Q1.

Two identical conducting spheres A and B carry equal charge Q, and are separated by a distance much larger than their diameters. Initially the electrostatic force between them is F. A third identical uncharged conducting sphere C is first touched to A, then to B, and then moved away. As a result of this, the electrostatic force between A and B becomes:

A) 3F/8
B) F/4
C) F/2
D) F/16
E) F

Ans:

The charge on A will be $\frac{Q}{2}$

The charge on B will be $\frac{3}{4}$ Q

$$F' = \frac{k\left(\frac{a}{2}\right)\left(\frac{3}{4}\right)Q}{r^2} = \frac{3}{8}\, k\frac{Q^2}{r^2} = \frac{3}{8}\, F$$

Q2.

A positively charged sphere of mass 1.00 g falls from rest from a height of 5.00 m, in a uniform electric field of magnitude 1.00×10^{4} N/C and is directed vertically downward. The sphere hits the ground with a speed of 20.0 m/s. What is the charge on the sphere?

A) + 3.02 μC
B) − 1.00 μC
C) + 5.23 μC
D) − 5.23 μC
E) + 1.00 μC

Ans:

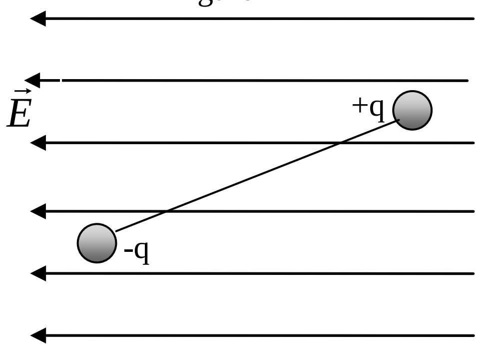
$$v_f^{\,2} = v_o^{\,2} + 2ay \Rightarrow a = \frac{v_f^{\,2}}{2y} = 40\ \mathrm{m/s^2}$$

$$F = ma = mg + qE \Rightarrow q = \frac{ma - mg}{E} = 3.02\times10^{-6}\ \mathrm{C}$$

Q3.

Figure 1 shows a dipole rotating under the effect of an electric field pointing along the negative x-axis. Which one of the following statements is TRUE

Figure 1



A) The potential energy of the dipole is decreasing.
B) The torque on the dipole is directed into of the page.
C) The dipole is rotating clockwise.
D) The work done on the dipole by the field is negative.
E) The dipole will stop when it is pointing parallel to the positive x-axis.

Ans:

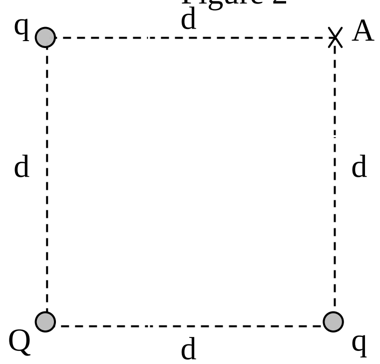
A

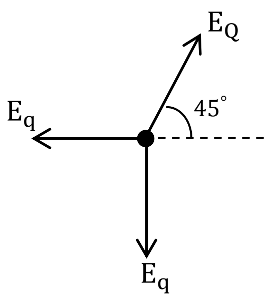
Q4.

Three point charges are located at the corners of a square as shown in Figure 2. Find the value of Q if the electric field at the corner A is zero. Take q = – 7.00 μC

A) 19.8 μC
B) 14.0 μC
C) 9.90 μC
D) 4.95 μC
E) 2.54 μC

Figure 2





Ans:

At A :

