Q1.

In **Figure 1**, three positively charged panicles form a right angle triangle with two equal sides a = 50 cm. The charges are q_1 =q_3=2Q and q_2=Q. Find the value of the charge q_2 if the magnitude of the net electrostatic force on it is 0.23 N.

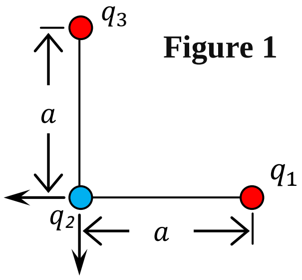


Figure 1

Ans.

$$F_{21} = k\frac{q_1 q_2}{(r_{21})^2} = 9\times10^9\frac{2Q\times Q}{(0.5)^2}(\cdot\hat{j}) \quad and \quad F_{23} = k\frac{q_1 q_2}{(r_{23})^2} = 9\times10^9\frac{2Q\times Q}{(0.5)^2}\cdot\hat{\imath}$$

$$F^2 = F_{21}^2 + F_{23}^2$$

$$(0.23)^2 = 2\cdot\left(9\times10^9\frac{2Q^2}{(0.5)^2}\right)$$

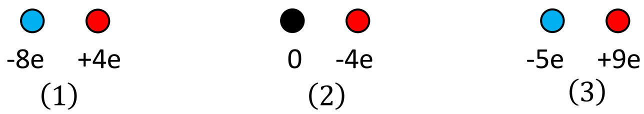
$$Q = 1.5\ \mu C$$

Stat# A_24_DIS_0.33_PBS_0.36_B_21_C_43_D_3_E_9_EXP_50_NUM_242

Q2.

Figure 2 shows three pairs of identical small conducting spheres that are to be touched together and then separated. The initial charges on them are indicated in the figure (e is the elementary charge and has the value 1.6×10^{-19} C). Rank the pairs according to the magnitude of the charges transferred during touching.

Figure 2



Ans

When touched, the conducting spheres reach the same potential ONLY. But as the spheres are identical in this case this also means the charges on them also become equal.

$\underline{Pair\ (1)}$

$Q_{net} = (-8e + 4e)/2 = -2e$

$\Delta Q_1 = -2e - (-8e) = 6e$

$\Delta Q_2 = -2e - (+4e) = -6e$

$\underline{Pair\ (2)}$

$Q_{net} = (0 - 4e)/2 = -2e$

$\Delta Q_1 = -2e - 0 = -2e$

$\Delta Q_2 = -2e - (-4e) = 2e$

$\underline{Pair\ (3)}$

$Q_{net} = (-5e + 9e)/2 = 2e$

$\Delta Q_1 = +2e - (-5e) = 7e$

$\Delta Q_2 = 2e - (+9e) = -7e$

$\therefore \quad (3), (1), (2)$

Stat# A_43_DIS_0.34_PBS_0.26_B_2_C_5_D_5_E_45_EXP_45_NUM_242

Q3.

Consider an object having a charge Q. Charge q is removed from it and is placed on a second initially uncharged object. The two objects are placed 1.0 m apart. What should be the value of q such that the force between the two objects is maximum?

Ans.

$$F = k\frac{(Q-q)q}{(1)^2}$$

$$\frac{dF}{dq} = \frac{kQ}{(1)^2} - \frac{2kq}{(1)^2} = 0$$

$$kQ - 2kq = 0$$

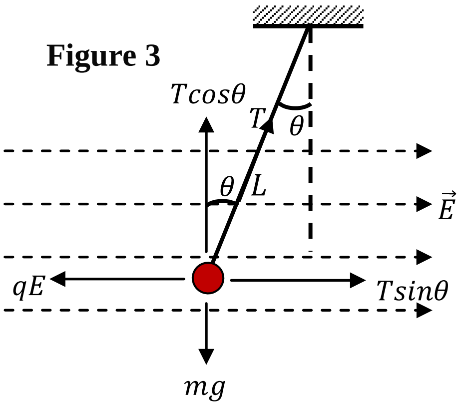
$$q = \frac{Q}{2}$$

Stat# A_33_DIS_0.49_PBS_0.37_B_37_C_14_D_6_E_10_EXP_40_NUM_242

Q4.

