_B = 3.2 \times 10^4 NC^{-1}$

E_B is directed towards the left.`

D. $E_A = 7.2 \times 10^4 NC^{-1}$

$E_B = 3.2 \times 10^{-4} NC^{-1}$

E_B is directed towards the left.`

Answer: C

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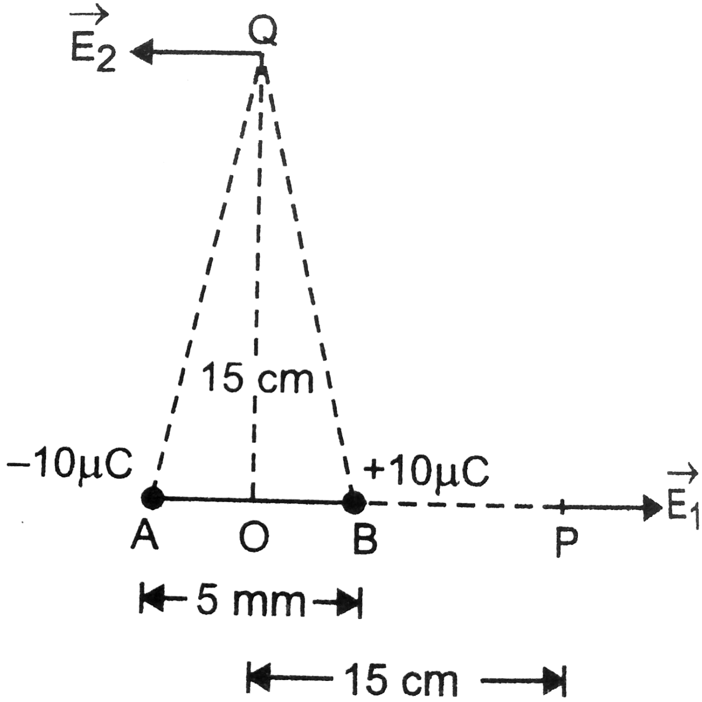
10. Two charges $\pm 10\mu C$ are placed $5 \cdot 0mm$ apart. Determine the electric field at (a) point P on the axis of dipole $15cm$ away from its center on the side of the positive charge. As shown in Figure and at (b) a point Q. $15cm$ away form O on a line passing through O and a line passing through O and normal to the axis of the dipole as shown in Fig.



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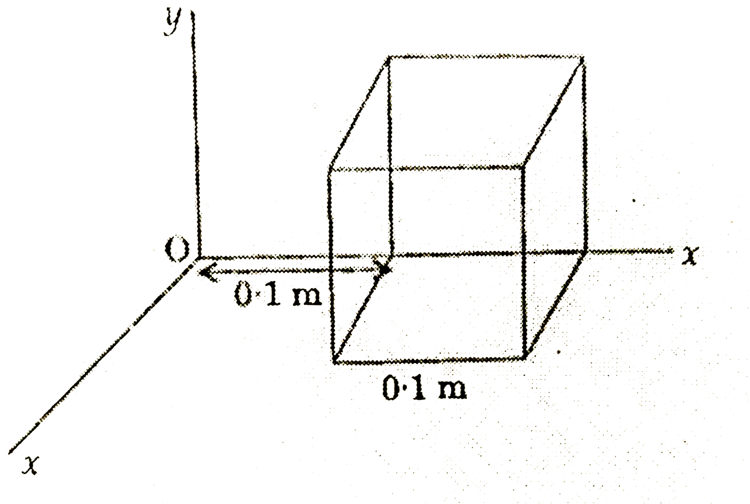
11. (a) Define electric flux. Write its SI units.

(b) The electric field components due to a charge inside the cube of side 0.1 m are as shown :



$E_x = \alpha x$, where $\alpha = 500N/C - m$

$E_y = 0, E_z = 0.$

Calculate (i) the flux through the cube, and (ii) the charge inside the cube.

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12. An electric field is uniform, and in the positive x-direction for positive x, and uniform with the same magnitude , but in the negative x-direction for negative x. It is given that $\overrightarrow{E} = 200\hat{i}N/Cf$ or $x > 0$ and $\overrightarrow{E} = -200\hat{i}N/C$ for $x < 0$. A right circular cylinder of length 20 cm and raidus 5cm has its center at the origin and its axis along the x-axis so that one face is at $x = +10cm$ and the other is at $x = -10cm$.

(a) What is the net outward flux through the side of the cylinder ? (b) What is the net outward flux through the cyclinder ? (c) what is net charge inside the cylinder ?

