PHYSICS

NCERT - FULL MARKS PHYSICS(TAMIL)

ELECTROSTATICS

Example

1. Calculate the number of electrons in one coulomb of negative charge.

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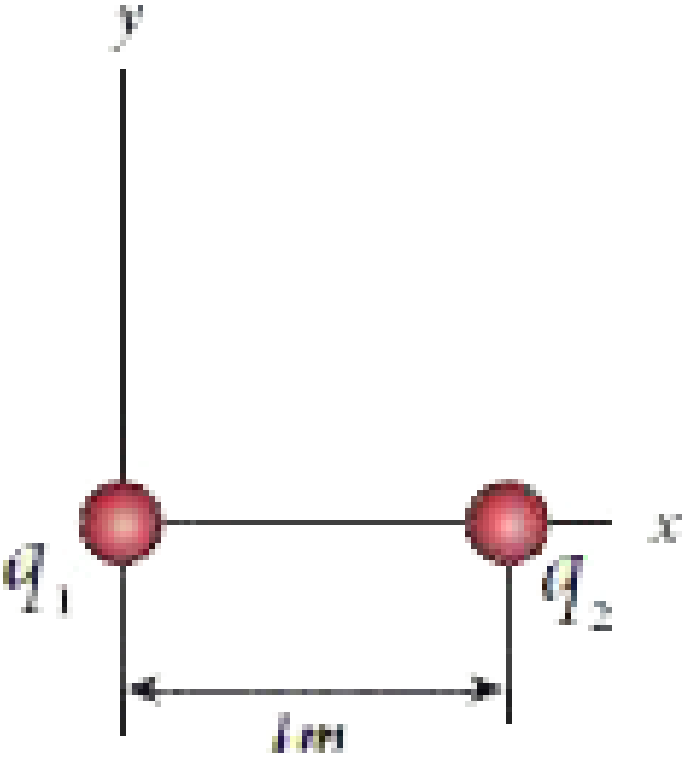
2. Consider two point charges q_1 and q_2 at rest as shown in the figure.

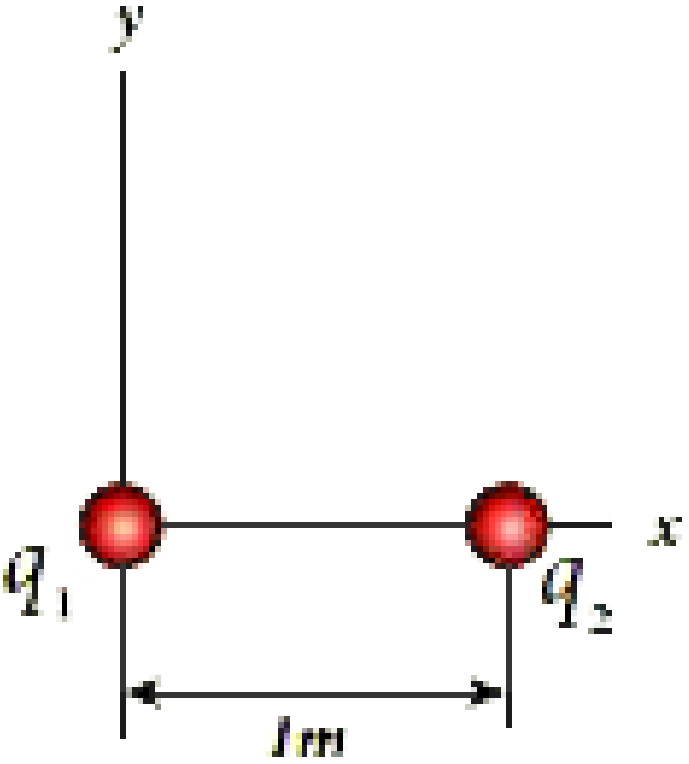


They are separated by a distance of 1m. Calculate the force experienced by the two charges for the following cases:

$q_1 = 2\mu C$ and $q_2 = +3\mu C$

View Text Solution

3. Consider two point charges q_1 and q_2 at rest as shown in the figure.



They are separated by a distance of 1m. Calculate the force experienced by the two charges for the following cases:

$q_1 = 2\mu C$ and $q_2 = -3\mu C$

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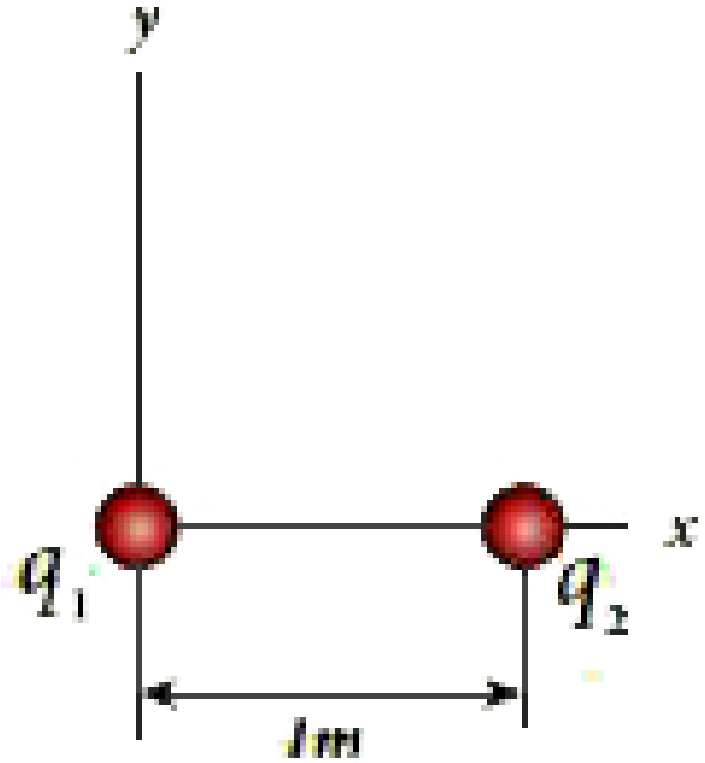
4. Consider two point charges q_1 and q_2 at rest as shown in the figure.



They are separated by a distance of 1m. Calculate the force experienced by the two charges for the following cases:

$q_1 = +2\mu C$ and $q_2 = -3\mu C$ kept in water $(\varepsilon_t = 80)$

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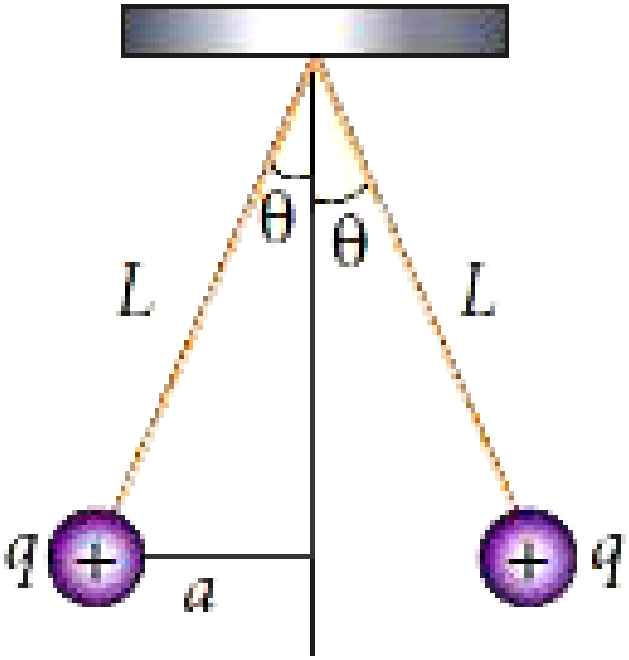
5. Two small-sized identical equally charged spheres, each having mass 1 mg are hanging in equilibrium as shown in the figure. The length of each string is 10 cm and the angle θ is 7^{o} with the vertical. Calculate the magnitude of the charge in each sphere.

(Take $g = 10 \ \ \mathrm{ms}^{-2}$)



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6. Calculate the electrostatic force and gravitational force between the proton and the electron in a hydrogen atom. They are separated by a distance of 5.3×10^{-11} m. The magnitude of charges on the electron and proton are 1.6×10^{-19}C. Mass

of the electron is $m_e = 9.1 \times 10^{-31}$ kg and mass of proton is $m_p = 1.6 \times 10^{-27}$ kg.

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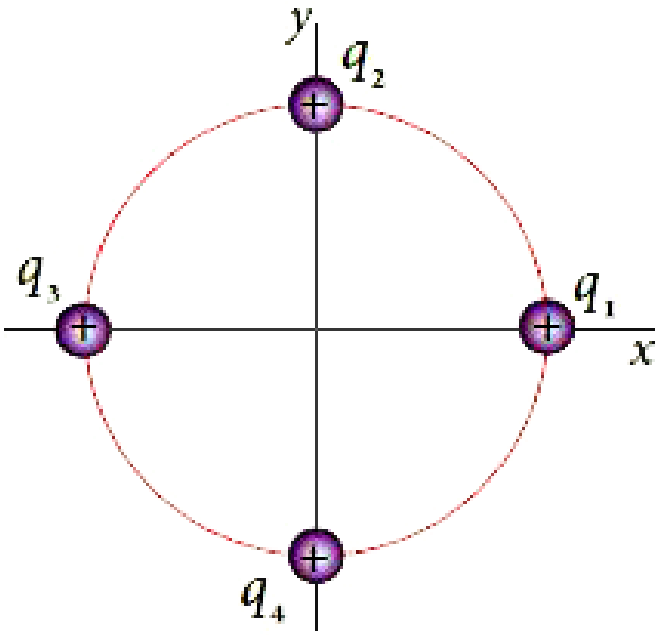
7. Consider four equal charges q_1, q_2, q_3 and $q_4 = q = +1\mu C$ located at four different points on a circle of radius 1m, as shown in the figure. Calculate the total force acting on the

charge q1 due to all the other charges.



