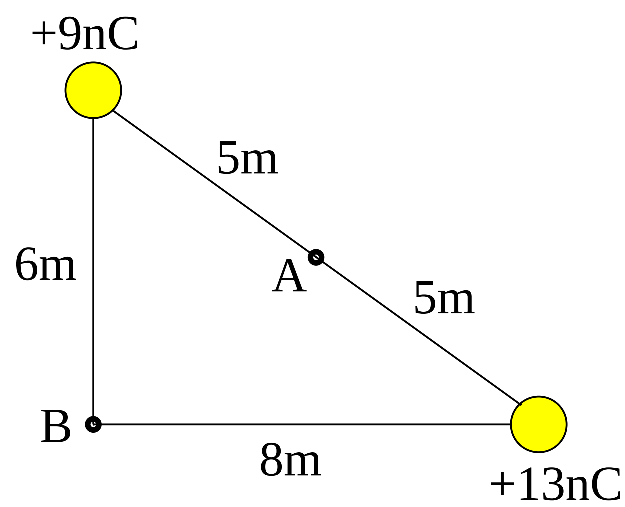
# Unit Exam I: Problem #1 (Spring '15)

Consider two point charges positioned as shown.

(a) Find the magnitude of the electric force acting between the two charges.

(b) Find the electric potential at point $B$.

(c) Find the magnitude and direction of the electric field at point $A$.



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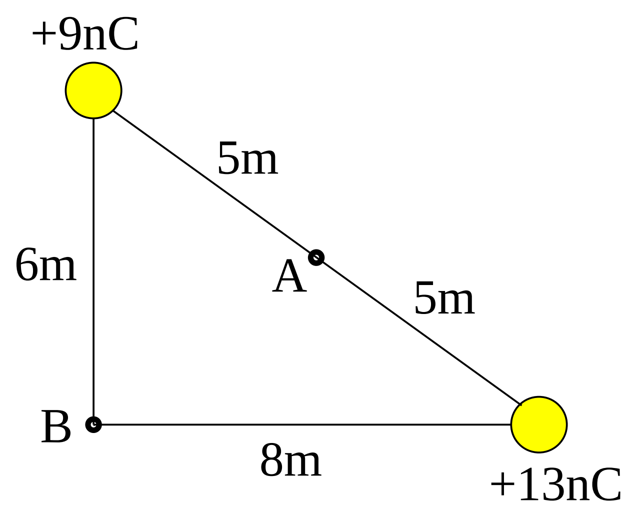



**Solution:**

(a) $F = k\dfrac{|(9\text{nC})(13\text{nC}|)}{(10\text{m})^2} = 10.53\text{nN}.$

(b) $V_B = k\dfrac{(9\text{nC})}{6\text{m}} + k\dfrac{(13\text{nC})}{8\text{m}} = 13.5\text{V} + 14.6\text{V} = 28.1\text{V}.$

(c) $E_A = \left| k\dfrac{9\text{nC}}{(5\text{m})^2} - k\dfrac{13\text{nC}}{(5\text{m})^2} \right| = |3.24\text{N/C} - 4.68\text{N/C}| = 1.44\text{N/C}.$

Direction along hypotenuse toward upper left.

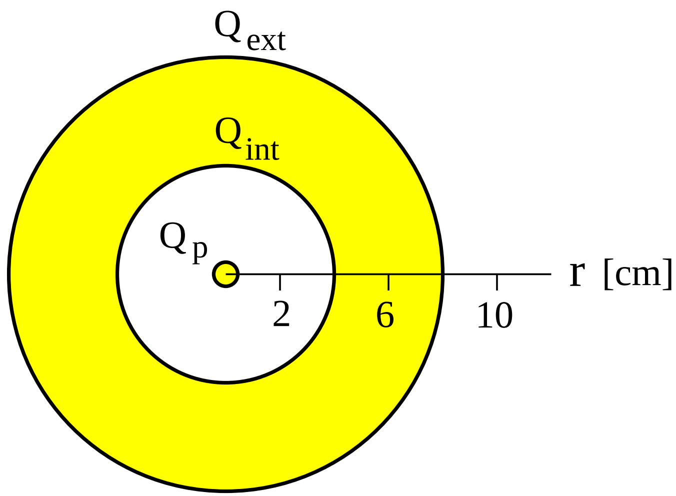
# Unit Exam I: Problem #2 (Spring '15)

The conducting spherical shell shown in cross section has a 4cm inner radius and an 8cm outer radius. The excess charges on its inner and outer surfaces are $Q_{\rm int} = +7{\rm nC}$ and $Q_{\rm ext} = +11{\rm nC}$, respectively. There is a point charge $Q_{\rm p}$ at the center of the cavity.

(a) Find the point charge $Q_{\rm p}$.

(b) Find the surface charge density $\sigma_{\rm int}$ on the inner surface of the shell.

