SAMPLE QUESTION BOOKLET

Q1A

Point charge $+q$ (C) moves from point P to point S along the path $PQRS$ in a uniform electric field $\vec{E} = E_0\hat{\imath}$ as shown in the figure, where $E_0 = 5\text{x}10^2\ \left(\frac{N}{C}\right), a = 3(cm)$ and $b = 4(cm)$. Which of the followings is the work done by the electric field in Joule?

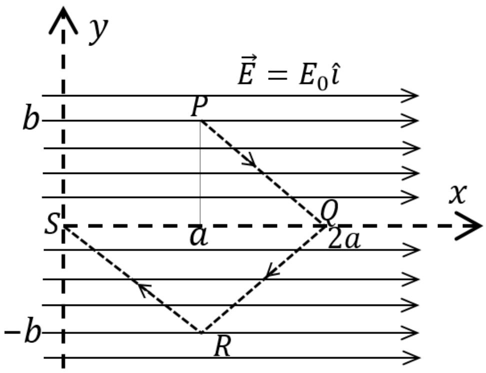
a) $-15q$

b) $-35q$

c) $-21q$

d) $-16q$

e) $-32q$



Q2B

Charge $+Q$ is distributed uniformly along the positive y-axis for $0 < y < a$, and charge $-Q$ is distributed uniformly along the negative y-axis for $-a < y < 0$ as shown in the figure.
What is the magnitude $|\vec{E}(x)|$ of the electric field on the x-axis for $x > 0$?

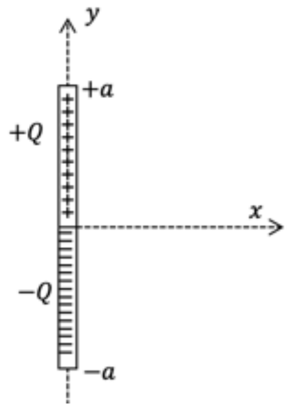
a) $\frac{2kQ}{a}\left(\frac{1}{x} - \frac{a}{(x^2+a^2)^{3/2}}\right)$

b) $\frac{2kQ}{a}\left(\frac{1}{x} - \frac{1}{(x^2+a^2)^{1/2}}\right)$

c) $\frac{2kQ}{a}\left(\frac{a}{x^2} - \frac{1}{(x^2+a^2)^{1/2}}\right)$

d) 0

e) $\frac{kQ}{2}\left(\frac{a}{(x^2+a^2)^{3/2}}\right)$



Q3D

Charge $+Q$ is distributed uniformly along the positive y-axis for $0 < y < a$, and charge $-Q$ is distributed uniformly along the negative y-axis for $-a < y < 0$ as shown in the figure.
What is the potential energy change of a negative point charge of $-q$ when it is displaced from $x = a$ to $x = 3a$.

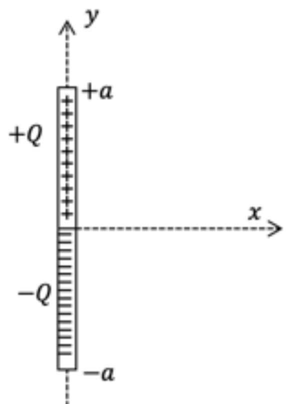
a) $-\frac{2kQq}{5a}$

b) $-\frac{kQq}{5a}$

c) $-\frac{2kQq}{a}\left(\frac{3-\sqrt{5}}{\sqrt{10}}\right)$

d) 0

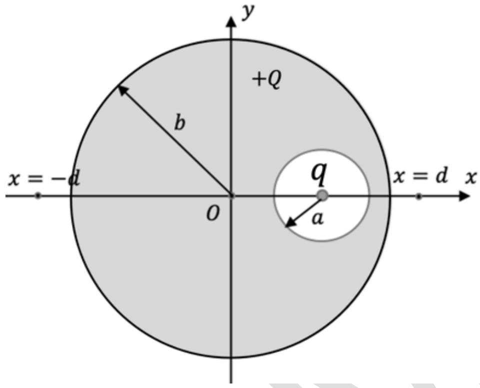
e) $-\frac{2kQq}{a}\left(\frac{1-\sqrt{5}}{\sqrt{10}}\right)$



Q4A

A solid conducting metal sphere of radius b and total charge $+Q$ has an empty spherical cavity of radius a. An unknown point charge q is placed at the center of the spherical cavity. The electric field at $x = +d$ is given by $\vec{E}(x = d) = -\frac{Q}{2\pi\varepsilon_0 d^2}\hat{\imath}$.

