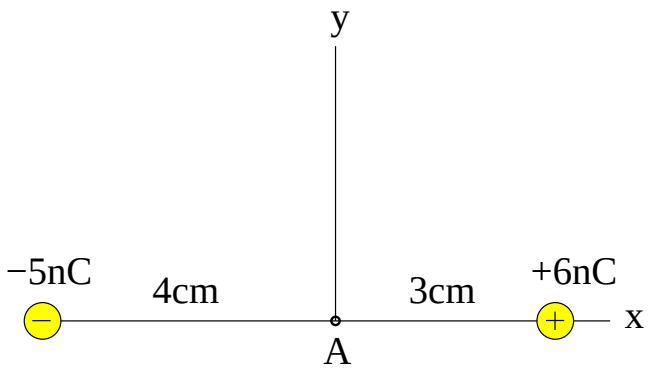
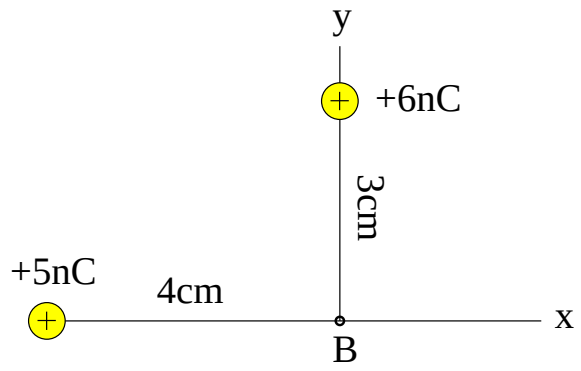
Unit Exam I: Problem #1 (Spring ’16)

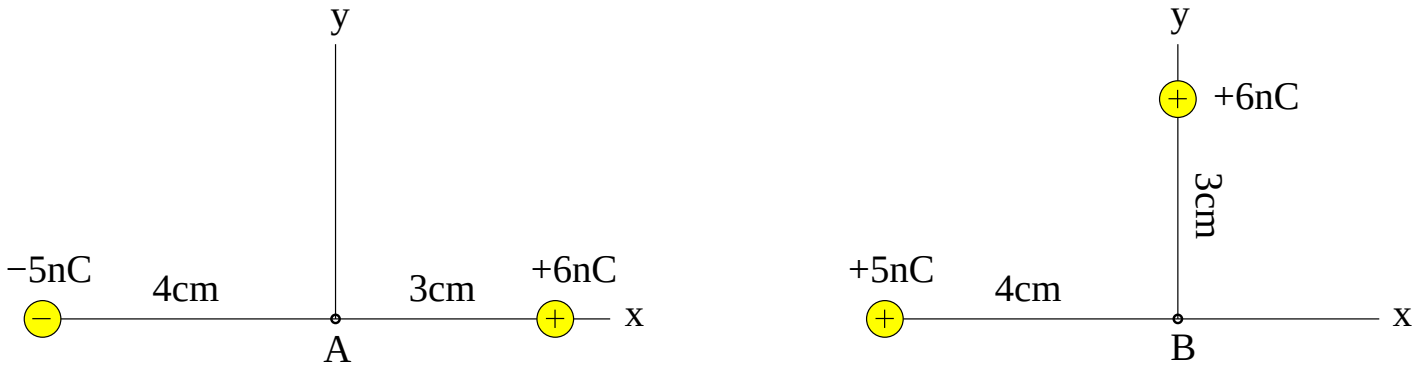
Consider a pair of point charges in two different configurations. Find the electric potential V and the components E_x and E_y of the electric field at point A and at point B.





Unit Exam I: Problem #1 (Spring '16)

Consider a pair of point charges in two different configurations. Find the electric potential V and the components E_x and E_y of the electric field at point A and at point B.



