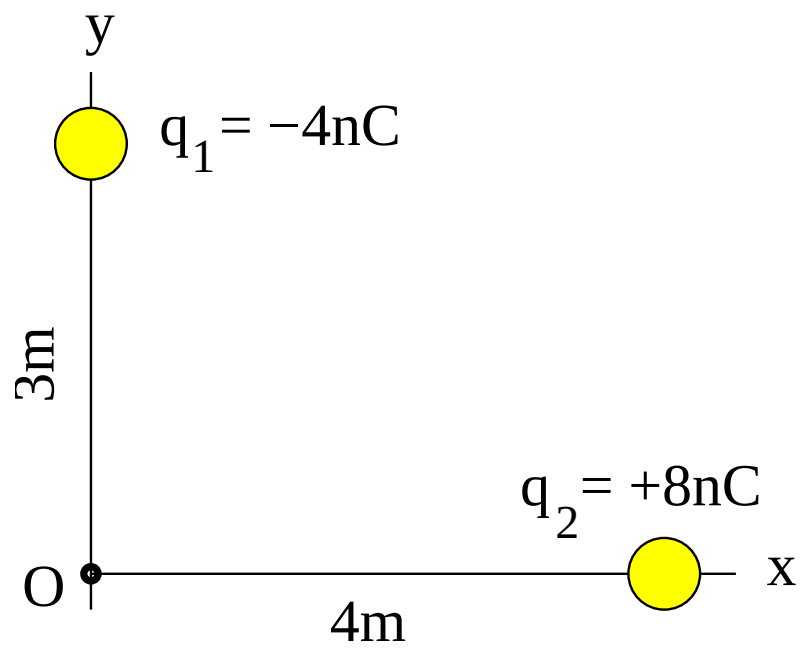
Unit Exam I: Problem #1 (Spring '08)

Consider two point charges positioned in the xy-plane as shown.

(a) Find the magnitude F of the force between the two charges.
(b) Find the components E_x and E_y of the electric field at point O.
(c) Find the electric potential V at point O.
(d) Find the potential energy U of charge q_2 in the presence of charge q_1.



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Solution:

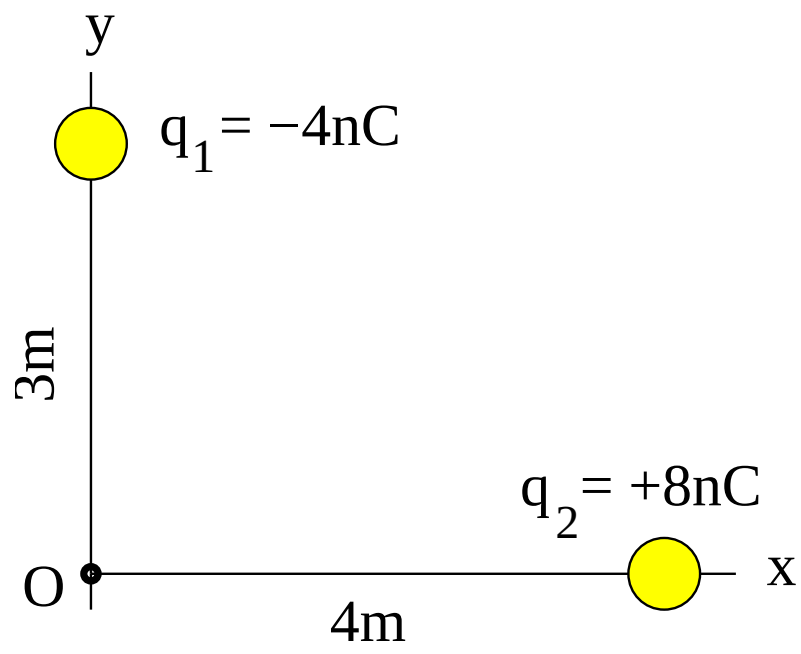
(a) $F = k\dfrac{|q_1 q_2|}{(5\mathrm{m})^2} = 1.15 \times 10^{-8}\mathrm{N}.$

(b) $E_x = -k\dfrac{|q_2|}{(4\mathrm{m})^2} = -4.5\,\mathrm{N/C},$

$E_y = +k\dfrac{|q_1|}{(3\mathrm{m})^2} = +4.0\,\mathrm{N/C}.$

(c) $V = k\dfrac{q_2}{4\mathrm{m}} + k\dfrac{q_1}{3\mathrm{m}} = 18\mathrm{V} - 12\mathrm{V} = 6\mathrm{V}.$

