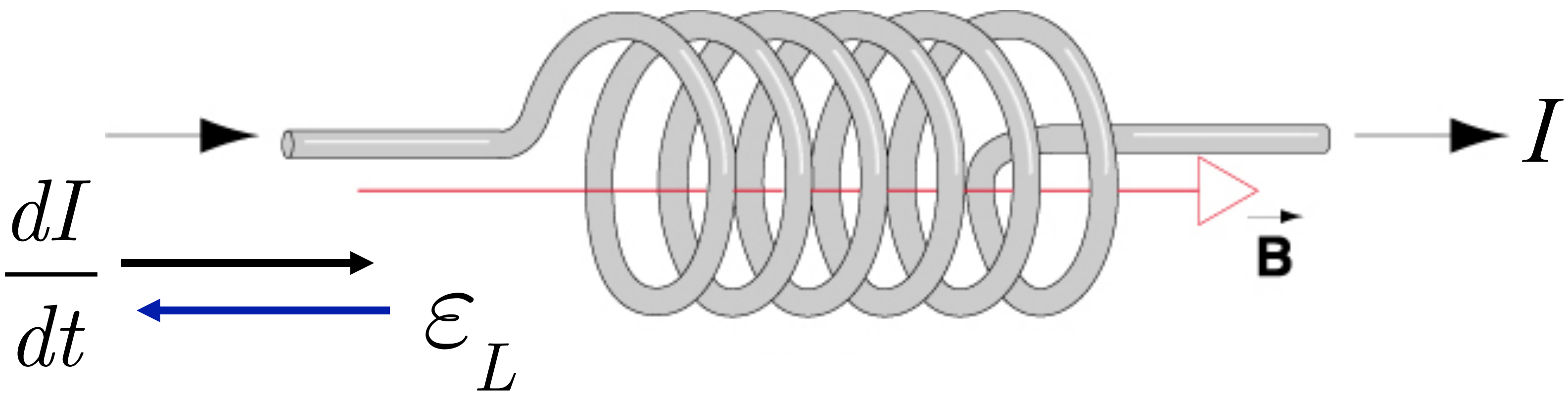
Finish Chapter 27: Electromagnetic Induction
Chapter 28: Alternating-Current Circuits
Tuesday November 1st

- **Mini-exam 4 on Thursday**
  - **Will cover Ch. 26 & 27 (LONCAPA 13-16)**

- Review of Inductors
- Review of *RL* Circuits
- Energy and oscillations in LC circuits
- Intro to alternating current theory
  - Def^n of terms, e.g., rms values
  - Resistance
  - Capacitive reactance
  - Inductive reactance

Reading: up to page 498 in the text book (Ch. 28)

Review: Inductors



- We can, therefore, define a quantity L called inductance, which relates I to Φ_B and, thus, dI/dt and ε:

$$\Phi_B = LI$$

$$\varepsilon_L = -L\frac{dI}{dt}$$

Units for L:
weber/amp
T.m^2/A
Henry (H)