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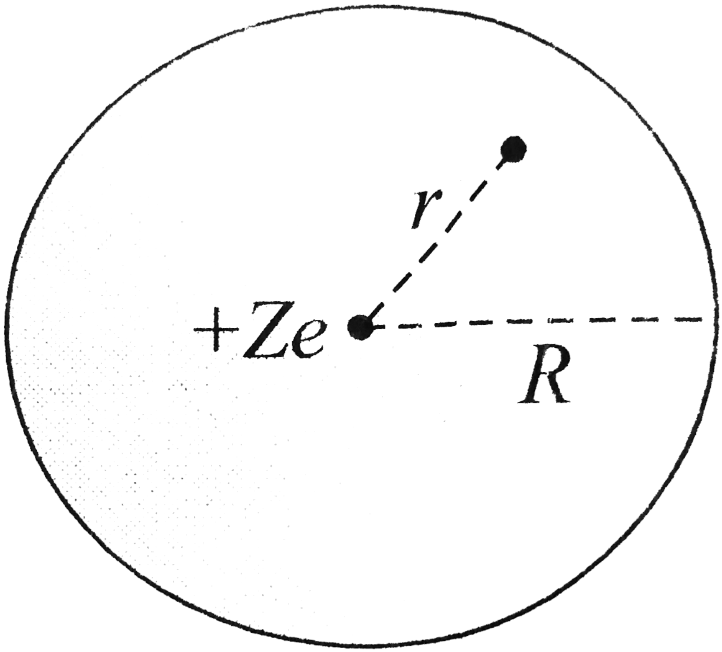
13. According to early model of an atom,the atom is considered it to have a positively charged point nucleus of charge Ze surrounded by a uniform density of negative charge up to a radius R. The atom as a whole is neutral. The electric field at a distance$r$ from the nucleus is $(r < R)$



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Exercise

1. What is the force between two small charged spheres having charges of $2 \times 10^{-7} C$ and $3 \times 10^{-7} C$ placed 30cm apart in air ?

A. 6×10^{-4} N

B. 6×10^{-3} N

C. 6×10^{-6} N

D. 5×10^{-3} N

Answer: B

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2. The electrostatic force on a small sphere of charge $0.4\mu C$ due to another small sphere of charge $-0.8\mu C$ in air 0.2 N (i) What is the distance between the two spheres? (ii) What is the force on the second sphere due to the first ?

A. The distance between the two spheres is 0.12 m. $0.2N$

B. The distance between the two spheres is 0.12

m. $1.2N$

C. The distance between the two spheres is 0.12

m. $2.2N$

D. The distance between the two spheres is 0.22

m. $22.2N$

Answer: A

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3. Check that the ratio ke2/G memp is dimensionless.

Look up a Table of Physical Constants and determine the value of this ratio. What does the ratio signify?

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4. (a) Explain the meaning of the statement 'electric charge of a body is quantised'. (b) Why can one ignore quantisation of electric charge when dealing with macroscopic i.e., large scale charges?

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5. When a glass rod is rubbed with a silk cloth, charges appear on both. A similar phenomenon is observed with many other pairs of bodies. Explain how this observation is consistent with the law of conservation of charge.

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6. Four point charges $q_A = 2\mu C, q_B = -5\mu C, q_C = 2\mu C$ and $q_D = -5\mu C$ are located at the corners of a square ABCD of side 10 cm. What is the force on a charge of $1\mu C$ placed at the center of the square ?

A. $0N$

B. $1N$

C. $2N$

D. $3N$

Answer: A

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7. (a) An electrostaic field line is a continous curve. That is a field line cannot have sudden breaks. Why not ?

(b) explain why two field lines never cross each other at any point.

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8. Two point charges $q_A = 3\mu C$ and $q_B = -3\mu C$ are located 20 cm apart in vaccum (a) what is the electric field at the mid point O of the line AB joining the two charges ? (b) If a negative test charge of magnitude $1.5 \times 10^{-9} C$ is placed at the point, what is the force experienced by the test charge ?