What is the electric field inside the metal $\vec{E}(r < b)$?



a) 0

b) $-\frac{3kQ}{r^2}\hat{r}$

c) $-\frac{2kQ}{r^2}\hat{r}$

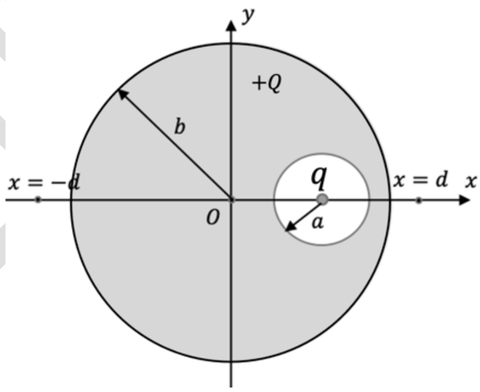
d) $-\frac{kQ}{r^2}\hat{r}$

e) $-\frac{4kQ}{r^2}\hat{r}$

Q5A

A solid conducting metal sphere of radius b and total charge $+Q$ has an empty spherical cavity of radius a. An unknown point charge q is placed at the center of the spherical cavity. The electric field at $x = +d$ is given by $\vec{E}(x = d) = -\frac{Q}{2\pi\varepsilon_0 d^2}\hat{\imath}$.

What is the electric field inside the cavity $\vec{E}(r < a)$?



a) $-\frac{3kQ}{r^2}\hat{r}$

b) $-\frac{4kQ}{r^2}\hat{r}$

c) $-\frac{5kQ}{r^2}\hat{r}$

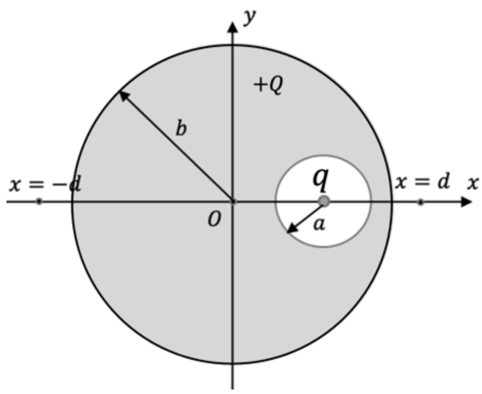
d) $-\frac{kQ}{r^2}\hat{r}$

e) $\frac{kQ}{r^2}\hat{r}$

Q6A

A solid conducting metal sphere of radius b and total charge $+Q$ has an empty spherical cavity of radius a. An unknown point charge q is placed at the center of the spherical cavity. The electric field at $x = +d$ is given by $\vec{E}(x = d) = -\frac{Q}{2\pi\varepsilon_0 d^2}\hat{\imath}$.

What is the charge density on the surface of the metal sphere $(r = b)$?



a) $-\frac{Q}{2\pi b^2}$

b) $-\frac{3Q}{4\pi b^2}$

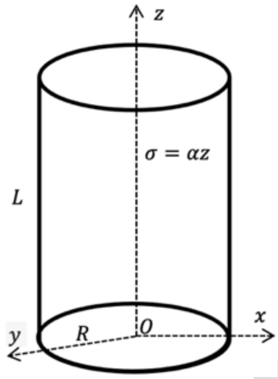
c) $-\frac{Q}{4\pi b^2}$

d) $-\frac{5Q}{4\pi b^2}$

e) $\frac{Q}{4\pi b^2}$

Q7A

The side surface of a thin cylindrical shell of length $L = R$ and radius R is nonuniformly charged. The surface charge density is given by $\sigma = \alpha z$, where α is a positive constant. The lower half of the cylinder has the total charge of Q. Which of the followings is the constant α?



