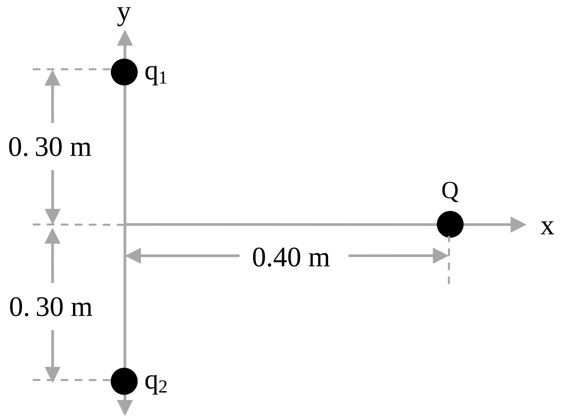
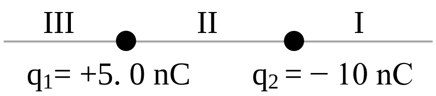
Q1. Three charges, $q_1 = q_2 = 2.0\ \mu C$ and $Q = 4.0\ \mu C$, are fixed in their places as shown in **Figure 1**. Find the net electrostatic force on Q due to q_1 and q_2. [$\hat{i}$ and $\hat{j}$ are the unit vectors in the direction of x and y, respectively]



A) $(0.46\hat{i})$ N
B) $(0.17\hat{i})$ N
C) $(0.46\hat{i} + 0.17\hat{j})$ N
D) $(0.17\hat{i} - 0.46\hat{j})$ N
E) $(0.17\hat{i} + 0.32\hat{j})$ N

Q2. Two charges, $q_1 = +5.0$ nC and $q_2 = -10$ nC, are shown in **Figure 2**. In which region (or regions) can the net electric field due to the two charges be zero?



A) III
B) II
C) I
D) I and II
E) II and III

Q3. Two point charges, $q_1 = -4.5$ nC and $q_2 = +4.5$ nC, are separated by 3.1 mm and forming an electric dipole. The charges are in a uniform electric field whose direction makes an angle of 37^{o} with the line connecting the charges. Find the magnitude of this electric field, in N/C, if the torque exerted on the dipole has magnitude of 7.2×10^{-9} N.m.

A) 8.6×10^{2}
B) 5.6×10^{3}
C) 2.3×10^{4}
D) 9.9×10^{3}
E) 4.5×10^{2}

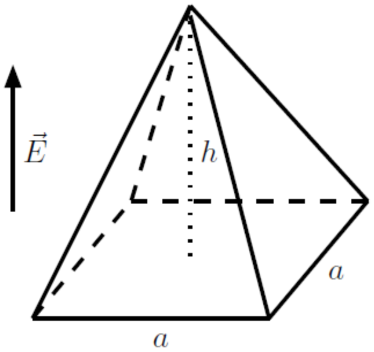
Q4. An electron is released from rest in a uniform electric field. The electron accelerates vertically upward, travelling 4.50 m in the first 3.00 micro second after it is released. What are the magnitude and direction of the electric field? [Note: Neglect the gravitational force]

A) 5.69 N/C downward
B) 5.69 N/C upward
C) 8.24 N/C upward
D) 8.24 N/C downward
E) 4.30 N/C downward

Q5. A 2.6 µC charge is at the center of a cube 7.0 cm on each side. What is the electric flux, in kN.m^2/C, through one face of the cube?

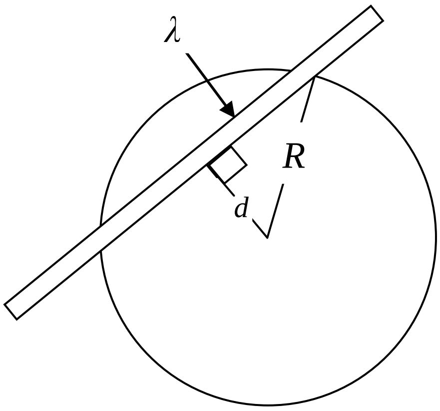
A) 49
B) 24
C) 12
D) 89
E) Zero

Q6. **Figure 3** shows a pyramid with horizontal square base, *a* = 6.00 m on each side, and a height, *h* = 4.00 m. The pyramid is placed in an upward vertical electric field of magnitude *E* = 52.0 N/C. If the pyramid does not include any charge inside, calculate the electric flux, in N.m^2/C, through its four slanted (inclined) surfaces.



