PHYSICS

BOOKS - NEW JYOTHI PHYSICS (TAMIL ENGLISH)

ELECTRIC CHARGES AND FIELDS

Solved Problem

1. What is the total +ve charges in Coulombs of all the protons in 1 mole of hydrogen atoms ?

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2. charges of an electron in esu determined as 4.806×10^{-10} esu. Show that 1C $= 3 \times 10^{9}$ esu

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

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4. If $10power9$ electrons move out of body to another body every seconds. How much time is required to get a total charges of 1 C on the other body?

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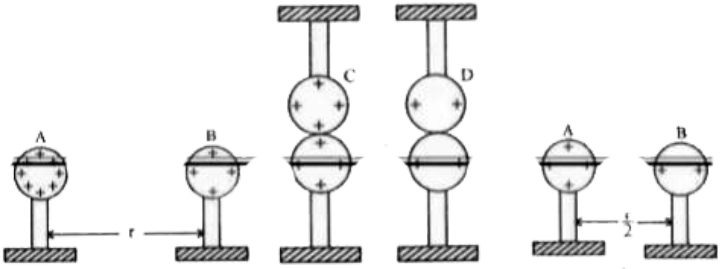
5. Two identical small metallic sphere having arbitrary charges are separated by a distance ' r ' in air. They are then touched by two more identical metal spheres respectively and seperated After- wards A and B are brought to $\frac{r}{2}$ distance. Show that initial interaction is same as final interaction-



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6. The magnitude of electrostatic force between two identical ions that are separted by a distance of $5 \times 10^{-10} m$ is 3.7×10^{-9} N.

a. What is the charges of each ions?

b . How many electrons are missing from each ions?

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7. Two insulated copper sphere of charges $+10\mu C$ and $-20\mu C$ have their centres seprated by a distance of 10 cm . What is the force of attraction if they placed.

a in free space b. in water of dielectric constant 81.

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8. Compare the electrostatic and gravitattional force between a proton and an electron separated by same distance .[Use standard data]

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9. Three charges +4q . Q and +q are placed along a straight line of length 'a' at points 0, $\frac{a}{2}$ and a respectively . Find the relation between Q and q in order to make the net force on q to be zero For the net force q to be zero.

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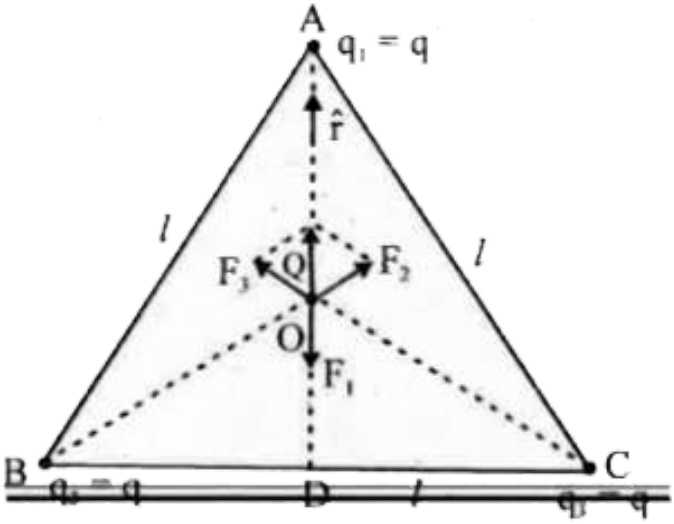
10. Consider three charges q_1, q_2, q_3 each equal to q at the vertices of an equilateral triangle of side l. what is the force on a charges Q (with the same sign as q) placed at the centroid

of the triangle,as shown in figure?



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11. Consider the charges q.q and -q placed at the vertices of an equilateral triangles as .Show in figure. What is the force on each charges?

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12. Two fixed point charges +9e and +4e units are placed on a straight line AB= a at A and B respectively . Where should the third point charge be placed on AB for it to be in equilibrium ?

