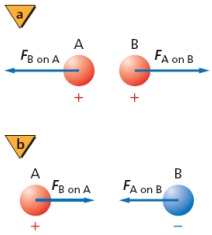
Coulomb's Law
Universal Gravitation

Objectives

- Demonstrate the forces exerted by charged objects
- Summarize the relationship between charges and distance
- Solve problems using Coulomb's law and the universal law of gravitation

Forces and Charges

- Charges exert forces
- What factors influence force?



Coulomb's Law

- $F = K\frac{q_a q_b}{r^2}$
- $K = 9.0x10^9\ \frac{N \cdot m^2}{C^2}$

Coulomb's Law

- Force depends on charge and distance
- Unit for charge is Coulomb (C)
- Electron has a charge of $-1.60x10^{-19}$ C
- Proton has a charge of $+1.60x10^{-19}$ C

Practice Problem 1

- Two electrons in an atom are separated by $1.5x10^{-10}$ m.
  - What is the electric force between them? ($q_{electron}$ = $-1.60x10^{-19}$ C) $+1.0x10^{-8}$ N
  - What does this positive force indicate?
  - What would a negative force indicate?

Practice Problem 2

- Two spheres each have a charge of 4.5×10^{-5} C. If the force between them is 6.2×10^{-2} N, what is the distance that separates them? 17 m

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Practice Problem 3

- Sphere A has a charge of -3.0 μC and sphere B has a charge of +6.0 μC. If the spheres are separated by 4.0 cm, what is the force between the two? -1.0×10^{2} N

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Problem 4
Interpreting the Equation

- Charges $\mathbf{q_A}$ and $\mathbf{q_B}$ are separated by a distance **r** and exert a force **F** on each other. Identify what new force would exist under the following conditions:
  - $\mathbf{q_A}$ is doubled — 2 F
  - $\mathbf{q_A}$ and $\mathbf{q_B}$ are each cut in half — F / 4
  - **r** is tripled — F / 9
  - **r** is cut in half — 4 F

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Universal Gravitation

- $F = G\frac{m_1 m_2}{r^2}$
- $G = 6.67x10^{-11}\frac{N \cdot m^2}{kg^2}$

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Practice Problem 5

- Two students are sitting side by side. Penelope has a mass of 57 kg. Mateo has a mass of 73 kg. What is the gravitational force between the two students if they are sitting 51 cm apart? 1.1×10^{-6} N

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Practice Problem 6

- What is the gravitational force between Penelope (57 kg) and the earth when she is at the earth's surface? ($m_{earth} = 5.98 \times 10^{24}$ kg; average $r_{earth} = 6.37 \times 10^{6}$ m) 560 N

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Practice Problem 7

- Use the law of universal gravitation to show *why* the acceleration due to gravity at the earth's surface is 9.80 m/s^2.