Q is positive

$$\left|E_Q \cos 45^0\right| = \left|E_q\right|$$

$$\frac{k|Q|}{(d^2 + d^2)} \cos 45^\circ = \frac{k|q|}{Q^2}$$

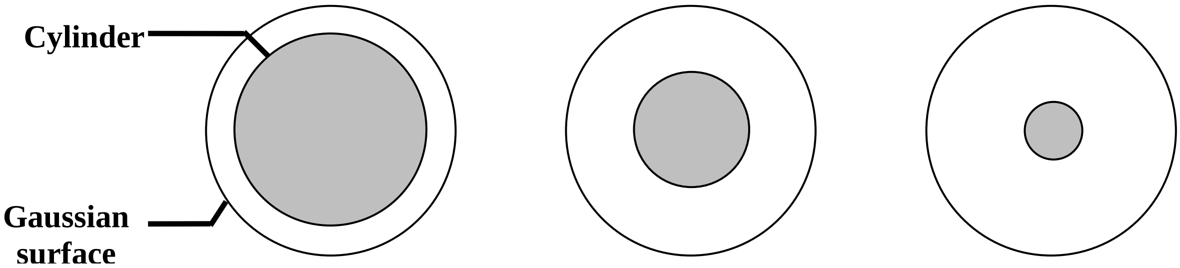
$$\frac{|Q|}{2} \cos 45^0 = |q|$$

$$\Rightarrow Q = 19.8\ \mu C$$

Q5.

Figure 3 a, b and c, show the cross sections of three cylinders each carrying a uniform charge Q. Concentric with each cylinder is a cylindrical Gaussian surface, all three with the same radius. Rank the Gaussian surfaces according to the electric field at any point on the surface, GREATEST FIRST.

Figure 3



(a) **(b)** **(c)**

Ans:

A) All tie
B) a, b, c
C) b, c, a
D) c, b, a
E) a, c, b

Q6.

A uniformly charged conducting sphere of 3.0 cm diameter has a surface charge density of 10 μC/m^2. Find the total electric flux leaving the surface of the sphere.

A) 3.2×10^{3} N.m^2/C
B) 1.3×10^{4} N.m^2/C
C) 2.5×10^{3} N.m^2/C
D) 1.4×10^{5} N.m^2/C
E) 6.7×10^{2} N.m^2/C

Ans:

$$\phi = \frac{q}{\epsilon_0} = \frac{\sigma A}{\epsilon_0}$$

$$= \frac{\sigma(4\pi r^2)}{\epsilon_0} = 3.2 \times 10^3 \text{ Nm}^2/\text{C}$$

Q7.

A 6.0 μC charge is placed on a thin spherical conducting shell of radius R = 5.0 cm. A particle with a charge of −10 μC is placed at the center of the shell. The magnitude and direction of the electric field at a point 2R from the center of the shell are:

A) 3.6×10^6 N/C, toward the center
B) 3.6×10^6 N/C, away from the center
C) 0
D) 5.4×10^6 N/C, toward the center
E) 5.4×10^6 N/C, away from the center

Ans:

$$E = \frac{k(6.0\mu C - 10\mu C)}{(2R)^2} = 3.6 \times 10^6 \text{ N/C}$$

Q8.

A long, straight wire has fixed negative charge with a linear charge density of magnitude 4.5 nC/m. The wire is enclosed by a coaxial, thin walled nonconducting cylindrical shell of radius 20 cm. The shell is to have a positive charge on its outside surface (with a surface charge density σ) that makes the net **electric** field at points 30 cm from the center of the shell equal to zero. Calculate σ.

A) 3.6×10^{-9} C/m^2
B) 3.0×10^{-10} C/m^2
C) 1.5×10^{-10} C/m^2
D) 4.5×10^{-7} C/m^2
E) 7.8×10^{-5} C/m^2

Ans:

$$E = \frac{\lambda_1}{2\pi\epsilon_0 r} + \frac{\lambda_2}{2\pi\epsilon_0 r} = 0$$

$$\lambda_1 = \lambda_2 = \frac{q}{l} = \frac{\sigma A}{l} = \frac{\sigma 2\pi R \not{l}}{\not{l}}$$

$$\Rightarrow \sigma = \frac{\lambda_1}{2\pi R} = \frac{4.5 \times 10^{-9}}{2\pi(0.2)}$$

$$= 3.6 \times 10^{-9} \text{ C}$$

Q9.

Two large metal plates of area 2.0 m^2 face each other, 6.0 cm apart, with equal charge magnitudes |q| but opposite signs. The magnitude of the electric field between the plates is 1.2×10^2 N/C. Find |q|.

