Equations 1112

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

$$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9 \ \tfrac{Nm^2}{C^2}$$

$$e = \pm1.6\times10^{-19}\,C$$

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

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

$$q_{enc} = \varepsilon_0 \sum_i \vec{E}_i \bullet \Delta\vec{A}_i$$

$$U = k\frac{q_1 q_2}{r}$$

$$V = k\frac{q}{r}$$

$$W = \Delta V q$$

$$\Delta U = \Delta V q$$

$$KE = \tfrac{1}{2} m v^2$$

$$\vec{F} = qvB\sin(\phi)$$

$$\vec{F} = iLB\sin(\phi)$$

$$\Delta B = \frac{\mu_0}{4\pi}\frac{i\Delta l\sin\theta}{r^2}$$

$$B = \frac{\mu_0 i}{2\pi r}$$

$$F = \frac{\mu_0 L i_a i_b}{2\pi d}$$

$$\sum_i \vec{B}_i \bullet \Delta\vec{s}_i = \mu_0 i_{enc}$$

$$\cancel{\Phi_B = BA}$$

$$\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$$

$$L = \frac{N\Phi}{i}$$

$$\mathcal{E} = \mathcal{E}_{max}\sin(\omega_d t)$$

$$i = I\sin(\omega_d t - \varphi)$$

$$X_C = \frac{1}{\omega_d C}$$

$$X_L = \omega_d L$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\mathcal{E}_{max} = IZ$$

$$\tan\varphi = \frac{X_L - X_C}{R}$$

$$P = i^2 R$$

$$V = iR$$

$$\cancel{\omega = 2\pi f}$$

$$1eV = 1.6\times10^{-19}\,J$$

$$\mu_0 = 4\pi\times10^{-7}\,\frac{T\cdot m}{A}$$

$$V_C = IX_C$$

$$V_L = IX_L$$

$$V_R = IR$$

Example 1

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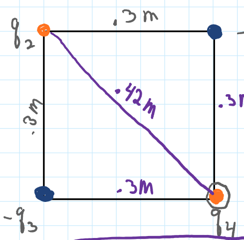
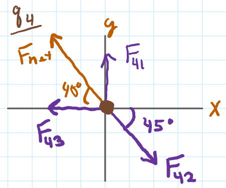
Four point charges with magnitude 5.0 µC are placed at the corners of a square that is 30 cm on a side. Two charges, diagonally opposite each other, are positive, and the other two are negative. What are the magnitude and the direction of the force on one of the charges?

$q = 5\times10^{-6}C$





$\sqrt{(.3m)^2 + (.3m)^2} = .42m$

$F = F_{41} = F_{43} = k\frac{q_4 q_1}{r_{41}^2} = (9\times10^9 N\frac{m^2}{c^2})\frac{(5\times10^{-6}c)^2}{(.3m)^2} = 2.5$

$F_{42} = k\frac{q_4 q_2}{r_{42}^2} = (9\times10^9 N\frac{m^2}{c^2})\frac{(5\times10^{-6}c)^2}{(.42m)^2} = 1.28N$

$\Sigma F_x = -F_{43} + F_{42}\cos(45°) = -(2.5N) + (1.28N)\cos(45°)$

$\Sigma F_x = -1.59N$

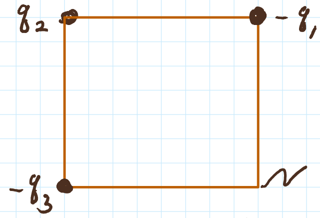
$\Sigma F_y = F_{41} - F_{42}\sin(45°) = (2.5N) - (1.28N)\sin(45°)$

$\Sigma F_y = 1.59N$

$|F_{net}| = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(-1.59N)^2 + (1.59N)^2}$

$|F_{net}| = 2.25N$

$\Theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = \tan^{-1}\left(\frac{1.59}{-1.59}\right) = -45°$



$V = k\frac{q}{r}$

$V = ?$

$V = V_1 + V_2 + V_3$

$V = k\frac{q_1}{r_1} + k\frac{q_2}{r_2} + k\frac{q_3}{r_3}$

q_1 q_2 q_3

$V = (9\times10^9 N\frac{m^2}{c^2})(5\times10^{-6}c)\left[\frac{-1}{.3m} + \frac{1}{.42m} - \frac{1}{.3m}\right]$

$\boxed{V = 4.5\times10^4\ V}$

Example 2

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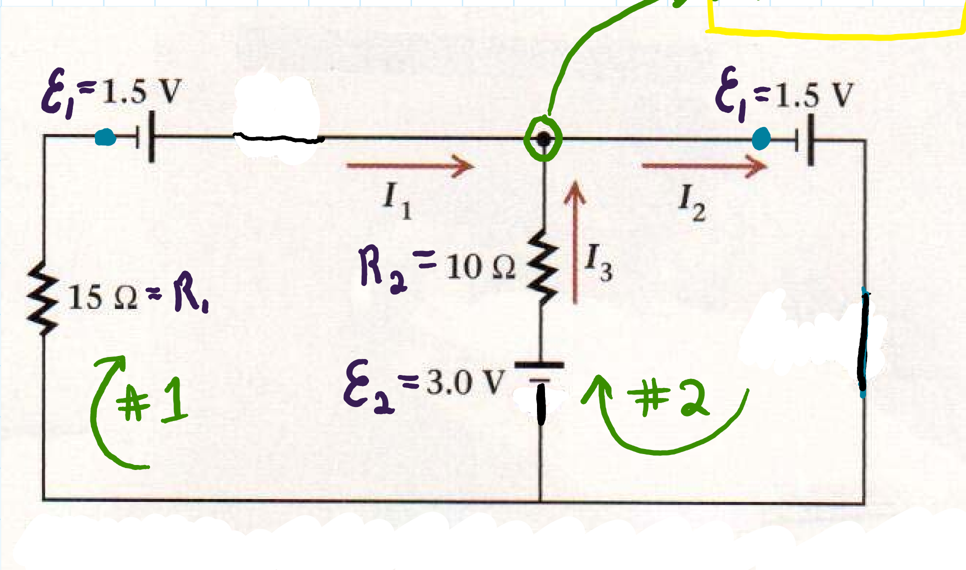
What are the 3 currents?