Solution:

- $V^{(A)} = k\dfrac{6\text{nC}}{3\text{cm}} + k\dfrac{(-5\text{nC})}{4\text{cm}} = 1800\text{V} - 1125\text{V} = 675\text{V}.$
- $E_x^{(A)} = -k\dfrac{|6\text{nC}|}{(3\text{cm})^2} - k\dfrac{|-5\text{nC}|}{(4\text{cm})^2} = -88\,125\text{V/m}, \qquad E_y^{(A)} = 0.$
- $V^{(B)} = k\dfrac{6\text{nC}}{3\text{cm}} + k\dfrac{5\text{nC}}{4\text{cm}} = 1800\text{V} + 1125\text{V} = 2925\text{V}.$
- $E_x^{(B)} = k\dfrac{|5\text{nC}|}{(4\text{cm})^2} = 28\,125\text{V/m}, \qquad E_y^{(B)} = -k\dfrac{|6\text{nC}|}{(3\text{cm})^2} = -60\,000\text{V/m}.$

Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

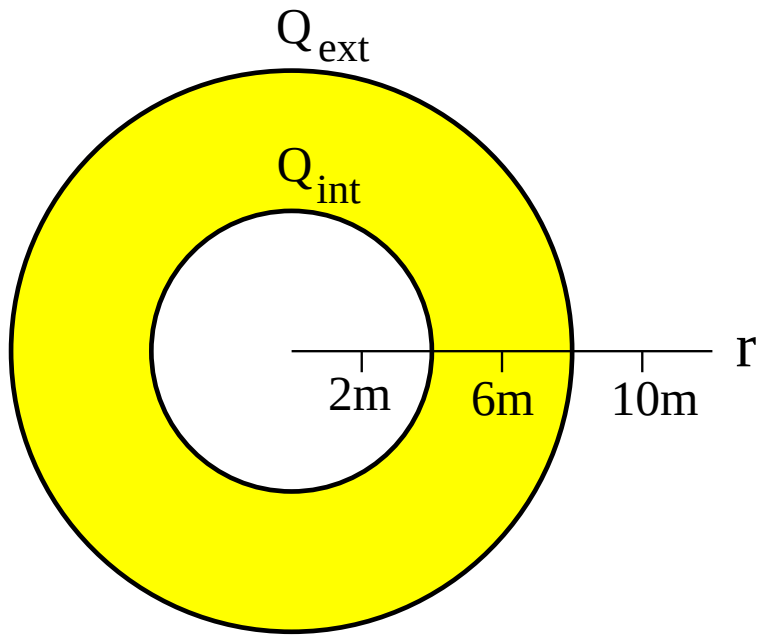
(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.



Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

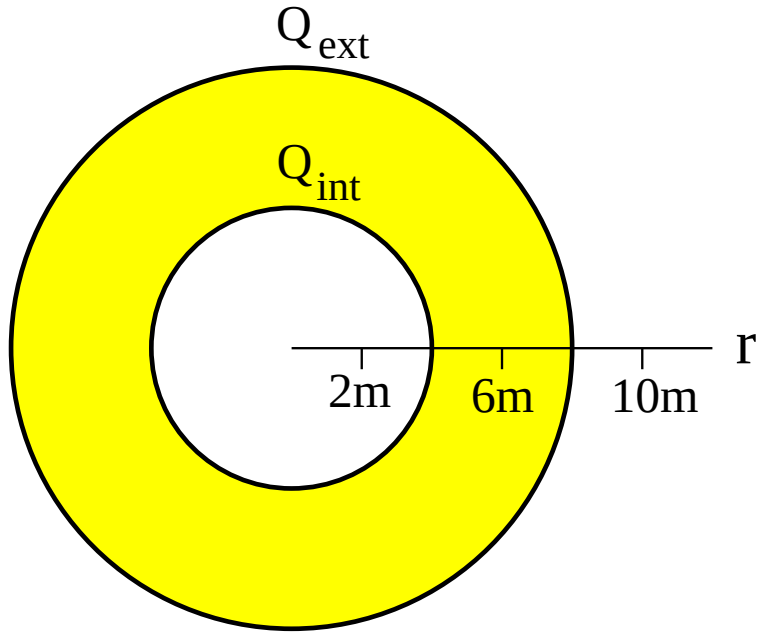
(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.

Solution:

(a) $Q_{\rm int} = 0$ (inferred from Gauss' law.)



Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

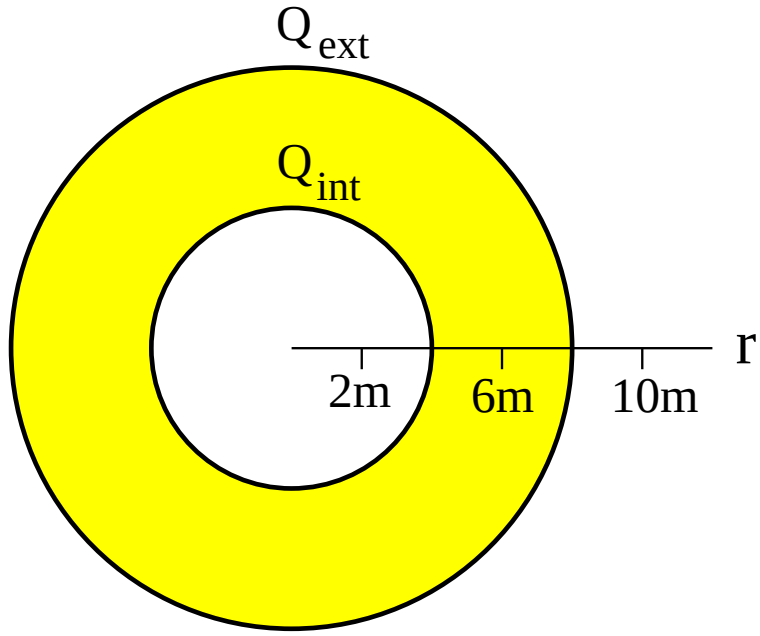
(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.

Solution:

(a) $Q_{\rm int} = 0$ (inferred from Gauss' law.)

(b) $\sigma_{\rm ext} = \dfrac{-7{\rm nC}}{4\pi(8{\rm m})^2} = -8.70 \times 10^{-12}{\rm C/m^2}.$



Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

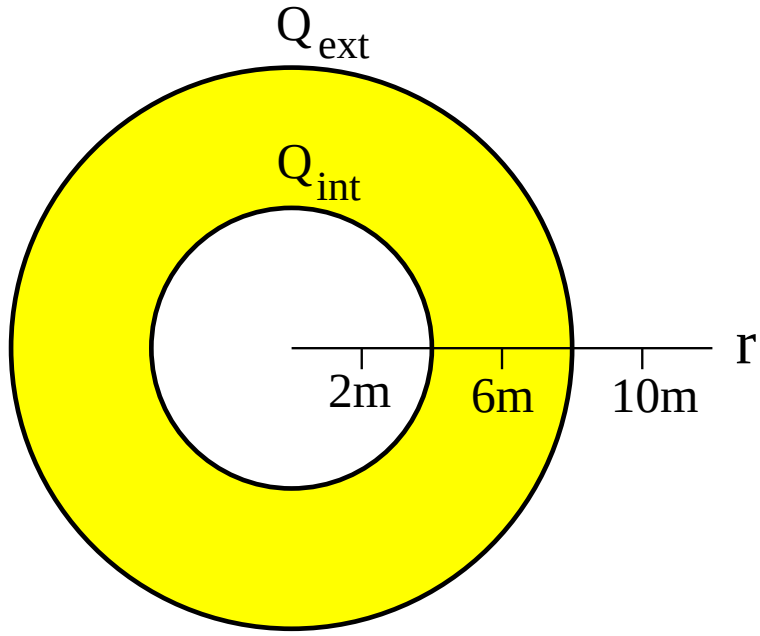
(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.

Solution:

(a) $Q_{\rm int} = 0$ (inferred from Gauss' law.)

(b) $\sigma_{\rm ext} = \dfrac{-7{\rm nC}}{4\pi(8{\rm m})^2} = -8.70 \times 10^{-12}{\rm C/m^2}.$

(c) $E = 0$ (inside conducting material.)



Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.

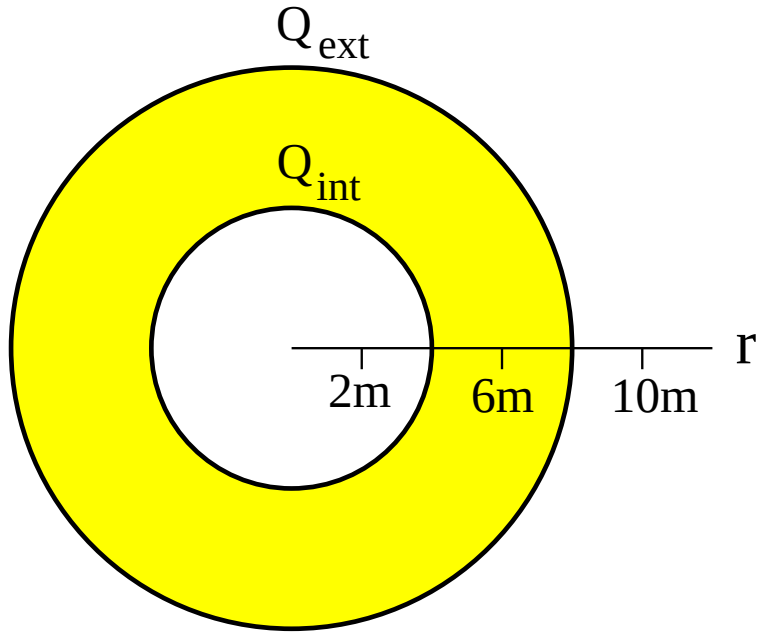
Solution:

(a) $Q_{\rm int} = 0$ (inferred from Gauss' law.)

(b) $\sigma_{\rm ext} = \dfrac{-7{\rm nC}}{4\pi(8{\rm m})^2} = -8.70 \times 10^{-12}{\rm C/m^2}.$

(c) $E = 0$ (inside conducting material.)

(d) $\Phi_E = \dfrac{-7{\rm nC}}{\epsilon_0} = -791{\rm Nm^2/C}.$



Unit Exam I: Problem #2 (Spring '16)

A charged conducting spherical shell has a 4m inner radius and an 8m outer radius. The charge on the outer surface is $Q_{\rm ext} = -7{\rm nC}$.

(a) Find the charge $Q_{\rm int}$ on the inner surface of the shell.

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

(c) Find the magnitude of the electric field E at radius $r = 6{\rm m}$.

(d) Find the electric flux Φ_E through a Gaussian sphere of radius $r = 10{\rm m}$.

(e) Find the magnitude of the electric field E at radius $r = 10{\rm m}$.

Solution:

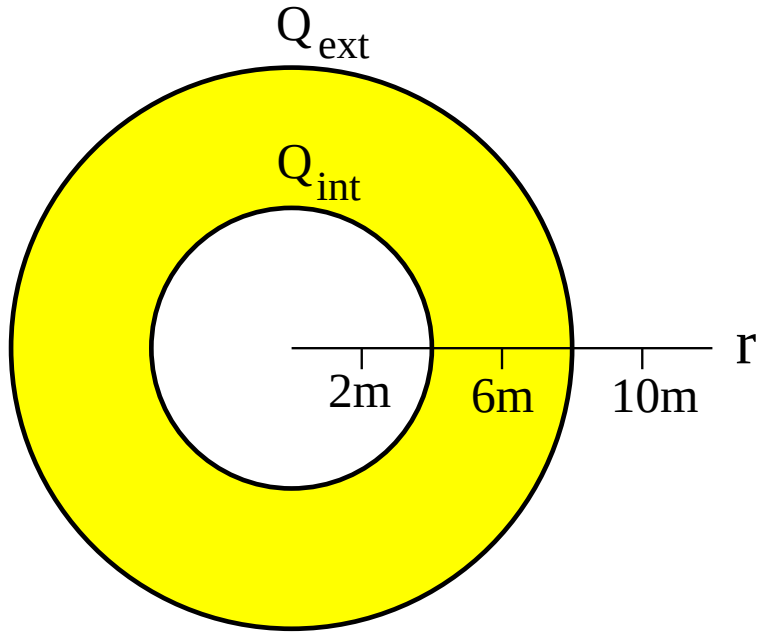
(a) $Q_{\rm int} = 0$ (inferred from Gauss' law.)

(b) $\sigma_{\rm ext} = \dfrac{-7{\rm nC}}{4\pi(8{\rm m})^2} = -8.70\times10^{-12}{\rm C/m^2}.$

(c) $E = 0$ (inside conducting material.)