a) $\frac{4Q}{\pi R^3}$

b) $\frac{4Q}{3\pi R^3}$

c) $\frac{Q}{4\pi R^3}$

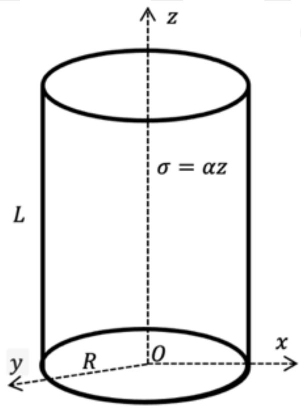
d) $\frac{Q}{\pi R^3}$

e) $\frac{Q}{3\pi R^3}$

Q8C

The side surface of a thin cylindrical shell of length L and radius R is nonuniformly charged with the surface charge density given by $\sigma = \alpha z$, where α is a positive constant.

What is the potential at the origin $V(r = 0)$.



a) $\frac{\alpha R}{\varepsilon_0}\left[(R^2 + L^2)^{1/2} - R\right]$

b) $\frac{\alpha R}{4\varepsilon_0}\left[(R^2 + L^2)^{1/2} - R\right]$

c) $\frac{\alpha R}{2\varepsilon_0}\left[(R^2 + L^2)^{1/2} - R\right]$

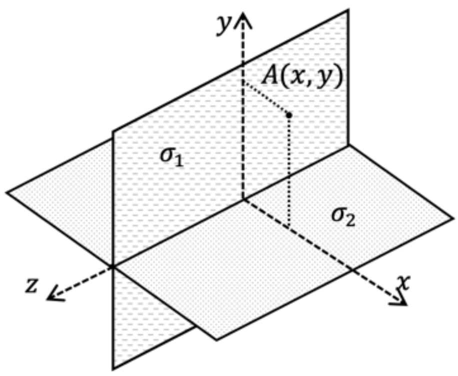
d) 0

e) $\frac{2\alpha R}{\varepsilon_0}\left[(R^2 + L^2)^{1/2} - R\right]$

Q9A

Two infinite plates of uniform surface charge densities are placed perpendicular to each other so that one with a charge density $\sigma_1 = -52.8\ (\frac{\mu C}{m^2})$ is in the yz-plane and the other with a charge density $\sigma_2 = +70.4\ (\frac{\mu C}{m^2})$ is in the xz-plane, as shown in the figure.

What is the electrostatic potential difference $\Delta V = V_C - V_B$ (V) between the points B(2,1,4) (cm) and C(1,3,6) (cm)? ($\varepsilon_0 = 8.8\text{x}10^{-12}(\frac{C^2}{Nm^2})$)



a) $-11\text{x}10^4$

b) $-55\text{x}10^3$

c) $-20\text{x}10^4$

d) $-50\text{x}10^3$

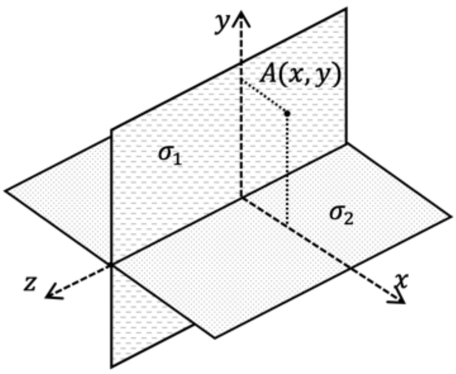
e) $-75\text{x}10^3$

Q10A

Two infinite plates of uniform surface charge densities are placed perpendicular to each other so that one with a charge density $\sigma_1 = -52.8\ (\frac{\mu C}{m^2})$ is in the yz-plane and the other with a charge density $\sigma_2 = +70.4\ (\frac{\mu C}{m^2})$ is in the xz-plane, as shown in the figure.

