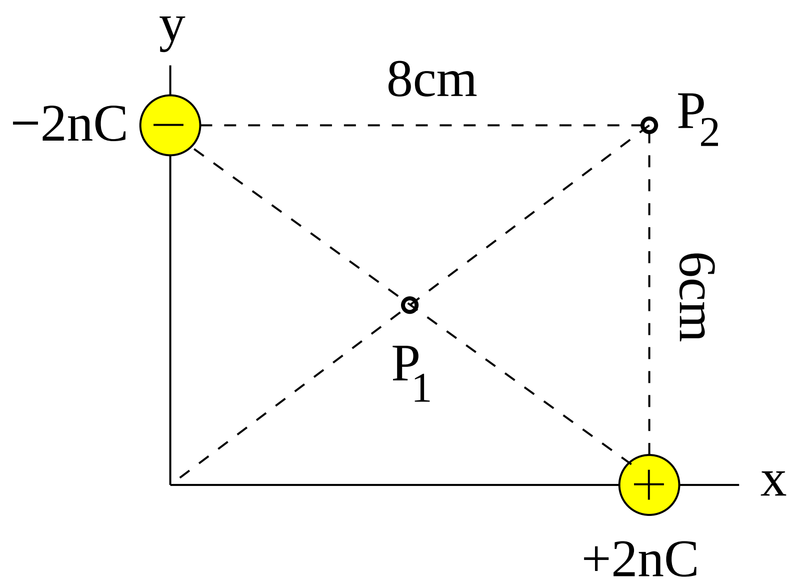
Unit Exam I: Problem #1 (Spring '12)

Consider two point charges at the positions shown.
(a) Find the magnitude E of the electric field at point P_1.
(b) Find the components E_x and E_y of the electric field at point P_2.
(c) Draw the direction of the electric field at points P_1 and P_2 in the diagram.
(d) Calculate the potential difference $\Delta V = V_2 - V_1$ between point P_2 and P_1.



Solution:

(a) $E = 2k\dfrac{2\text{nC}}{(5\text{cm})^2} = 1.44 \times 10^4\text{N/C}.$

(b) $E_x = -k\dfrac{2\text{nC}}{(8\text{cm})^2} = -2.81 \times 10^3\text{N/C}.$

$E_y = k\dfrac{2\text{nC}}{(6\text{cm})^2} = 5.00 \times 10^3\text{N/C}.$

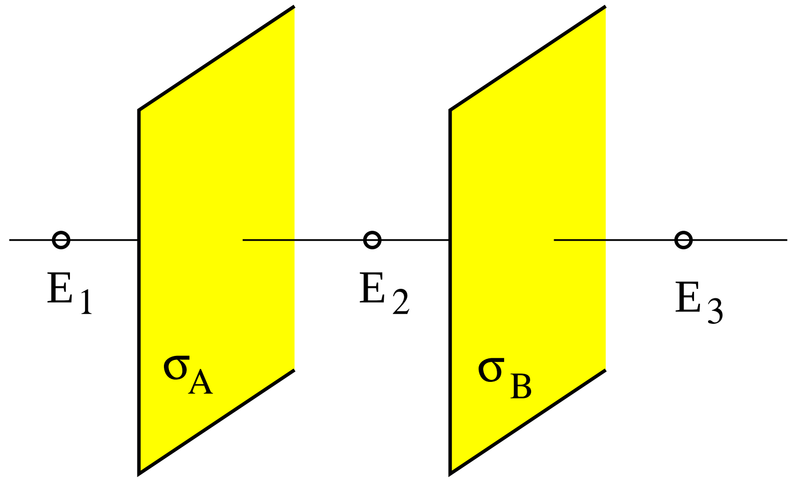
(c) $\mathbf{E}_1$ up and left toward negative charge; $\mathbf{E}_2$ more up and less left

(d) $\Delta V = V_2 - 0 = k\dfrac{2\text{nC}}{6\text{cm}} + k\dfrac{-2\text{nC}}{8\text{cm}} = 300\text{V} - 225\text{V} = 75\text{V}.$

Unit Exam I: Problem #2 (Spring '12)

Two very large, thin, uniformly charged, parallel sheets are positioned as shown.
Find the values of the charge densities (charge per area), σ_A and σ_B, if you know the electric fields $\mathbf{E}_1$, $\mathbf{E}_2$, and $\mathbf{E}_3$.

Consider two situations.
(a) $E_1 = 2\text{N/C}$ (directed left), $E_2 = 0$, $E_3 = 2\text{N/C}$ (directed right).
(b) $E_1 = 0$, $E_2 = 2\text{N/C}$ (directed right), $E_3 = 0$.

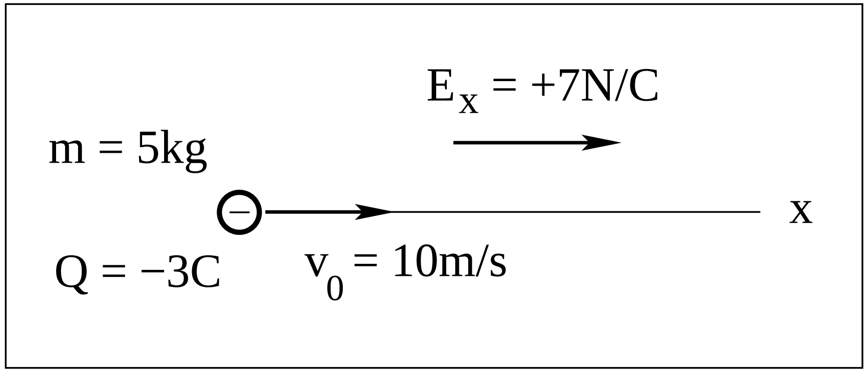


Solution:

(a) The two sheets are equally charged:
$\sigma_A = \sigma_B = 2\epsilon_0(1\text{N/C}) = 1.77 \times 10^{-11}\text{C/m}^2.$

(b) The two sheets are oppositely charged:
$\sigma_A = -\sigma_B = 2\epsilon_0(1\text{N/C}) = 1.77 \times 10^{-11}\text{C/m}^2.$

Consider a region of uniform electric field $E_x = +7$N/C. A charged particle (charge $Q = -3$C, mass $m = 5$kg) is launched at time $t = 0$ from initial position $x = 0$ with velocity $v_0 = 10$m/s in the positive x-direction. Ignore gravity.
(a) Find the force F_x acting on the particle at time $t = 0$.
(b) Find the force F_x acting on the particle at time $t = 3$s.
(c) Find the kinetic energy of the particle at time $t = 0$.
(d) Find the kinetic energy of the particle at time $t = 3$s.
(e) Find the work done on the particle between $t = 0$ and $t = 3$s.



Solution:

(a) $F_x = QE_x = (-3\mathrm{C})(7\mathrm{N/C}) = -21\mathrm{N}.$

(b) no change from (a).

(c) $K = \frac{1}{2}(5\mathrm{kg})(10\mathrm{m/s})^2 = 250\mathrm{J}.$

(d) $v_x = v_0 + a_x t = v_0 + (F_x/m)t = 10\mathrm{m/s} + (-21\mathrm{N}/5\mathrm{kg})(3\mathrm{s}) = -2.6\mathrm{m/s}.$

$K = \frac{1}{2}(5\mathrm{kg})(-2.6\mathrm{m/s})^2 = 16.9\mathrm{J}.$

(e) $W = \Delta K = 16.9\mathrm{J} - 250\mathrm{J} = -233\mathrm{J}.$