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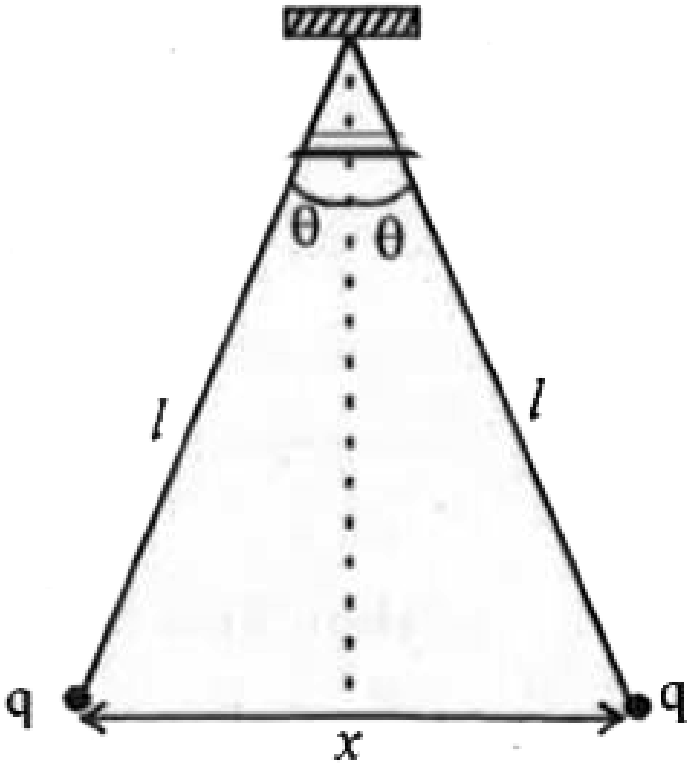
13. Two idential pith balls. Each of mass 'm' and charges 'q' hang from noncoducting threads of length I as shown in figure , θ is very small and hence $\tan\theta \approx \sin\theta$. Show that , for

equilibrium $x = \left[\frac{q^2 l}{2\pi \in_0 mg}\right]^{\frac{1}{3}}$



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14. Two charges q_1 and q_2 are placed on the X-axis at point x=-a and x =+a respectively.

a. How must q_1 and q_2 be related for the net electrostatic force on a charge Q at x=+ $\frac{a}{2}$ to be zero?

b. Repeat (a) but with +Q at x =+ $\frac{3a}{2}$

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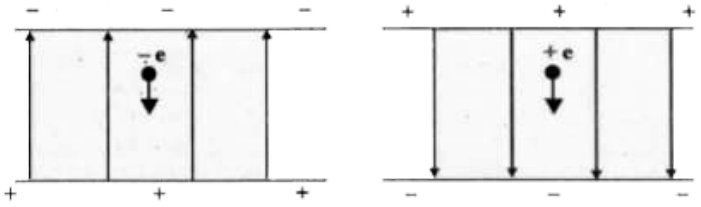
15. An electron falls through distance of 1.5 cm in a uniforth electric field of magnitude $2.0 \times 10^4 NC^{-1}$ The direction of the field is reversed keeping its magnitude unchanged and a proton falls through the same distance compute the time of falls in each case . Contrast the situation with that of 'free fall under gravity'



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16. 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 figure.

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17. A point charge produces an electric field $2NC^{-1}$ at a point 0.5 m distant from it. Calculate the value of q.

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18. Two point charges $20\mu C$ and $80\mu C$ are placed 18 cm apart. Find the position of the point where the electric field is

zero.

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19. An electron moves a distance of 8cm when accelerated from rest by an electric field of strength $3 \times 10^4 NC^{-1}$. Calculate the tme of travel.

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20. An oil drop with 10 excess electrons is held stationary under a constant electric field of $3 \times 10^4 NC^{-1}$ in Millikan oil drop experiment. The density of the oil is $1.26 \times 10^3 kgm^{-3}$. Calculate the radius of the drop.

