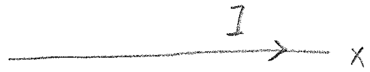
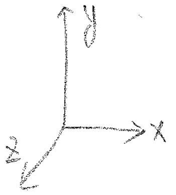
Problem 1 2008-05-31

a) $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \cdot 10^{-7} \cdot 300}{2\pi \cdot 10} = 6.0\mu T$

$H = \frac{B}{\mu_0} = \frac{I}{2\pi r} = \frac{300}{2 \cdot \pi \cdot 10} \approx 4.7746$

b)





$\vec{F}_m = q\vec{v} \times \vec{B}$

$\vec{v} = v\hat{x}$

$\vec{B} = B\hat{z}$

$\vec{F}_m = q v \hat{x} \times B\hat{z}$

$= qvB(-\hat{y})$

For electron, q is negative, so $\vec{F}_m = |\vec{F}_m|\hat{y}$

The positive charge will stay at the lower part of the antenna, and the upper part of the antenna becomes negatively charged.

c) By balance.

$F_e = F_m \Rightarrow qE = qvB \Rightarrow E = vB$

$U = \int_a^b E \cdot dr$

$= \int_a^b \frac{v \cdot \mu_0 I}{2\pi r} dr = \frac{v\mu_0 I}{2\pi} \int_a^b \frac{1}{r} dr = \frac{v\mu_0 I}{2\pi} [\ln r]_a^b = \frac{v\mu_0 I}{2\pi} \ln\left(\frac{11}{10}\right)$

$\approx 333.3 \cdot 6 \cdot 10^{-5} \cdot 0.0953$

$\approx 0.19 mV$

d) When the current is AC. then the $\vec{B}$ is a function of time.

$\vec{F} = q\vec{v}\times\vec{B}$ is also a function of time, which makes the electron and positive charge move up and down constantly. With the same frequency.

~~$F_m = F_e$~~

~~At the first half period, the electron will move up and down. the positive charge will~~

2008-05-31

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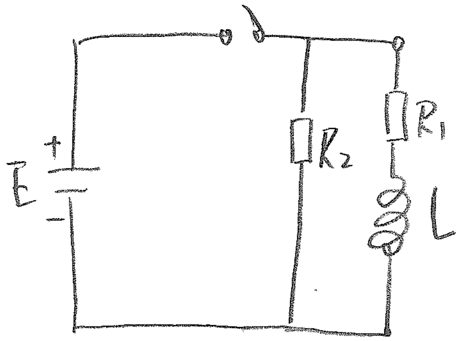
Problem 2 close switch at $t=0$



$E = 120V$

$R_1 = 50\Omega$

$R_2 = 500\Omega$

$L = 100mH$

a) write an expression for current i through L as a function of time. Specify the maximum value of current i. Calculate how long time it takes for current i through the inductor be 75% of the maximum value

b) After long time open the switch. Calculate the voltage over R_2 directly after switched off.

a) After switch on.

$$E = R_1 i + L\frac{di}{dt} \Rightarrow i = \frac{E}{R_1}\left(1 - e^{-\frac{t}{L/R_1}}\right) \Rightarrow i = \frac{E}{R_1}\cdot\left(1 - e^{-t/\tau_L}\right)$$

$$\tau_L = \frac{L}{R_1} = \frac{100\cdot10^{-3}}{50} = 2.0\cdot10^{-3}$$

$$i_{max} = \frac{E}{R_1} = \frac{12.0V}{50.0\Omega} = 0.24A$$

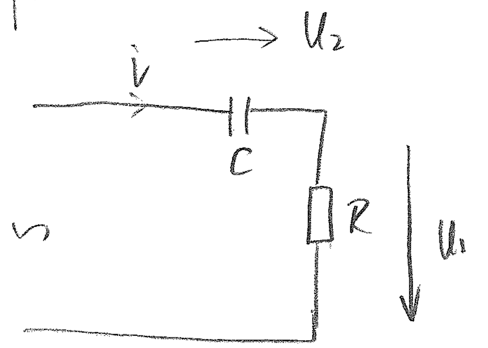
$$75\%\cdot i_{max} = i_{max}\cdot\left(1 - e^{-t/\tau_L}\right)$$

$$\Rightarrow e^{-t/\tau_L} = 0.25 \Rightarrow t \approx 2.77ms$$

b) $U = R_2 \cdot i_{max} = 500\Omega \cdot 0.24A = 120V$

2008-05-31

Problem 4



Assume
$i = 0.050 \sin \omega t$ A

Resistance is 100Ω. Capacitor impedance is 200Ω

$u_1 = R \cdot i = 5.0 \sin 100\pi t$

$u_2 = \frac{1}{\omega C} \hat{I} \sin(100\pi t - \frac{\pi}{2}) = 10.0 \sin(100\pi t - \frac{\pi}{2})$ V

Calculate the input voltage and capacitance C

$$Z_C = \frac{1}{\omega C} = 200\Omega$$

$$\omega = 100\pi$$

$$\Rightarrow C = \frac{1}{\omega Z_C}$$

$$= \frac{1}{100\pi \cdot 200} = 15.9 \mu F$$

The input voltage:

$$u_{in} = u_R + u_C$$

$$= 5.0 \sin 100\pi t + 10.0 \sin(100\pi t - \frac{\pi}{2})$$

$$= 5.0 \sin 100\pi t - 10.0 \cos 100\pi t$$

$$= \sqrt{5.0^2 + 10.0^2} \sin(100\pi t + \operatorname{atan} \frac{-10.0}{5.0})$$

$$\approx 11.2 \sin(100\pi t - 1.1) \text{ V}$$