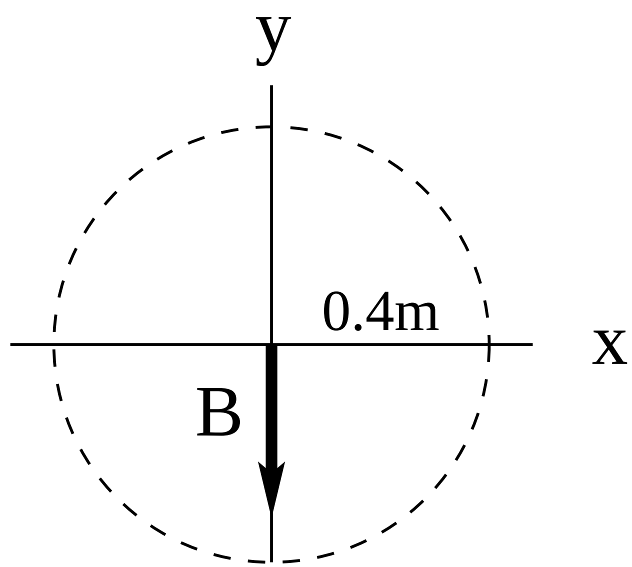
Intermediate Exam III: Problem #1 (Spring '05)

An infinitely long straight current of magnitude $I = 6$A is directed into the plane ($\otimes$) and located a distance $d = 0.4$m from the coordinate origin (somewhere on the dashed circle). The magnetic field $\vec{B}$ generated by this current is in the negative y-direction as shown.

(a) Find the magnitude B of the magnetic field.

(b) Mark the location of the position of the current $\otimes$ on the dashed circle.



Solution:

(a) $B = \dfrac{\mu_0}{2\pi}\dfrac{I}{d} = 3\mu\mathrm{T}.$

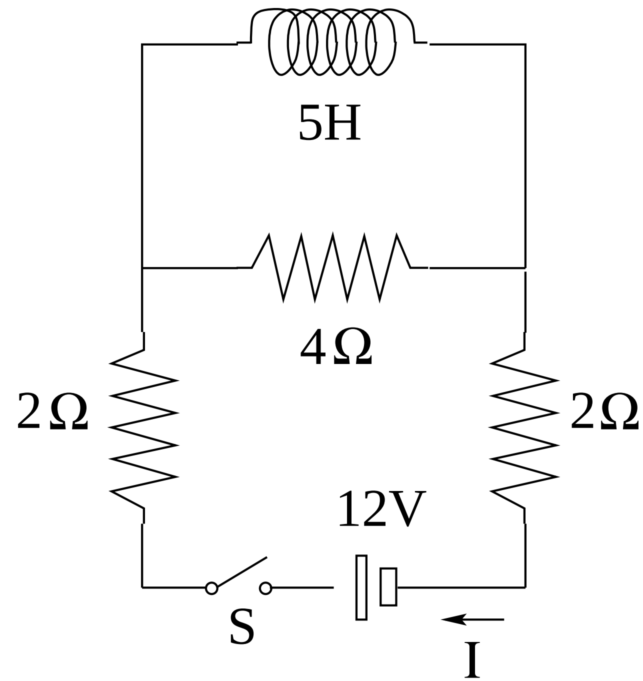
(b) Position of current $\otimes$ is at $y = 0,\ x = -0.4$m.

Intermediate Exam III: Problem #2 (Spring ’05)

In the circuit shown we close the switch S at time $t = 0$. Find the current I through the battery and the voltage V_L across the inductor

(a) immediately after the switch has been closed,

(b) a very long time later.



