Announcements

1. First exams will be returned at the end of class. Mid-term grades = 25% HW + 75% 1st exam (hopefully an underestimate).
2. Plan for 2nd exam
3. Changes in HW assignments

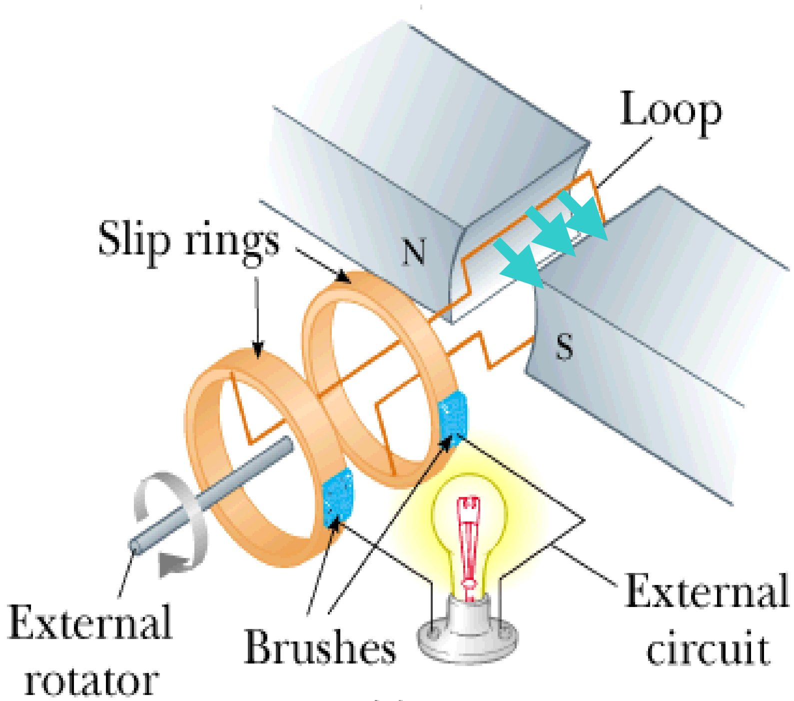
   -- HW 14 now due Wed 2/26/03 as is HW 15

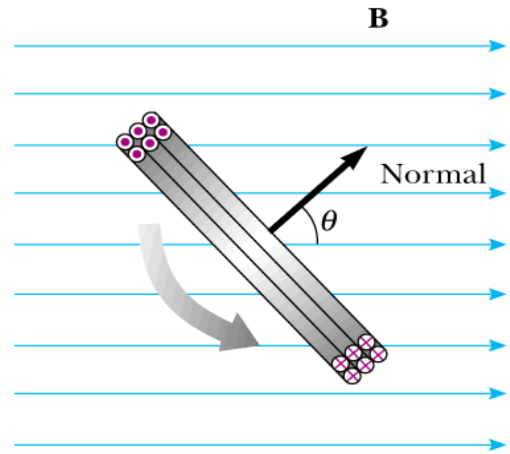
   -- HW 16 problems changed (due Fri 2/28/03)
4. Extra problem solving session? (In addition to Tuesday at 6 PM)
5. Today's topics
   Inductance
   AC circuits

PHY 114 – Second exam

Note: This is a take-home exam which must be turned in to the physics office (Olin 100) within 24 hours of when you received the exam. You may consult your text, your lecture notes, and your homework assignments, but *no other resources are allowed*. Please record all of your work (diagrams, mathematical manipulations, and numerical work) in the exam booklet. Please show your intermediate steps so that partial credit can be awarded if appropriate. When your work is completed, please place your work including (1) the exam booklet, (2) this exam, and (3) any scratch work, in the original envelope and return it to the physics office. It is assumed that all work will be done under the guidelines of the honor code. The exam is available starting at 9 AM Monday, March 3, 2003. All exams must be received by the Physics Office before 5 PM Friday, March 7, 2003.

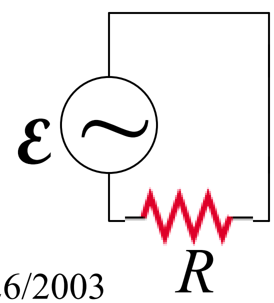
Example: AC generator





$$\frac{d}{dt}\int \mathbf{B}\cdot d\mathbf{A} = \frac{d}{dt}\left(BA\cos\omega t\right)$$
$$= -\omega BA\sin\omega t$$

$$\Rightarrow \mathcal{E} = \underbrace{\omega BA}_{\mathcal{E}_{max}}\sin\omega t$$



$$I = \frac{\mathcal{E}_{max}}{R}\sin\omega t$$

Inductors

Faraday's law $\rightarrow$ solenoid geometry $\rightarrow$ inductance

$$\boldsymbol{\varepsilon} = -\frac{d\Phi_B}{dt} \qquad \mathbf{B} = \mu_0\, n\, I \qquad \boldsymbol{\varepsilon}_L = -L\frac{dI}{dt}$$

