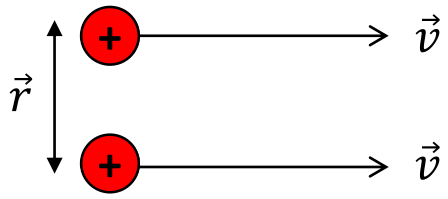
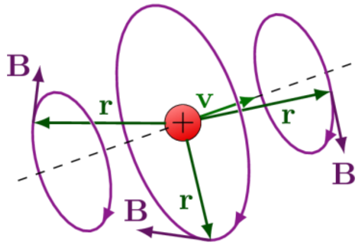
Find the ratio of F_B/F_E for two identical charges with velocities $\vec{v}$ separated by a distance $\vec{r}$



Field for a single moving charge, $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$



Force on a charge, $\vec{F} = q\vec{v} \times \vec{B}$

By considering the magnitudes only, $F_B = \frac{\mu_0}{4\pi}\frac{q^2v^2}{r^2}$

Now from Coulomb's law, $F_E = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$

$$\frac{F_B}{F_E} = \epsilon_0\mu_0 v^2$$

$$\frac{1}{\sqrt{\mu_0\epsilon_0}} = \left(\frac{1}{4\pi\times10^{-7}}4\pi\times9\times10^9\right)^{1/2} = \left(9\times10^{16}\right)^{1/2} = 3\times10^8\,\frac{m}{s}$$ Speed of light

$$\frac{F_B}{F_E} = \frac{v^2}{c^2}$$

In a pre–quantum-mechanical model of the hydrogen atom, an electron orbits a proton at a radius of 5.29×10^{-11} m. According to this model, what is the magnitude of the magnetic field at the proton due to the orbital motion of the electron? Neglect any motion of the proton.

The centripetal force acting on the orbiting electron is the Coulomb force between the electron and the proton.

Field for a single moving charge, $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$; $B = \frac{\mu_0}{4\pi}\frac{qv}{r^2}$

Coulomb's law, $F_E = k\frac{q^2}{r^2}$

Centripetal force, $F_c = \frac{v^2}{r} = k\frac{q^2}{r^2}$

$$v = \sqrt{\frac{kq^2}{mr}}$$

$$B = \frac{\mu_0}{4\pi}\frac{q}{r^2}\sqrt{\frac{kq^2}{mr}}$$

- An inductor is made by tightly wrapping 0.30-mm-diameter wire around a 4.0-mm-diameter cylinder. What length cylinder has an inductance of 10 μH?

(Hint: Since the wire is tightly wrapped, the number of turns per meter, n, is the reciprocal of the diameter of the wire, use $L = \mu_0 n^2 l A$).

- Let, the inductor is 5.7 cm long and it carries a 100 mA current. What are the energy stored in the inductor, the magnetic energy density, and the magnetic field strength?

(Hint: $U = \frac{1}{2} L i^2; u_B = \frac{1}{2} \mu_0 n^2 i^2; u_B = \frac{1}{2\mu_0} B^2$).

- An L = 4.0mH inductor with some initial current I_0 is discharged through a 0.25Ω resistor. How long does it take to lose half of the initial current? Half of the initial energy?

(Hint: $i = i_0 e^{-t/\tau_L}; \tau_L = \frac{L}{R}; U = \frac{1}{2} L i^2$)

- An MRI machine needs to detect signals that oscillate at very high frequencies. It does so with an LC circuit containing a 15 mH coil. To what value should the capacitance be set to detect a 450 MHz signal?

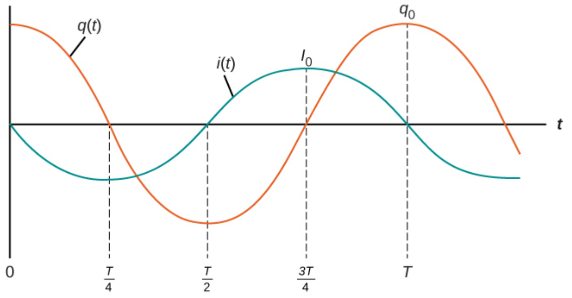
(Hint: $\omega = 1/\sqrt{LC}$)

- An FM radio station broadcasts at a frequency of 100 MHz. What inductance should be paired with a 10 pF capacitor to build a receiver circuit for this station?

(Hint: $\omega = 1/\sqrt{LC}$)

- An LC circuit is built with a 20 mH inductor and an 8.0 pF capacitor. The capacitor voltage has its maximum value of 25 V at t = 0 s. (a) How long is it until the capacitor is first fully discharged? (b) What is the inductor current at that time?

(Hint: $\omega = \frac{1}{\sqrt{LC}}$; the time it takes for the capacitor to be fully discharged is a quarter of the period (since the voltage goes from maximum to zero in one-quarter of the cycle. When the capacitor is fully discharged, all the energy in the circuit is stored in the inductor)



- An LC circuit has a 10 mH inductor. The current has its maximum value of 0.60 A at t = 0 s. A short time later the capacitor reaches its maximum potential difference of 60 V. What is the value of the capacitance?

(Hint: Use the principle of conservation of energy, $U_B = \frac{1}{2}Li_{max}^2 = \frac{1}{2C}q_{max}^2 = \frac{1}{2}CV_{max}^2$)