Solution:

(a) $I = \dfrac{12\mathrm{V}}{2\Omega + 4\Omega + 2\Omega} = 1.5\mathrm{A}, \qquad V_L = (4\Omega)(1.5\mathrm{A}) = 6\mathrm{V}.$

(b) $I = \dfrac{12\mathrm{V}}{2\Omega + 2\Omega} = 3\mathrm{A}, \qquad V_L = 0.$

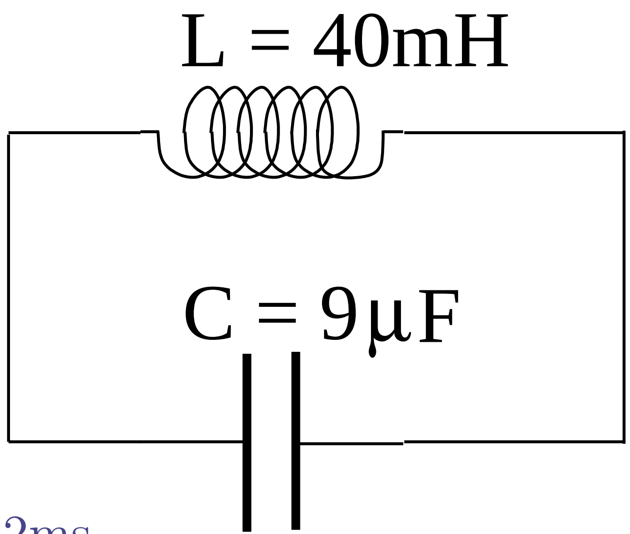
Intermediate Exam III: Problem #3 (Spring '05)

At time $t = 0$ the capacitor is charged to $Q_{max} = 3\mu$C and the current is instantaneously zero.

(a) How much energy is stored in the capacitor at time $t = 0$?

(b) At what time t_1 does the current reach its maximum value?

(c) How much energy is stored in the inductor at time t_1?



Solution:

(a) $U_C = \dfrac{Q_{max}^2}{2C} = 0.5\mu\mathrm{J}.$

(b) $T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{LC} = 3.77\mathrm{ms}, \qquad t_1 = \dfrac{T}{4} = 0.942\mathrm{ms}.$

(c) $U_L = U_C = 0.5\mu\mathrm{J}$ (energy conservation.)

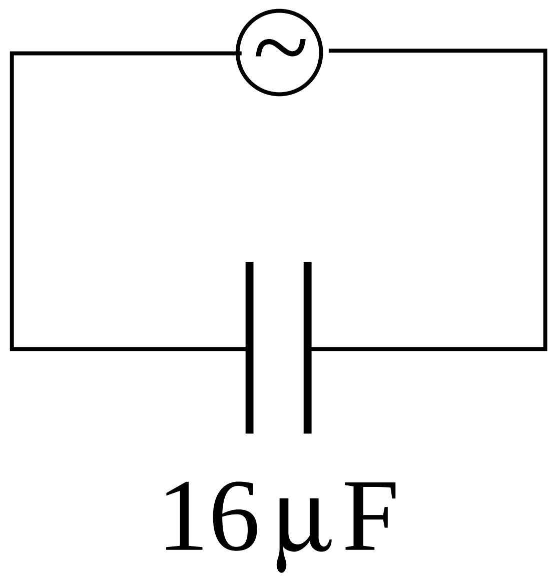
Intermediate Exam III: Problem #4 (Spring '05)

Consider the circuit shown. The ac voltage supplied is $\mathcal{E} = \mathcal{E}_{max}\cos(\omega t)$ with $\mathcal{E}_{max} = 170$V and $\omega = 377$rad/s.

(a) What is the maximum value I_{max} of the current?

(b) What is the emf $\mathcal{E}(t)$ at $t = 0.01$s?

(c) What is the current $I(t)$ at $t = 0.01$s?



Solution:

(a) $I_{max} = \dfrac{\mathcal{E}_{max}}{X_C} = \mathcal{E}_{max}\omega C = 1.03\mathrm{A}.$

(b) $\mathcal{E} = (170\mathrm{V})\cos(3.77\mathrm{rad}) = (170\mathrm{V})(-0.809) = -138\mathrm{V}.$

(c) $I = \mathcal{E}_{max}\omega C\cos(3.77\mathrm{rad} + \pi/2) = (1.03\mathrm{A})(0.588) = 0.605\mathrm{A}.$