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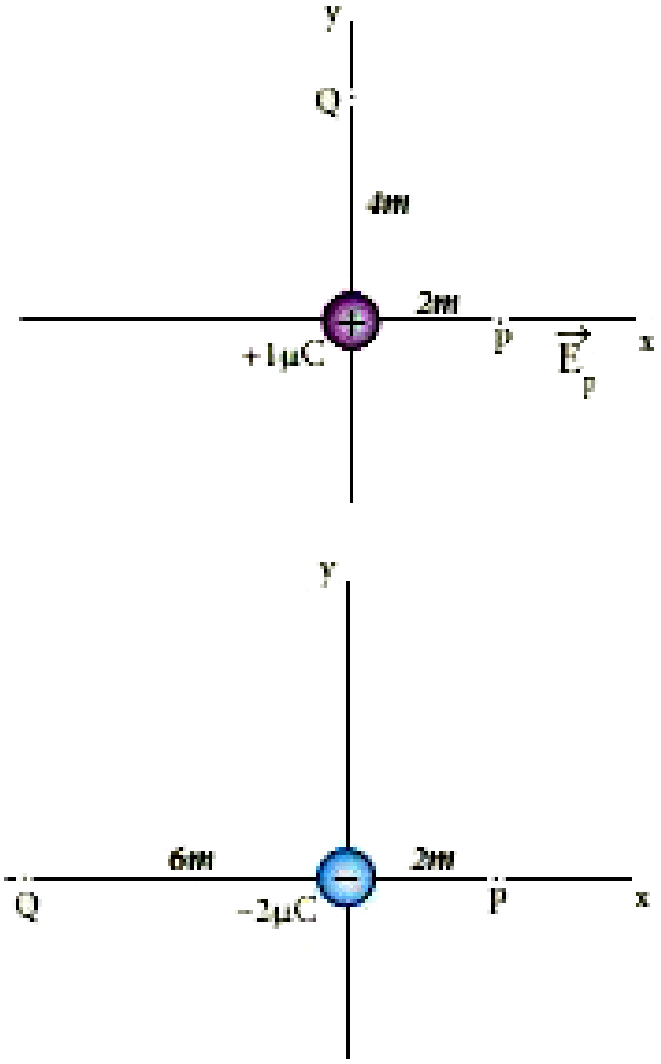
8. Calculate the electric field at points P, Q for the following two cases, as shown in the figure.

A positive point charge $+1\mu C$ is placed at the origin



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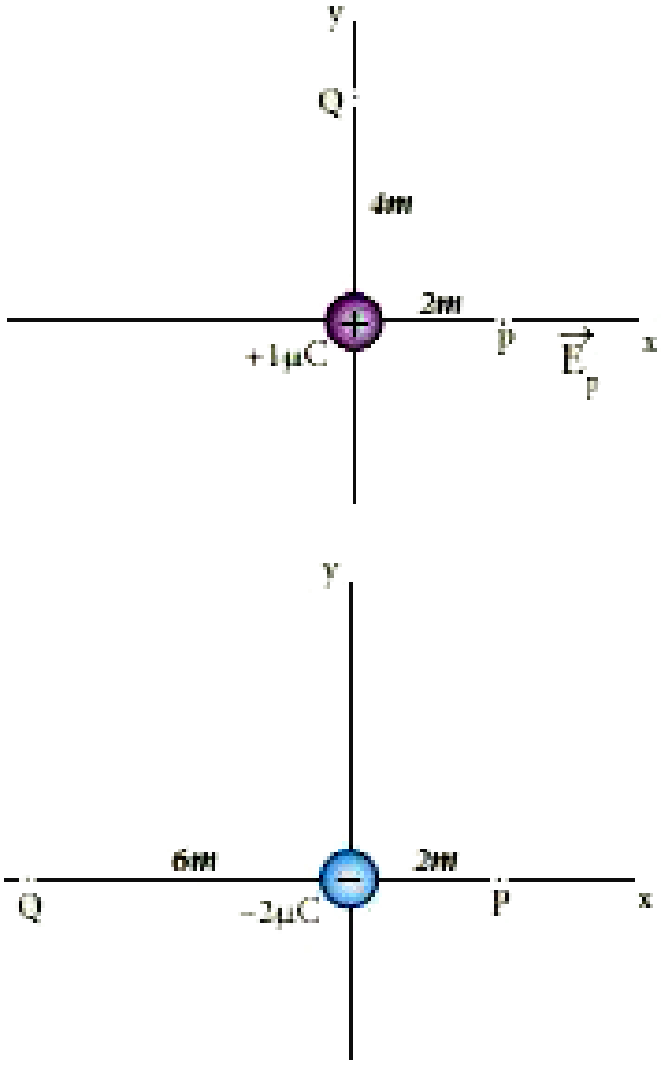
9. Calculate the electric field at points P, Q for the following two cases, as shown in the figure.

A negative point charge $-2\mu C$ is placed at the origin



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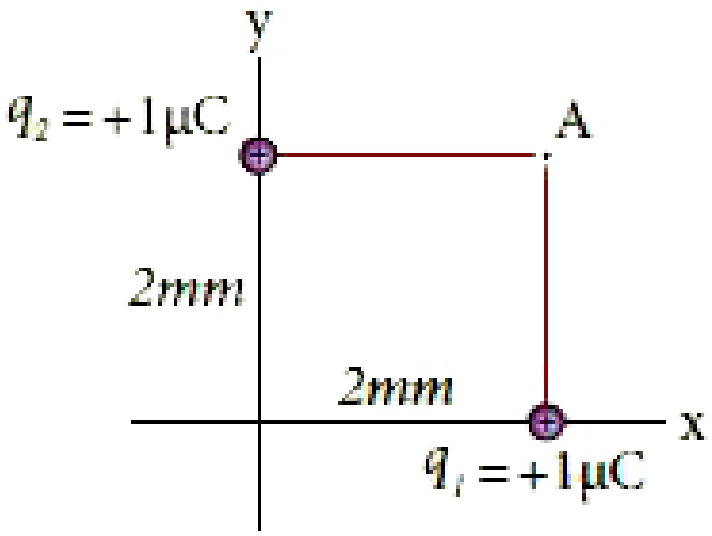
10. Consider the charge configuration as shown in the figure. Calculate the electric field at point A. If an electron is placed at points A, what is the acceleration experienced by this electron? (mass of the electron $= 9.1 \times 10^{-31}$ kg and charge of electron $= -1.6 \times 10^{-19}$ C)



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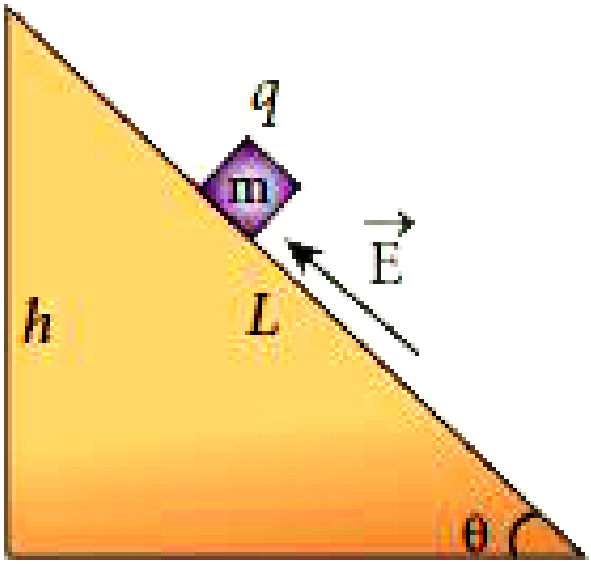
11. A block of mass m and positive charge q is placed on an insulated frictionless inclined plane as shown in the figure. A uniform electric field E is applied parallel to the inclined surface such that the block is at rest. Calculate the magnitude of the electric field E.



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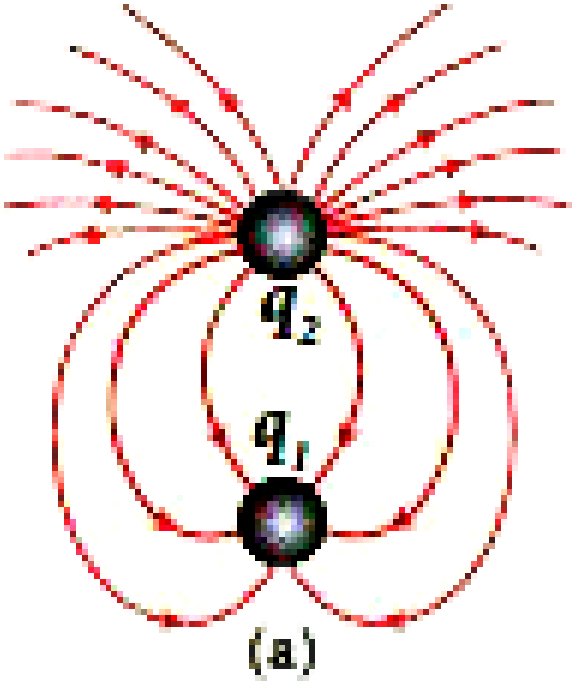
12. The following pictures depict electric field lines for various charge configurations.