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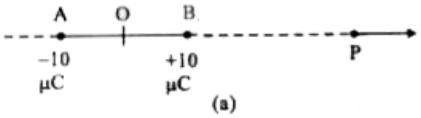
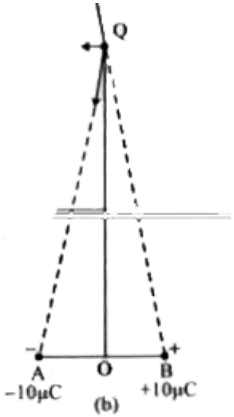
21. Two charges $\pm 10\mu C$ are placed 5.0 mm apart. Determine the electric field at (a) a point P on the axis of the dipole 15 cm away from its centre O on the side of the positive charges, as shown in Fig. (a) and (b) be a point Q, 15 cm away from O on a line passing through O and normal to the axis of the dipole, as shown in Fig (b).





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22. A dipole consisting of an electron and a proton separated by a distance of $4 \times 10^{-10} m$ is situated in an electric field of intensity $3 \times 10^5 NC^{-1}$ at an angle of 30° with the field. Calculate dipole and torque acting on it. $\left(e = 1.6 \times 10^{-19} C\right)$.

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23. How much electric flux will come out through a surface $\overrightarrow{d}\, s = 8\hat{j}$ kept in an electrostatic field $\overrightarrow{E} = 2\hat{i} + 3\hat{j} + 4\hat{k}$?

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24. A uniformly charged conducting sphere of radius one metre has a surface charge density $14 \mu m^{-2}$?. Find the

charge on the sphere and total electric flux leaving the spherical surface.

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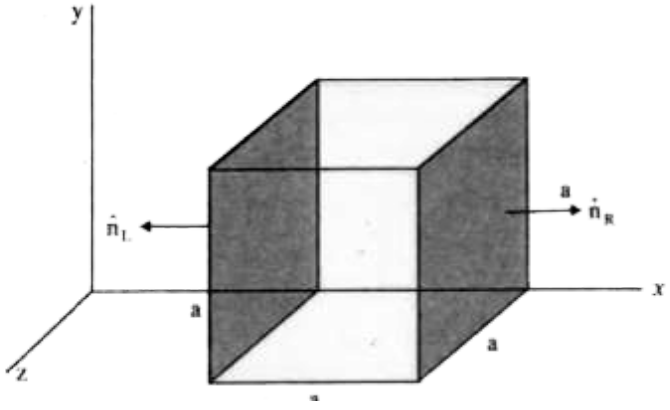
25. The electric field components in Figure are $E_x = \alpha x^{\frac{1}{2}}, E_y = E_z = 0$ in which $\alpha = 800 N/Cm^{\frac{1}{2}}$. Calculate (a) the flux through the cube, and (b) the charge within the cube. Assume that a=0.1m.



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26. An electric field is uniform and in the positive xdirection for positivex and uniform with the same magnitude but in the negative x direction for negative x. It is given that $E = 200\hat{i}N/C$ for $x > 0$ and $E = -200\hat{i}N/C$ for $3 < 0$.

A right circular cylinder of length 20 cm and radius 5 cm has its centre at the origin and its axis along the x-axis so that one tace is at x = +10 em and the other is at x=10 cm

a. What is the net outward flux through cach flat face?

b. What is the flux through the side of the cylinder?

c. What is the net outward flux through the cylinder?

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Solution To Exercises From Ncert Text

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 30 cm apart in air?

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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 is 0.2 N.

a. What is the distance between the two spheres?

b. What is the force on the second sphere due to the first?

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3. 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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4. When a glass rod is rubbed with a silk cloth, changes 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 charger.

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5. 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 10cm. What is

the force on a charge of $1\mu C$ placed at the centre of the square?

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6. a. An electrostatic field line is a continuous 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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7. Two point charges $q_A = 3\mu C$ and $q_B = -3\mu C$ are located 20 cm apart in vacuum.

a. What is the electric field at the midpoint 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 this point, what is the force experienced by the test charge?