An electric dipole of dipole moment $\vec{P} = 2\hat{k}\ (\mu Cm)$ is placed at a point in the region of $(x > 0, y > 0)$. What is the torque acting on the dipole $\vec{\tau}$ (Nm)?

$(\varepsilon_0 = 8.8\text{x}10^{-12}(\frac{C^2}{Nm^2}))$.



a) $(-8\hat{\imath} - 6\hat{\jmath})$

b) $(-4\hat{\imath} - 3\hat{\jmath})$

c) $(-16\hat{\imath} - 8\hat{\jmath})$

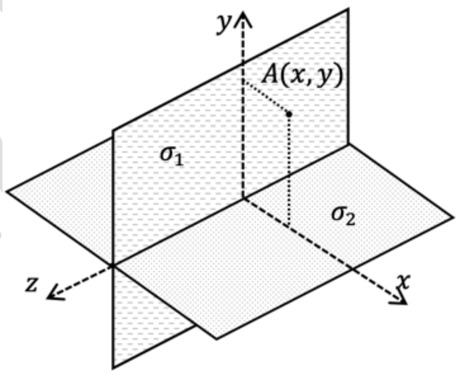
d) $(-4\hat{\imath} - 2\hat{\jmath})$

e) $(-6\hat{\imath} - 3\hat{\jmath})$

Q11A

Two infinite plates of uniform surface charge densities are placed perpendicular to each other so that one with a charge density $\sigma_1 = -52.8\ (\frac{\mu C}{m^2})$ is in the yz-plane and the other with a charge density $\sigma_2 = +70.4\ (\frac{\mu C}{m^2})$ is in the xz-plane, as shown in the figure. An electric dipole of dipole moment $\vec{P} = 2\hat{k}\ \mu Cm$ is placed at a point in the region of $(x > 0, y > 0)$.

How much work is done by the electric field on the dipole until it is aligned parallel to the electric field $\vec{E}(x, y)$ at the point A? $(\varepsilon_0 = 8.8\text{x}10^{-12}(\frac{C^2}{Nm^2}))$



a) 10 (J)

b) 5(J)

c) $8\sqrt{5}$ (J)

d) $2\sqrt{5}$(J)

e) $3\sqrt{5}$(J)

Q12A

Two identical parallel plate capacitors of plate area A and plate separation d with the capacitance $C_0 = 4.0\ (\mu F)$ are in series connected to a constant voltage $\Delta V = 16\ (V)$ as shown in the figure 1. The capacitors are fully charged.

A dielectric slab of dielectric constant $\kappa = 3.0$, thickness $d/3$ and the surface area A is placed between the plates of the capacitor C_2 as shown in the figure 2.

What is the charge stored in the capacitors (μC)?

Figure 1

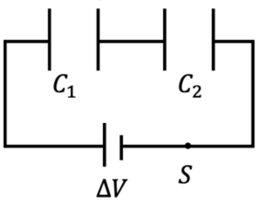
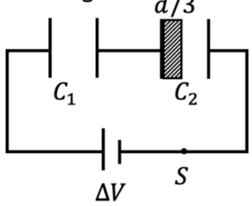


Figure 2



a) $Q = 36$

b) $Q = 24$

c) $Q = 18$

d) $Q = 48$

e) $Q = 54$

Q13D

The switch S is open, the capacitor $C_1 = C$ has charge Q, and the capacitor $C_2 = 2C$ is uncharged. The switch is closed at $t = 0$. Which of the followings is the charges on the capacitors as a function of time before the circuit reaches steady state situation ($t > 0$)?