In figure (a) identify the signs of two charges and find the ratio $\left|\frac{q_1}{q_2}\right|$

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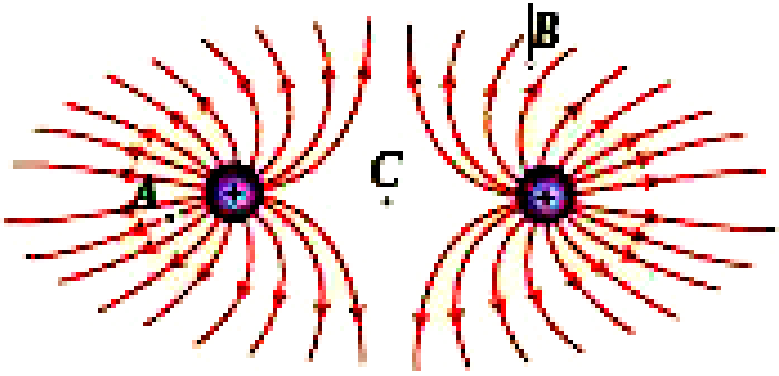
13. The following pictures depict electric field lines for various charge configurations.



In figure (b), calculate the ratio of two positive charges and identify the strength of the electric field at three points A, B, and C

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14. The following pictures depict electric field lines for various charge configurations.

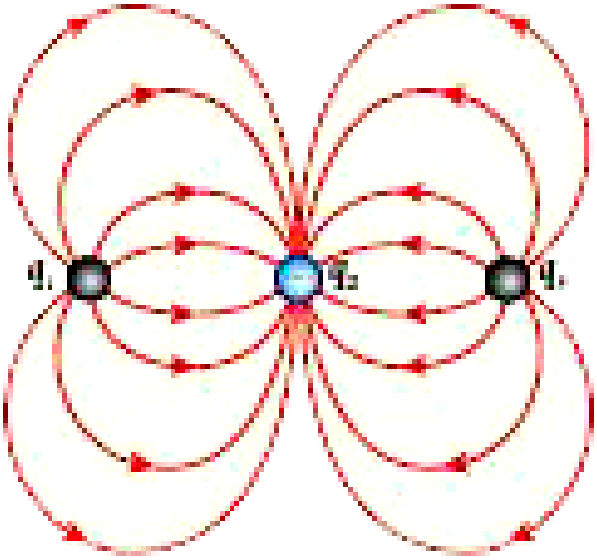

Figure (c) represents the electric field lines for three charges. If $q_2 = -20 \text{ nC}$, then calculate the values of q_1 and q_3.

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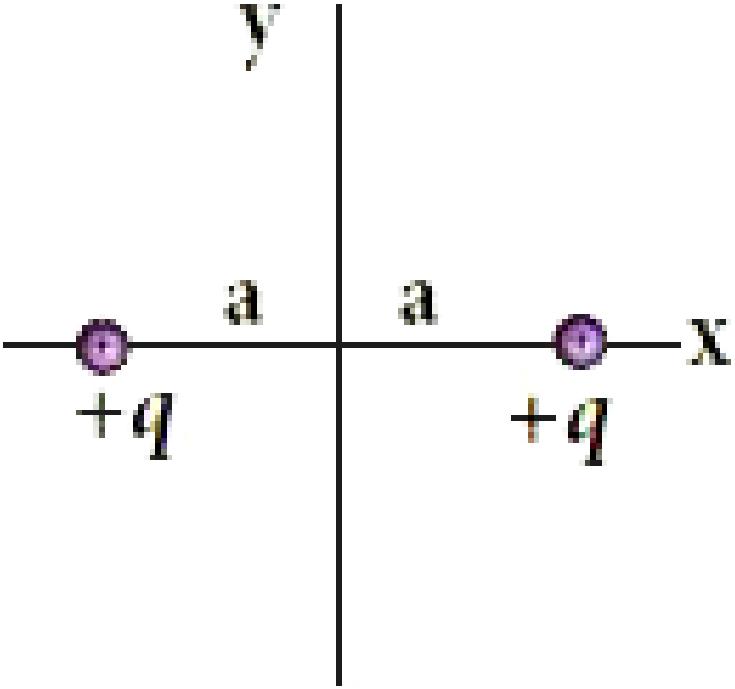
15. Calculate the electric dipole moment for the following charge configurations.



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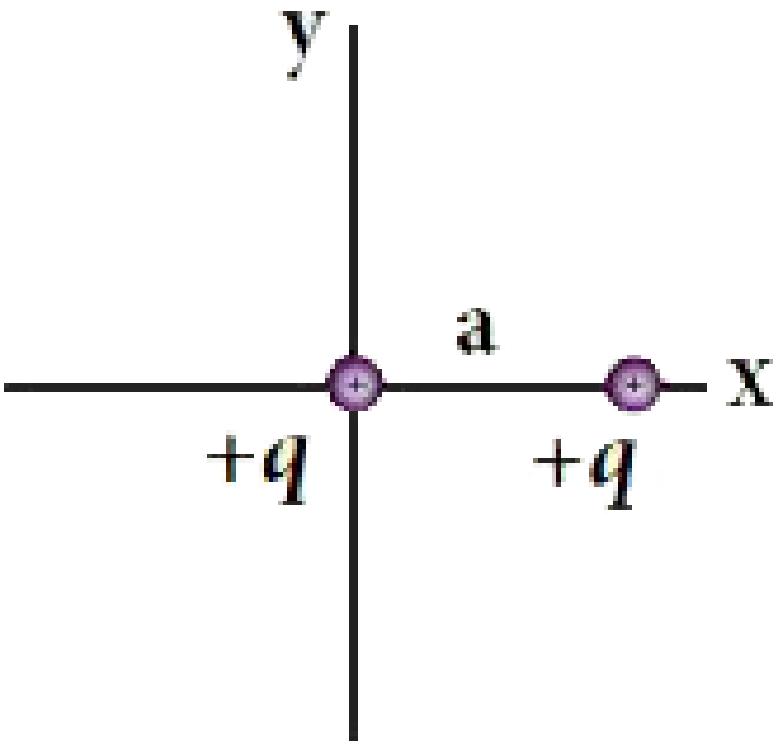
16. Calculate the electric dipole moment for the following charge configurations.



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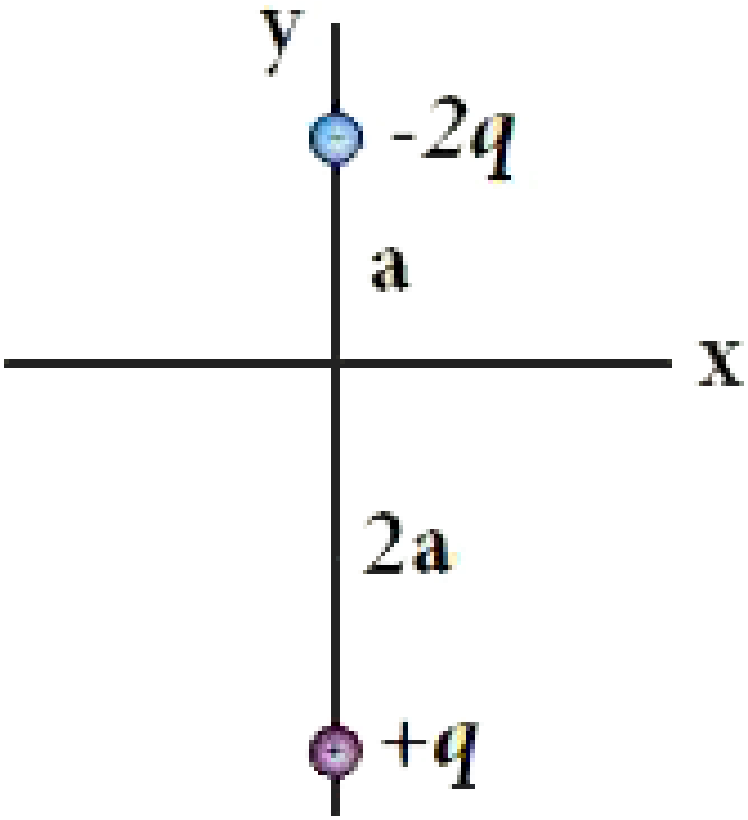
17. Calculate the electric dipole moment for the following charge configurations.



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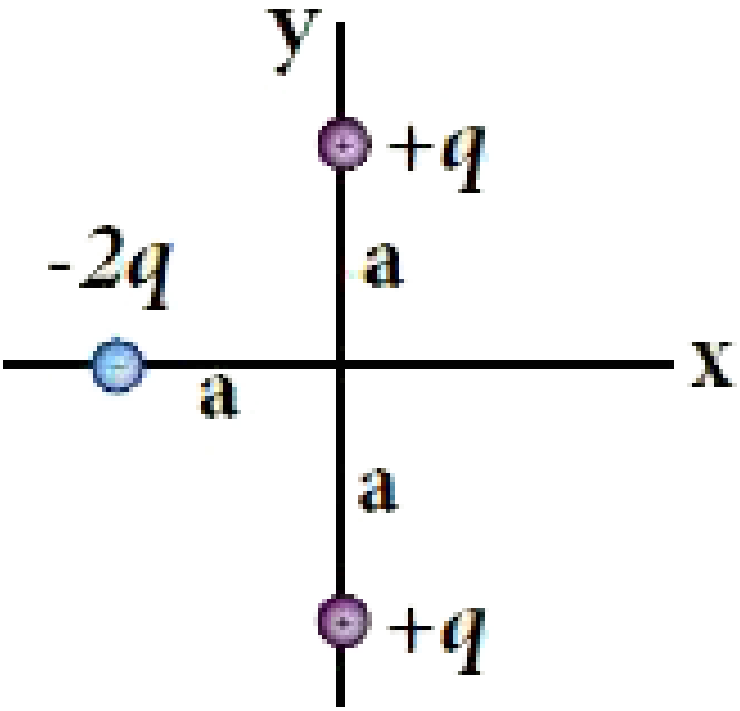
18. Calculate the electric dipole moment for the following charge configurations.



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19. A sample of HCl gas is placed in a uniform electric field of magnitude 3×10^4 $\mathrm{N\,C^{-1}}$. The dipole moment of each HCl molecule is 3.4×10^{-30} Cm. Calculate the maximum torque experienced by each HCl molecule.