A) $+1.87 \times 10^3$
B) -1.87×10^3
C) $+0.9 \times 10^3$
D) -0.9×10^3
E) -3.27×10^3

Q7. **Figure 4** show an infinitely long line of charge having a uniform charge per unit length λ. The line lies at a normal distance *d* from the center of a sphere of radius *R* ($d < R$). Determine the total electric flux through the surface of the sphere resulting from this line charge.



A) $\frac{2\lambda\sqrt{R^2-d^2}}{\varepsilon_o}$

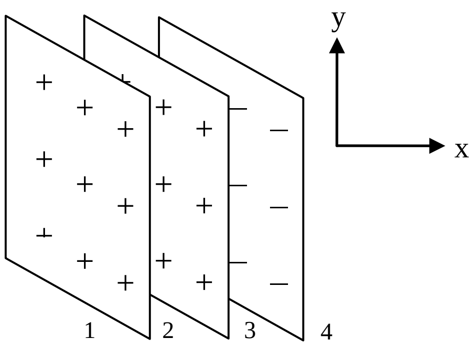
B) $\frac{4\lambda\sqrt{R^2-d^2}}{\varepsilon_o}$

C) $\frac{\lambda\sqrt{R^2-d^2}}{2\varepsilon_o}$

D) $\frac{\lambda\sqrt{R^2-d^2}}{\varepsilon_o}$

E) $\frac{2\lambda\left(R^2-d^2\right)}{\varepsilon_o}$

Q8. **Figure 5** shows sections of three infinitely flat thin insulating charge sheets, each carrying surface charge density of magnitude σ. Find the magnitude of the electric field in region 3.



A) $3\sigma/2\varepsilon_0$
B) $\sigma/2\varepsilon_0$
C) $3\sigma/\varepsilon_0$
D) σ/ε_0
E) $\sigma/3\varepsilon_0$

Q9. An insulating spherical ball of radius 4.0 cm has − 40 μC charge uniformly distributed throughout the volume. Find the magnitude and direction of the electric field at a point 2.0 cm from its center.

A) 1.13×10^{8} N/C towards the center
B) 1.13×10^{8} N/C away from the center
C) 0.45×10^{8} N/C towards the center
D) 0.45×10^{8} N/C away from the center
E) 3.23×10^{8} N/C towards the center

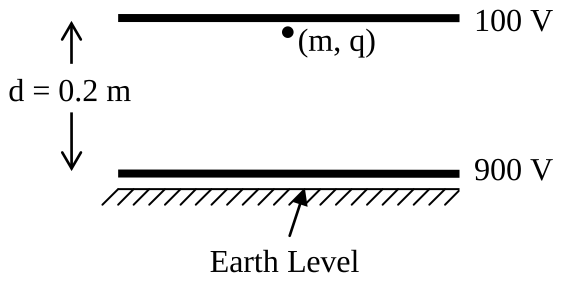
Q10. Two charged particles, q_1 and q_2, are fixed on the x-axis. q_1 is fixed at the origin and q_2 is fixed on the positive x-axis and at a distance d from the origin. It is found that the electric field is zero at x = d/3. Choose the correct answer.

A) The electric potential is never be zero except at infinity
B) The electric potential would be zero at x = −d/2
C) The electric potential would be zero at x = 4d
D) The electric potential would be zero at x = d/2
E) The electric potential would be zero at x = −d/6

Q11. Four identical charged particles, each of charge q = 30 μC, are fixed at the corner of a square of length 10.0 cm. How much work is required, **by an external agent**, to move one of them to infinity?

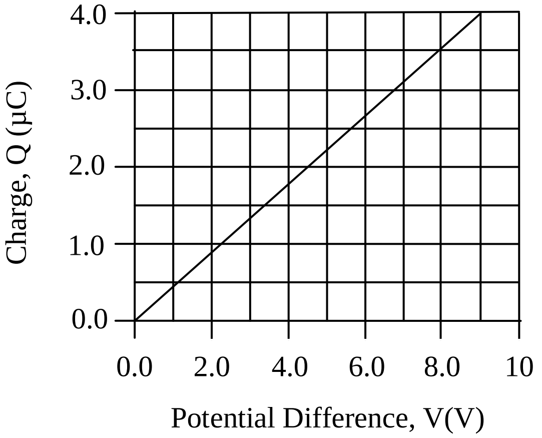
A) −219 J
B) +219 J
C) −510 J
D) +105 J
E) −105 J

Q12. **Figure 6** shows two parallel plates separated by a vertical distance of d = 0.2 m. The potentials at the upper and lower plates are 100 V and 900 V, respectively. A particle, of mass m = 0.1 kg and charge q = −500 μC, was released from rest, downwards, from the upper plate. What is the kinetic energy of the particle when it reaches the lower plate?