(d) $\Phi_E = \dfrac{-7{\rm nC}}{\epsilon_0} = -791{\rm Nm^2/C}.$

(e) $E = k\dfrac{|-7{\rm nC}|}{(10{\rm m})^2} = 0.63{\rm V/m}.$



Unit Exam I: Problem #3 (Spring '15)

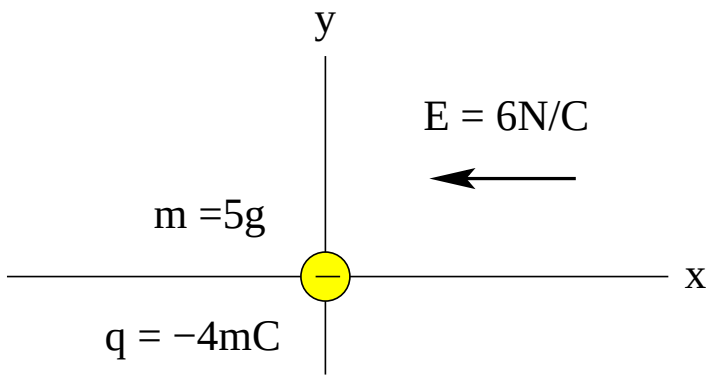
Consider a region of uniform electric field as shown. A charged particle is released from rest at time $t = 0$ at the origin of the coordinate system.

(a) Find the acceleration a_x of the particle at time $t = 3$s.

(b) Find the velocity v_x of the particle at time $t = 3$s.

(c) Find the position x of the particle at time $t = 3$s.

(d) In what time Δt does the particle move from $x = 10$m to $x = 20$m?



Unit Exam I: Problem #3 (Spring '15)

Consider a region of uniform electric field as shown. A charged particle is released from rest at time $t = 0$ at the origin of the coordinate system.

(a) Find the acceleration a_x of the particle at time $t = 3$s.

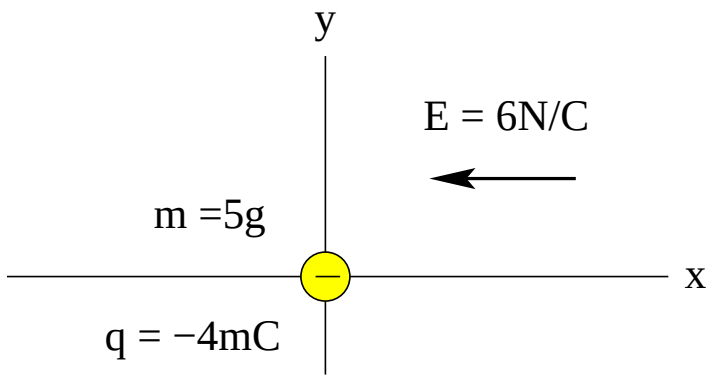
(b) Find the velocity v_x of the particle at time $t = 3$s.

(c) Find the position x of the particle at time $t = 3$s.

(d) In what time Δt does the particle move from $x = 10$m to $x = 20$m?

Solution:

(a) $a_x = \frac{q}{m}E = \frac{-4 \times 10^{-3}\text{C}}{5 \times 10^{-3}\text{kg}}(-6\text{N/C}) = 4.8\text{m/s}^2.$



Unit Exam I: Problem #3 (Spring '15)

Consider a region of uniform electric field as shown. A charged particle is released from rest at time $t = 0$ at the origin of the coordinate system.

(a) Find the acceleration a_x of the particle at time $t = 3$s.

(b) Find the velocity v_x of the particle at time $t = 3$s.

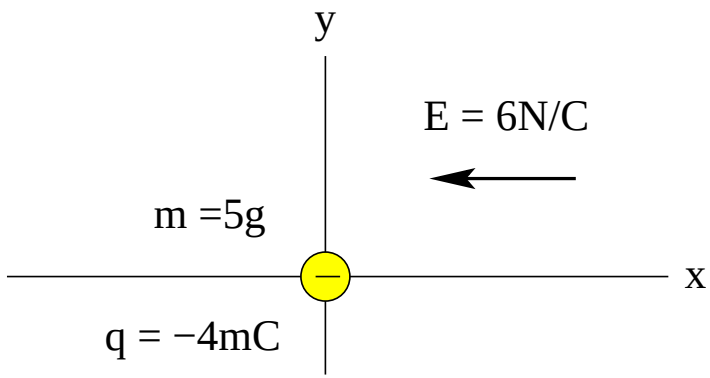
(c) Find the position x of the particle at time $t = 3$s.

(d) In what time Δt does the particle move from $x = 10$m to $x = 20$m?