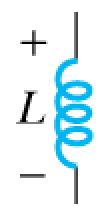
Energy stored in inductor:

$$U_L = \int_0^I LI'dI' = \frac{1}{2}LI^2$$

$$L = \mu_0\, n^2\, V$$

volume

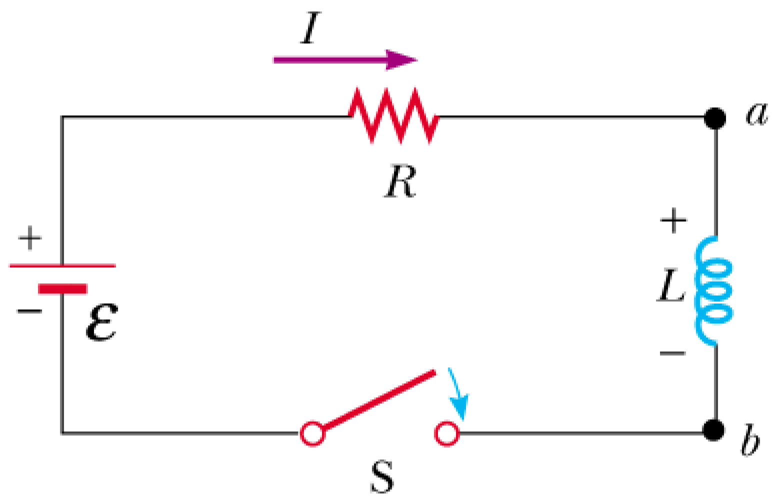
turns/length



Recall: energy stored in capacitor:

$$U_C = \frac{1}{2}\frac{q^2}{C}$$

Inductor in an LR (direct current) circuit:

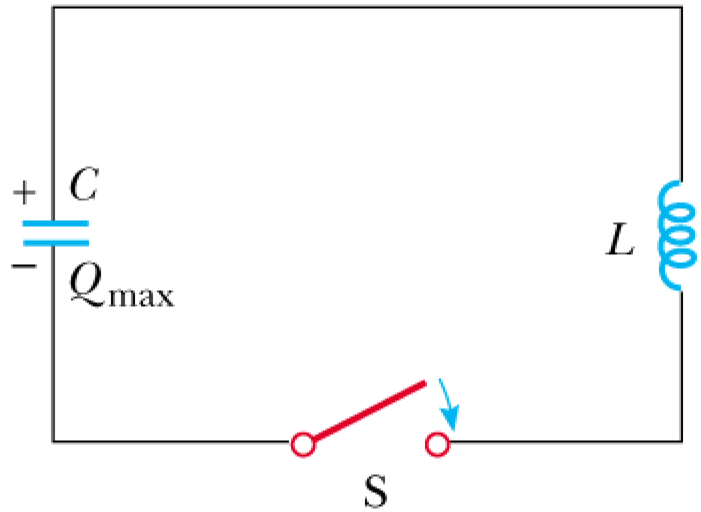


$$\mathcal{E}_{\text{battery}} - IR - L\frac{dI}{dt} = 0$$

solution for $I(t)$ assuming $I(t=0)=0$:

$$I(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/(L/R)}\right)$$

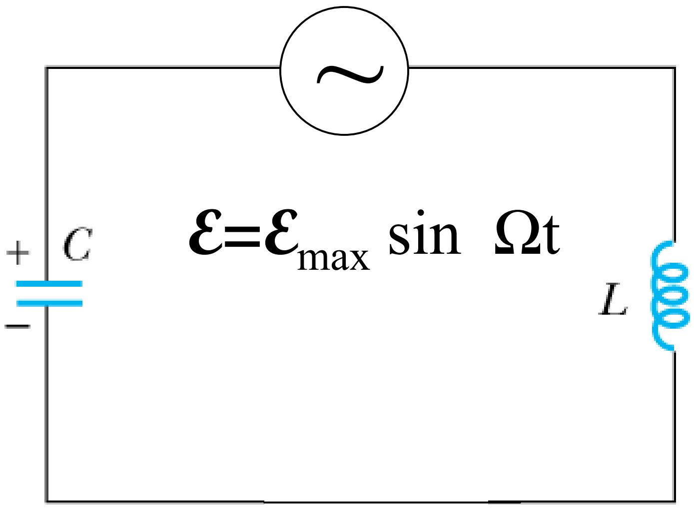
LC – circuits:



$$-\frac{q}{C} - L\frac{dI}{dt} = 0$$

$$\frac{d^2q}{dt^2} = -\frac{1}{LC}q \qquad \Rightarrow \; q(t) = Q_0\cos(\omega t + \varphi) \;\; \text{with} \;\; \omega \equiv \sqrt{\frac{1}{LC}}$$

