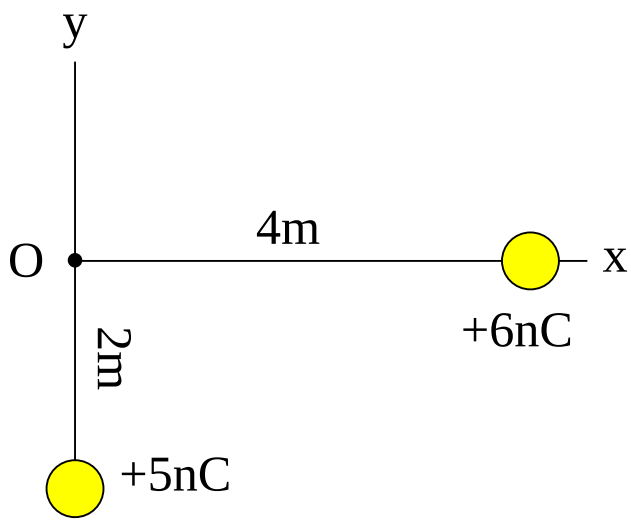
Unit Exam I: Problem #1 (Fall '14)

Two point charges are placed in the xy-plane as shown.
(a) Find the components E_x and E_y of the electric field at point O.
(b) Draw an arrow indicating the direction of $\vec{E}$ at point O.
(c) Find the electric potential V at point O.
(d) Find the magnitude F of the electric force between the two charges.



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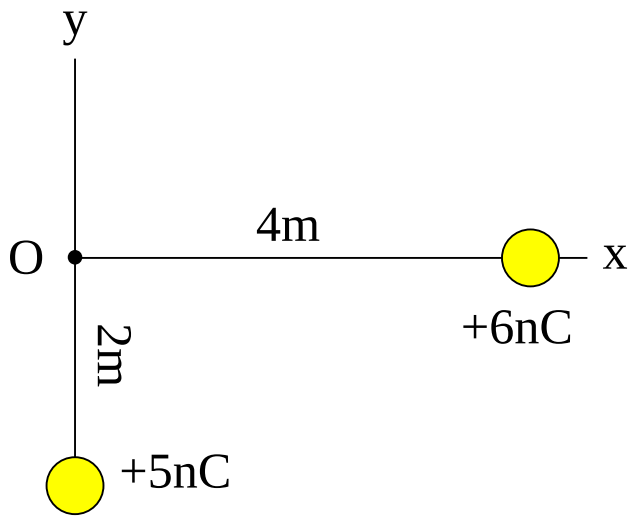


Solution:

(a) $E_x = -k\dfrac{|6\text{nC}|}{(4\text{m})^2} = -3.38\text{N/C}$

$E_y = +k\dfrac{|5\text{nC}|}{(2\text{m})^2} = 11.25\text{N/C}.$

(b) Up and left.

(c) $V = k\dfrac{6\text{nC}}{4\text{m}} + k\dfrac{5\text{nC}}{2\text{m}} = 13.5\text{V} + 22.5\text{V} = 36\text{V}.$

(d) $F = k\dfrac{|6\text{nC}||5\text{nC}|}{20\text{m}^2} = 13.5\text{nN}.$

Unit Exam I: Problem #2 (Fall '14)

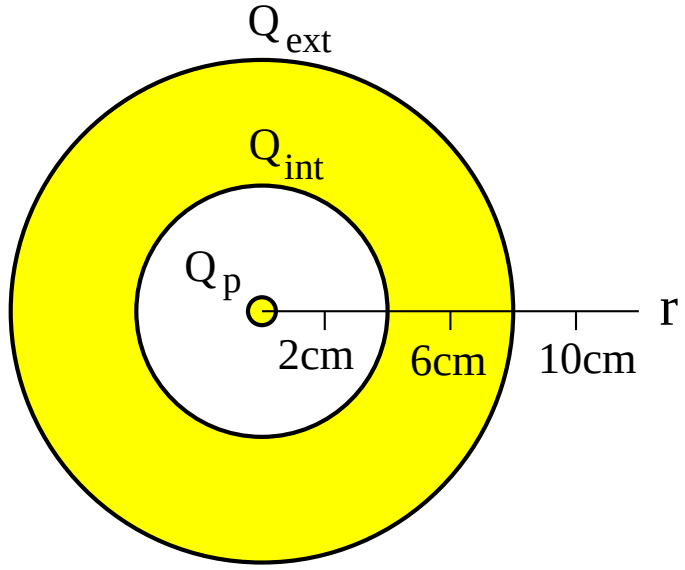
The conducting spherical shell shown in cross section has a 4cm inner radius and an 8cm outer radius. A point charge $Q_{\rm p}$ is placed at the center. The charges on the inner and outer surfaces of the shell are $Q_{\rm int} = 5{\rm nC}$ and $Q_{\rm ext} = 7{\rm nC}$, respectively.

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

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

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

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 6$cm.



