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\[ Q_e = -1.60 \times 10^{-19} \text{ C} \quad Q_p = +1.60 \times 10^{-19} \text{ C} \quad m_e = 9.11 \times 10^{-31} \text{ kg} \quad m_p = 1.67 \times 10^{-27} \text{ kg} \]

**Question 1:** WRITE THE FORM DESIGNATOR FOR THIS EXAM (A) IN THE ANSWER BOX FOR QUESTION #1 ON THE FIRST PAGE OF THE EXAM BOOKLET.

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2. A particle with a positive charge +q is unable to move and located at \((x, y) = (0, d)\) where \(q > 0\) and \(d > 0\). A particle with a negative charge -q is unable to move and located at \((x, y) = (0, -d)\). In which direction would an electron accelerate if it was located at \((x, y) = (L, 0)\) where \(L > 0\)?
   (A) the +x direction (B) the -x direction (C) the +y direction (D) the -y direction

3. A spherical conductor of radius 1.00 m has excess charge on its surface, the density of which is 1.00 C/m². What is the magnitude of the electric field at a point 9.00 m from its surface and 10.0 m from its center?
   (A) 1.13 \times 10^9 \text{ N/C} (B) 1.40 \times 10^9 \text{ N/C} (C) 9.00 \times 10^9 \text{ N/C} (D) 1.13 \times 10^{10} \text{ N/C}.

4. Four identical particles of charge +Q are equally spaced along one straight line. The distance between adjacent charges is \(d\). What is the magnitude of the electric force on the charges on the ends?
   (A) \(KQ^2/d^2\) (B) \(3KQ^2/6d^2\) (C) \(11KQ^2/(6d^2)\) (D) \(49KQ^2/(36d^2)\) (E) \(107KQ^2/(49d^2)\).

5. One mole (6.022 \times 10^{23}) of excess protons is uniformly distributed over the surface of a 1.00 m radius sphere. What is the surface charge density on the sphere?
   (A) 7670 \text{ C/m}^2 (B) 15300 \text{ C/m}^2 (C) 30700 \text{ C/m}^2.

6. A wire's linear charge density as a function of the distance from the origin is given as \(\lambda = cx^2\), where \(x\) is the distance from the origin and \(c\) is a constant. The wire extends from the origin to \(x = d\). What is the total amount of charge contained in the wire?
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7. **Four Point Charges** (25 pts.)

Four point charges are arranged as shown in the diagram with one charge at each corner of a square. What is the net electric force, both magnitude and direction, on the charge is the lower left corner? $q = 8.00 \text{ nC}$ and $d = 5.00 \text{ cm}$. 

Hint: Use symmetry.

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Two thin curved insulators are each bent into the shape of a semicircle and placed end-to-end to form a circle. The insulator on the left has a positive charge of $+q_1$ uniformly distributed along its length. The insulator on the right has a negative charge of $-q_2$ uniformly distributed along its length. The radius of the circle is $A$. What is the electric field, both magnitude and direction, at the center of the circle? Hint: Use symmetry.

9. **Electric Field Inside an Insulator** (25 pts.)

A spherical insulator has constant charge density, total charge $Q > 0$, and radius $B$. What is the magnitude of the electric field at a distance $B/2$ from the center of the sphere? Give the answer in terms of $Q$, $B$, and $K$, where $K$ is the constant from Coulomb's law. Hint: Use Gauss's law.

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**Question 1:** WRITE THE FORM DESIGNATOR FOR THIS EXAM (B) IN THE ANSWER BOX FOR QUESTION #1 ON THE FIRST PAGE OF THE EXAM BOOKLET.

Questions 2-6 (5 points each) Multiple Choice. You will be graded on your answer only. It is not necessary to show your work for these problems. Put the answer for each question in the proper numbered box on the first page of your test booklet.

2. A wire's linear charge density as a function of the distance from the origin is given as \( \lambda = cx^2 \), where \( x \) is the distance from the origin and \( c \) is a constant. The wire extends from the origin to \( x = d \). What is the total amount of charge contained in the wire? (A) \( cd^3 \) (B) \( cd^3 \)/2 (C) \( cd^3 \)/3 (D) \( cd^3 \)/4 (E) \( cd^3 \)/5.