resonance frequency



$$-\frac{q}{C}-L\frac{d^2q}{dt^2}+\mathcal{E}_{max}\sin\Omega t=0$$

$$q(t)=\frac{\mathcal{E}_{max}/L}{\frac{1}{LC}-\Omega^2}\sin\Omega t$$

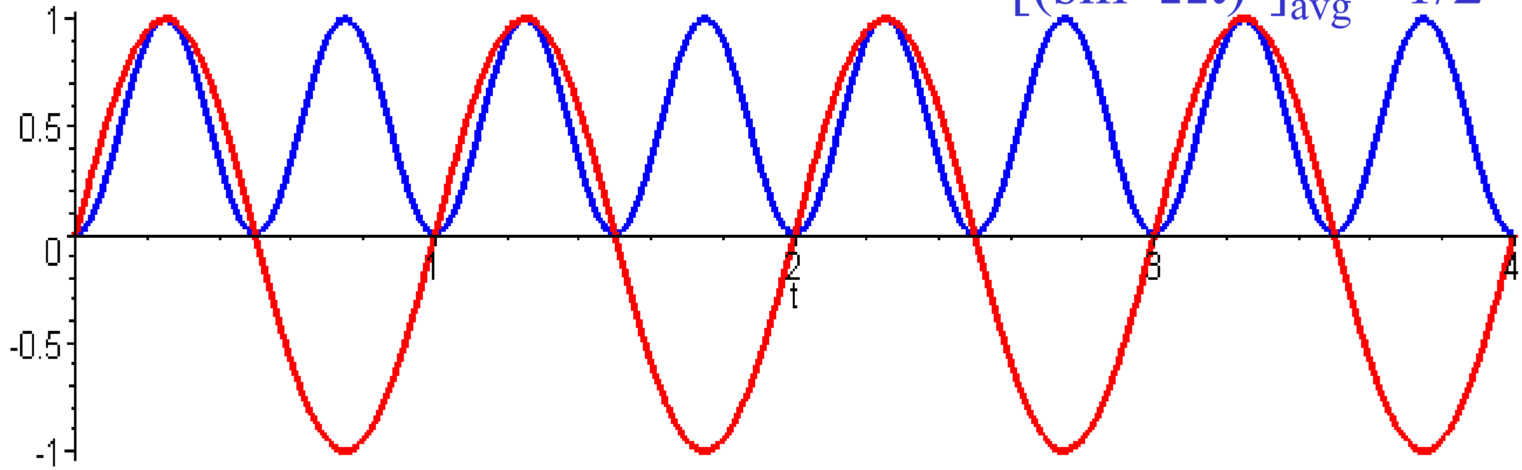
large response when

$$\Omega=\frac{1}{\sqrt{LC}}$$

Properties of AC circuits

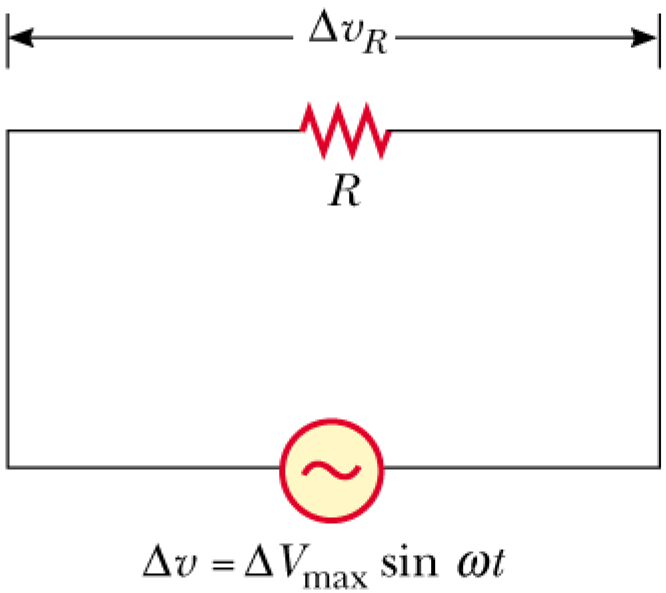
$\mathcal{E} = \mathcal{E}_{max} \sin \Omega t$ or $\mathcal{E}_{max} \cos \Omega t$

