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PH106 Exam 1a - key Sept. 14, 2012

1. You have three metal spheres with the same net charge Q. The spheres have radii R, 2R, and 3R. Which sphere gives the largest electric field at a distance r = 4R from its center?

(a) sphere with radius R  (b) sphere with radius 2R  (c) sphere with radius 3R  (d) same for all

Depends only on distance from center.

2. In what region(s) along the line can the electric field be zero? (I = left of q1, II = between q1 and q2, III = right of q2)

(a) I  (b) II  (c) III  (d) I and II  (e) II and III

I: |E1| > |E2|  II: E1 and E2 in same direction  III: |E1| = |E2|/when r1^2 = r2^2

3. Which of the following statements is false regarding an isolated conductor in equilibrium?

(a) Any excess charge resides on the surface.
(b) The electric field is zero everywhere inside the conductor.
(c) More charge per unit area collects on the sharper parts of the surface than on the flatter parts.
(d) The electric field just outside the surface is greater near the flatter parts than near the sharper parts.
(e) The electric field just at the surface is perpendicular to the surface.

4. In the figure S_a and S_b represent surfaces that enclose unknown charges. For S_a, \( \int \mathbf{E} \cdot d\mathbf{A} = 1 \times 10^5 \, \text{N} \cdot \text{m}^2 / \text{C} \), and for S_b, \( \int \mathbf{E} \cdot d\mathbf{A} = -3 \times 10^5 \, \text{N} \cdot \text{m}^2 / \text{C} \). What is q_2?

(a) 0.89 \, \mu\text{C}  (b) -3.5 \, \mu\text{C}  (c) 2.7 \, \mu\text{C}  (d) 5.2 \, \mu\text{C}  (e) zero

\( q_1 = \varepsilon_0 \Phi_a, \) \( q_1 + q_2 = \varepsilon_0 \Phi_b \) Solve for \( q_1 \) and \( q_2 \).

5. A charged particle with mass 0.2 g can be balanced in a region where there is a 5000 V/m electric field directed upward. What is the charge?

(a) 0.4 \, \mu\text{C}  (b) 1 \, \mu\text{C}  (c) 1 \, \text{nC}  (d) 25 \, \text{nC}  (e) none of these

\( qE = mg \)
6. A solid metal sphere of radius \( R_1 \) is in the center of a hollow metal sphere of inner radius \( R_2 \) and outer radius \( R_3 \). The inner sphere has a net charge \(+2Q\) and the hollow sphere has a net charge \( Q\). What is the amount of charge on the outer surface of the hollow sphere?

(a) \( Q \)  (b) \(-Q\)  (c) \(+2Q\)  (d) \(-2Q\)  (e) none of these

\[ Q_{in} = -2Q, \quad Q_{in} + Q_{out} = Q, \quad Q_{out} = -Q_{in} + Q = 3Q \]

7. Which plot below best represents the electric field as a function of distance from the center of the spheres in the above problem?

\[ E = 0 \text{ in metal. } E = k \frac{Q}{r^2} \text{ for } R_1 < r < R_2, \quad E = k \frac{3Q}{r^2} \text{ for } r > R_3 \]

8. A coaxial cable consists of a thin inner cylinder with charge density \( 2 \times 10^9 \text{ C/m} \) at the center of a thin cylindrical shell of radius 10 cm with uniform charge density \(-6 \times 10^9 \text{ C/m} \). What is the electric field 8 cm from the center of the cylinders? (+ if radially out and – if radially in)

(a) 900 N/C  (b) -1350 N/C  (c) 450 N/C  (d) 360 N/C  (e) -250 N/C

\[ E = k \frac{2\lambda_1}{r} \]
9. What is the electric field 15 cm from the center?
   (a) -960 N/C  (b) -720 N/C  (c) 450 N/C  (d) 1440 N/C  (e) 480 N/C
   
\[ E = k \frac{2(\lambda_1 + \lambda_2)}{r} \]

10. The electric field 10 cm from an infinitely large plane with uniform charge density is 900 N/C. What is the electric field 30 cm from the plane?
   (a) 300 N/C  (b) 100 N/C  (c) 450 N/C  (d) 900 N/C  (e) 2700 N/C
   
\[ E = \sigma / 2\varepsilon_0, \text{ independent of position} \]

11. A car with a flat roof 1.5 m wide and 2 m long travels up a 30° slope where there is a vertical electric field of strength 200 V/m. What is the magnitude of the electric flux through the roof?
   (a) 600 N·m²/C  (b) 173 N·m²/C  (c) 300 N·m²/C  (d) 250 N·m²/C  (e) 520 N·m²/C
   
\[ \Phi_E = EA\cos\theta \]

12. What is the magnitude of the electric field at the origin?
   (a) 7.5 x 10⁴ N/C  (b) 1.5 x 10⁵ N/C  (c) 5.4 x 10⁵ N/C
   (d) 8.8 x 10³ N/C  (e) 2.3 x 10⁴ N/C
   
\[ E_1 = k \frac{q_1}{r_1^2}, \quad E_2 = k \frac{|q_2|}{r_2^2}, \quad E = \sqrt{E_1^2 + E_2^2} \]

13. What is the direction of the electric field with respect to the x-axis?
   (a) 56°  (b) 34°  (c) -45°  (d) 124°  (e) -67°
   
\[ \theta = \tan^{-1} \left( \frac{E_1}{E_2} \right) \]

14. An insulating sphere of radius R has a uniform charge density. If the field at the surface is E, then what is the field inside the sphere a distance R/2 from its center?
   (a) 4E  (b) 2E  (c) E  (d) E/2  (e) E/4
   
\[ E = k \frac{q r}{R^3} \]