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20. Calculate the electric potential at points P and Q as shown in the figure below.

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21. Suppose the charge $+9\mu C$ is replaced by $-9\mu C$ find the electrostatic potentials at points P and Q

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22. Calculate the work done to bring a test charge $2\mu C$ from infinity to the point P. Assume the charge $+9\mu C$ is held fixed at origin and $+2\mu C$ is brought from infinity to P.

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23. Consider a point charge +q placed at the origin and another point charge -2q placed at a distance of 9 m from the charge +q. Determine the point between the two charges at which electric potential is zero.

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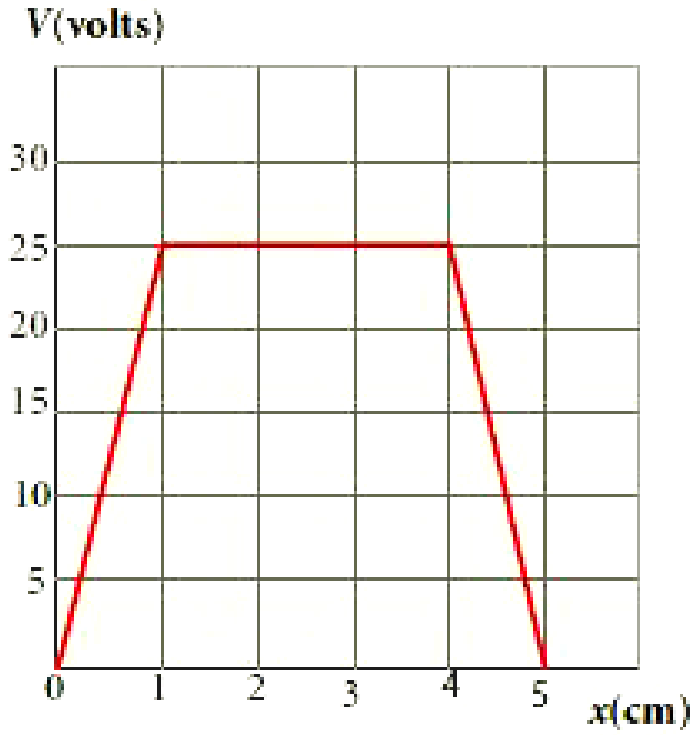
24. The following figure represents the electric potential as a function of x – coordinate. Plot the corresponding electric field as a function of x.



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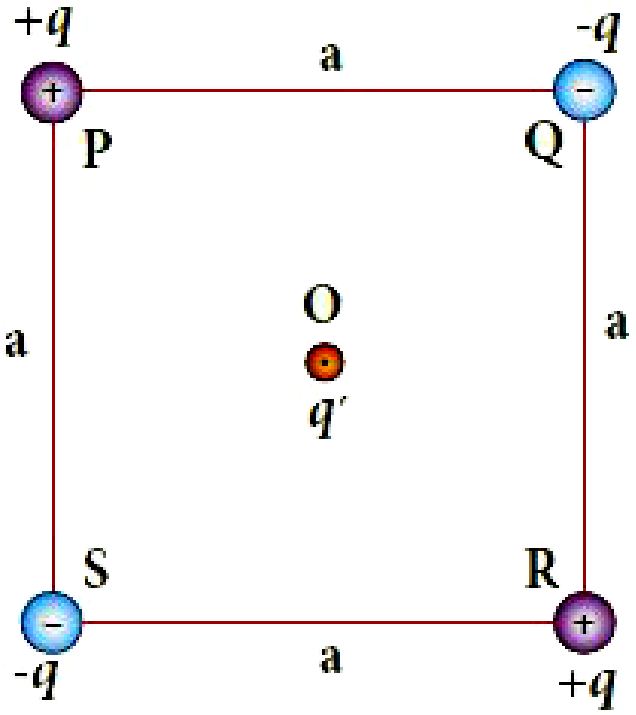
25. Four charges are arranged at the corners of the square PQRS of side a as shown in the figure.



Find the work required to assemble these charges in the given configuration.

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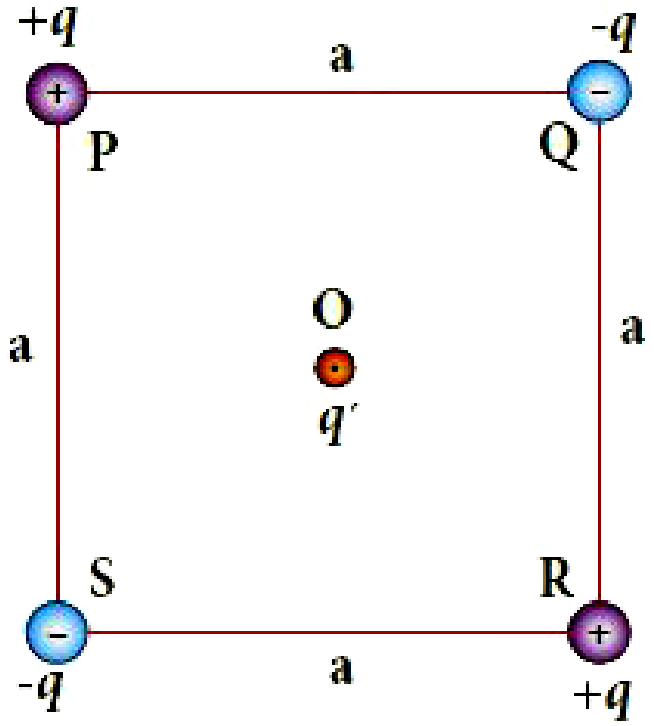
26. Four charges are arranged at the corners of the square PQRS of side a as shown in the figure.



Suppose a charge q' is brought to the center of the square, by keeping the four charges fixed at the corners, how much extra work is required for this?

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27. A water molecule has an electric dipole moment of 6.3×10^{-30} Cm. A sample contains 10^{22} water molecules, with all the dipole moments aligned parallel to the external electric field of magnitude $3 \times 10^{5} \mathrm{N\ C^{-1}}$. How much work is required to rotate all the water molecules from $\theta = 0^{\circ}$ to 90°?

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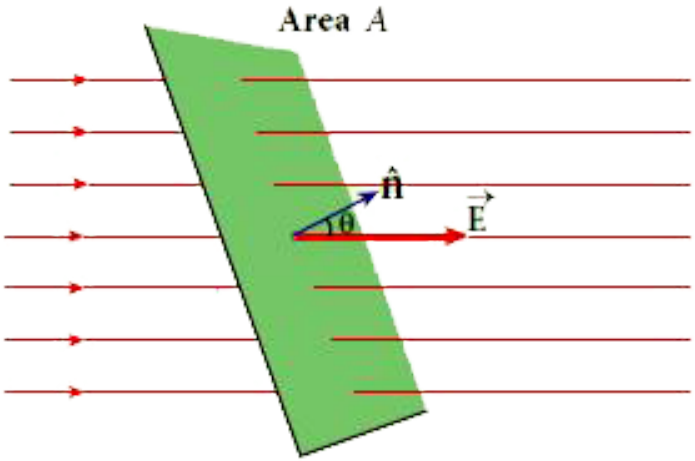
28. Calculate the electric flux through the rectangle of sides 5 cm and 10 cm kept in the region of a uniform electric field 100 $\mathrm{N\ C^{-1}}$. The angle θ is 60°. Suppose θ becomes zero, what is

the electric flux?



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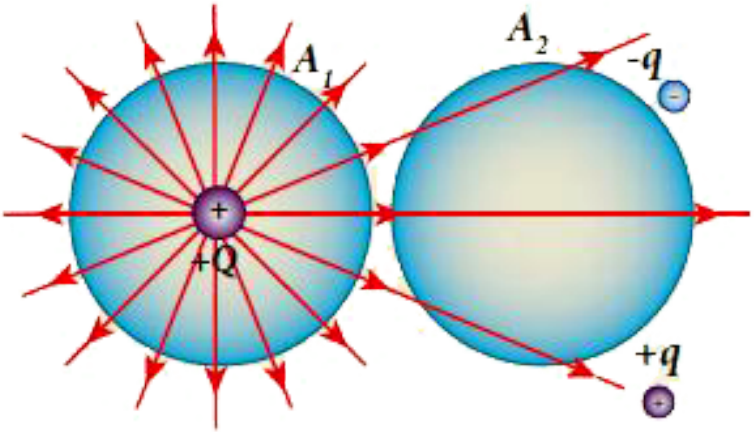

29.

In figure , calculate the electric flux through the closed areas

A_1 and A_2.

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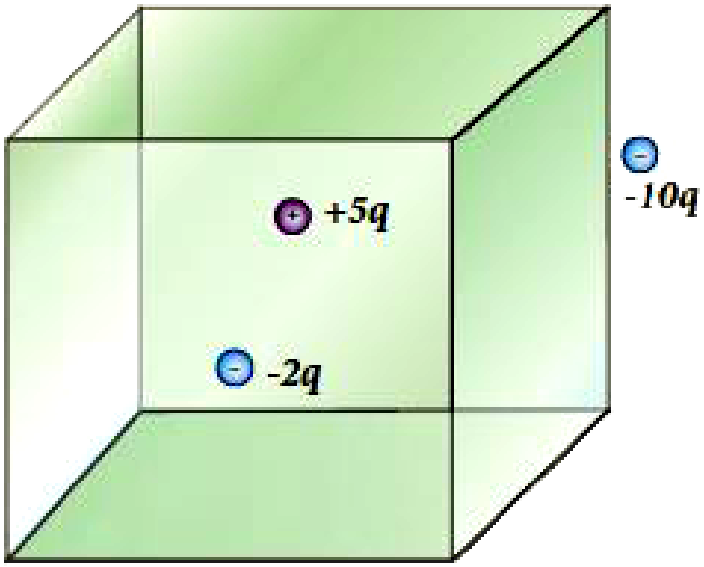

30.