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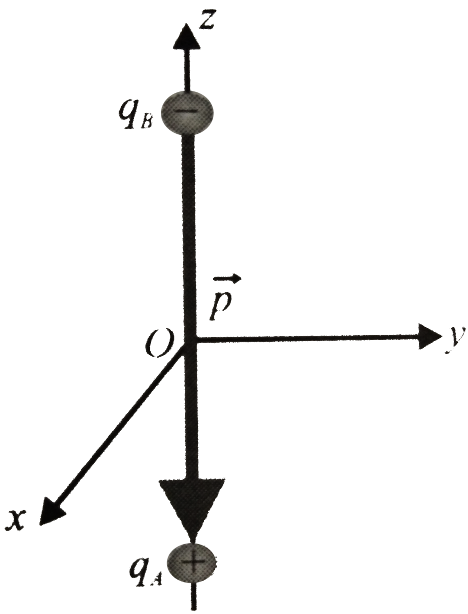
9. A system has two charges $q_A = +2.5 \times 10^{-7} C$ and $q_B = -2.5 \times 10^{-7} C$ located at point A: (0,0,-15 cm)and B: (0,0,+15 cm)`, respectively. What are the total charge and electric dipole moment of the system?



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10. An electrtic dipole with dipole moment $4 \times 10^{-9} Cm$ is aligned at 30° with the direction of a uniform electric field of magnitude $5 \times 10^4 NC^{-1}$.

Calculate the magnitude of the torque acting on the dipole .

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11. A polythene piece rubbed with wool is found to have a negative charge of $3.0 \times 10^{-7} C$.

(a) Estimate the number of electrons transferred (from which to which)?

(b) Is there a transfer of mass from wool to polythene?

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12. (a) Two insulated charged copper spheres A and B have their centers separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is $6.5 \times 10^{-7} C$? The radius of A and B are negligible compared to the distance of separation.

(b) What is the force of repulsion if each sphere is charged double the above amount, and the distance between them is halved ?

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13. Suppose the spheres A and B in the above question have identical sizes. A third sphere of the same size but uncharged is brought in contact with the first, then brought in contact with the second, and finally removed from both. What is the new force of repulsion between A and B?

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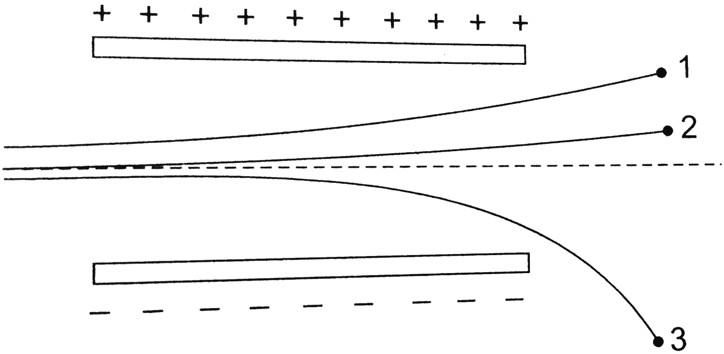
14. Figure shows tracks of three charged particles crossing a uniform electrostatic field with same velocities along horizontal. Give the sign of the three charges. Which particle has the highest charge to mass ratio?



A. 1 and 2 are negatively charged 3 positively charged Third particle has highest charge to mass ratio

B. 1 and 2 are positively charged 3 positively charged Third particle has highest charge to mass ratio

C. 1 and 2 are negatively charged 3 positively charged second particle has highest charge to mass ratio

D. 1 and 2 are negatively charged 3 negatively charged Third particle has highest charge to mass ratio

Answer: A

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15. Consider a uniform electric field $E = 3 \times 10^3 \hat{i} N / C$. (a) What is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane ? (b) What is the flux through the same square if the normal to its plane makes a 60° angle with the x-axis ?

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16. What is the net flux of the uniform electric field of the above question through a cube of side 20 cm oriented so that its faces are parallel to the coordinate planes?

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17. Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is $8.0 \times 10^3 Nm^2 / C$ (a) what is the net charge inside the box ? (b) If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box ? Why or why not?

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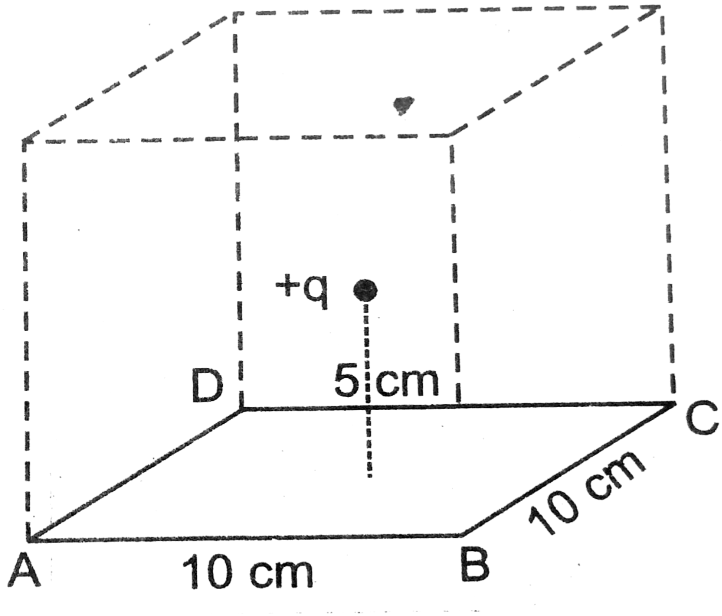
18. A point charge $+10\mu C$ is at distance of 5cm directly above the center of a square of side 10 cm as shown in Fig. What is the magnitude of the electric