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8. A system has two charges $q_A = 2.5 \times 10^{-7} C$ and $q_B = -2.5 \times 10^{-6} C$ located at paint 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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9. An electrle dipole with dipole moment $4 \times 10^{-9} Cm$ is aligned at 30° with the direction of a uniform clectric field of

magnitude $5 \times 10^4 NC^{-1}$ Calculate the magnitude of the torque acting on the dipole.

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10. A polythene piece rubbed with wool is found to have a negative charge of $3 \times 10^{-7} C$.

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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11. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is

$6.5 \times 10^{-2} C$? The radii 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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12. Two insulated identically sized charged copper spheres A and B have their centers separated by a distance of 50 cm. $q = 6.5 \times 10^{-7} C$. 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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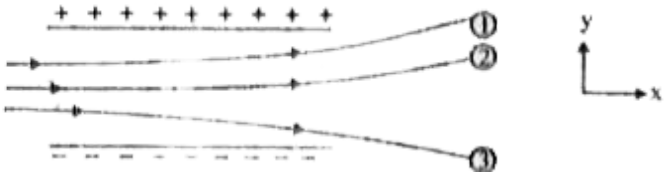
13. Figure below shows tracks of three charged particles in a uniform clectrostatic field. Give the signs of the three charges. Which partiele has the highest charge to mass ratio?



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14. Consider a uniform eleceric field $= 3 \times 10^3 \hat{i} N/C.$

a. What is the flux of this field through a square of 10cm on a slide whose plane is parallel to the yz plane?

b. What is the flux through the same square if the moral to its plane makes a 60° and with the satis?

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15. Consider a uniform electric field $E = 3 \times 10^3 iN/C$ What is the net flux of the uniform electric flux of through a cube of side 20 cm oriented so that its faces are parellel to the coordinate planes?

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16. 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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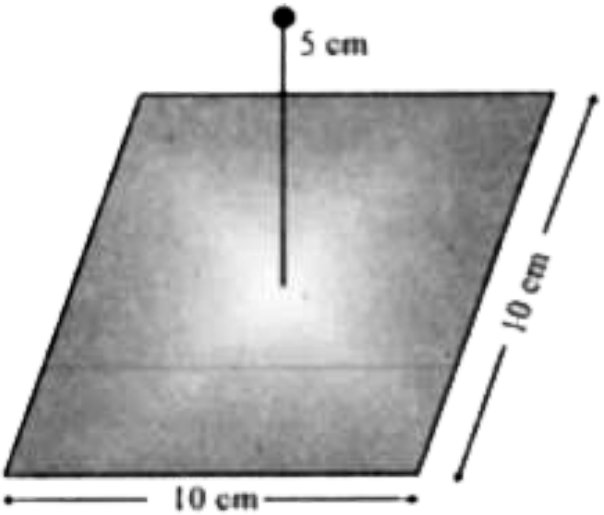
17. A point charge $+10\mu C$ is at a distance 5 cm directly above the centre of a square of side 10 cm, as shown in figure. What is the magnitude of the electric flux through the square? (Hint: Think of the square as one face of a cube with edge 10cm)



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

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19. 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 Gaussion surface were doubled, how much flux would passes through the surface?

b. What is the value of the point charge?

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

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21. A uniformly charged conducting sphere of 2.4 m diameter has a surface charge 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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22. An infinite line charge produces a field of $9 \times 10^4 N/C$ at a distance of 2cm. Calculate the linear charge density.

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23. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite sign and of magnitude $17.0 \times 10^{-11} C/m^2$. What is E

(a) in the outer region of the first plate,

(b) in the outer region of the second plate, and (c) between the plates?

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24. An oil drop of 12 excess electrons is field stationary under constant clectric field of $2.55 \times 10^4 NC^{-1}$ in Millikan's oil drop experiment. Then density of the oil is 1.26g cm^{-3}. Estimate the radius of the drop. $\left(g = 9.81 ms^{-2}, e = 1.60 \times 10^{-19} C\right)$.