In figure , calculate the electric flux through the cube

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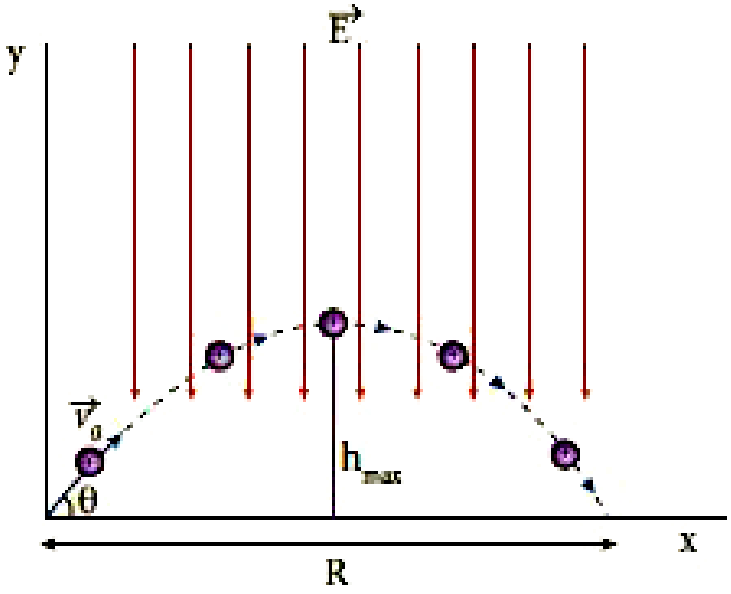
31. A small ball of conducting material having a charge +q and mass m is thrown upward at an angle θ to horizontal surface with an initial speed v_o as shown in the figure. There exists an uniform electric field E downward along with the gravitational field g. Calculate the range, maximum height and time of flight in the motion of this charged ball. Neglect the effect of air and treat the ball as a point mass.



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32. A parallel plate capacitor has square plates of side 5 cm and separated by a distance of 1 mm.

Calculate the capacitance of this capacitor.

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33. A parallel plate capacitor has square plates of side 5 cm and separated by a distance of 1 mm.

If a 10 V battery is connected to the capacitor, what is the charge stored in any one of the plates? (The value of $\varepsilon_o = 8.85 \times 10^{-12} \mathrm{Nm}^2\mathrm{C}^{-2}$)

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34. A parallel plate capacitor filled with mica having $\varepsilon_r = 5$ is connected to a 10 V battery. The area of the parallel plate is $6m^2$ and separation distance is 6 mm.

Find the capacitance and stored charge.

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35. A parallel plate capacitor filled with mica having $\varepsilon_r = 5$ is connected to a 10 V battery. The area of the parallel plate is $6m^2$ and separation distance is 6 mm.

After the capacitor is fully charged, the battery is disconnected and the dielectric is removed carefully.

Calculate the new values of capacitance, stored energy and charge.

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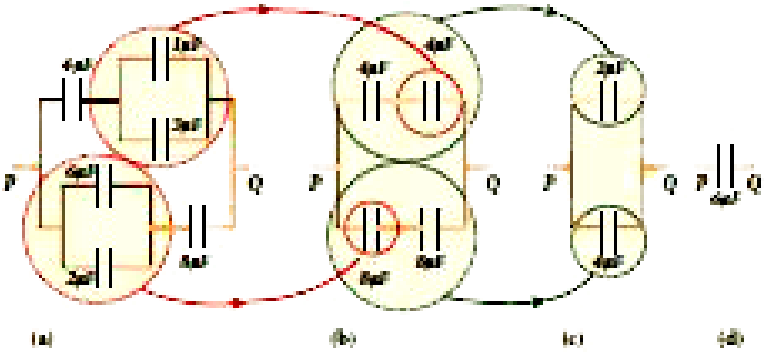
36. Find the equivalent capacitance between P and Q for the configuration shown below in the figure (a).



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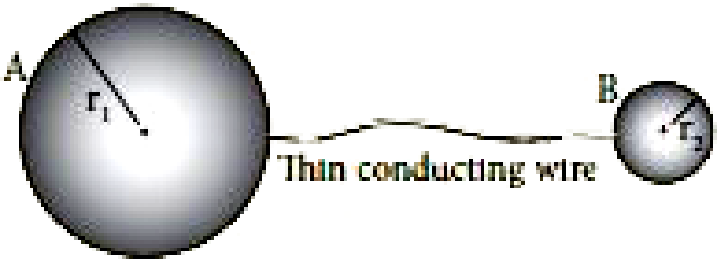
37. Two conducting spheres of radius $r_1 = 8cm$ and $r_2 = 2cm$ are separated by a distance much larger than 8 cm and are connected by a thin conducting wire as shown in the figure. A total charge of $Q = +100\ \mathrm{nC}$ is placed on one of the spheres. After a fraction of a second, the

charge Q is redistributed and both the spheres attain electrostatic equilibrium.



(a). Calculate the charge and surface charge density on each sphere.

(b). Calculate the potential at the surface of each sphere.

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38. Dielectric strength of air is $3 \times 10^6 \mathrm{V\ m^{-1}}$. Suppose the radius of a hollow sphere in the Van de Graff generator is R = 0.5 m, calculate the maximum potential difference created by this Van de Graaff generator.

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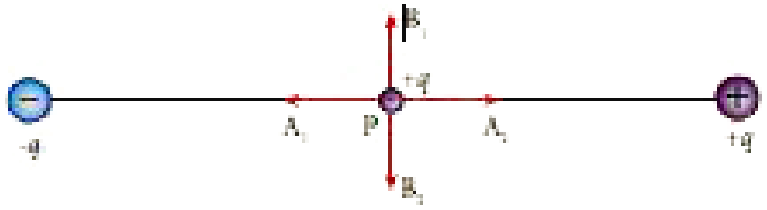
Evaluation Multiple Choice Questions

1. Two identical point charges of magnitude –q are fi xed as shown in the figure below. A third charge +q is placed midway between the two charges at the point P. Suppose this charge +q is displaced a small distance from the point P in the directions indicated by the arrows, in which direction(s) will +q be stable with respect to the displacement?



A. A_1 and A_2

B. B_1 and B_2

C. both directions

D. No stable

Answer: B

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2. Which charge configuration produces a uniform electric field?

A. point Charge

B. infinite uniform line charge

C. uniformly charged infinite plane

D. uniformly charged spherical shell

Answer: C

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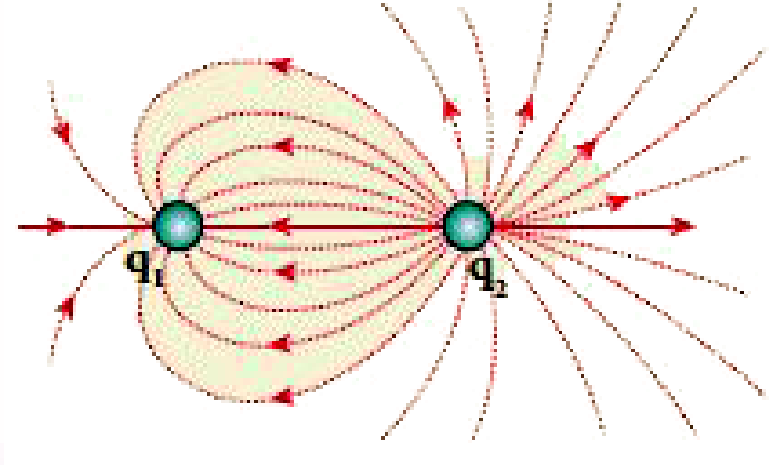
3. What is the ratio of the charges $\left|\frac{q_1}{q_2}\right|$ for the following electric field line pattern?



A. $\frac{1}{5}$

B. $\frac{25}{11}$

C. 5

D. $\frac{11}{25}$

Answer: D

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4. An electric dipole is placed at an alignment angle of 30° with an electric field of $2 \times 10^{5} \mathrm{N\ C}^{-1}$. It experiences a torque equal to 8 N m. Th e charge on the dipole if the dipole length is 1 cm is

A. 4 mC

B. 8 mC

C. 5 mC

D. 7 mC

Answer: B

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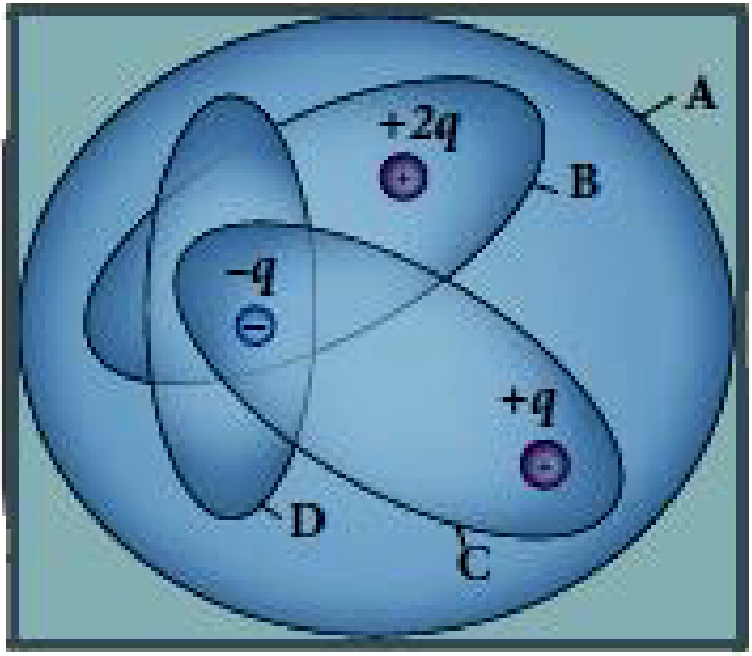
5. Four Gaussian surfaces are given below with charges inside each Gaussian surface. Rank the electric flux through each Gaussian surface in increasing order.