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(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 6{\rm cm}$.

Solution:

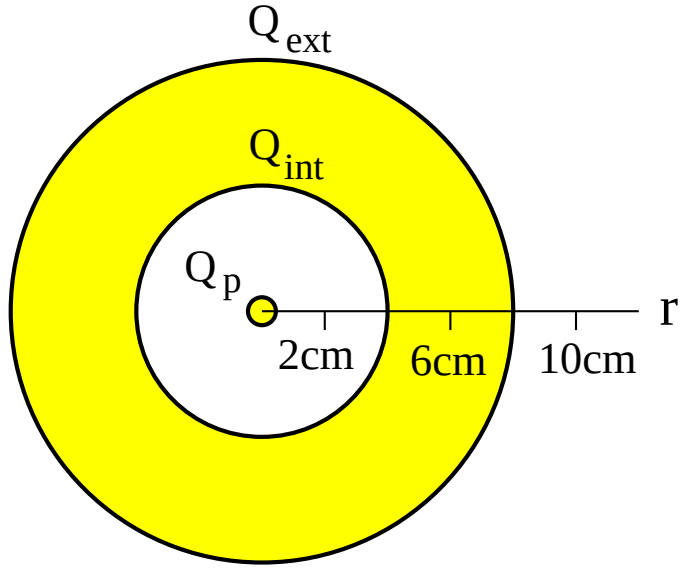
(a) $Q_{\rm p} = -Q_{\rm int} = -5{\rm nC}$.

(b) $E[4\pi(10{\rm cm})^2] = \dfrac{Q_{\rm p} + Q_{\rm int} + Q_{\rm ext}}{\epsilon_0} = \dfrac{Q_{\rm ext}}{\epsilon_0}$

$\Rightarrow \; E = 6300{\rm N/C}$.

(c) $\sigma_{\rm int} = \dfrac{Q_{\rm int}}{4\pi(4{\rm cm})^2} = 2.49 \times 10^{-7}{\rm C/m^2}$.

(d) $\Phi_E = 0$ inside conducting material.



Unit Exam I: Problem #3 (Fall '14)

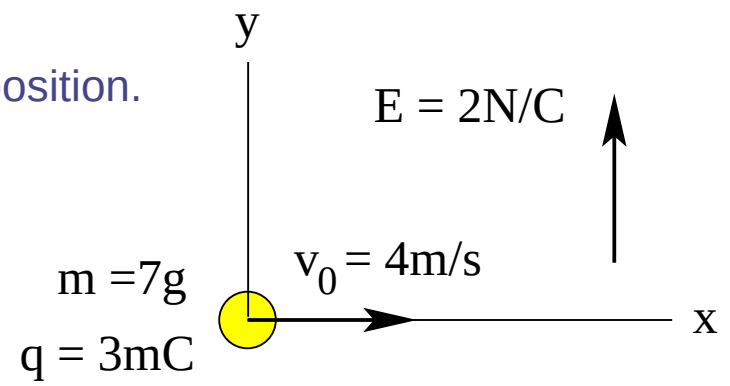
Consider a region of uniform electric field as shown. A charged particle is projected at time $t = 0$ with initial velocity as shown.

(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 $t = 2$s.

(c) Find the kinetic energy at time $t = 2$s.

(d) Sketch the path of the particle as it moves from the initial position.



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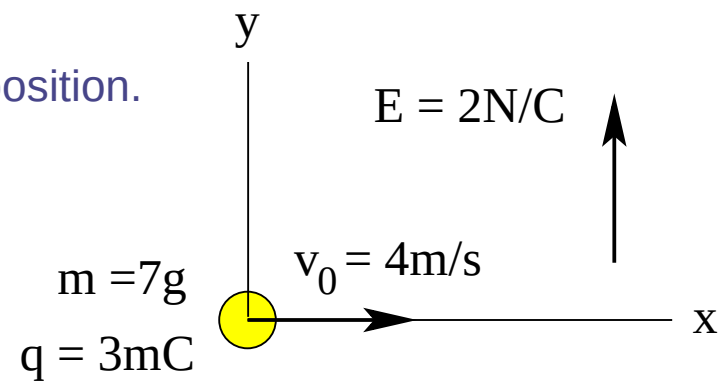

Solution:

(a) $a_x = 0, \quad a_y = \dfrac{q}{m}E = \dfrac{3 \times 10^{-3}\text{C}}{7 \times 10^{-3}\text{kg}}(2\text{N/C}) = 0.857\text{m/s}^2.$

(b) $v_x = v_0 = 4\text{m/s}, \quad v_y = a_y t = (0.857\text{m/s}^2)(2\text{s}) = 1.71\text{m/s}.$

(c) $E = \dfrac{1}{2}(7 \times 10^{-3}\text{kg})[(4\text{m/s})^2 + (1.71\text{m/s})^2] = 6.62 \times 10^{-2}\text{J}.$

(d) Upright parabolic path.