# Unit Exam I: Problem #1 (Spring '09)

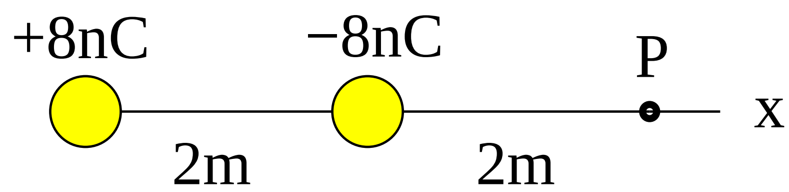
Consider two point charges positioned on the $x$-axis as shown.

(a) Find magnitude and direction of the electric field at point P.

(b) Find the electric potential at point P.

(c) Find the electric potential energy of an electron (mass $m = 9.1 \times 10^{-31}$kg, charge $q = -1.6 \times 10^{-19}$C) when placed at point P.

(d) Find magnitude and direction of the acceleration the electron experiences when released at point P.




**Solution:**

(a) $E_x = +k\frac{8\text{nC}}{(4\text{m})^2} + k\frac{(-8\text{nC})}{(2\text{m})^2} = 4.5\text{N/C} - 18\text{N/C} = -13.5\text{N/C}$ (directed left).

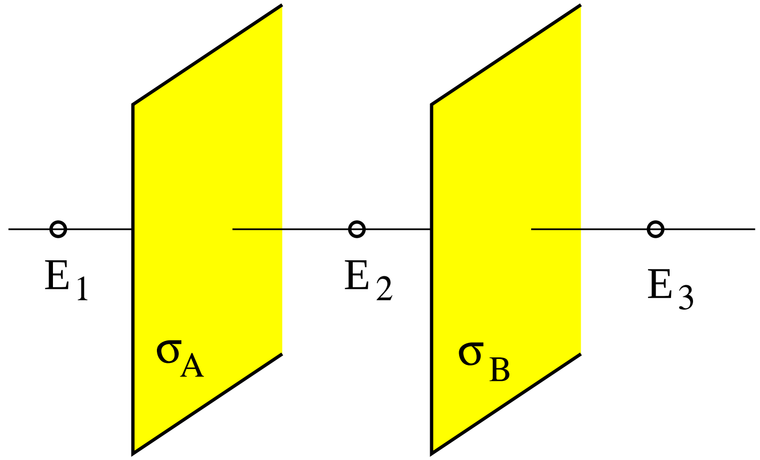
(b) $V = +k\frac{8\text{nC}}{4\text{m}} + k\frac{(-8\text{nC})}{2\text{m}} = 18\text{V} - 36\text{V} = -18\text{V}.$

(c) $U = qV = (-18\text{V})(-1.6 \times 10^{-19}\text{C}) = 2.9 \times 10^{-18}\text{J}.$

(d) $a_x = \frac{qE_x}{m} = \frac{(-1.6 \times 10^{-19}\text{C})(-13.5\text{N/C})}{9.1 \times 10^{-31}\text{kg}} = 2.4 \times 10^{12}\text{ms}^{-2}$ (directed right).

# Unit Exam I: Problem #2 (Spring '09)

Consider two very large uniformly charged parallel sheets as shown. The charge densities are $\sigma_A = +7 \times 10^{-12}\mathrm{Cm}^{-2}$ and $\sigma_B = -4 \times 10^{-12}\mathrm{Cm}^{-2}$, respectively. Find magnitude and direction (left/right) of the electric fields $\mathbf{E}_1$, $\mathbf{E}_2$, and $\mathbf{E}_3$.




**Solution:**

$$E_A = \frac{|\sigma_A|}{2\epsilon_0} = 0.40\mathrm{N/C}$$ (directed away from sheet A).

$$E_B = \frac{|\sigma_B|}{2\epsilon_0} = 0.23\mathrm{N/C}$$ (directed toward sheet B).

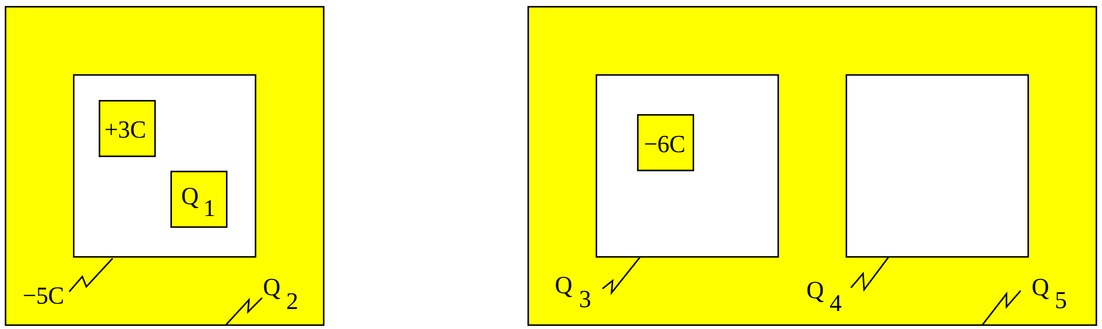
$$E_1 = E_A - E_B = 0.17\mathrm{N/C}$$ (directed left).

$$E_2 = E_A + E_B = 0.63\mathrm{N/C}$$ (directed right).

$$E_2 = E_A - E_B = 0.17\mathrm{N/C}$$ (directed right).

(a) Consider a conducting box with no net charge on it. Inside the box are two small charged conducting cubes. For the given charges on the surface of one cube and on the inside surface of the box find the charges $Q_1$ on the surface of the other cube and $Q_2$ on the outside surface of the box.

(b) Consider a conducting box with two compartments and no net charge on it. Inside one compartment is a small charged conducting cube. For the given charge on the surface of the cube find the charges $Q_3$, $Q_4$, and $Q_5$ on the three surfaces of the box.




(a) (b)

**Solution:**

(a) Gauss's law implies $Q_1 + 3\text{C} + (-5\text{C}) = 0 \quad \Rightarrow \quad Q_1 = +2\text{C}$.
Net charge on the box: $Q_2 + (-5\text{C}) = 0 \quad \Rightarrow \quad Q_2 = +5\text{C}$.

(b) Gauss's law implies $Q_3 + (-6\text{C}) = 0 \quad \Rightarrow \quad Q_3 = +6\text{C}$.
Gauss's law implies $Q_4 = 0$.
Net charge on box: $Q_3 + Q_4 + Q_5 = 0 \quad \Rightarrow \quad Q_5 = -6\text{C}$.