A. $D < C < B < A$

B. $A < B = C < D$

C. $C < A = B < D$

D. $D > C > B > A$

Answer: A

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6. The total electric flux for the following closed surface which is kept inside water

A. $\frac{80q}{\varepsilon_o}$

B. $\frac{q}{40\varepsilon_o}$

C. $\frac{q}{80\varepsilon_o}$

D. $\frac{q}{160\varepsilon_o}$

Answer: B

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7. Two identical conducting balls having positive charges q_1 and q_2 are separated by a center to center distance r. If they are made to touch each other and then separated to the same distance, the force between them will be (NSEP 04-05)

A. less than before

B. same as before

C. more than before

D. zero

Answer: C

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8. Rank the electrostatic potential energies for the given system of charges in increasing order.

A. $1 = 4 < 2 < 3$

B. $2 = 4 < 3 < 1$

C. $2 = 3 < 1 < 4$

D. $3 < 1 < 2 < 4$

Answer: A

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9. An electric field $\overrightarrow{E} = 10x\hat{i}$ exists in a certain region of space. Then the potential difference$V = V_o - V_A$, where V_o is the potential at the origin and V_A is the potential at $x = 2$ m is:

A. 10 J

B. $-20J$

C. $+20J$

D. $-10J$

Answer: B

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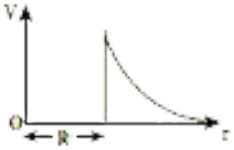
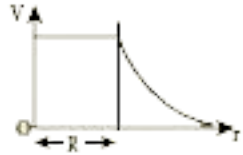
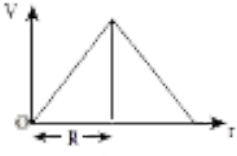
10. A thin conducting spherical shell of radius R has a charge Q which is uniformly distributed on its surface. The correct plot for electrostatic potential due to this spherical shell is

A. 

B. 

C. 

D. 

Answer: B

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11. Two points A and B are maintained at a potential of 7 V and -4 V respectively. The work done in moving 50 electrons from A to B is

A. 8.80×10^{-17} J

B. -8.80×10^{-17} J

C. 4.40×10^{-17} J

D. 5.80×10^{-17} J

Answer: A

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12. If voltage applied on a capacitor is increased from V to 2V, choose the correct conclusion.

A. Q remains the same, C is doubled

B. Q is doubled, C doubled

C. C remains same, Q doubled

D. Both Q and C remain same

Answer: C

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13. A parallel plate capacitor stores a charge Q at a voltage V. Suppose the area of the parallel plate capacitor and the distance between the plates are each doubled then which is the quantity that will change?

A. Capacitance

B. Charge

C. Voltage

D. Energy density

Answer: D

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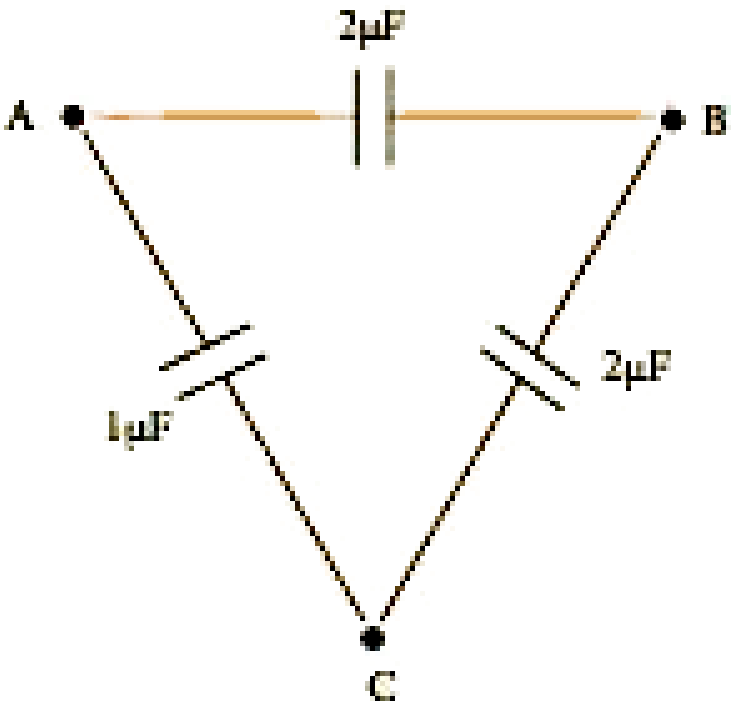
14. Three capacitors are connected in triangle as shown in the figure. The equivalent capacitance between the points A and C

is



A. $1\mu F$

B. $2\mu F$

C. $3\mu F$

D. $\frac{1}{4}\mu F$

Answer: B

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15. Two metallic spheres of radii 1 cm and 3 cm are given charges of -1×10^{-2} C and 5×10^{-2} C respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is

A. 3×10^{-2}C

B. 4×10^{-2} C

C. 1×10^{-2}C

D. 2×10^{-2}C

Answer: A

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Exercises

1. When two objects are rubbed with each other, approximately a charge of 50 nC can be produced in each object. Calculate the number of electrons that must be transferred to produce this charge.

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2. The total number of electrons in the human body is typically in the order of 10^{28}. Suppose, due to some reason, you and your friend lost 1% of this number of electrons. Calculate the electrostatic force between you and your friend separated at a distance of 1m. Compare this with your weight. Assume mass of each person is 60 kg and use point charge approximation.

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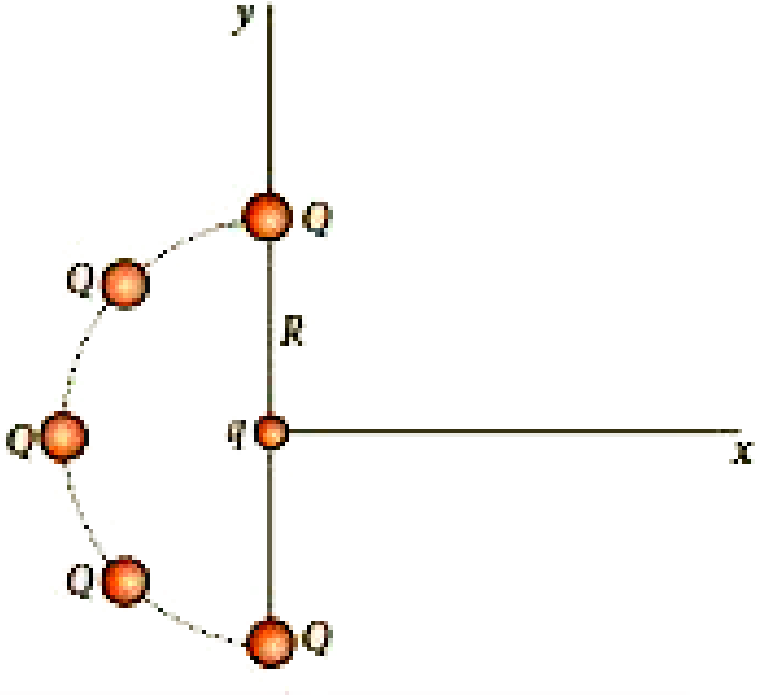
3. Five identical charges Q are placed equidistant on a semicircle as shown in the figure. Another point charge q is kept at the center of the circle of radius R. Calculate the electrostatic force experienced by the charge q.



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4. Suppose a charge +q on Earth's surface and another +q charge is placed on the surface of the Moon.

Calculate the value of q required to balance the gravitational attraction between Earth and Moon

(Take $m_E = 5.9 \times 10^{24}$ kg,$\mathrm{m}_M = 7.9 \times 10^{22}$ kg)

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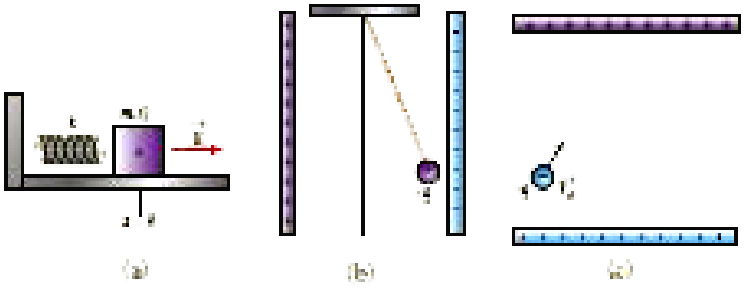
5. Suppose a charge +q on Earth's surface and another +q charge is placed on the surface of the Moon.

Suppose the distance between the Moon and Earth is halved, would the charge q change?

(Take $m_E = 5.9 \times 10^{24}$ kg,$\mathrm{m}_M = 7.9 \times 10^{22}$ kg)

View Text Solution

6. Draw the free body diagram for the following charges as shown in the figure (a), (b) and (c).



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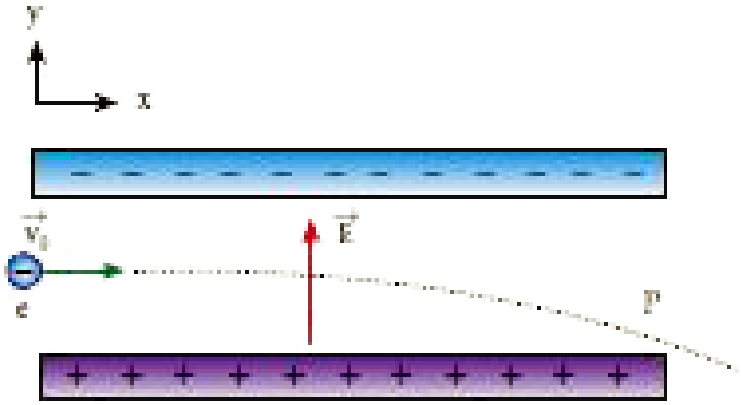
7. Consider an electron travelling with a speed v_o and entering into a uniform electric field $\overrightarrow{E}$ which is perpendicular to $\overrightarrow{v}_o$ as shown in the Figure. Ignoring gravity, obtain the electron's

acceleration, velocity and position as functions of time.



