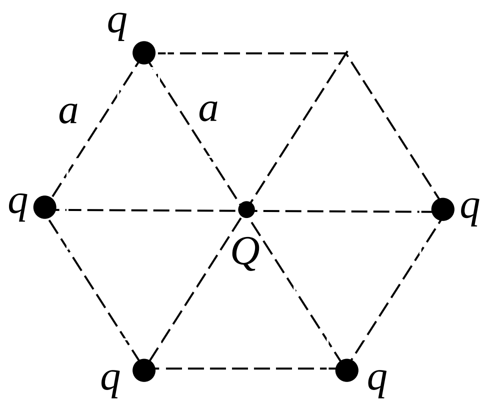
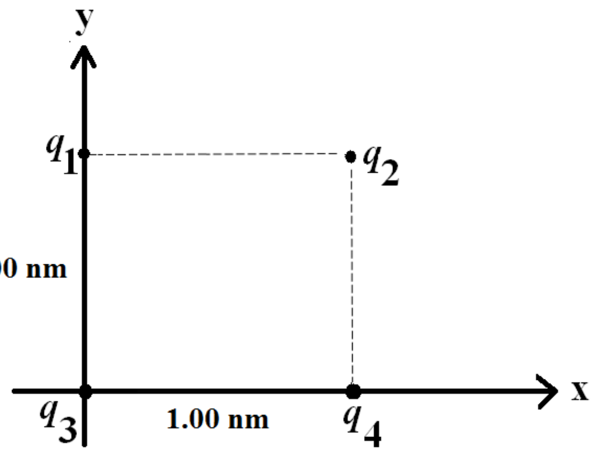
Q1. Five identical point charges each with charge $\boldsymbol{q}$ **=10** nC are located at the corners of a regular hexagon, as shown in **Figure 1**. Find the magnitude of the net electric force on a point electric charge $\boldsymbol{Q}$ **= 5.0** nC located at the center of the hexagon. (The distance between Q and q is a = **1.0** micro-meter).



A) 4.5×10^5 N
B) 0.0 N
C) 1.0×10^4 N
D) 9.8×10^5 N
E) 2.5×10^6 N

Q2. Four point charges are located at the corners of a square (**1.00** nm side), as shown in **Figure 2**. If the point charges are given by $q_1 = q_4$ = **300** nC and $q_2 = q_3 = q$, find the value of q so that the net electrostatic force on charge q_2 is zero?

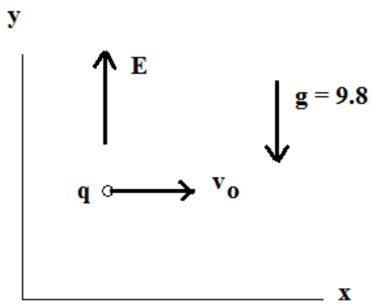


A) − 849 nC
B) + 849 nC
C) − 235 nC
D) + 300 nC
E) − 300 nC

Q3. Consider three distant spheres with initial charges Q_{1i} = **2.0** C; Q_{2i} = **3.0** C and Q_{3i} = **10** C. If we allow these spheres to touch each other for a short time and then we separate them. The new electrostatic charges of these spheres become Q_{1f} = q ; Q_{2f} = **1.5** q and Q_{3f} = **2.5** q. Find the value of q.

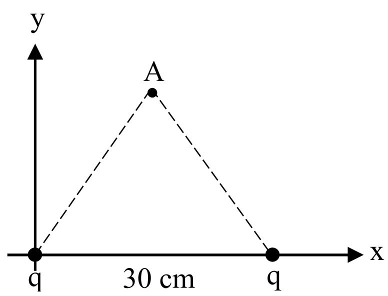
A) 3.0 C
B) 1.0 C
C) 2.5 C
D) 1.5 C
E) 0

