Four Identical Charges Particles Of Charge 1Uc, 2Uc,3Uc And 4Ucare Placed At X = Lm, X=2m,x=3m Andx=5m.

Four Identical Charges Particles Of Charge 1Uc, 2Uc, 3Uc And 4Uc are placed at X = Lm, X=2m, X=3m, and X=5m. This configuration presents an interesting scenario in electrostatics, involving multiple charges positioned at different points along a straight line. Understanding the forces, potential energies, and equilibrium conditions in such a system is essential for students and professionals working in physics, electrical engineering, and related fields. In this article, we explore the behavior of these charges, analyze the electric forces acting upon them, and discuss the principles governing their interactions.

Introduction to Electric Charges and Coulomb's Law

Basic Concepts of Electric Charge

- Electric Charge (Q): A fundamental property of matter that causes it to experience a force when placed in an electric field.
- Units of Charge: Coulombs (C), with common charges being microcoulombs (μC), where 1 μC = 1×10^{-6} C.
- Types of Charges: Positive and negative; in this scenario, all charges are positive.

Coulomb’s Law

Coulomb's Law describes the electrostatic force between two point charges:

$$
F = k_e \frac{|q_1 q_2|}{r^2}
$$

Where:
- F is the magnitude of the force between charges,
- k_e is Coulomb's constant ($8.99 \times 10^9\, \mathrm{Nm}^2/\mathrm{C}^2$),
- q_1, q_2 are the magnitudes of the charges,
- r is the distance between the charges.

This law indicates that like charges repel, and the force magnitude varies inversely with the square of the distance between charges.

System Configuration and Parameters

Positions of Charges

The charges are placed along a straight line at specified positions:

Charge	Magnitude (U)	Position (m)
q_1	1 μC	$x = L$
q_2	2 μC	$x = 2$
q_3	3 μC	$x = 3$
q_4	4 μC	$x = 5$

Note: The value of L is a variable; for practical calculations, it can be assigned a specific value or treated symbolically.

Assumptions and Simplifications

- All charges are point charges.
- The medium is vacuum or air, with dielectric constant ε_0.
- The system is static; charges are fixed in position.
- No other external electric fields are present.

Calculating Electric Forces Between the Charges

Pairwise Interactions

For each pair of charges, the force can be calculated using Coulomb's Law. Since all charges are positive, the forces are repulsive.

Example: Force between q_1 at $x = L$ and q_2 at $x = 2$ m:

$$
F_{12} = k_e \frac{(1 \times 10^{-6})(2 \times 10^{-6})}{(x_2 - x_1)^2}
$$

where $x_1 = L$, $x_2 = 2$, and the distance $r_{12} = |2 - L|$.

Similarly, forces between other pairs are computed as:

- F_{13} between q_1 and q_3,
- F_{14} between q_1 and q_4,
- F_{23} between q_2 and q_3,
- F_{24} between q_2 and q_4,

- F_{34} between q_3 and q_4.

Direction of Forces

- For all pairs, forces are directed away from each other due to repulsion.
- The net force on any charge is the vector sum of all individual forces exerted by the other charges.

Calculating Net Force on Each Charge

Net Force on q_1 at $x = L$

- Sum of forces exerted by q_2, q_3, q_4 on q_1.
- Each force's magnitude calculated from Coulomb's Law.
- Directions determined based on positional relationships; all are repulsive, pushing q_1 away from other charges.

Net Force on q_2 at $x=2$ m

- Sum of forces due to q_1, q_3, q_4.
- Consider the attractive or repulsive directionality based on positions.

Net Force on q_3 at $x=3$ m

- Sum of forces from q_1, q_2, q_4.

Net Force on q_4 at $x=5$ m

- Sum of forces from q_1, q_2, q_3.

Note: Because all charges are positive, the net forces tend to push each charge away from the others, possibly leading to equilibrium or instability depending on the configurations.

Potential Energy of the System

Electrostatic Potential Energy

The total potential energy U of a system of point charges is given by:

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U = \sum_{i