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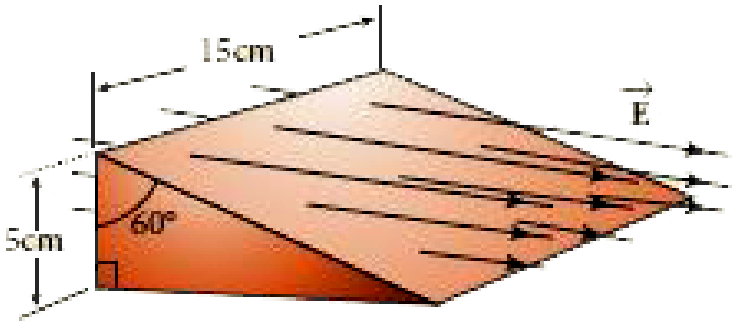
8. A closed triangular box is kept in an electric field of magnitude $E = 2 \times 10^3 \mathrm{N\ C^{-1}}$ as shown in figure.



Calculate the electric flux through the

vertical rectangular surface

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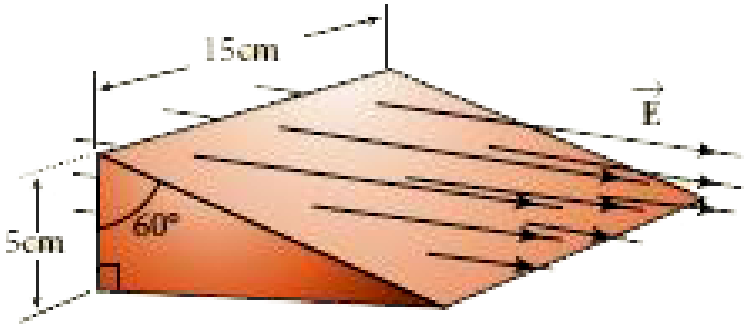
9. A closed triangular box is kept in an electric field of magnitude $E = 2 \times 10^3 \mathrm{N\ C^{-1}}$ as shown in figure.

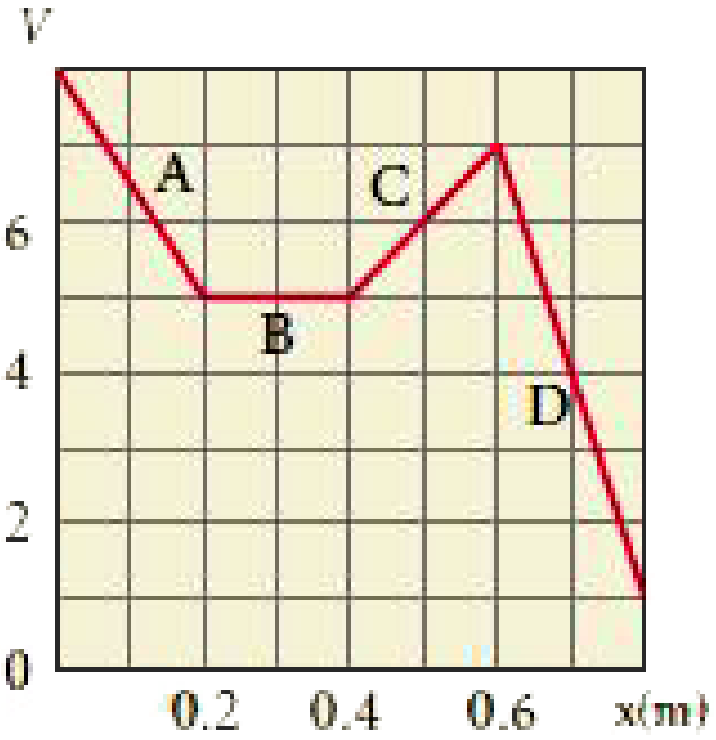


Calculate the electric flux through the

slanted surface and

View Text Solution

10. The electrostatic potential is given as a function of x in figure (a) and (b). Calculate the corresponding electric fields in regions A, B, C and D. Plot the electric field as a function of x for the figure (b).



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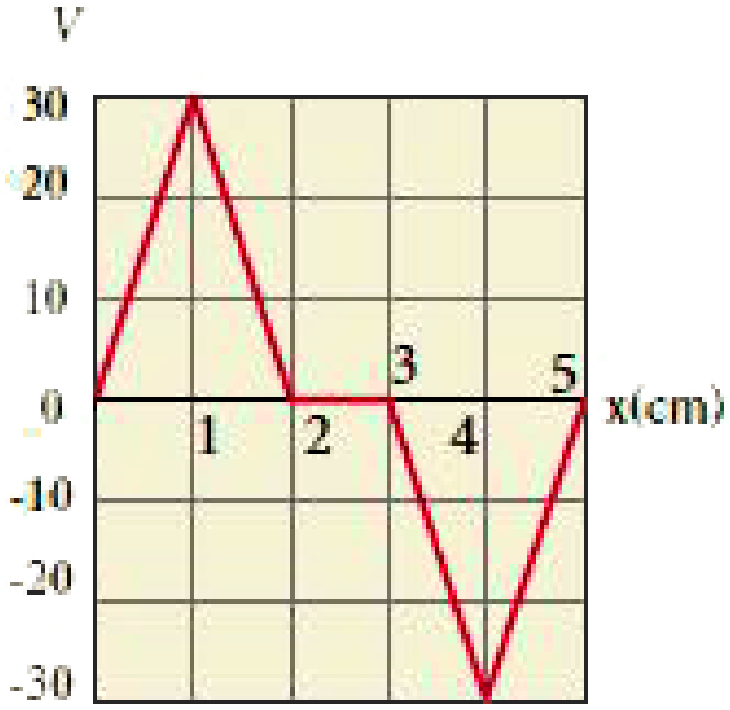
11. The electrostatic potential is given as a function of x in figure (a) and (b). Calculate the corresponding electric fields in regions A, B, C and D. Plot the electric field as a function of x for the figure (b).



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12. A spark plug in a bike or a car is used to ignite the air-fuel mixture in the engine. It consists of two electrodes separated by a gap of around 0.6 mm gap as shown in the figure.

To create the spark, an electric field of magnitude $3 \times 10^{6} \ \mathrm{Vm}^{-1}$ is required.

If the gap is increased, does the potential difference increase, decrease or remains the same?

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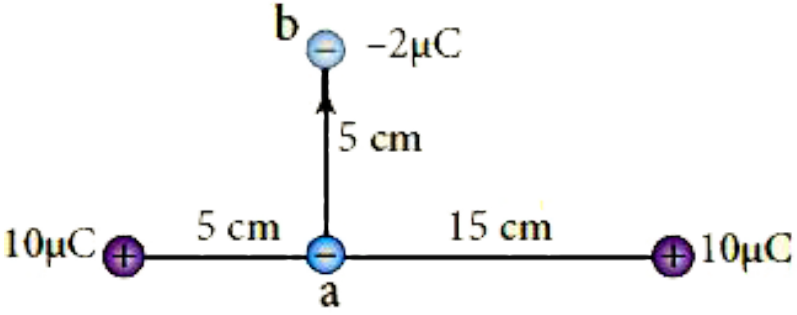
13. A point charge of $+10\mu C$ is placed at a distance of 20 cm from another identical point charge of $+10\mu C$. A point charge of $-2\mu C$ is moved from point a to b as shown in the figure. Calculate the change in potential energy of the system? Interpret your result.



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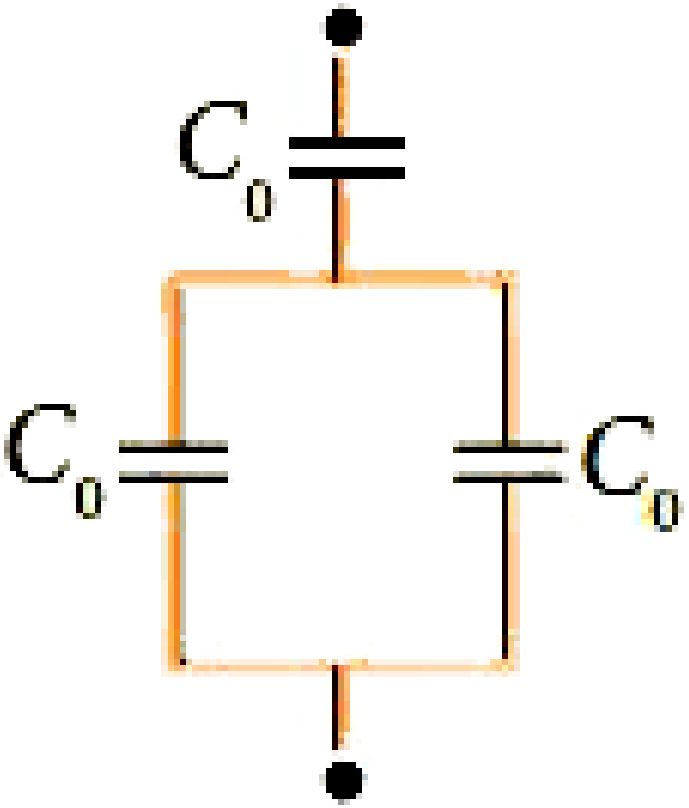
14. Calculate the resultant capacitances for each of the following combinations of capacitors.



