Equations

Wednesday, February 11, 2015 7:09 AM

Stuff that you should know!

$$F = k\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0} = 9.0\times10^9\,N\frac{m^2}{C^2}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

$$F = Eq$$

$$\varepsilon_0 = 8.85\times10^{-12}\frac{C^2}{N\cdot m^2}$$

$$a = \frac{Eq}{m}$$

$F = ma$

$Eq = ma$

$$\Phi = \sum_i \left(E_i \cdot \Delta A_i \cos\theta_i\right)$$

$$\Phi\varepsilon_0 = q_{enc}$$

$\Phi = \frac{q_{enc}}{\varepsilon_0}$

$\Phi \to EA\cos\theta$

$$A = 4\pi R^2$$

$$A = 2\pi rL$$

$$e = 1.6\times10^{-19}\,C$$

$$m_e = 9.11\times10^{-31}\,kg$$

$$\mu = 10^{-6}$$

$$n = 10^{-9}$$

$$\Delta x = \left[\frac{v_{0x}+v_{1x}}{2}\right]\Delta t$$

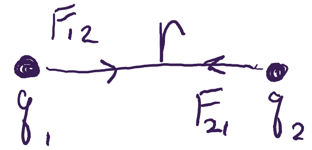
$$\Delta x = v_{0x}\Delta t + \tfrac{1}{2}a_x\Delta t^2$$

$$v_{1x} = v_{0x} + a_x\Delta t$$

$$v_{1x}^2 = v_{0x}^2 + 2a_x\Delta x$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\theta = \tan^{-1}\left[\frac{A_y}{A_x}\right]$$



$F = k\frac{q_1 q_2}{r^2}$

$E = k\frac{q}{r^2}$

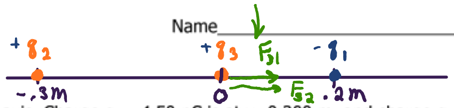
$\int E\cos\theta\, dA$ or $\int \vec{E}\cdot d\vec{A} \to EA\cos\theta$

Test 1

TEST 1 Review

Name_________________________

Show all work in the spaces provided.



1) Three point charges are along the x-axis. Charge q_1=-4.50 nC is at x=0.200 m, and charge q_2=+2.5 nC is at x=-0.300 m. A positive point charge q_3 is located at the origin.

a) What must the value of q_3 be for the net force on this point charge to have a magnitude of 4.00 μN? (4 pts)

$$F_{31} + F_{32} = 4\times10^{-6}N$$

$$k\frac{q_3 q_1}{r_{31}^2} + k\frac{q_3 q_2}{r_{32}^2} = 4\times10^{-6}N$$

$$q_3 k\left(\frac{q_1}{r_{31}^2} + \frac{q_2}{r_{32}^2}\right) = 4\times10^{-6}N$$

$$q_3 = \frac{4\times10^{-6}N}{k\left(\frac{q_1}{r_{31}^2} + \frac{q_2}{r_{32}^2}\right)}$$

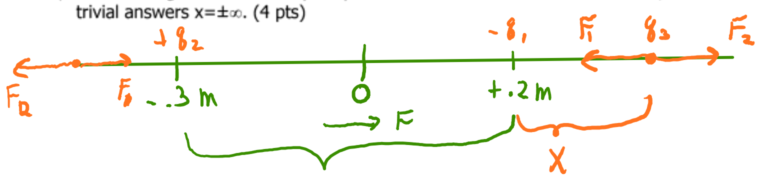
$$q_3 = \frac{4\times10^{-6}N}{9\times10^{9}\,N\frac{m^2}{C^2}\left[\frac{4.5\times10^{-9}C}{(.2m)^2} + \frac{2.5\times10^{-9}C}{(.3m)^2}\right]}$$

$$q_3 = 3.16\times10^{-9}C$$

b) What is the direction of the net force on q_3? (2 pts)