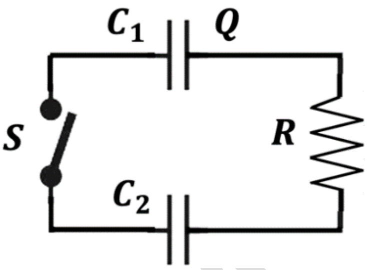
a) $q_1(t) = \frac{2}{3}Qe^{-\frac{3t}{2RC}} + \frac{Q}{3}$, $\quad q_2(t) = \frac{2}{3}Qe^{-3t/2RC}$

b) $q_1(t) = Qe^{-3t/2RC}$, $\quad q_2(t) = Q(1 - e^{-3t/2RC})$

c) $q_1(t) = \frac{1}{3}Qe^{-3t/2RC} + \frac{2Q}{3}$, $\quad q_2(t) = \frac{2}{3}Q(1 - e^{-3t/2RC})$

d) $q_1(t) = \frac{2}{3}Qe^{-3t/2RC} + \frac{Q}{3}$, $\quad q_2(t) = \frac{2}{3}Q(1 - e^{-3t/2RC})$

e $q_1(t) = \frac{2}{3}Qe^{-3t/2RC}$, $\quad q_2(t) = \frac{1}{3}Q(1 - e^{-3t/2RC})$



Q14A

The switch is open and capacitors are uncharged. At $t = 0$ the switch S is closed. Find the equivalent resistance of the circuit at $t = 0$.

$R_1 = 2R, R_2 = 2R, R_3 = R, R_4 = R, R_5 = R, C_1 = C, C_2 = C$

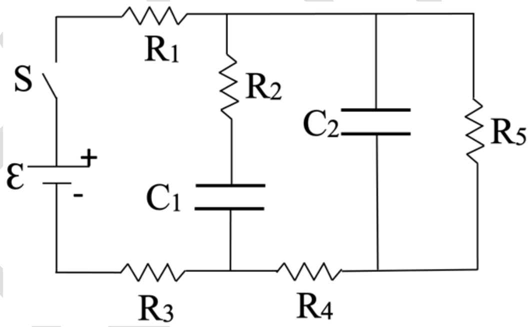
a) $\frac{11}{3}R$

b) $\frac{2}{3}R$

c) $\frac{6}{13}R$

d) R

e) $\frac{12}{19}R$



Q15A

The switch is open and capacitors are uncharged. At $t = 0$ the switch S is closed. Find the charge stored on the capacitor C_2 at steady state situation ($t \to \infty$).

$R_1 = 2R, R_2 = 2R, R_3 = R, R_4 = R, R_5 = 6R, C_1 = C, C_2 = C$

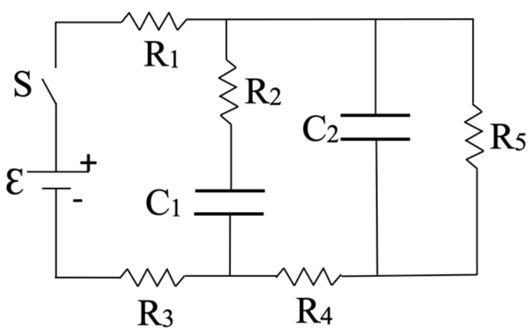
a) $\frac{3C\varepsilon}{5}$

b) $\frac{C\varepsilon}{3}$

c) $\frac{3C\varepsilon}{10}$

d) $\frac{C\varepsilon}{2}$

e) $\frac{5C\varepsilon}{9}$



Q16A

A potential difference of $\Delta V = 10$ volts is applied to the ends of a straight wire with cross section A length of $L = 1\ (m)$. The resistivity of the wire varies with $\rho(x) = (1 + x)$ (Ωm). Here x is the distance measured from one end of the wire in meters.

What is the magnitude of the electric field at the midpoint ($x = L/2$) of the wire, in (V/m)?