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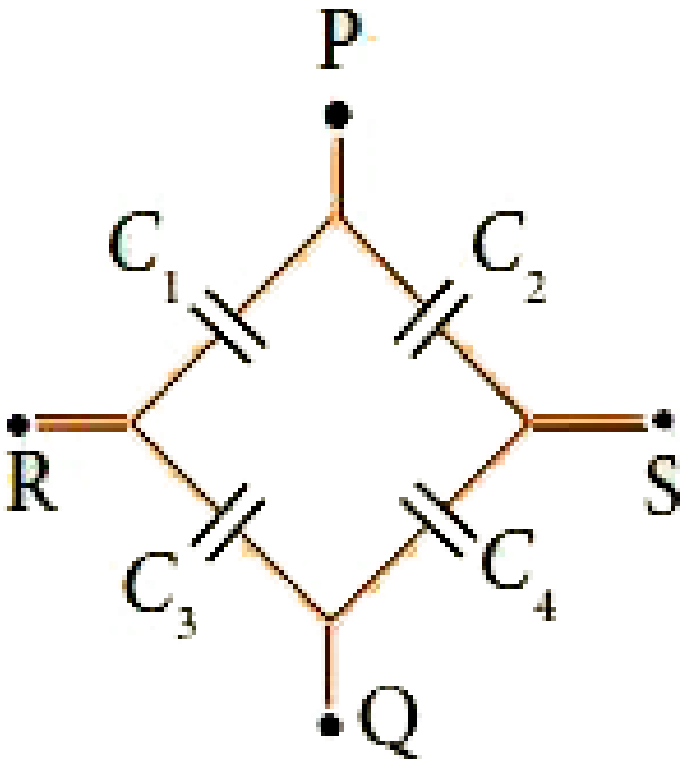
15. Calculate the resultant capacitances for each of the following combinations of capacitors.



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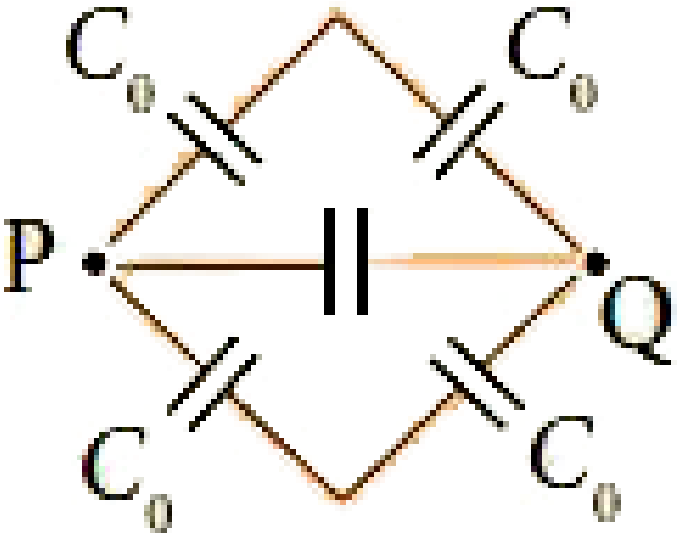
16. Calculate the resultant capacitances for each of the following combinations of capacitors.



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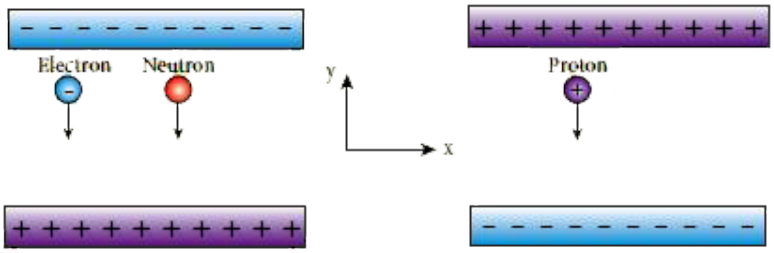
17. An electron and a proton are allowed to fall through the separation between the plates of a parallel plate capacitor of voltage 5 V and separation distance h = 1 mm as shown in the figure.



Calculate the time of flight for both electron and proton

(Take

$m_p = 1.6 \times 10^{-27}$ kg, $m_e = 9.1 \times 10^{-31}$ kg and $g = 10$ ms^{-2}

)

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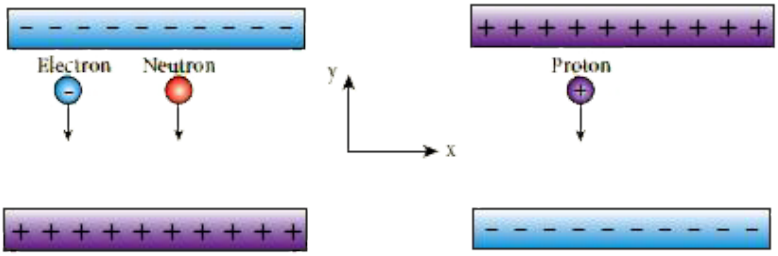
18. An electron and a proton are allowed to fall through the separation between the plates of a parallel plate capacitor of voltage 5 V and separation distance h = 1 mm as shown in the figure.



Suppose if a neutron is allowed to fall, what is the time of flight?

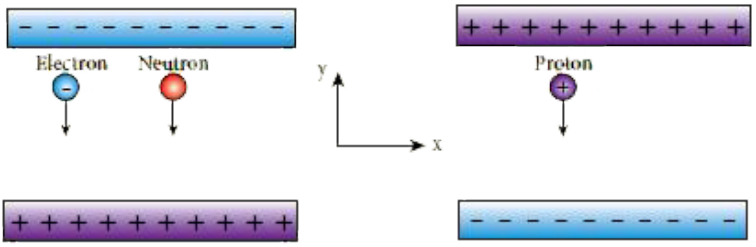
(Take

$m_p = 1.6 \times 10^{-27}$ kg, $m_e = 9.1 \times 10^{-31}$ kg and $g = 10$ ms^{-2}

)

View Text Solution

19. An electron and a proton are allowed to fall through the separation between the plates of a parallel plate capacitor of voltage 5 V and separation distance h = 1 mm as shown in the figure.



Among the three, which one will reach the bottom first?

(Take

$m_p = 1.6 \times 10^{-27}$ kg, $m_e = 9.1 \times 10^{-31}$ kg and $g = 10$ ms^{-2}

)

View Text Solution

20. During a thunder storm, the movement of water molecules within the clouds creates friction, partially causing the bottom part of the clouds to become negatively charged. This implies that the bottom of the cloud and the ground act as a parallel plate capacitor. If the electric field between the cloud and ground exceeds the dielectric breakdown of the air

$\left(3 \times 10^{6} \quad \mathrm{Vm}^{-1}\right)$, lightning will occur.

If the bottom part of the cloud is 1000 m above the ground, determine the electric potential difference that exists between the cloud and ground.

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21. During a thunder storm, the movement of water molecules within the clouds creates friction, partially causing the bottom part of the clouds to become negatively charged. This implies that the bottom of the cloud and the ground act as a parallel plate capacitor. If the electric field between the cloud and ground exceeds the dielectric breakdown of the air $\left(3 \times 10^{6} \ \ \mathrm{Vm}^{-1}\right)$, lightning will occur.

In a typical lightning phenomenon, around 25C of electrons are transferred from cloud to ground. How much electrostatic potential energy is transferred to the ground?

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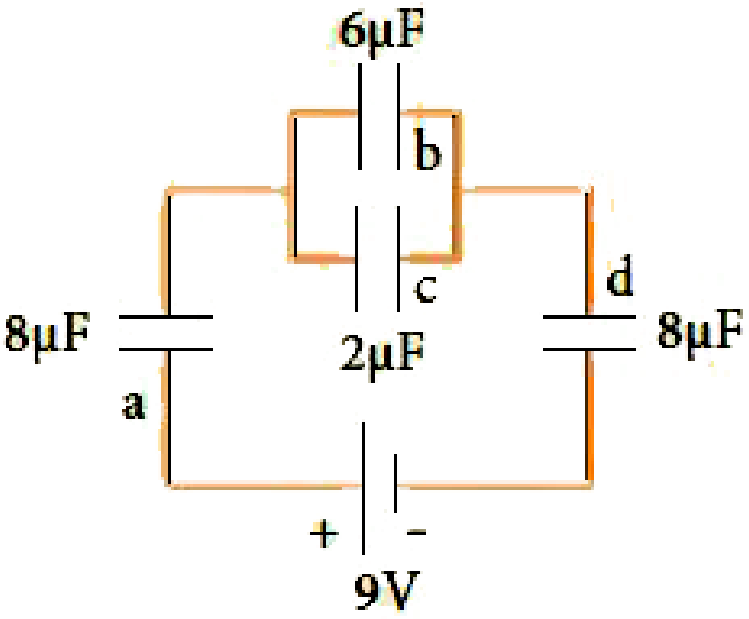
22. For the given capacitor configuration

(a) Find the charges on each capacitor

(b) potential difference across them

(c) energy stored in each capacitor



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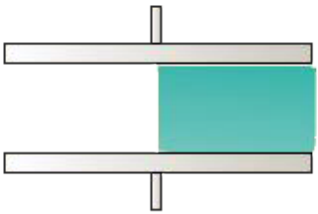
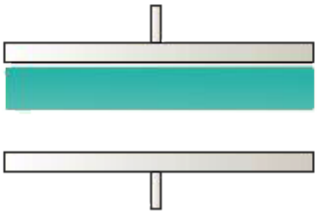
23. Capacitors P and Q have identical cross sectional areas A and separation d. The space between the capacitors is filled with a dielectric of dielectric constant ε_r as shown in the

figure. Calculate the capacitance of capacitors P and Q.



P



Q

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