flux through the square ? (Hint. Think of the square of the square as one face of a cube with edge 10 cm)



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19. A point charge of $2.0 \mu C$ is at center of a cublic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface?

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20. A point charge causes an electric flux of $-1.0 \times 10^3 Nm^2 / C$ to pass through a spherical Gaussian surface of 10.0 cm radius centred on the charge. (a) If the radius of the Gaussian surface were doubled, how much flux would pass through the surface ? (b) What is the is the value of the point charge ?

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21. A conducting sphere fo radius 10 cm has an unknown charge. If the electric field 20 cm from the center of the sphere is $1.5 \times 10^3 N/C$ and points radially inwards, what is the net charge on the sphere ?

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22. A uniformly charged conducting sphere of 2.4m diameter has a surface density of $80.0 \mu C/m^2$. (a) Find the charge on the sphere (b) What is the total electric flux leaving the surface of the sphere ?

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23. An infinite line charge produces a field of $9 \times 10^{-4} NC^{-1}$ at a distance of 2 cm. Calculate the linear charge density.

A. $10 \mu C / m$

B. $12 \mu C / m$

C. $16 \mu C / m$

D. $18 \mu C / m$

Answer: A

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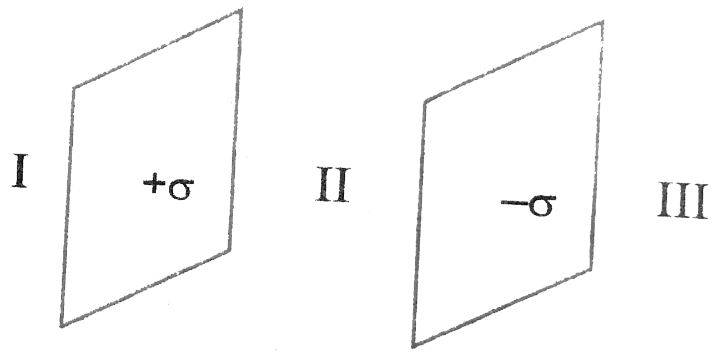
24. Two large this metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and magnitude $17.0 \times 10^{-22} C / m^2$. What is $\overrightarrow{E}$: (a) In the outer region of the first plate. (b) In the outer region of the secound plate, and (c) Between the plates ? See Fig.



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25. An oil drop of 12 excess electrons is held stationaty under a constant electric field of $2.55 \times 10^4 NC^{-1}$ in Millikan's oil drop experiment. The density of the oil is $1.26 gcm^{-3}$. Estimate the radius of the drop. $(g = 9.81 ms^{-2}, e = 1.60 \times 10^{19} C)$

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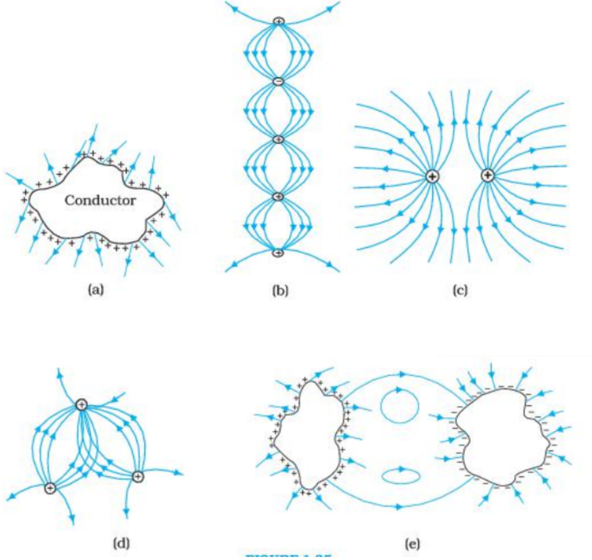
26. Which of the following curves shown below cannot possibly represent electrostatic field lines?



