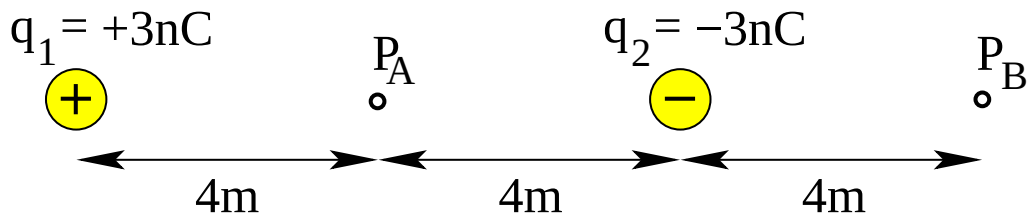
Unit Exam I: Problem #1 (Spring '07)

Consider the configuration of two point charges as shown.

(a) Find magnitude and direction of the force $\mathbf{F}_{21}$ exerted by q_2 on q_1.

(b) Find magnitude and direction of the electric field $\mathbf{E}_A$ at point P_A.

(c) Find the electric potential V_B at point P_B.



Solution:

(a) $F_{12} = k\dfrac{|3\text{nC}|^2}{(8\text{m})^2} = 1.27\text{nN}$ (directed right).

(b) $E_A = 2k\dfrac{|3\text{nC}|}{(4\text{m})^2} = 3.38\text{N/C}$ (directed right).

(c) $V_B = k\dfrac{(+3\text{nC})}{12\text{m}} + k\dfrac{(-3\text{nC})}{4\text{m}} = -4.50\text{V}.$

Unit Exam I: Problem #2 (Spring '07)

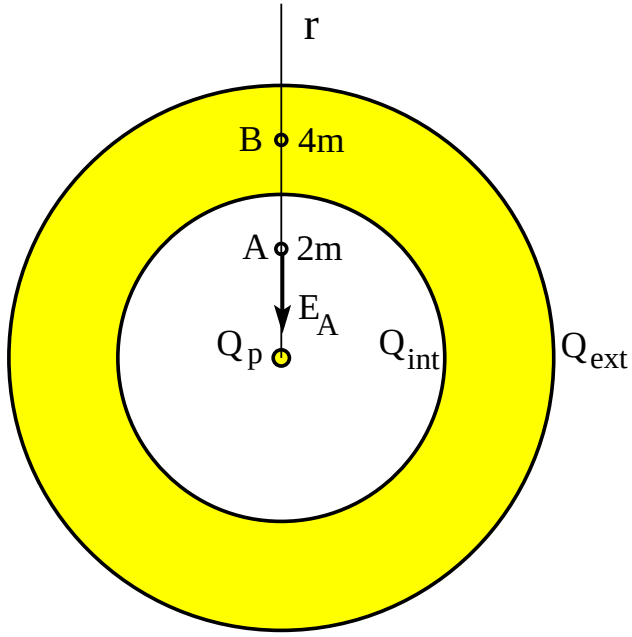
A point charge Q_p is positioned at the center of a conducting spherical shell of inner radius $r_2 = 3.00$m and outer radius $r_3 = 5.00$m. The total charge on the shell $Q_s = +7.00$nC. The electric field at point A has strength $E_A = 6.75$N/C and is pointing radially inward.

(a) Find the value of Q_p (point charge).

(b) Find the charge Q_{int} on the inner surface of the shell.

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

(d) Find the electric field at point B.



Solution:

(a) Gauss' law implies that $-E_A(4\pi r_A^2) = \dfrac{Q_p}{\epsilon_0}$

$\Rightarrow\ Q_p = -3.00$nC.

(b) Gauss' law implies that $Q_{int} = -Q_p = +3.00$nC.

(c) Charge conservation, $Q_{int} + Q_{ext} = Q_s = 7.00$nC, then implies that $Q_{ext} = +4.00$nC.

(d) $E_B = 0$ inside conductor.

Unit Exam I: Problem #3 (Spring '07)

Consider two regions of uniform electric field as shown. Charged particles of mass $m = 2$kg and charge $q = 1$C are projected at time $t = 0$ with initial velocities as shown. Both particles will hit the screen eventually. Ignore gravity.

(a) At what time t_1 does the particle in region (1) hit the screen?

(b) At what height y_1 does the particle in region (1) hit the screen?

(c) At what time t_2 does the particle in region (2) hit the screen?

(d) At what height y_2 does the particle in region (2) hit the screen?

Solution:

(a) $x_1 = \frac{1}{2}at_1^2 \quad \text{with} \quad a = \frac{q}{m}E = 2.5\text{m/s}^2,$
$x_1 = 8\text{m} \quad \Rightarrow \quad t_1 = 2.53\text{s}.$

(b) $y_1 = v_0 t_1 = 5.06\text{m}.$

(c) $x_2 = v_0 t_2 \quad \Rightarrow \quad t_2 = \frac{8\text{m}}{2\text{m/s}} = 4\text{s}.$

(d) $y_2 = \frac{1}{2}at_2^2 = 20\text{m}.$