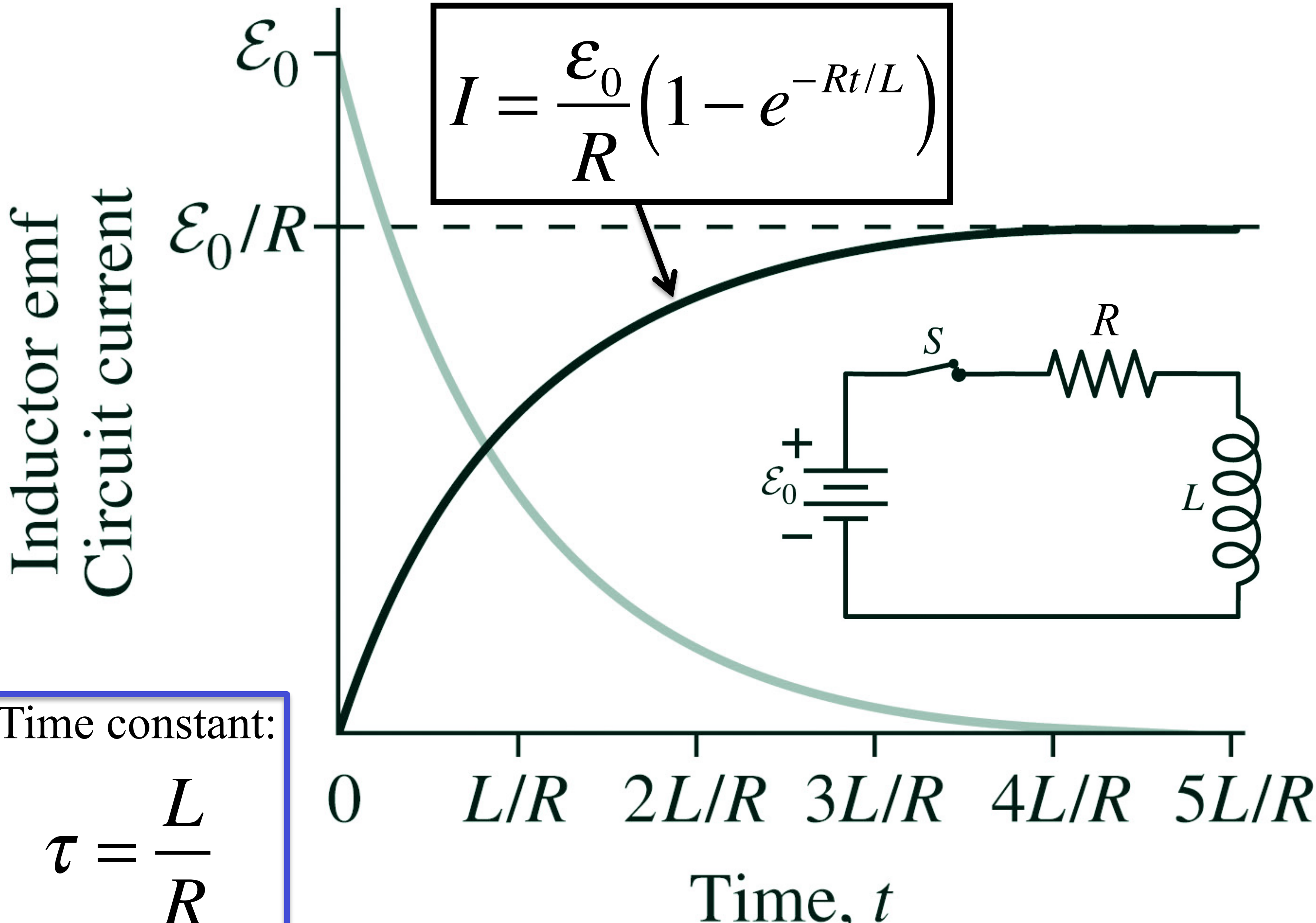
Solenoid:

$$B = \mu_o nI$$

$$L = \mu_o n^2 Al$$

LR circuits (similarity to *RC* circuit)