A small charged sphere of mass 0 .40 g is suspended by a light string (L = 24 cm) in a uniform electric field directed along the positive x direction as shown in **Figure 3**, The sphere has a charge of q = -90 nC. The charge is in equilibrium at an angle θ= 33°, Find the magnitude of the electric field to achieve equilibrium.

Figure 3



Ans

$$qE = Tsin\theta - - - - - (1) \quad and \quad mg = Tcos\theta - - - - - (2)$$

$$divide\ Eq(1)\ by\ Eq(2) we\ get: \quad \frac{qE}{mg} = tan\theta$$

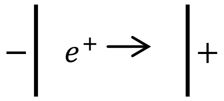
$$E = \frac{mg\ tan\theta}{q} = \frac{0.4 \times 10^{-3} \times 9.8 \times\ tan33°}{90 \times 10^{-9}} \quad \Longrightarrow \quad E = 28\ \frac{kN}{C}$$

Stat# A_40_DIS_0.51_PBS_0.41_B_14_C_15_D_13_E_17_EXP_55_NUM_242

Q5.

A proton is moving to the right with a constant velocity of 4.5×10^5 m/s. Find its velocity 3.0 μs after entering a uniform electric field of 1100 N/C directed to the left. Ignore gravity.

Ans.



$$v = v_\circ + at$$

$$v = v_\circ - \frac{eE}{m}t$$

$$v = 4.5 \times 10^5(\hat{\imath}) - \frac{1.6 \times 10^{-19} \times 1100}{1.67 \times 10^{-27}} 3 \times 10^{-6}(\hat{\imath})$$

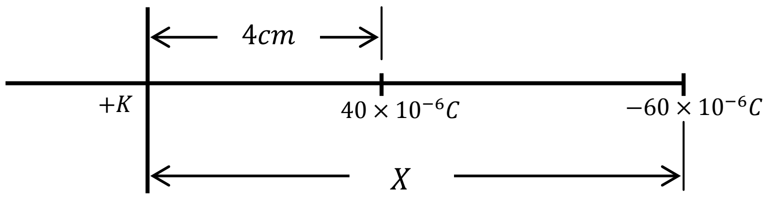
$$v = 1.3 \times 10^5 \ m/s(\hat{\imath}) \ to \ the \ left$$

Stat# A_38_DIS_0.57_PBS_0.44_B_6_C_22_D_6_E_27_EXP_50_NUM_242

Q6.

A 40μC charge is positioned on the x-axis at x = +4.0 cm, Where on this axis should a -60μC charge be placed in order to produce a zero net electric field at the origin?

Ans.



$$K\frac{40 \times 10^{-6}}{(40 \times 10^{-2})^2} = K\frac{60 \times 10^{-6}}{(X)^2}$$

$$(X)^2 = \frac{(40 \times 10^{-2})^2 \times 60 \times 10^{-6}}{40 \times 10^{-6}} = 24 \ cm$$

$$X = 4.9 \ cm$$

Stat# A_46_DIS_0.49_PBS_0.40_B_6_C_29_D_6_E_14_EXP_55_NUM_242

Q7.

The dipole moment of a dipole in a 200 N/C electric field is initially perpendicular to the field, but it rotates so it is in the same direction as the field. Find the work done by the field if the dipole moment has a magnitude of 2×10^{-8} C.m.

Ans.

$$W = -\Delta U = U_i - U_f$$

$$W = PE.cos90° - (-PE.cos0°)$$

$$W = 0 + PE$$

$$W = 2 \times 10^{-8} \times 200 = 4\mu J$$

Stat# A_48_DIS_0.44_PBS_0.37_B_2_C_27_D_7_E_16_EXP_45_NUM_242

Q8.

Consider a spherical shell of radius R and charge Q distributed uniformly on its surface. Find the radial distance where the electric field due to the shell is half its maximum value.

Ans.