Q4. A charged particle of mass m = **2.5** g and **charge 5.0** mC has a velocity of V_o = **25** m/s in the positive *x* direction when it first enters a region where the electric field is uniform (E = **4.9** N/C in the positive *y* direction) as shown in **Figure 3**. What is the speed of the particle **2.0** s after it enters this region? (Take g = **9.8** m/s^2)



A) 25 m/s
B) 32 m/s
C) 49 m/s
D) 44 m/s
E) 35 m/s

Q5. Two point charges **q = 2.7** micro-Coulomb each, are located at two corners of an **equilateral triangle** whose sides have a length of **30** cm. Find the electric field created by the two charges at the other corner of the triangle (point A in **Figure 4**). ($\hat{i}$ and $\hat{j}$ are unit vectors along the positive x and y axes, respectively)

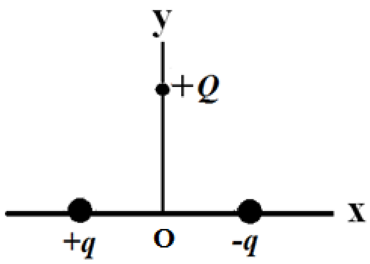


A) $4.7\times10^5\ \hat{j}$ N/C
B) $1.3\times10^5\ \hat{j}$ N/C
C) $(5.0\ \hat{i} + 1.3\ \hat{j})\times10^5$ N/C
D) 0.00 N/C
E) $4.7\times10^5\ \hat{i}$ N/C

Q6. A point charge q = **0.25** nC is located in the xy-plane at a point having coordinates (**+60** cm, **+40** cm). At what point in the xy-plane will the electric field created by this point charge be **10** N/C and pointing in the negative x-direction?

A) (+13 cm, +40 cm)
B) (−13 cm, +40 cm)
C) (+40 cm, +40 cm)
D) (−40 cm, +40 cm)
E) (+60 cm, −40 cm)

Q7. A positive charge **+ q** and a negative charge **– q** are located at equal distances from the origin **O** while a positive test charge **+Q** is placed on the y axis as shown in **Figure 5**. Which diagram below gives the **CORRECT** direction of the net electric force on the test charge **+Q**?



A) →
B) ↑
C) □
D) ←
E) ↓

Q8. A flat surface with area **0.20** m^2 lies in the xy-plane, in a uniform electric field $\vec{E}$ = (**5.1** $\hat{i}$ + **2.1** $\hat{j}$ +**3.5**$\hat{k}$) ×$\mathbf{10^3}$ N/C. Find the magnitude of the electric flux through this surface.

A) 0.70 ×10^3 N.m^2/C
B) 1.1 ×10^3 N.m^2/C
C) 0.10 ×10^3 N.m^2/C
D) 1.9 ×10^3 N.m^2/C
E) 0.30 ×10^3 N.m^2/C

Q9. A hollow spherical conductor, with inner radius **2.00** cm and outer radius **2.10** cm carries a charge of **–2.00** C. If a point charge of **+ 5.00** C is placed at the center of the hollow conductor, find the surface charge density at the outer surface of the spherical conductor.

A) + 541 C/m^2
B) – 541 C/m^2
C) – 150 C/m^2
D) + 250 C/m^2
E) – 250 C/m^2

Q10. An infinitely long charged wire located at x = **−2.00** m has a uniform linear charge density λ = **−1.50** μC/m and lies parallel to the y-axis. A point charge of **+1.50** μC is located at a point (x =**1.00** m, y = **0.00** m). Find the magnitude and direction of the resultant electric field at a point (x = **+2.00** m, y = **0.00** m) due to the point charge and the charged wire.

A) 6.75×10^3 N/C, pointing towards positive x-axis
B) 6.75×10^3 N/C, pointing towards negative x-axis
C) 1.52×10^3 N/C, pointing towards positive x-axis
D) 1.52×10^3 N/C, pointing towards negative x-axis
E) 2.22×10^3 N/C, pointing towards negative y-axis

Q11. A point charge q = **+ 12.0** μC is located at the geometric center of a cube of side L = **10.0** cm. What is the electric flux through one face of the cube?