(+)x

c) Where along the x-axis can q_3 be placed so that the net force on it is zero, other than the trivial answers x=±∞. (4 pts)



$$F_2 - F_1 = 0$$

$$F_2 = F_1$$

$$k\frac{q_3 q_2}{r_{32}^2} = k\frac{q_3 q_1}{r_{31}^2}$$

$$\frac{q_2}{(x+.5m)^2} = \frac{q_1}{x^2}$$

$$q_2 x^2 = q_1 (x+.5m)^2$$

$$x^2 = \frac{q_1}{q_2}(x+.5m)^2$$

$$x = \pm\sqrt{\frac{q_1}{q_2}}\,(x+.5m)$$

(+)

$$x = \sqrt{\frac{q_1}{q_2}}\,(x+.5m)$$

$$x = \sqrt{\frac{(4.5nC)}{2.5nC}}\,(x+.5m)$$

(-)

$$x = -\sqrt{\frac{q_1}{q_2}}\,(x+.5m)$$

$$x = -1.34x - .67m$$

$$x + 1.34x = -.67m$$

$x = \sqrt{\frac{(4.5\,nC)}{2.5\,nC}}\,(x + .5\,m)$

$x = 1.34\,(x + .5\,m)$

→ $x = 1.34x + .67\,m$

$x - 1.34x = .67\,m$

$x\,(1 - 1.34) = .67\,m$

$x\,(-.34) = .67\,m$

$x = \frac{.67\,m}{-.34}$

$\boxed{x = -1.97\,m}$

$x + 1.34x = -.67\,m$

$x\,(1 + 1.34) = -.67\,m$

$x\,(2.34) = -.67\,m$

$x = \frac{-.67\,m}{2.34}$

~~$x = -0.29\,m$~~

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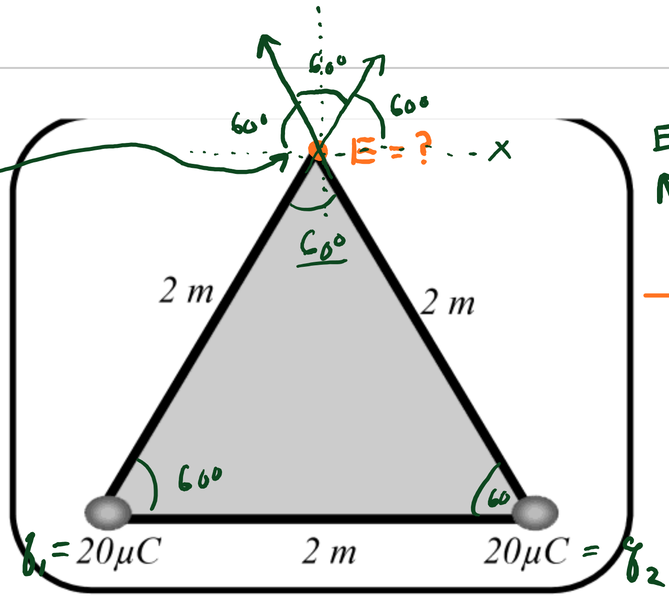
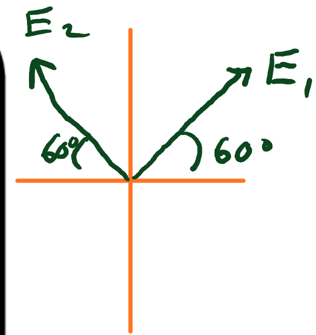
Test 1

q_3

$F = E q_3$





2) Positive point-charges of *20 μC* are fixed at two of the vertices of an equilateral triangle with sides of *2.0 m*. Determine the magnitude of the electric field at the third vertex. (10 pts)

$$E = E_1 = E_2 = k\frac{q}{r^2} = \left(9\times10^9 N\frac{m^2}{C^2}\right)\frac{(20\times10^{-6} C)}{(2 m)^2} = 4.5\times10^3 N/C$$

$$\Sigma E_x = E_1 \cos(60°) - E_2 \cos(60°) = E\cos(60°) - E\cos(60°) = 0$$

$$\Sigma E_y = E_1 \sin(60°) + E_2 \sin(60°) = 2E\sin(60°)$$

$$\Sigma E_y = 2(4.5\times10^3 N/C)\sin(60°) = 7.79\times10^4 N/C$$

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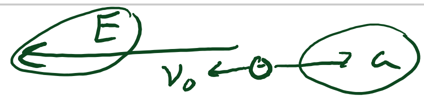
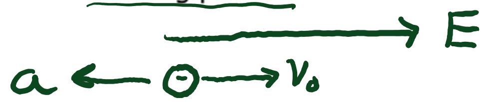