A) 2.1 nC
B) 1.1 nC
C) 0.50 nC
D) 13 nC
E) 0.40 nC

Ans:

$$E = \frac{\sigma}{\epsilon_0} = \frac{q}{A\epsilon_0} \Rightarrow q = E(A\epsilon_0) = 2.1\ nC$$

Q10.

A glass sphere of diameter 1.00 mm has been charged to + 100 nC. A proton is fired from a large distance toward the sphere. What initial speed must the proton have to just reach the surface of the sphere? (Take V=0 at a large distance from the sphere)

A) 1.86×10^{7} m/s
B) 9.10×10^{7} m/s
C) 5.34×10^{6} m/s
D) 4.50×10^{9} m/s
E) 2.67×10^{6} m/s

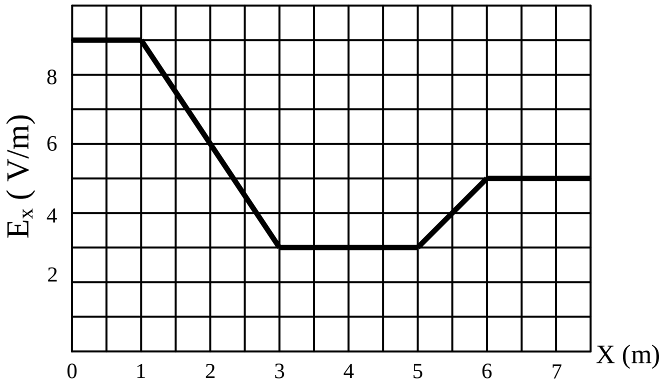
Ans:

$$\frac{1}{2}mv^2 = eV = e\frac{kq}{r} \Rightarrow v = \sqrt{\frac{2}{m}e\frac{kq}{r}}$$ (e is teh change of the electron)

Q11.

Figure 4 shows a plot for the electric field E_x as a function of x. Find the magnitude of the potential difference between the points x = 2.00 m and x = 6.00 m.

Figure 4



A) 14.5 V
B) 12.5 V
C) 10.0 V
D) 16.5 V
E) 11.0 V

Ans:

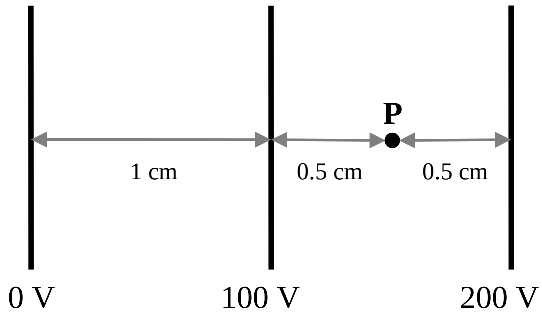
Area under the curve betwen x = 2 and x = 6 m

Q12.

What are the magnitude and direction of the electric field at point P in Figure 5?

Figure 5

A) 1.0×10^4 V/m to the left
B) 1.0×10^4 V/m to the right
C) 2.0×10^4 V/m to the left
D) 2.0×10^4 V/m to the right
E) 3.0×10^3 V/m upward



Ans:

$$E = -\frac{dV}{dx} = -\frac{\Delta V}{\Delta x} = -\frac{100}{1\ \text{cm}} = -10000\ \text{V/m}$$

Q13.

What is the charge on a conducting sphere of radius R = 0.20 m if the potential at a distance r = 0.10 m from the center of the sphere is 1500 V. (Take V = 0 at infinity).

A) 3.3×10^{-8} C
B) 1.7×10^{-8} C
C) 1.5×10^{-8} C
D) 2.5×10^{-8} C
E) 4.5×10^{-8} C

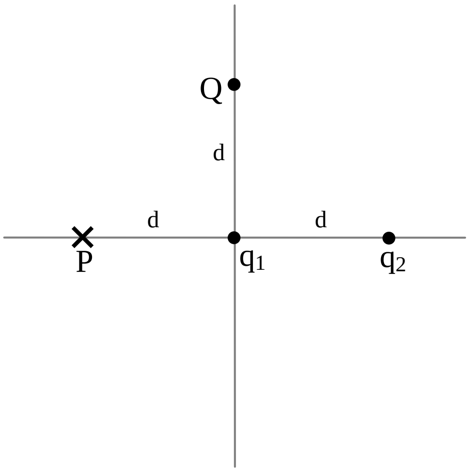
Ans:

$$V = k\frac{Q}{R} \Rightarrow Q = \frac{RV}{k}$$

Q14.