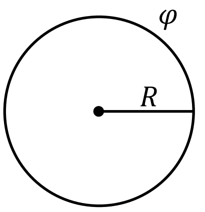
$$E_s = k\frac{Q}{R^2}$$

$$E = E_s$$

$$k\frac{Q}{r^2} = \frac{k}{2}\frac{Q}{R^2}$$

$$r^2 = 2R^2$$

$$r = \sqrt{2}\ R$$



Stat# A_38_DIS_0.43_PBS_0.37_B_18_C_20_D_20_E_4_EXP_45_NUM_242

Q9.

The flux (in N,m^2/C) of the electric field $\vec{E} = (24\ N/C)\ \hat{\imath}\ +\ (30\ N/C)\ \hat{\jmath}\ +$ $(16\ N/C)\ \hat{k}$ through a 1.5 m^2 portion of the yz plane is:

Ans.

$$\overrightarrow{A_{yz}} = 1.5\ m^2\ \hat{\imath}$$

$$\phi_{yz} = \vec{E}\cdot\overrightarrow{A}_{yz} = 24\times 1.5(\hat{\imath}\cdot\hat{\imath}) = 36\ Nm^2/C$$

$$(\hat{\jmath}\cdot\hat{\imath}) = (\hat{k}\cdot\hat{\imath}) = 0$$

Stat# A_75_DIS_0.48_PBS_0.39_B_2_C_4_D_13_E_5_EXP_60_NUM_242

Q10.

The electric field just outside the surface of a hollow conducting sphere of radius 20 cm is 500 N/C and directed radially outward. An unknown charge Q is placed at the center of the sphere and it is noted that the electric field at the same location is still directed radially outward, but has decreased to 100 N/C. What is the magnitude of the charge Q?

Ans.

$$E = k\frac{Q}{R^2} \Longrightarrow Q = \frac{ER^2}{k}$$

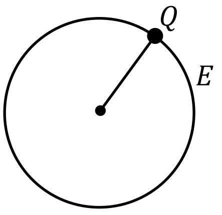
$$Q = \frac{500\times(20\times10^{-2})^2}{9\times10^9} = 2.22\ nC$$

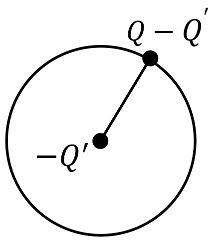
$$E' = k\frac{Q-Q'}{R^2} \Longrightarrow Q - Q' = \frac{E'R^2}{k}$$

$$2.22 - Q' = \frac{100\times(20\times10^{-2})^2}{9\times10^9}$$

$$2.22 - Q' = 0.44$$

$$Q' = 1.8\ nC$$



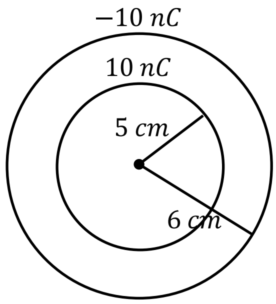


Stat# A_61_DIS_0.54_PBS_0.44_B_3_C_14_D_13_E_10_EXP_45_NUM_242

Q11.

A point charge of 10.0 nC is placed at the center of a hollow spherical conductor of inner radius 5.00 cm and outer radius 6.00 cm. The spherical conductor has a net charge of -5.00nC. Determine the surface charge density on the inner surface of the conductor.

Ans.



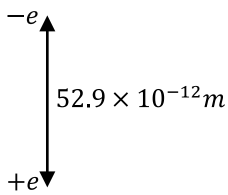
$$\sigma_{in} = \frac{Q_{in}}{4\pi r_{in}^2} = \frac{-10\times10^{-9}}{4\times\pi\times(5\times10^{-2})^2} = -318\ nC$$

Stat# A_33_DIS_0.61_PBS_0.52_B_19_C_22_D_19_E_7_EXP_55_NUM_242

Q12.

Calculate the electrostatic potential energy between a proton and an electron in a hydrogen atom of radius 52.9 pm (I m = IxI012 pm). Assume the electrostatic potential energy between the proton and electron is zero at infinite separation. Express your answer in electron-volts (eV).