Test 1

3) An electron with speed $v_{0_x} = 1.5\times10^6 m/s$ is traveling parallel to an electric field of magnitude $E = 7.7\times10^3 N/C$.



a) How far will it travel before it stops? (5 pts)

$$a = \frac{qE}{m} = \frac{(1.6\times10^{-19}C)(7.7\times10^3 N/C)}{9.11\times10^{-31} kg} = -1.35\times10^{15} m/s^2$$

$$v_x^2 \xrightarrow{} 0 = v_{x_0}^2 + 2a_x\Delta x$$

$$\Delta x = \frac{-v_{x_0}^2}{2a_x} = \frac{-(1.5\times10^6 m/s)^2}{2(-1.35\times10^{15} m/s^2)}$$

$$\Delta x = 8.3\times10^{-4} m$$

b) How much time elapse before it returns to its starting point? (5 pts)

$$\Delta x \xrightarrow{} 0 = v_{x_0}t + \tfrac{1}{2}a_x t^2$$

$$0 = v_{x_0}t + \tfrac{1}{2}a_x t^2$$

$$0 = t\left(v_{x_0} + \tfrac{1}{2}a_x t\right)$$

$$t = 0 \qquad v_{x_0} + \tfrac{1}{2}a_x t = 0$$

$$t = \frac{-2v_{x_0}}{a_x}$$

$$t = \frac{-2(1.5\times10^6 m/s)}{(-1.35\times10^{15} m/s^2)}$$

$$\boxed{t = 2.2\times10^{-9} s}$$

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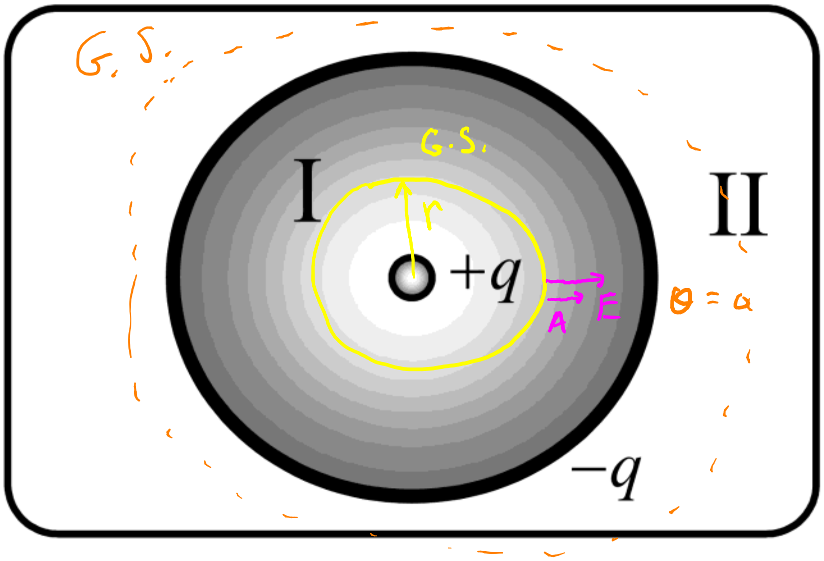

4) Consider a positive point charge surrounded by a spherical shell with a negative charge. Find the electric field:

a) Between the point charge and the shell (region I). (5 pts)

$$\Phi = \frac{q_{enc}}{\epsilon_0}$$

$$E A_s \cos\theta = \frac{q_{enc}}{\epsilon_0}$$

$$E(4\pi r^2) = \frac{q}{\epsilon_0}$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2} = k\frac{q}{r^2}$$

b) Outside the spherical shell (region II). (5 pts)

$E = 0$ $\quad q_{enc} = 0$