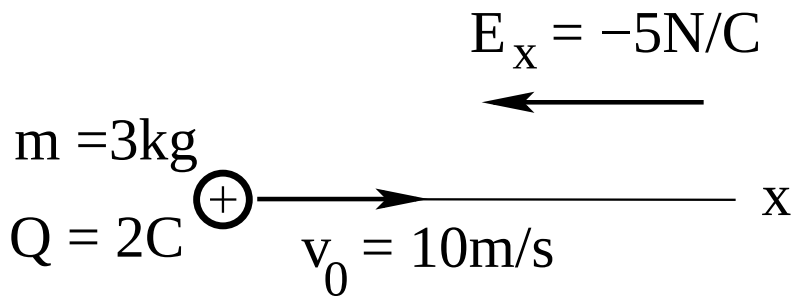
(d) $U = k\dfrac{q_1 q_2}{5\mathrm{m}} = -57.6\mathrm{nJ}.$



Unit Exam I: Problem #2 (Spring '08)

Consider a region of uniform electric field $E_x = -5$N/C. A charged particle (charge $Q = 2$C, mass $m = 3$kg) is launched from initial position $x = 0$ with velocity $v_0 = 10$m/s in the positive x-direction.

(a) Find the (negative) acceleration a_x experienced by the particle.
(b) Find the time t_s it takes the particle to come to a stop.
(c) Find the position x_s of the particle at time t_s.
(d) Find the work W done by the electric field to bring the particle to a stop.



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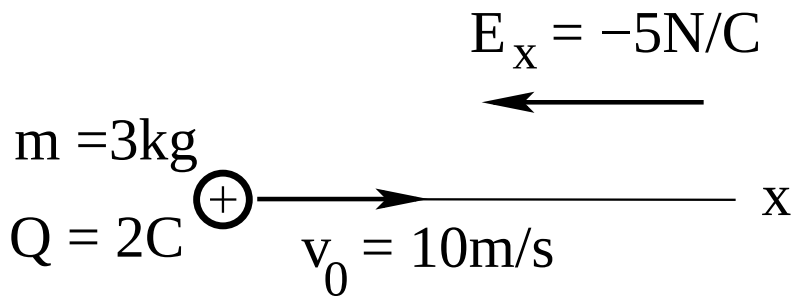
Solution:

(a) $a_x = \dfrac{2\text{C}}{3\text{kg}}(-5\text{N/C}) = -3.33\text{m/s}^2.$

(b) $t_s = \dfrac{v_0}{|a_x|} = 3.00\text{s}.$

(c) $x_s = \dfrac{v_0^2}{2|a_x|} = 15.0\text{m}.$

(d) $W = \Delta K = -\dfrac{1}{2}mv_0^2 = -150\text{J}.$



Unit Exam I: Problem #3 (Spring '08)

Consider a conducting spherical shell of inner radius $r_{int} = 3$m and outer radius $r_{ext} = 5$m. The net charge on the shell is $Q_{shell} = 7\mu$C.

(a) Find the charge Q_{int} on the inner surface and the charge Q_{ext} on the outer surface of the shell.

(b) Find the direction (left/right/none) of the electric field at points A, B, C.

Now place a point charge $Q_{point} = -3\mu$C into the center of the shell ($r = 0$m).

(c) Find the charge Q_{int} on the inner surface and the charge Q_{ext} on the outer surface of the shell.

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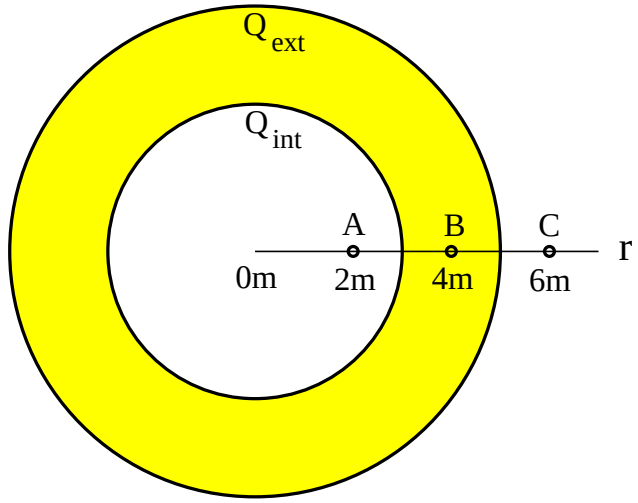

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(c) Find the charge Q_{int} on the inner surface and the charge Q_{ext} on the outer surface of the shell.

(d) Find the direction (left/right/none) of the electric field at points A, B, C.

Solution:

(a) $Q_{int} = 0, \quad Q_{ext} = 7\mu\text{C}.$

(b) A: none, B: none, C: right.

(c) $Q_{int} = 3\mu\text{C}, \quad Q_{ext} = 4\mu\text{C}.$

(d) A: left, B: none, C: right.