(c) Find the magnitude $E$ of the electric field at radius $r = 10$cm.



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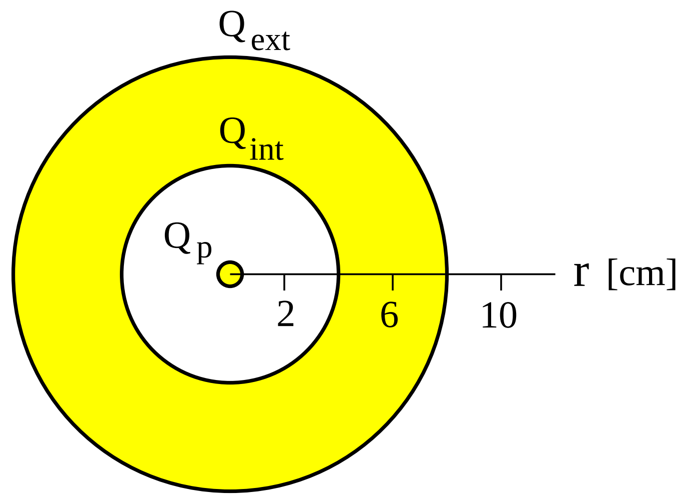



**Solution:**

(a) $Q_{\rm p} = -Q_{\rm int} = -7{\rm nC}$.

(b) $\sigma_{\rm int} = \dfrac{Q_{\rm int}}{4\pi(4{\rm cm})^2} = 3.48 \times 10^{-7}{\rm C/m^2}$.

(c) $E = \dfrac{k(11{\rm nC})}{(10{\rm cm})^2} = 9900{\rm N/C}$.

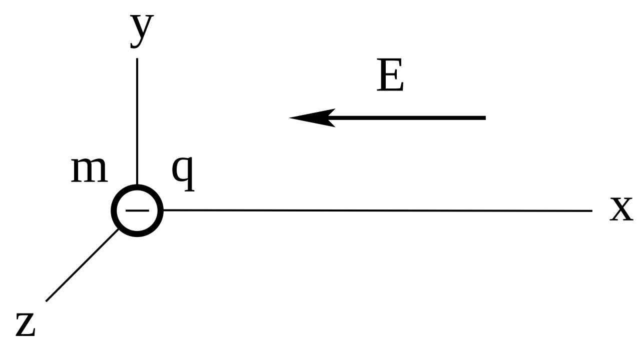
# Unit Exam I: Problem #3 (Sprin ’15)

Consider a region of uniform electric field $\mathbf{E} = -7\hat{\mathbf{i}}$ N/C. At time $t = 0$ a charged particle (charge $q = -5$nC, mass $m = 4 \times 10^{-6}$kg) is released from rest at the origin of the coordinate system as shown.

(a) Find the acceleration, the velocity, and the position of the particle $t = 0$.

(b) Find the acceleration, the velocity, and the position of the particle at $t = 3$s.

(c) Find the work $W$ done by the electric field on the particle between $t = 0$ and $t = 3$s.



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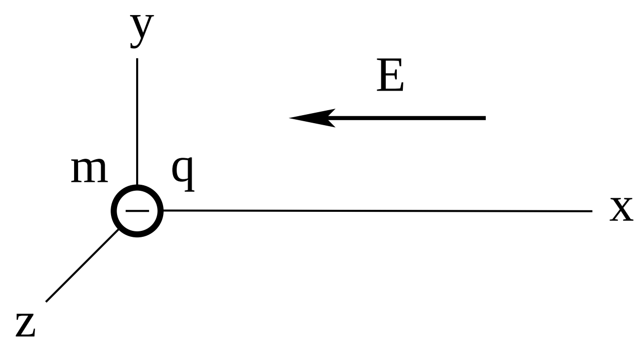


**Solution:**

(a) $a_x = \dfrac{(-5\text{nC})}{4 \times 10^{-6}\text{kg}}(-7\text{N/C}) = 8.75 \times 10^{-3}\text{m/s}^2,$

$v_x = 0, \quad x = 0.$

(b) $a_x = 8.75 \times 10^{-3}\text{m/s}^2,$

$v_x = a_x t = (8.75 \times 10^{-3}\text{m/s}^2)(3\text{s}) = 2.63 \times 10^{-2}\text{m/s},$

$x = \dfrac{1}{2}a_x t^2 = (0.5)(8.75 \times 10^{-3}\text{m/s}^2)(3\text{s})^2 = 3.94 \times 10^{-2}\text{m}.$

(c) $W = F\Delta x = (-5\text{nC})(-7\text{N/C})(3.94 \times 10^{-2}\text{m}) = 1.38\text{nJ}.$

$W = \Delta K = \dfrac{1}{2}(4 \times 10^{-6}\text{kg})(2.63 \times 10^{-2}\text{m/s})^2 = 1.38\text{nJ}.$