A) 0.226×10^6 Nm^2/C
B) 1.45×10^6 Nm^2/C
C) 12.0×10^6 Nm^2/C
D) 48.0×10^6 Nm^2/C
E) 0

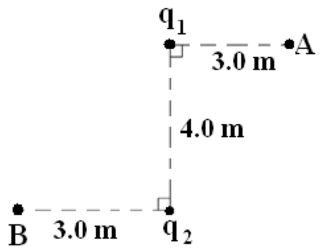
Q12. A thin spherical shell of radius **20** cm carries a charge of **−5.0** nC distributed uniformly over its surface. At the center of the shell there is a point charge q. If the electric field at a distance of **10** cm from the center of the shell is **$1.8\text{x}10^3$** N/C, find the **magnitude** of q.

A) 2.0 nC
B) 15 nC
C) 3.0 nC
D) 10 nC
E) 18 nC

Q13. Consider two point charges + q and – *q* located at x = - a and x = + a, respectively. Which one of the following answers is TRUE for the electric field ($\vec{E}$) and potential (V) at the origin? ($\hat{i}$ is a unit vector in the positive x direction)

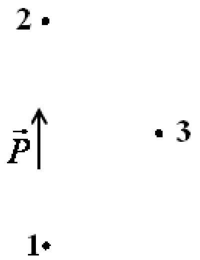
A) $\vec{E} = (2kq/a^2)\hat{i}$, V=0
B) $\vec{E} = 0$, V=$2kq/a$
C) $\vec{E} = 0$, V=0
D) $\vec{E} = (2kq/a^2)\hat{i}$, V=$2kq/a$
E) $\vec{E} = (-2kq/a^2)\hat{i}$, V=$-2kq/a$

Q14. Two point charges q_1= **+12** nC and q_2 are placed as shown in **Figure 6**. If the potential difference between points A and B is $V_A - V_B$ = **35** V, what is the value of the charge q_2.



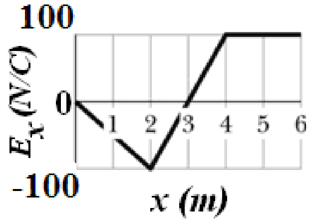
A) − 17 nC
B) + 17 nC
C) − 10 nC
D) + 10 nC
E) − 33 nC

Q15. In **Figure 7**, points 1, 2, and 3 are all located at the same very large distance from a dipole $\vec{P}$. Rank them according to the values of the electric dipole potential at these points, from the **most negative to the most positive**.



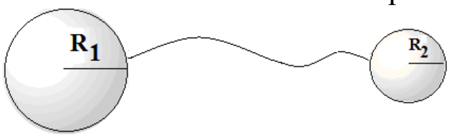
A) 1, 3, 2
B) 3, 2, 1
C) 2, 3, 1
D) 1, 2, 3
E) 1 and 2 tie, then 3

Q16. A graph of the x component of the electric field as a function of x in a region of space is shown in **Figure 8** (the electric field along y and z directions is zero). What is the potential difference between x = **3.00** m and x = **6.00** m?



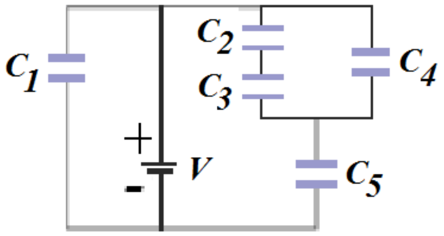
A) − 250 V
B) + 50.0 V
C) 0 V
D) − 50.0 V
E) − 150 V

Q17. Two metallic spheres 1 and 2, far away from each other have radii R_1 and R_2, respectively (**Figure 9**), and $\boldsymbol{R_1 = 3R_2}$. The sphere with radius R_1 carries **–10** nC charge while the other one carries **+38** nC charge. The spheres are then connected by a thin long wire until electrostatic equilibrium is reached. What is the ratio of electric fields ($\boldsymbol{E_2/E_1}$) where $\boldsymbol{E_1}$ is the electric field at the surface of sphere 1 and $\boldsymbol{E_2}$ is the electric field at the surface of sphere 2?