In Figure 6, particles with charges q_1 = + 10 μC and q_2 = – 30 μC are fixed in place with a separation of d = 24 cm. What is the value of Q that will make the potential equal zero at point P.

Figure 6



A) 7.1 μC
B) 5.1 μC
C) 10 μC
D) 3.5 μC
E) 4.5 μC

Ans:

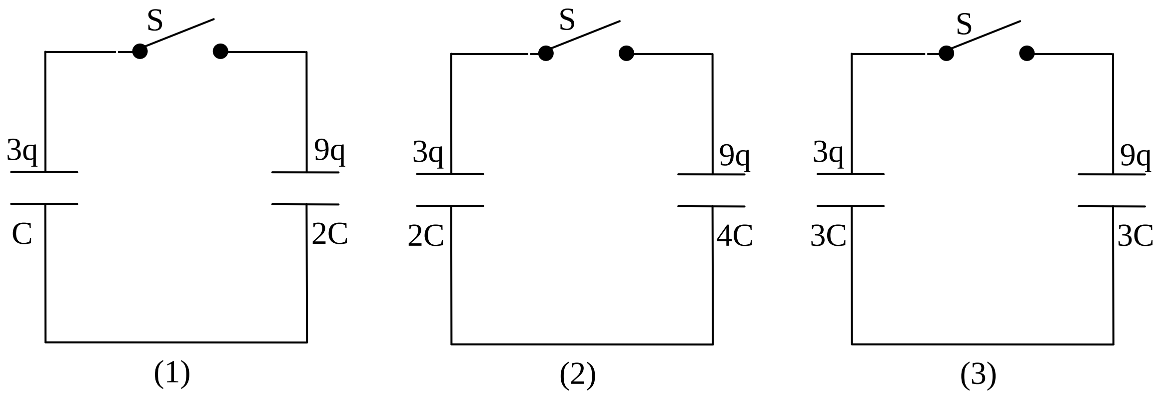
$$V = 0 = k\frac{q_1}{d} + k\frac{q_2}{2d} + k\frac{Q}{\sqrt{2}\,d}$$

$$Q = \left(-q_1 - \frac{q_2}{2}\right)\sqrt{2} = \left(-10 - \frac{-30}{2}\right)\sqrt{2} = 7.1\mu C$$

Q15.

Figure 7 shows three circuits, each consisting of a switch S and two capacitors, initially charged as indicated (top plate positive). After the switches have been closed, rank the charge on the right capacitor, GREATEST FIRST.

Figure 7



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

Ans:

A

Q16.

Two capacitors are identical except that one is filled with air and the other is filled with oil. Both capacitors carry the same charge. If E_{air} refers to the electric field inside the capacitor filled with air, and E_{oil} refers to the electric field inside the capacitor filled with oil, then the ratio of the electric fields E_{air}/E_{oil} will be:

A) greater than 1
B) less than 1
C) 0
D) 1
E) None of the other answers

Ans:

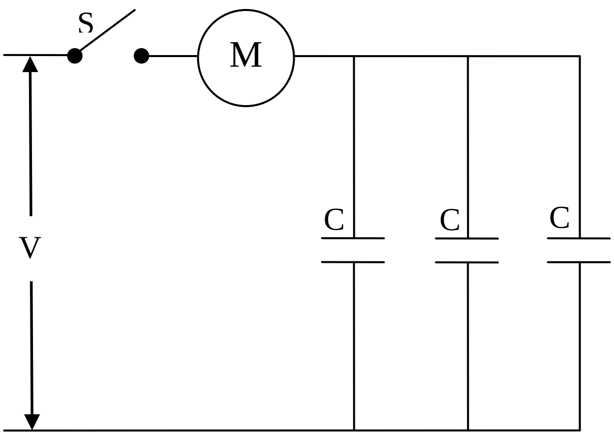
$$\frac{E_{air}}{E_{oil}} = \frac{\kappa_{oil}}{\kappa_{air}}$$

Q17.