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27. In a certain region of space, electric field is along the z-direction throughout. The magnitude of electric field is , however, not constant but increases uniformly along the positive z-direction. At the rate of $10^5 NC^{-1}m^{-1}$. What are the force and torque experienced by system having a total dipole moment equal to 10^{-7}Cm in the negative z-direction?

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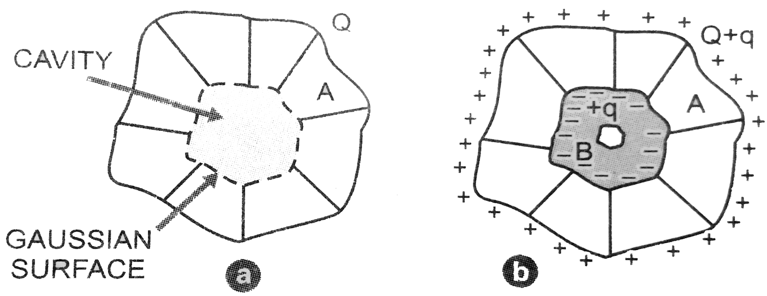
28. (a) A conductor A with a cavity as shown in Fig, is given a charge Q. Show that the entire charge must appear on the outer surface of the conductor.

(b) Another conductor B with charge q is inserted into the cavity keeping B insulated from A. Show that the total charge on the outside surface of A is $(Q + q)$ fig.

(c) A sensitive instrument is to be shielded from the strong electrostatic field in its environment. Suggest a possible way.



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29. A hollow charged conductor has a tiny hole cut into its surface. Show that the electric field in the holes is $(\sigma / 2 \in_0 \ \hat{n}$, where $\hat{n}$ is the unit vector in the outward normal direction, and σ is the surface charge density near ther hole.

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30. Obtain the formula for the electric field due to a long thin wire of uniform linear charge density λ without using Gauss's law. [Hint.use Coulomb's law directly and evaluate the necessary integral].

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31. It is now believed that protons and neutrons (which constitute nuclei of ordinary matter) are themselves built out of more elementary units called quarks. A proton and a neutron consist of three quarks each. Two types of quarks , the so called 'up' quark, (denoted by U) of charge $+(2/3)$ e and the 'down' quark (denoted by d) of charge $(-1/3)$ e together with electrons build up ordinary matter. (Quarks of each other types have also been found which give rise to different unusual varieties of matter). Suggest a possible quark composition of a proton and neutron.

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32. (a) Consider an arbitrary electrostatic field configuration. A small test charge is placed at a null point (i.e, where $\overrightarrow{E}=0$) of the configuration. Show that the equilibrium of the test charge is necessarily unstable.

(b) Verify this result for the simple configuration of two charges of the same magnitude and sign placed a certain distance apart.

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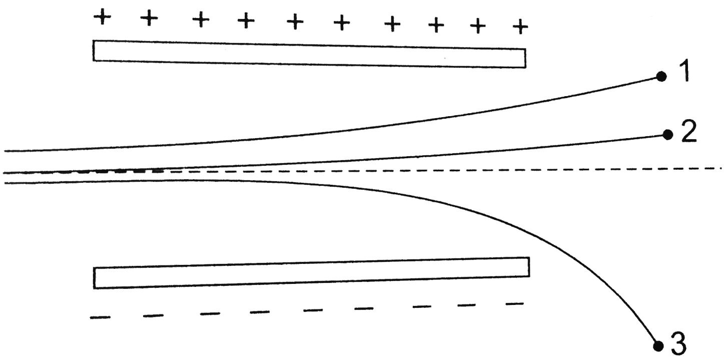
33. A particle of mass m and charge (-q) enters the region between the two charged plates initially moving along x-axis with speed v_x (like particle 1 in Figure). The length of plate is L and an uniform electric field E is maintained between the plates. Show that the vertical deflection of the particle at the far edge of the plate is $\frac{qEL^2}{2mv_x^2}$. Compare this motion with motion of a projectile in gravitational field.



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34. Suppose that the particle in the above question is an electron projected with velocity $v_x = 2.0 \times 10^6 ms^{-1}$. If E between the plates separated by $0.5cm$ is $9.1 \times 10^2 N/C$, where will be the electron strike the upper plate? $(|e| = 1.6 \times 10^{-19} C, m_e = 9.1 \times 10^{-31} kg)$.

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