Problem 1, 2 Two particles, each with charge +Q, are located at the opposite corner of a square of side d. Given Q = 15 nC and d = 0.5 m, what is the magnitude of electric field at point P?

A) 611 N/C  
B) 324 N/C  
C) 458 N/C  
D) 764 N/C  
E) 540 N/C

What is the direction of the electric field at point P?

A) up  
B) down  
C) 45 ° CCW from the +x axis  
D) -135 ° CW from the +x axis  
E) left

Problem 3 A small ball with charge Q is suspended by a string of length L in a uniform electric field E as shown in the figure. If the ball is in equilibrium when the string makes an angle θ with the vertical, what is the tension force on the string?

A) \( T = EQL/\tan\theta \)  
B) \( T = EQ/\sin\theta \)  
C) \( T = EQ^2/\sin^2\theta \)  
D) \( T = g\cos\theta/\ ER \)  
E) \( T = EQ/L\sin\theta \)

Problem 4 A wire having a uniform linear charge density \( \lambda \) is bent into the shape shown in the figure. Find the electric potential at point \( O \). (Use the following as necessary: \( R \), \( k_e \) and \( \lambda \)).

A) \( K_e\lambda(\pi+\ln5) \)  
B) \( K_e\lambda(\pi+\ln9) \)  
C) \( K_e\lambda(\pi+\ln4) \)  
D) \( K_e\lambda\ln4 \)  
E) \( K_e\lambda(\pi+4) \)

\[
\int x^n \, dx = \frac{1}{n+1} x^{n+1}
\]

\[
\int \frac{1}{x} \, dx = \ln |x|
\]
**Problem 5** A sphere of radius $2a$ with a spherical cavity of radius $a$ is made of a nonconducting material that has a uniform volume charge density $\rho (>0)$. The magnitude of electric field at the location $(0, -2a)$ is

A) $68k\pi pa/27$
B) $k\pi pa^2/27$
C) $3k\pi pa/19$
D) $12k\pi \rho a^2/27$
E) $23k\pi pa/27$

**Problem 6** A small styrofoam ball with a layer of metallic coating is lowered into the gap between two large metal plates. A large potential difference $V$ is kept between the two plates. What will be the motion of the Styrofoam ball?

A) Styrofoam ball has no net charge, so it will not move
B) Move to the positive plate, then stick to the plate
C) Move to the negative plate, then stick to the plate
D) Oscillate back and forth between two plates
E) None of above

**Problem 7** Two parallel plates are separated by 0.1 mm. A 10 V potential difference is maintained between those plates. If a proton is released from the positive plate, calculate the kinetic energy of the proton when it reaches the negative plate.

A) $3.7\times10^{-18}$ J
B) $1.6\times10^{-18}$ J
C) $1.1\times10^{-18}$ J
D) $4.6\times10^{-18}$ J
E) $4.0\times10^{-18}$ J

**Problem 8** A long straight metal rod has a radius of 5.4 cm and a charge per unit length of 33.2 nC/m. Find the electric field at 13.0 cm from the axis of the rod, where distances is measured perpendicular to the rod’s axis.

A) 1343 N/C
B) 3572 N/C
C) 5487 N/C
D) 4592 N/C
E) 2921 N/C
Problem 9  At distance $r$ from a point charge $q$, the electric potential is 800 V and the magnitude of the electric field is 260 N/C. Determine the value of $q$.

A) $2.7 \times 10^{-7}$ C  
B) $4.5 \times 10^{-7}$ C  
C) $8.3 \times 10^{-7}$ C  
D) $2.1 \times 10^{-9}$ C  
E) $6.3 \times 10^{-8}$ C

Problem 10, 11 A solid conducting sphere is surrounded by a larger concentric, spherical, conducting shell. The solid sphere has a net charge of $-3Q$ ($Q>0$), and the outer shell has a net charge of $+Q$. The charges are in electrostatic equilibrium. What are the amount of charges accumulating on the surface of solid sphere, the inner surface of the conducting shell, and the outer surface of the shell?

A) 0, -3Q, +4Q  
B) -Q, +Q, -2Q  
C) -3Q, 0, +Q  
D) -3Q, +3Q, Q  
E) -3Q, +3Q, -2Q

What is the magnitude and direction of the electric field outside the conducting shell?

A) $|E| = \frac{kQ}{r^2}$, pointing away from the shell  
B) $|E| = \frac{kQ}{r^2}$, pointing towards the shell  
C) $|E| = \frac{4kQ}{r^2}$, pointing towards the shell  
D) $|E| = \frac{2kQ}{r^2}$, pointing away from the shell  
E) $|E| = \frac{2kQ}{r^2}$, pointing toward the shell

Problem 12 The electrostatic potential generated by multiple charges, is the vector addition of the potentials generated by individual charges.

(A) True  
(B) False

Problem 13 Inside a conductor, the electric field and potential are both zero.

(A) True  
(B) False

Problem 14 An electric field line points to the direction of lower electric potential.

(A) True  
(B) False

Problem 15 The magnitude of force required to bring a charge $q$ from point $A$ to point $B$ is $|qV_{BA}|$.

(A) True  
(B) False

Problem 16 The electric field just outside a charged conductor is perpendicular to the surface and has a magnitude $\frac{\sigma}{2\varepsilon_0}$.

(A) True  
(B) False

Problem 17 A proton carries positive charge, and weights much heavier than an electron.

(A) True  
(B) False

Problem 18 The force on a negative charge is in the opposite direction of the electric field.

(A) True  
(B) False