A) 3
B) 4
C) 5
D) 1
E) 2

Q18. In **Figure 10** the battery has a potential difference of **15** *V* and five **identical capacitors** each having capacitance of **6.0** µF. What is the potential difference across capacitor $\boldsymbol{C_5}$?



A) 9.0 V
B) 2 .0 V
C) 12 V
D) 14 V
E) 7.0 V

Q19. *n* **identical capacitors** (each of capacitance **5.0** µF) are connected in parallel across a **10** V battery. If the total electrostatic energy stored in all these capacitors is $\mathbf{1.5x10^{-3}}$ J, what is the value of integer n?

A) 6
B) 5
C) 10
D) 60
E) 100

Q20. An air filled parallel-plate capacitor has a capacitance C = **25.0** pF and each of its plates has an area of **0.400** m^2. If the space between the plates is filled with a dielectric material having **κ** = **4.50** and the area is increased to **0.600** m^2, what will be the new capacitance?

A) 169 pF
B) 75.0 pF
C) 112. pF
D) 22.5 pF
E) 134 pF

$$F = k\frac{q_1 q_2}{r^2}$$

$$\vec{F} = q\vec{E} = m\vec{a}$$

$$U = -\vec{p}\cdot\vec{E}$$

$$\vec{\tau} = \vec{p}\times\vec{E}$$

$$\Phi = \int_{Surface} \vec{E}.d\vec{A}$$

$$\Phi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

$$E = \frac{\sigma}{2\varepsilon_o}$$

$$E = \frac{\sigma}{\varepsilon_o}$$

$$E = k\frac{q}{r^2}$$

$$E = k\frac{q}{R^3}r$$

$$E = \frac{2k\lambda}{r}$$

$$\Delta V = V_B - V_A = -\int_A^B \vec{E}.d\vec{S} = \frac{\Delta U}{q_0}$$

$$V = k\frac{q}{r} \quad , \quad V = \sum_{i=1}^{N}\frac{kq_i}{r_i}$$

$$E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$$

$$U = k\frac{q_1 q_2}{r_{12}}$$

$$\Delta U = -W$$

$$C = \frac{q}{V}$$

$$C = \kappa C_{air}$$

$$C_{air} = \frac{\varepsilon_o A}{d} \quad (\text{for parallel plate capacitor})$$

$$C_{air} = 2\pi\varepsilon_o \frac{L}{\ln\left(\frac{b}{a}\right)} \quad (\text{for cylindrical capacitor})$$

$$C_{air} = 4\pi\varepsilon_o\left(\frac{ab}{b-a}\right) \quad (\text{for spherical capacitor})$$

$$C = 4\pi\varepsilon_o R$$

$$U = \frac{1}{2}CV^2$$

$$u = \frac{1}{2}\varepsilon_o E^2$$

$$I = \frac{dQ}{dt} = JA$$

$$R = \frac{V}{I} = \rho\frac{L}{A}$$

$$J = nev_d$$

$$J = \sigma E$$

$$R = R_0\,[1 + \alpha(T - T_0)]$$

$$\rho = \rho_0\,[1 + \alpha(T - T_0)]$$

$$P = IV$$

$v = v_o + at$

$x - x_o = v_o t + \frac{1}{2} a t^2$

$v^2 = v_o^2 + 2a(x - x_o)$

Constants:

$k = 9.00 \times 10^9$ N.m^2/C^2

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2

$e = 1.60 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg

$g = 9.80$ m/s^2

μ = micro = 10^{-6}	M = mega = 10^6
n = nano = 10^{-9}	p = pico = 10^{-12}
m = milli = 10^{-3}	k = kilo = 10^3