$[(\sin \Omega t)^2]_{avg} = 1/2$



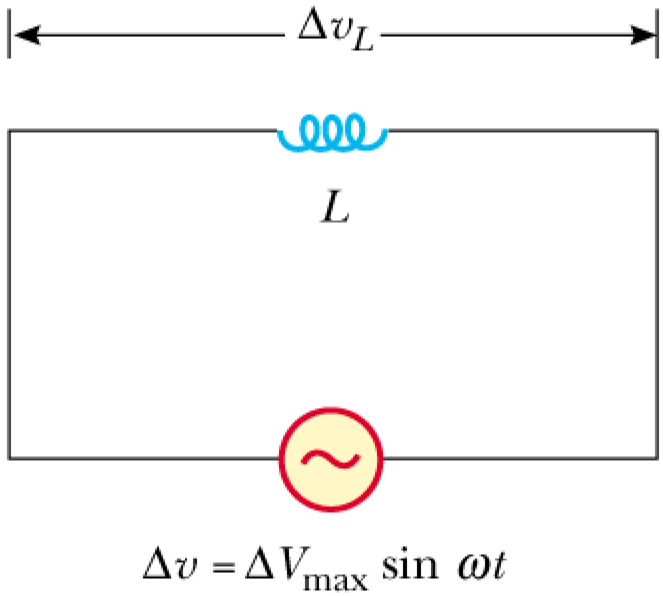
$[\sin \Omega t]_{avg} = 0$

$\mathcal{E}_{rms} = \sqrt{\tfrac{1}{2}}\, \mathcal{E}_{max}$ similarly, $I_{rms} = \sqrt{\tfrac{1}{2}}\, I_{max}$



$$- IR + \Delta V_{max} \sin \omega t = 0$$

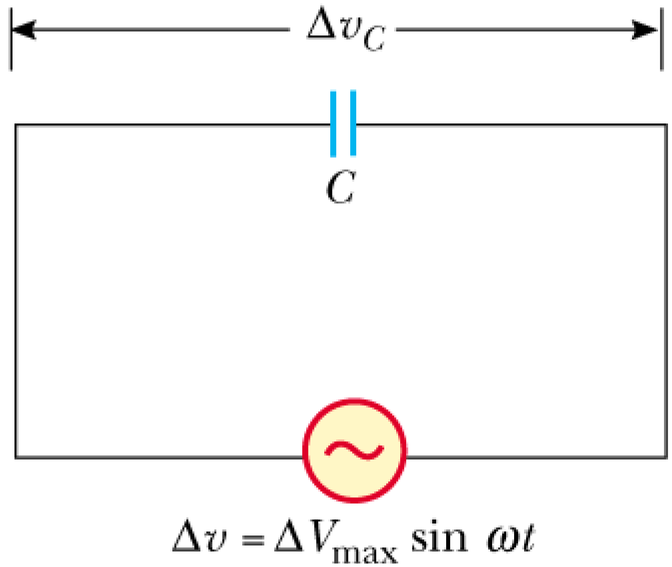
$$I = \frac{\Delta V_{max}}{R} \sin \omega t$$



$$-L\frac{dI}{dt} + \Delta V_{\max}\sin\omega t = 0$$

$$\frac{dI}{dt} = \frac{\Delta V_{\max}}{L}\sin\omega t$$

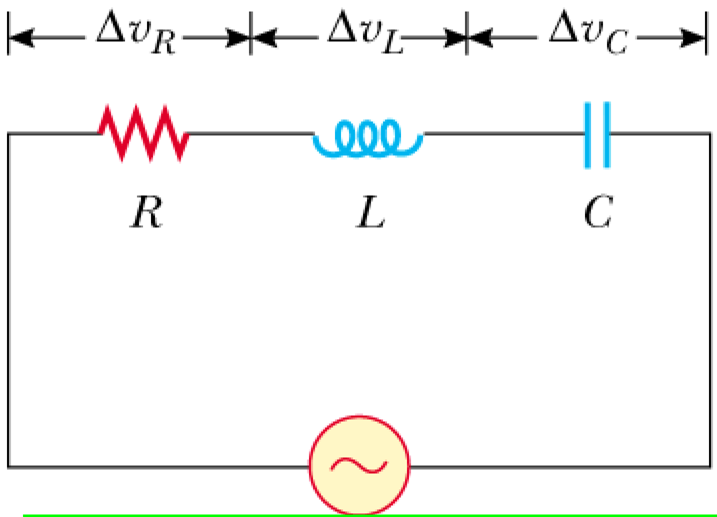
$$I = -\frac{\Delta V_{\max}}{\omega L}\cos\omega t$$



$$-\frac{q}{C} + \Delta V_{\max} \sin \omega t = 0$$

$$q = C\Delta V_{\max} \sin \omega t$$

$$I = \omega C \Delta V_{\max} \cos \omega t$$



$$-RI - L\frac{dI}{dt} - \frac{q}{C} + \Delta V_{\max}\sin\omega t = 0$$

$$I = I_{\max}\sin(\omega t - \varphi)$$

$$I_{\max} = \frac{\Delta V_{\max}}{Z} \qquad Z \equiv \sqrt{R^2 + (\omega L - 1/\omega C)^2}$$

$$\tan\varphi = \frac{\omega L - 1/\omega C}{R}$$