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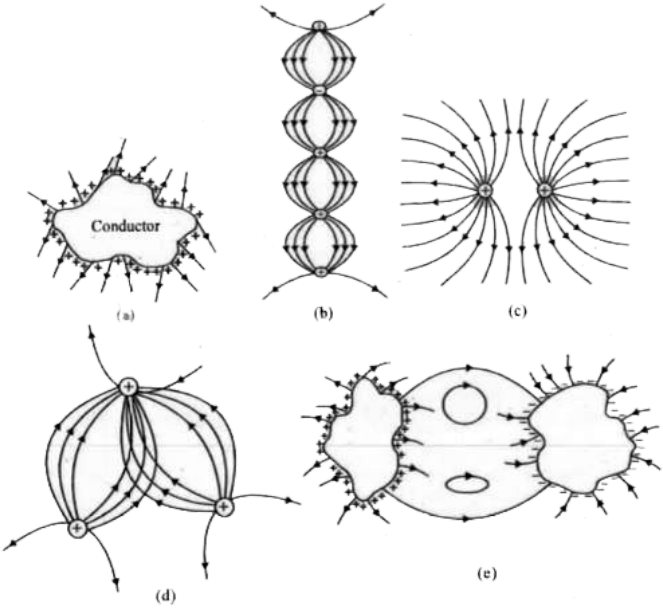
25. Which among the curves shown in figure cannot possibly represent electrostatic field lines?



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26. The direction of the magnetic field due to a solenoid is given by

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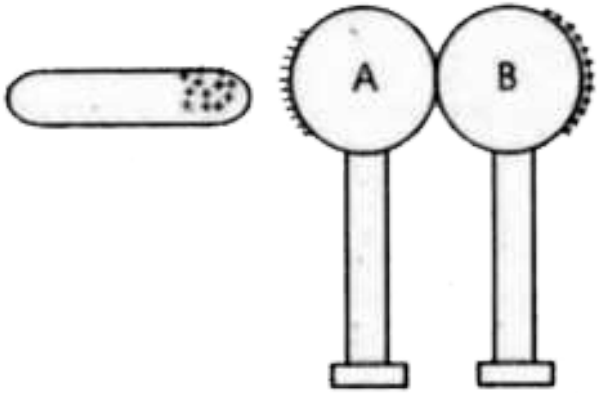
Evaluation Questions And Answers

1. A glass rod rubbed with silk is brought close to two uncharged spheres in contact with each other inducing charges on them as shown in figure.

a. What happens when the spheres are slightly separated.

b. the glass rod is subsequently removed.

c. the spheres are separated far apart.



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2. Although ordinary rubber is an insulator, the special rubber tyres of aircraft are made slightly conducting. Explain why.

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3. Vehicles carrying inflammable material usually have metallic ropes touching the ground during motion. Why?

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4. Is Coulomb a very big unit of charge?

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5. The electric field can be studied in terms of electric field intensity.

a. What is an electric field?

Define electric field strength. Given its unit and dimensional

formula.

c. Who introduced the concept of electric field?

d. Is electric field a scalar quantity or a vector quantity?

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6. Show mathematically that the electric field strength due to a short electric dipole at a distance 'r' along its axis is twice that at the same distance along its equatorial axis.

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7. What is the total force acting on the dipole placed in a uniform electric field?

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8. What is the effect of keeping the dipole in the field?

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9. What happens if the field is not uniform?

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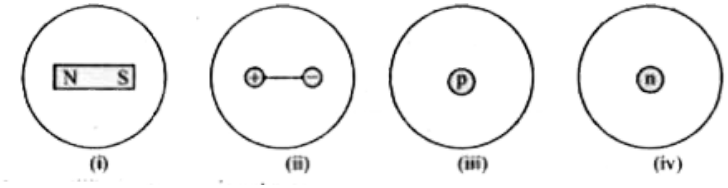
10. The following four insulating spheres contain magnet, dipole, proton and neutron. Pick the odd one out of the following based on the net flux.



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11. How does the electric field (E) vary with distance (r) in the following cases?

i. Uniformly charged spherical shell

ii. Uniformly charged solid sphere.

iii. Uniformly charged plane sheet of large size.