3. A particle with a positive charge \( +q \) is unable to move and located at \( (x, y) = (0, d) \) where \( q > 0 \) and \( d > 0 \). A particle with a negative charge \( -q \) is unable to move and located at \( (x, y) = (0, -d) \). In which direction would an electron accelerate if it was located at \( (x, y) = (L, 0) \) where \( L > 0 \)? (A) the +x direction (B) the -x direction (C) the +y direction (D) the -y direction

4. A spherical conductor of radius 1.00 m has excess charge on its surface, the density of which is 1.00 C/m². What is the magnitude of the electric field at a point 9.00 m from its surface and 10.0 m from its center? (A) 1.13 \times 10^9 \text{ N/C} (B) 1.40 \times 10^9 \text{ N/C} (C) 9.00 \times 10^8 \text{ N/C} (D) 1.13 \times 10^10 \text{ N/C}.

5. Four identical particles of charge \( +Q \) are equally spaced along one straight line. The distance between adjacent charges is \( d \). What is the magnitude of the electric force on the charges on the ends? (A) \( KQ^2/d^2 \) (B) \( 3KQ^2/4d^2 \) (C) \( 11KQ^2/3(6d^2) \) (D) \( 49KQ^2/(36d^2) \) (E) \( 107KQ^2/(49d^2) \).

6. One mole (\( 6.022 \times 10^{23} \)) of excess protons is uniformly distributed over the surface of a 1.00 m radius sphere. What is the surface charge density on the sphere? (A) 7670 C/m² (B) 15300 C/m² (C) 30700 C/m².

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7. **Four Point Charges** (25 pts.)

Four point charges are arranged as shown in the diagram with one charge at each corner of a square. What is the net electric force, both magnitude and direction, on the charge is the lower left corner? \( q = 8.00 \text{ nC} \) and \( d = 5.00 \text{ cm} \). Hint: Use symmetry.

8. **Two Thin Curved Insulators** (25 pts.)

Two thin curved insulators are each bent into the shape of a semicircle and placed end-to-end to form a circle. The insulator on the left has a positive charge of \( +q_1 \) uniformly distributed along its length. The insulator on the right has a negative charge of \( -q_2 \) uniformly distributed along its length. The radius of the circle is \( A \). What is the electric field, both magnitude and direction, at the center of the circle? Hint: Use symmetry.

9. **Electric Field Inside an Insulator** (25 pts.)

A spherical insulator has constant charge density, total charge \( Q > 0 \), and radius \( B \). What is the magnitude of the electric field at a distance \( B/2 \) from the center of the sphere? Give the answer in terms of \( Q, B, \) and \( K \), where \( K \) is the constant from Coulomb's law. Hint: Use Gauss's law.

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**Question 1:** WRITE THE FORM DESIGNATOR FOR THIS EXAM (C) IN THE ANSWER BOX FOR QUESTION #1 ON THE FIRST PAGE OF THE EXAM BOOKLET.

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2. One mole (6.022 \times 10^{23}) of excess protons is uniformly distributed over the surface of a 1.00 m radius sphere. What is the surface charge density on the sphere? (A) 7670 C/m^2 (B) 15300 C/m^2 (C) 30700 C/m^2.

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5. A spherical conductor of radius 1.00 m has excess charge on its surface, the density of which is 1.00 C/m^2. What is the magnitude of the electric field at a point 9.00 m from its surface and 10.0 m from its center? (A) \( 1.13 \times 10^9 \) N/C (B) \( 1.40 \times 10^9 \) N/C (C) \( 9.00 \times 10^9 \) N/C (D) \( 1.13 \times 10^{10} \) N/C.

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Question 1: WRITE THE FORM DESIGNATOR FOR THIS EXAM (D) IN THE ANSWER BOX FOR QUESTION #1 ON THE FIRST PAGE OF THE EXAM BOOKLET.

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2. Four identical particles of charge +Q are equally spaced along one straight line. The distance between adjacent charges is d. What is the magnitude of the electric force on the charges on the ends?
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5. A particle with a positive charge +q is unable to move and located at \((x, y) = (0, d)\) where \( q > 0 \) and \( d > 0 \). A particle with a negative charge -q is unable to move and located at \((x, y) = (0, -d)\). In which direction would an electron accelerate if it was located at \((x, y) = (L, 0)\) where \( L > 0 \)?
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