Ans.



$$V = \frac{Ke(-e)}{r^2} = \frac{-9\times10^9\times(1.6\times10^{-19})^2}{(52.9\times10^{-12})^2} = -27.2\ eV$$

Stat# A_60_DIS_0.44_PBS_0.39_B_10_C_7_D_12_E_10_EXP_60_NUM_242

Q13.

Consider two points in an electric field. The potentials at point $P_1$is V_1 = -0.24 kV, and at point P_2 is V_2 = + 0.36 kV. How much work is done by an external force in moving a charge q= -8.0μC from P_2 to P_1?

Ans.

$$W = -\Delta U = U_f - U_i = qV_1 - qV_2 = -8\times10^{-6}(-0.24-0.36) = 4.8\ mJ.$$

Stat# A_81_DIS_0.43_PBS_0.38_B_5_C_5_D_4_E_5_EXP_45_NUM_242

Q14.

The electric potential in a certain region is given by V = 4 x z - 5 Y + 3 z^2, where x, y, and z are in meters, and V is in volts. Find the magnitude of the electric field at the point (+2 m, -1m, +3 m).

Ans.

$$E_x = -\frac{\partial V}{\partial x} = 4z = -4\times3 = -12\ V/m$$

$$E_y = -\frac{\partial V}{\partial y} = 5\ V/m$$

$$E_z = -\frac{\partial V}{\partial z} = -4\,\mathrm{x} - 6\,\mathrm{z} = -4\times2 - 6\times3 = -26\ V/m$$

$$E = \sqrt{(E_x)^2 + (E_y)^2 + (E_z)^2} \implies E = \sqrt{(-12)^2 + (5)^2 + (-26)^2} = \frac{29V}{m}$$

Stat# A_54_DIS_0.59_PBS_0.47_B_12_C_6_D_12_E_15_EXP_60_NUM_242

Q15.

A proton of kinetic energy 4.8 x10^6 eV travels head-on toward a lead nucleus (with 82protons). Assuming that the proton does not penetrate the nucleus and that the only force between the proton and the nucleus is Coulomb force, calculate the smallest separation between the proton and the nucleus when the proton comes momentarily to rest.

Ans.

$$\Delta KE = -qV$$

$$KE_f - KE_i = \frac{-Ke(82e)}{r^2}$$

$$0 - 4.8 \times 10^6\ e = \frac{-9 \times 10^9\ e(82e)}{r^2}$$

$$r^2 = \frac{9 \times 10^9 \times\ (82 \times 1.6 \times 10^{-19})}{4.8 \times 10^6}$$

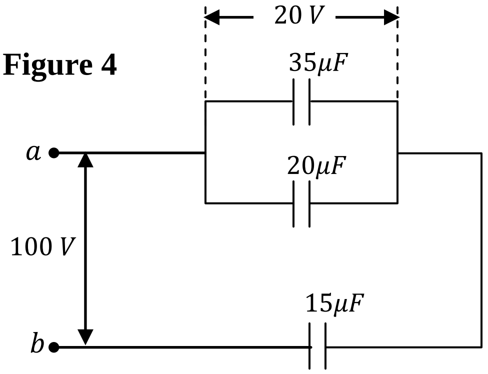
$$r = 2.5 \times 10^{-15} m$$

Stat# A_37_DIS_0.51_PBS_0.42_B_21_C_15_D_15_E_12_EXP_45_NUM_242

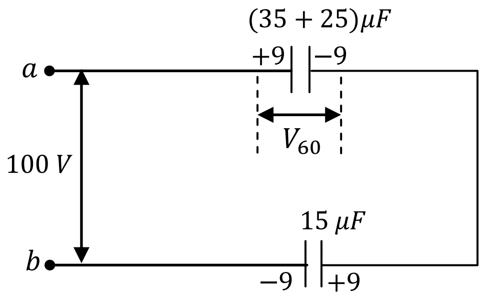
Q16.

If V_{ab} is equal to 100 V, find the charge stored and the potential difference across the 35 μF capacitor shown in **Figure 4**.