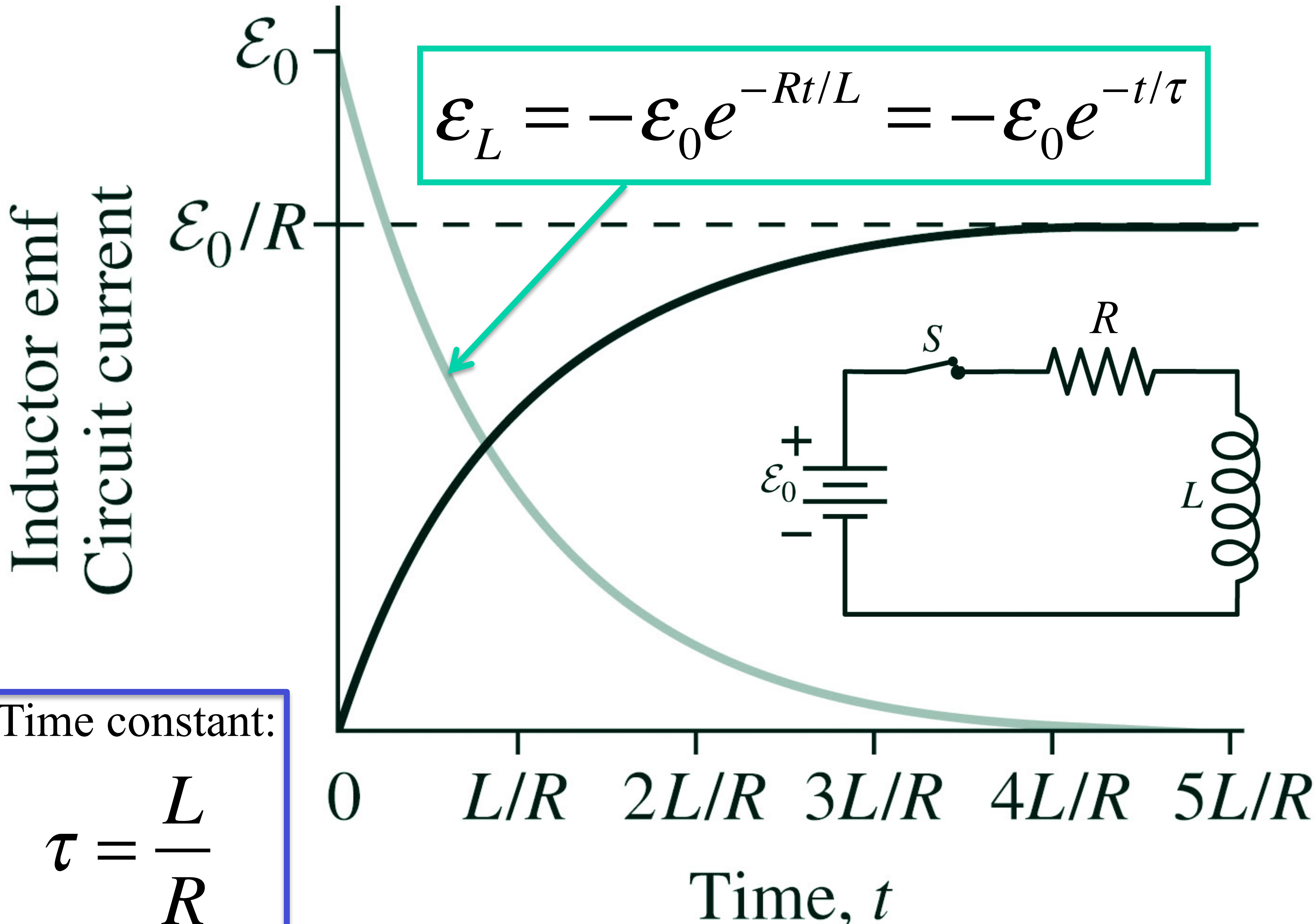
$$I = \frac{\mathcal{E}_0}{R}\left(1 - e^{-Rt/L}\right)$$



Time constant:

$$\tau = \frac{L}{R}$$

LR circuits (similarity to *RC* circuit)