Also plot a graph between E and r in each case.

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12. Give the expression for the time-period of oscillation of an electric dipole in a uniform electric field.

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Previous Year Questions

1. Match column I with II.

Column I	Column II
i. Methano bacteria	a. Plague
ii. Bacillus thuringiensis	b. Cyclosporin A
iii. Azospirillum	c. Gobar gas production
iv. Trichoderma polysporum	d. Bio control
	e. Citric acid production
	f. Biofertilizer

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2. "Gauss's law is true for any closed surface, no matter what its shape or size" say the following statements are true or false.

a. Gauss's law implies that the total electric flux through a closed surface is zero if no charge is enclosed by the surface.

b. This law is useful for the calculation of electrostatic field when the system doesn't possess any symmetry.

c. In a uniform electric field, we know that the dipole

experiences no net force, but experiences a torque having a relation with P and E is given by ..... where the parameters P and E have their usual meaning.

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3. Electric field lines are a pictorial representation of the electric field around charges.

A. State Gauss's Law in Electrostatics.

B. Using this law derive an expression for the electric field intensity due to a uniformly charged thin spherical shell at a point.

i. Outside the shell ii. Inside the shell

C. Suppose that you are in a cave deep withing the earth. Are you safe from thunder and lighting? Why?

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Competitive Exam Corner

1. Two charged spherical conductors of radii R_1 and R_2 are connected by a wire. Then the ratio of surface charge densitites of the spheres σ_1 / σ_2 is

A. $\frac{R_1}{R_2}$

B. $\frac{R_2}{R_1}$

C. $\sqrt{\frac{R_1}{R_2}}$

D. $\frac{R_1^2}{R_2^2}$

Answer: B

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2. A negatively charged oil drop is prevented from failing under gravity by applying a vertical electric field $100Vm^{-1}$. If the mass of the drop is $1.6 \times 10^{-3}g$ the number of electrons carried by the drop is $(g = 10ms^{-2})$

A. 10^{18}

B. 10^{15}

C. 10^{6}

D. 10^{12}

Answer:

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3. An electric dipole of moment p is placed in a uniform electric field E. Then (i) the torque on the dipole is $p \times E$, (ii) the potential energy of the system is p.E, (iii) the resultant force on the dipole is zero

A. (i), (ii) and (iii) are correct

B. (i) and (iii) are correct and (ii) is wrong

C. Only (i) is correct

D. (i) and (ii) are correct and (ii) is wrong

Answer: B

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4. 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. 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. $\frac{100Q}{\pi\varepsilon_0}$

Answer: B

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5. A charged particle q is shot towards another charged particle Q which is fixed, with a speed v. It approaches Q upto a closest distance r and then returns. If g is shot with speed 2v, the closest distance of approach would be

A. $\frac{r}{4}$

B. $\frac{r}{2}$

C. 2r

D. r

Answer: A

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6. A dipole of electric dipole moment p is placed in a uniform electrie field of strength E. If θ is the angle between positive directions of p and E, then the potential energy of the electric dipole is largest when θ is

A. $\frac{\pi}{4}$

B. $\frac{\pi}{2}$

C. π

D. zero

Answer: C

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7. If $q_1 + q_2 = q$, then the value of the ratio $\frac{q_1}{q}$, for which force between q_1 and q_2 is maximum is

A. 0.25

B. 0.75

C. 1

D. 0.5

Answer: D

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8. The total electric flux emanating from a closed surface enclosing an α-particle (e- electronic charge) is

A. $\frac{2e}{\varepsilon_0}$

B. $\frac{e}{\varepsilon_0}$

C. $e\varepsilon_0$

D. $\frac{\varepsilon_0 e}{4}$

Answer: A

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9. The electric field between two infinitely charged plates with air mediuun in between, in terms of the surface charge density σis