Figure 4



Ans.



$$C_{eq} = \frac{60 \times 15}{60 + 15} \mu F = 12\mu F$$

$$q = C_{eq} V = 12 \times 100 = 1200\ \mu C$$

$$V_{60} = \frac{q}{60\ \mu F} = \frac{12 \times 100\ \mu C}{60\ \mu F} = 20\ volts$$

$$V_{35} = V_{25} = V_{60} = 20\ volts$$

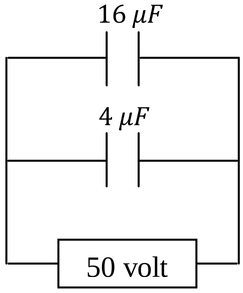
$$q_{35} = 35\mu F \times V_{35} = 35\mu F \times 20 = 700\ \mu C$$

Stat# A_45_DIS_0.56_PBS_0.47_B_11_C_19_D_18_E_7_EXP_50_NUM_242

Q17.

Two capacitors, C_1 = 16 μF and C_2 = 4.0 μF are connected in parallel and charged with a 50V power supply. What potential difference would be required across the same capacitors connected in series so that the combination stores the same energy as when connected in parallel?

Ans.



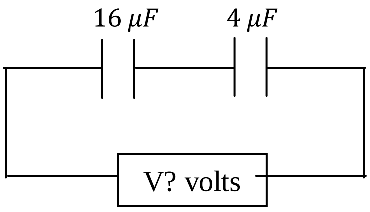
$$E_p = \frac{1}{2}(C_1 + C_2)V^2$$

$$E_p = \frac{1}{2}(16 \times 10^{-6} + 4 \times 10^{-6}) \times (50)^2$$

$$E_s = \frac{1}{2}\left(\frac{C_1 \times C_2}{C_1 + C_2}\right)V^2$$

$$E_s = \frac{1}{2}\left(\frac{16 \times 4}{16 + 4} \times 10^{-6}\right)V^2 = \frac{1}{2}\left(\frac{16}{5} \times 10^{-6}\right)V^2$$

$$but\ E_p = E_s\ so$$



$$\frac{1}{2}(16 \times 10^{-6} + 4 \times 10^{-6}) \times (50)^2 = \frac{1}{2}\left(\frac{16}{5} \times 10^{-6}\right)V^2$$

$$20 \times (50)^2 = \frac{16}{5}V^2$$

$$V = \sqrt{100 \times (50)^2 \times \frac{1}{16}} = 10 \times 50 \times \frac{1}{4}$$

$$V = 125\ volts$$

Stat# A_58_DIS_0.54_PBS_0.44_B_8_C_10_D_7_E_17_EXP_55_NUM_242

Q18.

Which of the following statements is TRUE?

Ans.

The answer A $\quad C = \epsilon_\circ \frac{A}{d}$

Stat# A_78_DIS_0.46_PBS_0.40_B_9_C_7_D_2_E_4_EXP_60_NUM_242

Q19.

An electric device heats water by immersing a resistance wire in the water. It generates 300 J of heat per second when an electric potential difference of 12 V is applied across its ends. What is the resistance of the heater wire?

Ans.

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} = \frac{(12)^2}{300} = 0.48\ \Omega$$

Stat# A_81_DIS_0.33_PBS_0.36_B_6_C_6_D_2_E_5_EXP_60_NUM_242

Q20.

A cylindrical wire of radius R = 2.0 mm has a uniform current density J=2.0 × l0[5] A/m[2]. What is the current through the portion of the wire between radial distances R/3 and R/2?

Ans.

$$J = \frac{i_{1/3}}{\pi\left(R/3\right)^2} = \frac{i_{1/2}}{\pi\left(R/2\right)^2}$$

$$i_{1/3} = \frac{J\pi(R)^2}{9} \ and \ i_{1/2} = \frac{J\pi(R)^2}{4}$$

$$i = i_{1/2} - i_{1/3}$$

$$i = J\pi(R)^2\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$i = 2 \times 10^5 \times 3.14 \times (2 \times 10^{-3})^2\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$i = 0.35\ A$$

Stat# A_48_DIS_0.62_PBS_0.47_B_14_C_17_D_11_E_9_EXP_45_NUM_242