$\boxed{i_1 + i_3 = i_2}$



$i_2 = .2A + .45A$

$\boxed{i_2 = .65A}$

loop #1

$\boxed{\mathcal{E}_1 + i_3 R_2 - \mathcal{E}_2 - i_1 R_1 = 0}$

$$i_1 = \frac{\mathcal{E}_1 + i_3 R_2 - \mathcal{E}_2}{R_1}$$

$$i_1 = \frac{1.5V + (.45A)(10\Omega) - 3V}{15\Omega}$$

$\boxed{i_1 = .2A}$

loop #2

$\boxed{\mathcal{E}_1 + \mathcal{E}_2 - i_3 R_2 = 0}$

$i_3 R_2 = \mathcal{E}_1 + \mathcal{E}_2$

$$i_3 = \frac{4.5V}{10\Omega}$$

$\boxed{i_3 = .45A}$

Example 3

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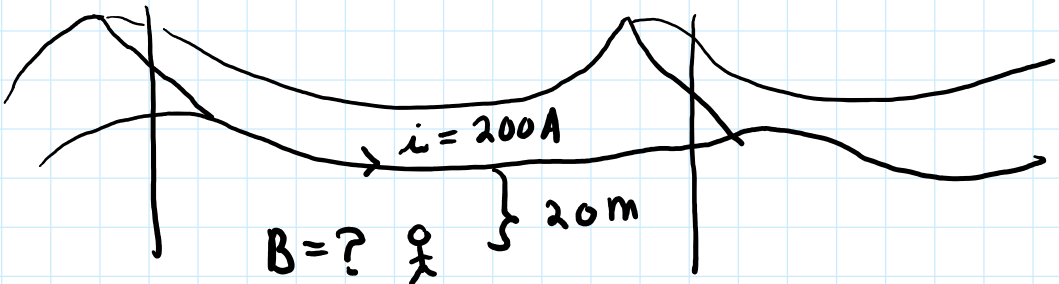
Although the evidence is weak, there has been concern in recent years over possible health effects from the magnetic fields generated by transmission lines. A typical high-voltage transmission line is 20 m off the ground and carries a current of 200 A. Estimate the magnetic field strength on the ground underneath such a line. What percentage of the earth 's magnetic field does this represent?



$$B = \frac{\mu_0 i}{2\pi r} = \frac{(\cancelto{2}{4\pi} \times 10^{-7}\, \frac{T\cdot m}{A})(\cancelto{10}{200A})}{\cancel{2\pi}\,(\cancel{20m})} = 20\times 10^{-7}\,T$$

$$2\times 10^{-6}\,T$$

Earth's $3.2\times 10^{-5}\,T$

$$\frac{2\times 10^{-6}\,T}{3.2\times 10^{-5}\,T} = 6.3\% \cong 6\%$$

Example 4

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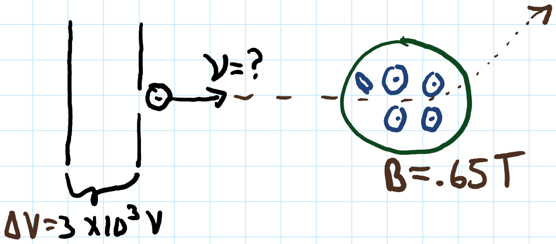
Early black-and-white television sets used an electron beam to draw a picture on the screen. The electrons in the beam were accelerated by a voltage of 3.0 kV; the beam was then steered to different points on the screen by coils of wire that produced a magnetic field of up to 0.65 T.
a)What is the speed of electrons in the beam?
b)What acceleration do they experience due to the magnetic field, assuming that it is perpendicular to their path? What is this acceleration in units of g?
c)If the electrons were to complete a full circular orbit, what would be the radius?



$$a = \frac{v^2}{r}$$

a) $\Delta KE = \Delta V q$

$$KE_f - \cancel{KE_i}^{\to 0} = \Delta V q$$

$$\frac{1}{2} m v_f^2 = \Delta V q$$

$$v_f = \sqrt{\frac{2\Delta V q}{m}} = \sqrt{\frac{2(3\times10^3\,V)(1.6\times10^{-19}\,C)}{(9.11\times10^{-31}\,kg)}}$$

$$v_f = 3.25\times10^7\,m/s$$

b) $F = qvB\cancel{\sin\phi}^{\to 1}$

$$F = (1.6\times10^{-19}\,C)(3.25\times10^7\,m/s)(.65\,T)$$

$$F = 3.38\times10^{-12}\,N$$

$$a = \frac{F}{m} = \frac{3.38\times10^{-12}\,N}{9.11\times10^{-31}\,kg} = \frac{3.71\times10^{18}\,m/s^2}{9.8\,m/s^2} \approx 3.7\times10^{17}\,g's$$

c) $r = \frac{qB}{mv}$ or

$$a = \frac{v^2}{r} \Rightarrow r = \frac{v^2}{a} = \frac{(3.25\times10^7\,m/s)^2}{3.7\times10^{18}\,m/s^2}$$

$$\boxed{r = 2.85\times10^{-4}\,m}$$