Solution:

(a) $a_x = \dfrac{q}{m}E = \dfrac{-4 \times 10^{-3}\text{C}}{5 \times 10^{-3}\text{kg}}(-6\text{N/C}) = 4.8\text{m/s}^2.$

(b) $v_x = a_x t = (4.8\text{m/s}^2)(3\text{s}) = 14.4\text{m/s}.$



Unit Exam I: Problem #3 (Spring '15)

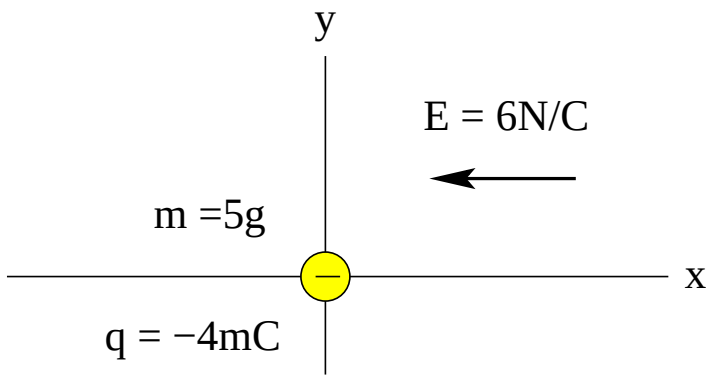
Consider a region of uniform electric field as shown. A charged particle is released from rest at time $t = 0$ at the origin of the coordinate system.

(a) Find the acceleration a_x of the particle at time $t = 3$s.

(b) Find the velocity v_x of the particle at time $t = 3$s.

(c) Find the position x of the particle at time $t = 3$s.

(d) In what time Δt does the particle move from $x = 10$m to $x = 20$m?



Solution:

(a) $a_x = \dfrac{q}{m}E = \dfrac{-4 \times 10^{-3}\text{C}}{5 \times 10^{-3}\text{kg}}(-6\text{N/C}) = 4.8\text{m/s}^2.$

(b) $v_x = a_x t = (4.8\text{m/s}^2)(3\text{s}) = 14.4\text{m/s}.$

(c) $x = \dfrac{1}{2}a_x t^2 = 0.5(4.8\text{m/s}^2)(3\text{s})^2 = 21.6\text{m}.$

Unit Exam I: Problem #3 (Spring '15)

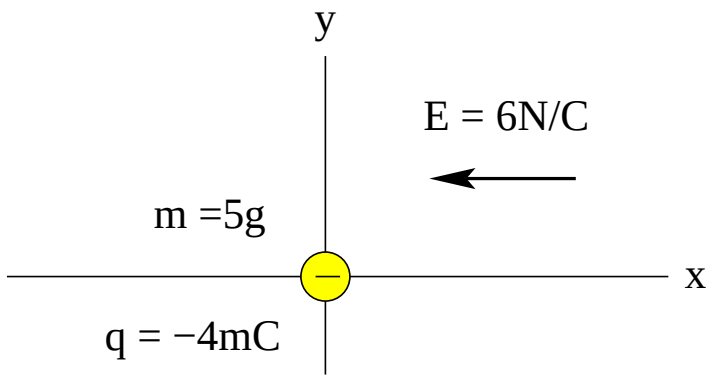
Consider a region of uniform electric field as shown. A charged particle is released from rest at time $t = 0$ at the origin of the coordinate system.

(a) Find the acceleration a_x of the particle at time $t = 3$s.

(b) Find the velocity v_x of the particle at time $t = 3$s.

(c) Find the position x of the particle at time $t = 3$s.

(d) In what time Δt does the particle move from $x = 10$m to $x = 20$m?



Solution:

(a) $a_x = \dfrac{q}{m}E = \dfrac{-4 \times 10^{-3}\text{C}}{5 \times 10^{-3}\text{kg}}(-6\text{N/C}) = 4.8\text{m/s}^2.$

(b) $v_x = a_x t = (4.8\text{m/s}^2)(3\text{s}) = 14.4\text{m/s}.$

(c) $x = \dfrac{1}{2}a_x t^2 = 0.5(4.8\text{m/s}^2)(3\text{s})^2 = 21.6\text{m}.$

(d) $\Delta t = \sqrt{\dfrac{2(20\text{m})}{4.8\text{m/s}^2}} - \sqrt{\dfrac{2(10\text{m})}{4.8\text{m/s}^2}} = 2.89\text{s} - 2.04\text{s} = 0.85\text{s}.$