A) 0.6 J
B) 1.5 J
C) 0.2 J
D) 3.1 J
E) 0.4 J

Q13. The graph (**Figure 7**) shows how the charge of a capacitor varies with the potential difference across it. Use the graph to find the energy stored in the capacitor when the potential difference across it is 12 V.

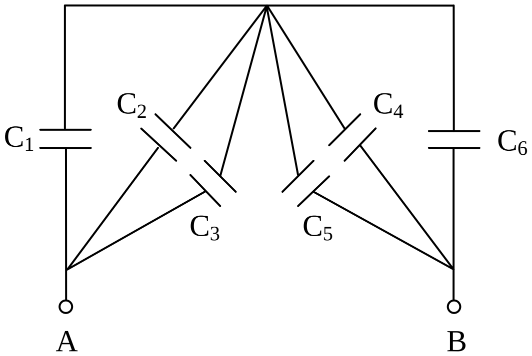


A) 32 μJ
B) 63 μJ
C) 17 μJ
D) 23 μJ
E) 48 μJ

Q14. Two capacitors, C_1 and, C_2 are connected in series to a 40 V power supply. If the capacitance of C_1 = 35 nF, and of C_2 = 85 nF, find the voltage across C_1.

A) 28 V
B) 12 V
C) 16 V
D) 40 V
E) 24 V

Q15. **Figure 8** shows 6 identical capacitors, each with a capacitance of 1.0 μF. Find the equivalent capacitance C_{eq} between points A and B.



A) 1.5 μF
B) 4.0 μF
C) 3.0 μF
D) 2.5 μF
E) 9.0 μF

Q16. An air-filled parallel plate capacitor has a capacitance of 5.0 μF and a plate area of 60 cm^2. What is the energy density stored, in J/m^3, between the plates if the potential difference across them is 8.0 V?

A) 2.5×10^{6}
B) 5.0×10^{5}
C) 1.2×10^{6}
D) 1.6×10^{6}
E) 8.9×10^{5}

Q17. An air-filled parallel plate capacitor with a plate area of 12 cm^2 and a separation of 1.5 mm is connected to a battery. What happens if the gap is filled completely with mica of a dielectric constant 4.0 while the battery is connected?

A) The energy stored in the capacitor increases.
B) The energy stored in the capacitor decreases.
C) The energy stored in the capacitor remains the same.
D) The voltage across the capacitor increases.
E) The voltage across the capacitor decreases.

Q18. At what temperature will aluminum have a resistivity that is three times the resistivity that of copper has at 20 ^{o}C? At 20 ^{o}C, the resistivity of aluminum is 2.75×10^{-8} Ω.m and the resistivity of copper is 1.69×10^{-8} Ω.m. The temperature coefficient of aluminum $\alpha_{Al} = 4.4\times10^{-3}$ K^{-1}.

A) 212 ^{o}C
B) 250 ^{o}C
C) 130 ^{o}C
D) 600 ^{o}C
E) 420 ^{o}C

Q19. A continuous beam of electrons, of current 125 mA, is incident on a target. How many electrons strike the target in a period of 23.0 s?

A) 1.80×10^{19}
B) 1.37×10^{19}
C) 7.21×10^{19}
D) 2.16×10^{19}
E) 1.56×10^{19}

Q20. A light bulb, has a resistance of 15 Ω, is connected between the terminals of a 120 V source. **If the temperature is not ignored**, which one of the following answers can be the expected output power of the bulb?

A) 840 W
B) 950 W
C) 1000 W
D) 1800 W
E) 5000 W

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\Delta U = -W$$

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

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

$$C = \frac{\varepsilon_o A}{d} \quad (\textit{for parallel plate capacitor})$$

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

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

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

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

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

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

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

$$J = nev_d$$

$$J = \sigma E$$

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

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

$$P = IV$$

$$v = v_o + at$$

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

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

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}

n = nano = 10^{-9}

p = pico = 10^{-12}