A. $4\pi\varepsilon_0$

B. $\frac{\sigma}{4\pi\varepsilon_0}$

C. $\frac{\sigma}{\varepsilon_0}$

D. $\frac{\sigma}{4\pi r^2}$

Answer:

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10. Two equal point charges each of $3\mu C$ are separated by a certain distance in metres. If they are located at $\left(\hat{i}+\hat{j}+\hat{k}\right)$ and $\left(2\hat{i}+3\hat{j}+\hat{k}\right)$. then the elestastatic force between them is

A. $9\times 10^3 N$

B. $9\times 10^{-3} N$

C. $10^{-3} N$

D. $9 \times 10^{-2} N$

Answer: B

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11. The electric field due to an infinitely long straight uniformly charged wire at a distance r is directly proportional to

A. r

B. r^2

C. $\frac{1}{r}$

D. $\frac{1}{r^2}$

Answer: C

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12. When a comb rubbed with dry hair attracts pieces of paper. This is because the

A. comb polarizes the piece of paper

B. comb induces a net dipole moment opposite to the direction of field

C. electric field due to the comb is uniform

D. comb inducas a net dipole mocnont perpendi-cular to the direction of field

Answer: A

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13. If the electric flux entering and leaving a closed surface are 6×10^6 and 9×10^6 S.I. units respectively, then the charge inside the surface of permittivity of free space ε_0 is

A. $\varepsilon_0 \times 10^6$

B. $-\varepsilon_0 \times 10^6$

C. $-2\varepsilon_0 \times 10^6$

D. $3\varepsilon_0 \times 10^6$

Answer: D

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14. The force of repulsion between two electrons at a certain distance is F. The force between two protons separated by the

same distance is $(m_p = 1836 m_e)$

A. a)2F

B. b) F

C. c)1836F

D. d) $\frac{F}{1836}$

Answer: B

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15. The electrostatic force between two point charges is directly proportional to the

A. a) sum of the charges

B. b) distance between the charges

C. c) permittivity of the medium

D. d) product of the charges

Answer:

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16. The time period of revolution of a charge q_1 and of mass m moving in a circular path of radius due to Coulomb force of attraction with another charge q_2, at its centre is

A. a) $\sqrt{\frac{16\pi\varepsilon_0 mr^3}{q_1 q_2}}$

B. b) $\sqrt{\frac{8\pi^2\varepsilon_0 mr^3}{q_1 q_2}}$

C. c) $\sqrt{\frac{\varepsilon_0 mr^3}{16q_1 q_2}}$

D. d) $\sqrt{\frac{16\pi^3\varepsilon_0 mr^3}{q_1 q_2}}$

Answer: D

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17. An electric dipole of dipole moment $\vec{p}$ is placed in a uniform external electric field $\vec{E}$. Then the

A. torque experienced by the dipole is $\vec{E} \times \vec{p}$

B. torque is zero if $\vec{p}$ is perpendicular to $\vec{E}$

C. torque is maximum if $\vec{p}$ is perpendicular to $\vec{E}$

D. potential energy is maximumn if $\vec{P}$ is parallel to $\vec{E}$

Answer: C

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18. Electric field at a point of distance from a uniformly charged wire of infinite length having linear charge density λ is directly proportional to

A. r^{-1}

B. r

C. r^2

D. r^{-2}

Answer: A

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19. An electric dipole of dipole moment $\vec{p}$ is placed in a uniform external electric field $\vec{E}$. Then the

A. 10^{-2} Nm acts along the direction of $\vec{E}$.

B. $10^{-3}Nm$ acts along the direction of $\vec{\mu}$.

C. 10^{-5} Nm acts normal to both $\vec{E}$ and $\vec{\mu}$.

D. $10^{-2}Nm$ acts normal to both $\vec{E}$ and μ.

Answer:

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20. An electron moving with uniform velocity enters a uniform electric field perpendicular to its direction of motion . The path of the lelectron will be _____ .

A. with uniform acceleration along Y-axis

B. without any acceleration along Y-axis

C. in a trajectory represented as $y = ax^2$

D. with uniform deceleration along X-axis

Answer: C

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