Intermediate Exam I: Problem #1 (Spring '06)

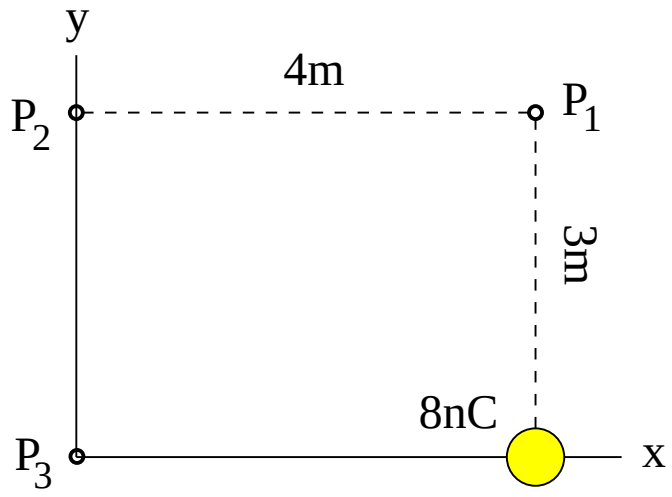
Consider a point charge $q = +8\text{nC}$ at position $x = 4\text{m}$, $y = 0$ as shown.

(a) Find the electric field components E_x and E_y at point P_1.

(b) Find the electric field components E_x and E_y at point P_2.

(c) Find the electric potential V at point P_3.

(d) Find the electric potential V at point P_2.



Solution:

(a) $E_x = 0, \qquad E_y = k\dfrac{8\text{nC}}{(3\text{m})^2} = 7.99\text{N/C}.$

(b) $E_x = -k\dfrac{8\text{nC}}{(5\text{m})^2}\cos\theta = -2.88\text{N/C} \times \dfrac{4}{5} = -2.30\text{N/C}.$

$E_y = k\dfrac{8\text{nC}}{(5\text{m})^2}\sin\theta = 2.88\text{N/C} \times \dfrac{3}{5} = 1.73\text{N/C}.$

(c) $V = k\dfrac{8\text{nC}}{4\text{m}} = 17.98\text{V}.$

(d) $V = k\dfrac{8\text{nC}}{5\text{m}} = 14.38\text{V}.$

Intermediate Exam I: Problem #2 (Spring '06)

Consider a conducting sphere of radius $r_1 = 1$m and a conducting spherical shell of inner radius $r_2 = 3$m and outer radius $r_3 = 5$m. The charge on the inner sphere is $Q_1 = -0.6\mu$C. The net charge on the shell is zero.

(a) Find the charge Q_2 on the inner surface and the charge Q_3 on the outer surface of the shell.

(b) Find magnitude and direction of the electric field at point A between the sphere and the shell.

(c) Find magnitude and direction of the electric field at point B inside the shell.

(d) Find magnitude and direction of the electric field at point C outside the shell.

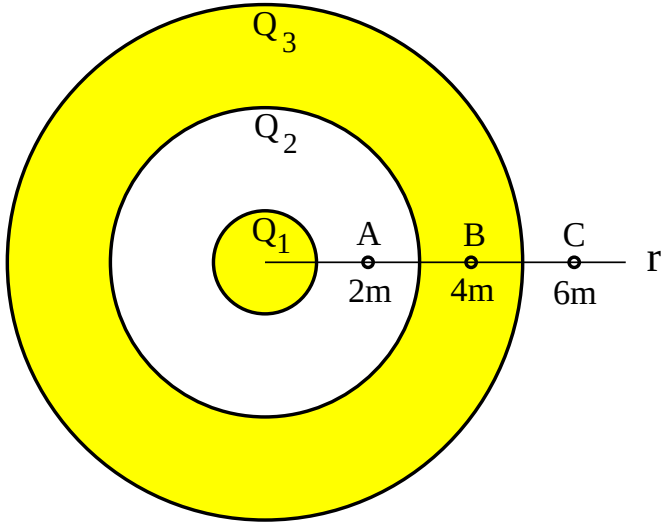
Solution:

(a) Gauss' law implies that $Q_2 = -Q_1 = +0.6\mu$C. Given that $Q_2 + Q_3 = 0$ we infer $Q_3 = -0.6\mu$C.

(b) $E_A = k\dfrac{0.6\mu\mathrm{C}}{(2\mathrm{m})^2} = 1349\mathrm{N/C}$ (inward).

(c) $E_B = 0$ inside conductor.

(d) $E_C = k\dfrac{0.6\mu\mathrm{C}}{(6\mathrm{m})^2} = 150\mathrm{N/C}$ (inward).



Intermediate Exam I: Problem #3 (Spring '06)

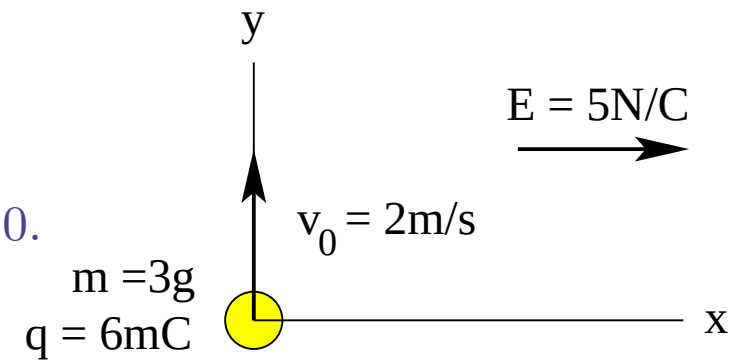
Consider a region of uniform electric field as shown. A charged particle is projected at time $t = 0$ with initial velocity as shown. Ignore gravity.

(a) Find the components a_x and a_y of the acceleration at time $t = 0$.

(b) Find the components v_x and v_y of the velocity at time $t = 0$.

(c) Find the components v_x and v_y of the velocity at time $t = 1.2$s.

(d) Find the components x and y of the position at time $t = 1.2$s.



Solution:

(a) $a_x = \dfrac{q}{m}E = \dfrac{6 \times 10^{-3}\text{C}}{3 \times 10^{-3}\text{kg}}(5\text{N/C}) = 10\text{m/s}^2, \quad a_y = 0.$

(b) $v_x = 0, \quad v_y = v_0 = 2\text{m/s}.$

(c) $v_x = a_x t = (10\text{m/s}^2)(1.2\text{s}) = 12\text{m/s}, \quad v_y = v_0 = 2\text{m/s}.$

(d) $x = \dfrac{1}{2}a_x t^2 = 0.5(10\text{m/s}^2)(1.2\text{s})^2 = 7.2\text{m}, \quad y = v_y t = (2\text{m/s})(1.2\text{s}) = 2.4\text{m}.$