1. Which diagram best represents the field lines around a negative charge, \(-q\), and a positive charge, \(+2q\), as shown in the diagrams?

![Diagrams](diagrams.png)

Note: in all figures, the \(-q\) charge is on the left and the \(+2q\) is on the right.

2. Consider a closed Gaussian surface. Which of the following is false?

   a) If the total electric flux through the surface is zero, then the electric field must be zero everywhere on the surface.
   b) If there is no net charge enclosed by the surface, then the total electric flux through the surface is zero.
   c) If the total electric flux through the surface is zero, then the total charge enclosed by the surface is zero.
   d) If the electric field is zero everywhere on the surface, then there can be no net charge enclosed by the surface.
   e) If the electric field is zero everywhere on the surface, then the total electric flux through the surface is zero.

3. In an \(xyz\)-coordinate system, a plane of infinite extent with uniform surface charge density \(+\sigma\) lies in the \(xy\)-plane \((z=0)\). Which graph best represents the \(z\)-component of the electric field \(E\) vs. \(z\) along the \(z\)-axis?

![Graphs](graphs.png)

4. Consider a conductor in electrostatic equilibrium. Which of the following statements is false?

   a) The electric potential must be constant inside the conductor.
   b) The electric field at the surface cannot have a component parallel to the surface.
   c) Any net charge on the conductor must reside on the surface.
   d) No work is done by the electric field in moving a charge on the surface.
   e) The conductor cannot be given a net charge.

5. A charge of \(+1.0\ \mu\text{C}\) is placed at \(x = 0\). Where along the \(x\)-axis must a second charge of \(+4.0\ \mu\text{C}\) be placed so that the electric field at \(x = 10\ \text{cm}\) is zero?

   a) 60 cm
   b) 50 cm
   c) 30 cm
   d) 20 cm
   e) 40 cm
6. An empty hemispherical surface of radius 0.3 m is placed in a uniform electric field of 10 N/C. The field is oriented perpendicular to the flat circular bottom of the hemisphere as shown. The flux of electric field passing through the top curved surface is:

a) $5.7 \text{ Nm}^2/\text{C}$
b) $19 \text{ Nm}^2/\text{C}$
c) $2.8 \text{ Nm}^2/\text{C}$
d) $11 \text{ Nm}^2/\text{C}$
e) $0$

7. A rod containing charge $+Q$ is brought near an initially uncharged isolated conducting rod as shown. Regions with total surface charge $+Q$ and $-Q$ are induced in the conductor as shown in the Figure. The only regions where the net charge in this configuration is non-zero are indicated by the “+” and “−” signs. Let us denote the total flux of electric field outward through closed surface $S_1$ as $\Phi_1$, through $S_2$ as $\Phi_2$, etc. Which of the following is necessarily false.

a) $\Phi_2 = \Phi_1$
b) $\Phi_4 = 0$
c) $\Phi_3 = \Phi_1$
d) $\Phi_5 = \Phi_1$
e) $\Phi_1 > 0$

8. Two large parallel conducting plates are 10 cm apart and carry equal but opposite charges on their facing surfaces. An electron placed midway between the plates experiences a force of $3.2 \times 10^{-17}$ N. The potential difference between the plates is

a) $2000 \text{ V}$
b) $20 \text{ V}$
c) $40 \text{ V}$
d) $10 \text{ V}$
e) $200 \text{ V}$

9. Two charges, each of $+2.00 \text{ nC}$, are at $x=2.00 \text{ cm}$ and $x=-2.00 \text{ cm}$, on the $x$-axis, respectively. Relative to $V = 0$ at infinity, the electric potential at $y=5.00 \text{ cm}$ on the $y$-axis is:

a) $668 \text{ V}$
b) $719 \text{ V}$
c) $12,400 \text{ V}$
d) $334 \text{ V}$
e) $0$

10. A proton with a velocity of $\vec{v} = (1 \times 10^6 \text{ m/s})\hat{i}$ enters a region with a uniform electric field $\vec{E} = E_0\hat{i}$ and is observed to come to rest in 1 second. It is concluded that $E_0 =$

a) $-100 \text{ N/C}$
b) $-(1 \times 10^{-2}) \text{ N/C}$
c) $500 \text{ N/C}$
d) $-(4 \times 10^4) \text{ N/C}$
e) $(1 \times 10^{-2}) \text{ N/C}$