Three identical capacitors are shown in Figure 8. A potential difference V = 10 kV is established when the switch S is closed. Find the value of the capacitance C if the charge that passes through the meter M is 0.20 C.

A) 6.7 μF
B) 20 μF
C) 1.6 μF
D) 13 μF
E) 2.5 μF

Figure 8



Ans:

$C_{eq} = 3C \Rightarrow 3C = \frac{q}{V}$

$= 2 \times 10^{-5}$ F

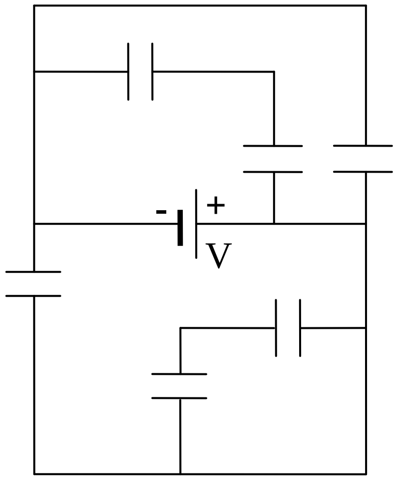
$\Rightarrow C = 6.7 \times 10^{-6}$ F

Q18.

Consider the circuit of identical capacitors shown in Figure 9. A potential difference of 2.0×10^{2} V is applied by the battery V. Calculate the energy stored in the system if the capacitance of each capacitor is 50 μF.

A) 3.0 J
B) 4.0 J
C) 6.0 J
D) 1.0 J
E) 7.0 J

Figure 9



Ans:

Take one branch : $C_{eq} = \frac{C}{2} + C = \frac{3}{2}C$

$E = \frac{1}{2} C_{eq} v^2$

For the whole circuit $E = 2\left(\frac{1}{2} C_{eq} v^2\right) = 3.0$ J

Q19.

A cylindrical resistor of radius 2.5 mm and length 4.0 cm is made of a material that has a resistivity of 3.5×10^{-5} Ω. m. What is the potential difference when the energy dissipation rate in the resistor is 1.0 W?

A) 0.27 V
B) 1.8 V
C) 2.2 V
D) 0.17 V
E) 1.1 V

Ans:

$$R = \rho\frac{L}{A} = 0.071\ \Omega$$

$$P = 1.0 = \frac{V^2}{R} \Rightarrow V = \sqrt{R} = 0.27\ \text{V}$$

Q20.

A 1.0-m-long wire has a resistance equal to 0.30 Ω. A second wire made of identical material has a length of 2.0 m and a mass equal to the mass of the first wire. What is the resistance of the second wire?

A) 1.2 Ω
B) 1.0 Ω
C) 3.4 Ω
D) 4.3 Ω
E) 5.6 Ω

Ans:

$$R_1 = \rho\frac{L_1}{A_1}, \qquad R_2 = \rho\frac{L_2}{A_2}, \quad \text{density} = \frac{m}{V} = \frac{m}{AL} \Longrightarrow A = \frac{V}{L}$$

$$\frac{R_2}{R_1} = \frac{L_2}{L_1}\frac{A_1}{A_2} = \frac{L_2}{L_1}\frac{V}{L_1}\frac{L_2}{V}$$

$$= \left(\frac{L_2}{L_1}\right)^2 = 4$$

$$R_2 = 4R_1 = 1.2\ \Omega$$

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

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

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

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

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

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

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

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

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

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

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

$$V = k\frac{q}{r}$$

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

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

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

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

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

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

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

$$I = JA$$

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

$$J = \sigma E$$

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

$$P = IV$$

$v = v_o + at$

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

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

<u>Constants:</u>

k = 9.00 × 10^9 $N.m^2/C^2$
ε_0 = 8.85 × 10^{-12} $C^2/N.m^2$
e = 1.60 × 10^{-19} C
m_e = 9.11 × 10^{-31} kg
m_p = 1.67 × 10^{-27} kg
g = 9.8 m/s^2

μ = micro = 10^{-6}
n = nano = 10^{-9}
p = pico = 10^{-12}