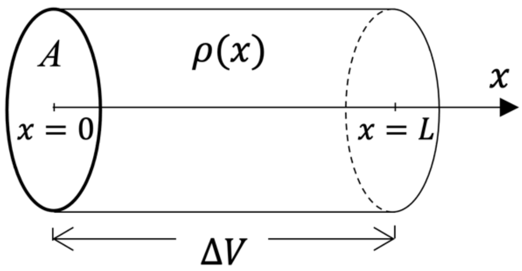
a) 10

b) 9.0

c) 30

d) 15

e) 20



Q17A

Two particles with charges $q_1 = -q$ and $q_2 = +2q$, and masses $m_1 = m$ and $m_2 = m$ are travelling with velocities $\vec{v}_1 = \vec{v}$ and $\vec{v}_2 = 3\vec{v}$ lying in the xy plane. The particles simultaneously enter at time $t = 0$ into a region of uniform magnetic field $\vec{B}$ which is perpendicular to the xy plane and is directed in the negative z direction, as shown in the figure. There is a large distance d between their points of entrance and the paths of particles do not intersect as they travel in the magnetic field. Gravitational and electrical forces are ignored. Which of the followings is the distance between the particles at their closest approach?

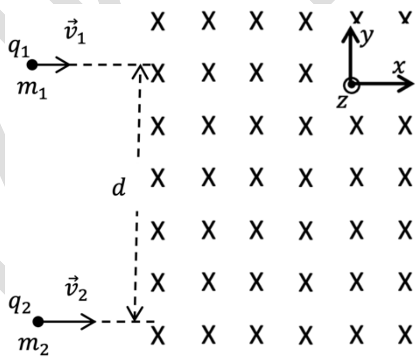
a) $d - \frac{5mv}{qB}$

b) $d - \frac{12mv}{qB}$

c) $d - \frac{43mv}{3qB}$

d) $d - \frac{26mv}{3qB}$

e) $d - \frac{18mv}{qB}$



Q18A

A current wire I is bent in to the shape given in the figure and placed in a varying magnetic field of $\vec{B} = B_0(1 + \frac{x}{a})\hat{\jmath}$. Where $I = 4.0\ (A)$, $B_0 = 3.5\ (T)$ and $a = 50\ (cm)$.

Which of the followings is the total force acting on current wire in Newton?

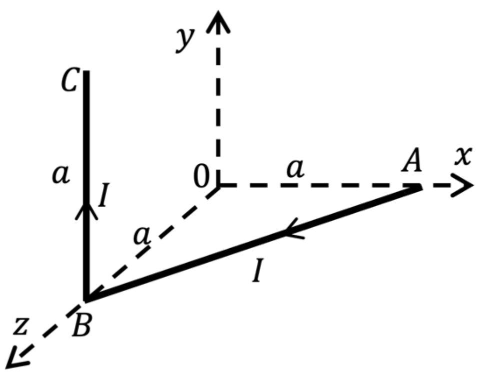
a) $10.5(-\hat{\imath} - \hat{k})$

b) $1.35(-\hat{\imath} - \hat{k})$

c) $8.10(-\hat{\imath} - \hat{k})$

d) $7.50(-\hat{\imath} - \hat{k})$

e) $13.5(-\hat{\imath} - \hat{k})$



Q19A

In the experiment of Electric Charges and Fields (Experiment 1), the mass of the conducting spheres and the separation between the center of the spheres are given as 3 (g) and 3 (cm). If the charges on each sphere calculated as 20 (nC), which of the following is the tangent of the measured vertical angle of deflection from the equilibrium position?

$\tan(\theta) = ?$

$(g = 10\frac{m}{s^2}, k = 9\text{x}10^9\ (\frac{Nm^2}{C^2}))$

a) $\frac{4}{3}\text{x}10^{-1}$

b) $\frac{9}{8}\text{x}10^{-1}$

c) $\frac{27}{4}\text{x}10^{-1}$

d) $\frac{3}{4}\text{x}10^{-1}$

e) $\frac{3}{2}\text{x}10^{-1}$

Q20E

In the experiment of Charging and Discharging a Capacitor (Experiment 2), the logarithm of the discharge current versus time graph represented as 1 in the figure. Assume that, later on one of the three parameters steady potential V, resistance R or capacitance C is changed, keeping the other two unchanged, in such a way that the graph represented by straight line 2 in the figure. Which of the followings is correct?

a) V decreased

b) V increased

c) R decreased

d) R increased

e) C decreased.