11. An infinitely long, straight metal rod has a radius of 0.03 m and a charge per unit length, $\lambda = 5 \times 10^{-9} \text{ C/m}$. Find the magnitude of electric field at a distance 0.15 m from the axis of the rod.

a) $3000 \text{ N/C}$
b) $600 \text{ N/C}$
c) $6 \text{ N/C}$
d) $30 \text{ N/C}$
e) $300 \text{ N/C}$

12. In the CRT display of a computer terminal, electrons are emitted from a source and impinge upon a fluorescent screen. If the potential difference between the source and the screen is $10^4 \text{ V}$, what is the velocity of an electron just before it hits the screen?

a) $(5.9 \times 10^7) \text{ m/s}$
b) $(8 \times 10^3) \text{ m/s}$
c) $(3.6 \times 10^{15}) \text{ m/s}$
d) $(1.8 \times 10^4) \text{ m/s}$
e) $(2.4 \times 10^5) \text{ m/s}$
3. Three particles of equal mass and having charges +Q, +2Q and −2Q are located at the corners of an equilateral triangle of edge length L. How much total work must be done by an external agent to separate completely the three particles from one another?

a) none of the others.
b) −2kQ^2/L
c) −4kQ^2/L
d) 8kQ^2/L
e) 4kQ^2/L

4. Two tiny aluminum-foil balls of mass 10.0g each are suspended from the same point with weightless strings that are 50.0 cm long. When equal charges q are given to each ball, they repel and then come to equilibrium with their centers 50.0 cm apart. The value of q and the tension in the string are respectively.

a) 2.17 µC, 0.196 N
b) 1.65 µC, 0.196 N
c) 1.65 µC, 0.113 N
d) 1.25 µC, 0.113 N
e) 0.627 µC, 0.125 N

Take g = 9.80 m/s^2

5. A charge of +6.00 µC is placed at (x, y) = (+1.00 cm, 0), and a charge of −6.00 µC is placed at (x, y) = (−1.00 cm, 0). What is the magnitude and direction of the force on a charge of +3.00 µC located at (x,y) = (0, +1.00 cm)?

a) +16200 N
b) −16200 N
c) +11460 N
d) −5730 N
e) −11460 N

16. The electrostatic potential in a region of space is given by

\[ V(x, y) = (324x^2 - 425y) \text{ V} \]

The electric field at the point (2, 2) is:

a) \((850\hat{i} + 425\hat{j}) \text{ N/C}\)
b) \((-1296\hat{i} + 425\hat{j}) \text{ N/C}\)
c) \((1296\hat{i} - 425\hat{j}) \text{ N/C}\)
d) \((648\hat{i} - 850\hat{j}) \text{ N/C}\)
e) \((1296\hat{i} - 850\hat{j}) \text{ N/C}\)

17. A uniformly charged insulated rod extends along the x-axis from x = 1m to x = 4m, and carries a total charge of +12 nC. The electric field at a point y = 5m on the y axis has an x-component given by

a) \(-180 \int_1^4 \frac{dx}{(x^2 + 25)^{3/2}} \text{ N/C}\)
b) \(-72 \int_1^4 \frac{dx}{(x+5)^2} \text{ N/C}\)
c) \(-36 \int_1^4 \frac{dx}{(x^2 + 25)^{3/2}} \text{ N/C}\)
d) \(-108 \int_1^4 \frac{dx}{(x^2 + 25)} \text{ N/C}\)
e) \(-36 \int_1^4 \frac{dx}{x^2 + 25} \text{ N/C}\)
8. A nonconducting sphere with radius $a$ is concentric with and surrounded by a conducting spherical shell with inner radius $b$ and outer radius $c$. The inner sphere has a negative charge uniformly distributed throughout its volume, while the spherical shell has no net charge. The potential $V(r)$ as a function of distance from the center is given by

- a) $V(r)$
- b) $V(r)$
- c) $V(r)$
- d) $V(r)$
- e) $V(r)$