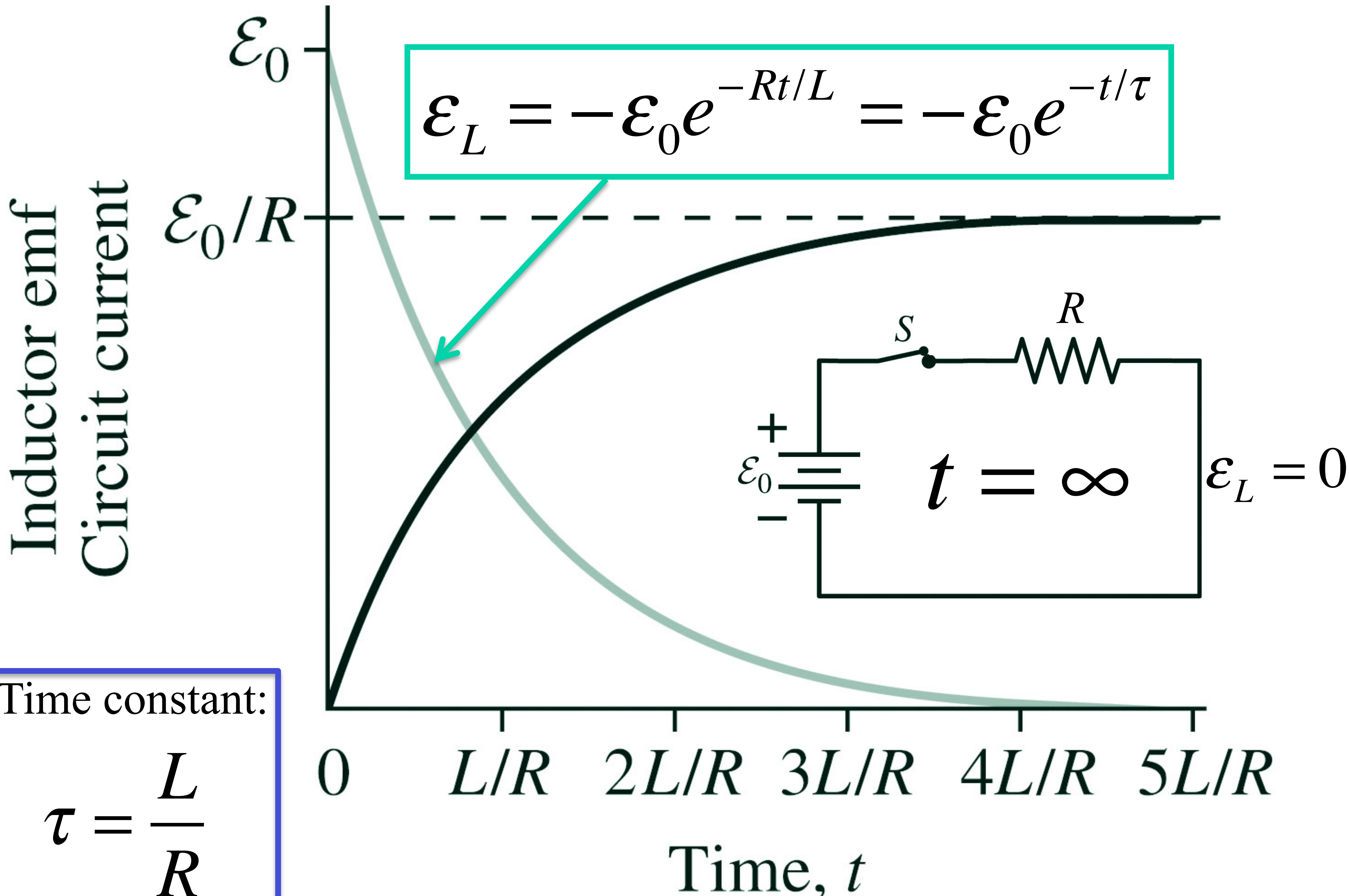


$$\varepsilon_L = -\varepsilon_0 e^{-Rt/L} = -\varepsilon_0 e^{-t/\tau}$$

Time constant:

$$\tau = \frac{L}{R}$$

LR circuits (similarity to *RC* circuit)



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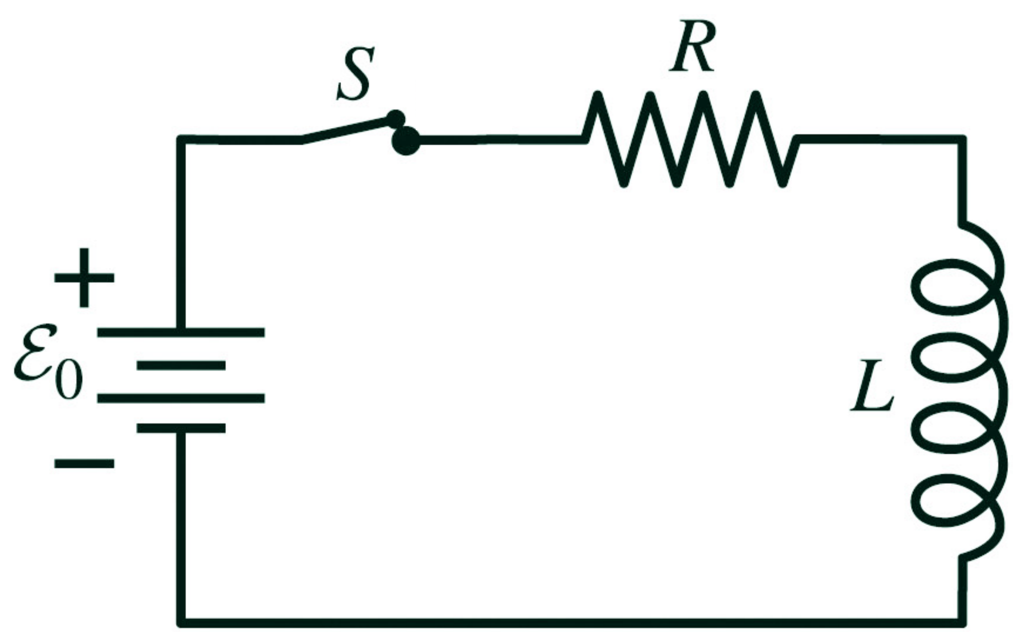
Time constant:

$$\tau = \frac{L}{R}$$

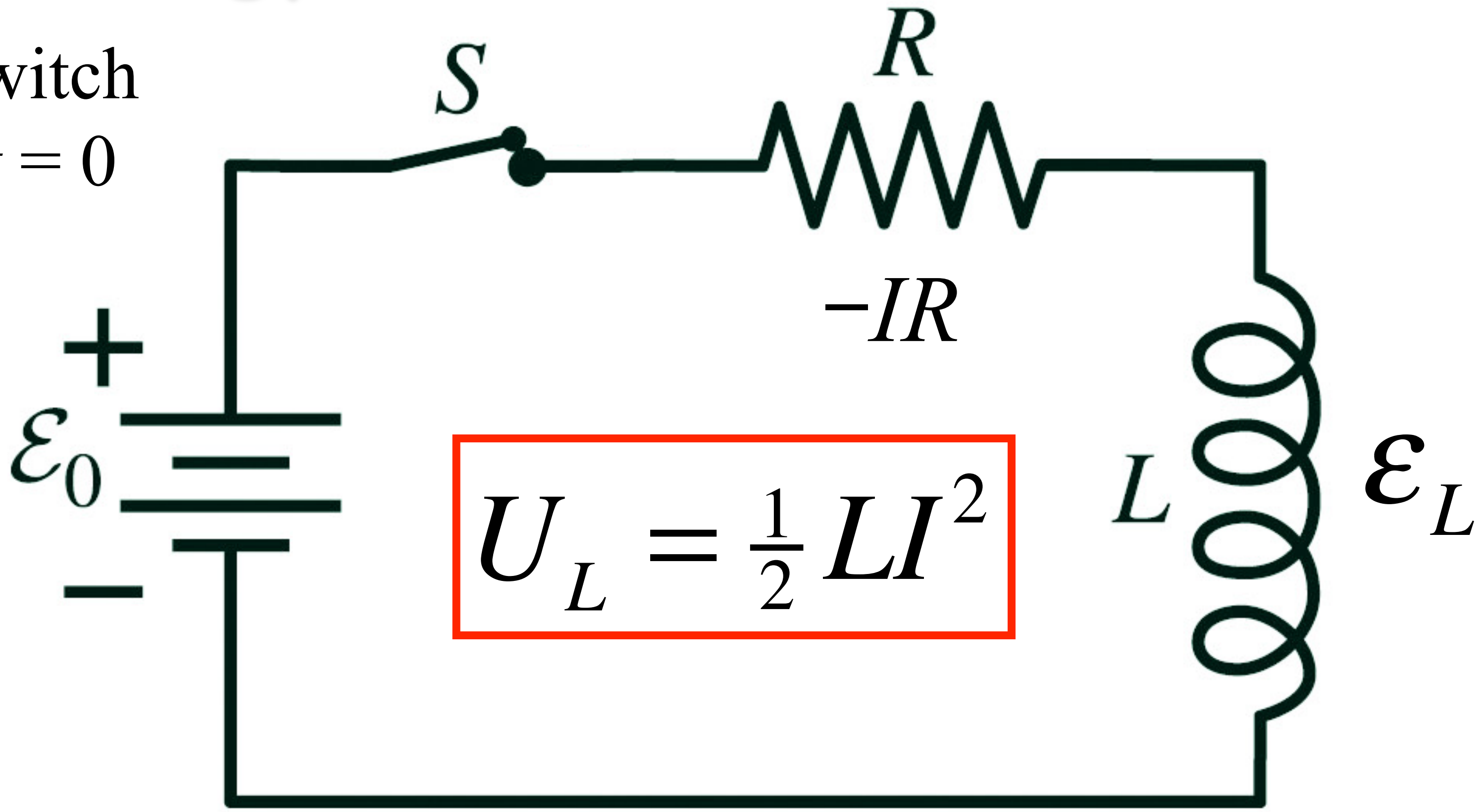
Example

A 3.5 V battery is connected in series with a switch, a resistor and an inductor. The switch is thrown at time $t = 0$. The current reaches half its maximum value after 1.2 ms. After a long time, the current reaches a maximum of 255 mA. Deduce values for the resistance and inductance in the circuit.



Energy Stored in an Inductor

Close switch
at time $t = 0$

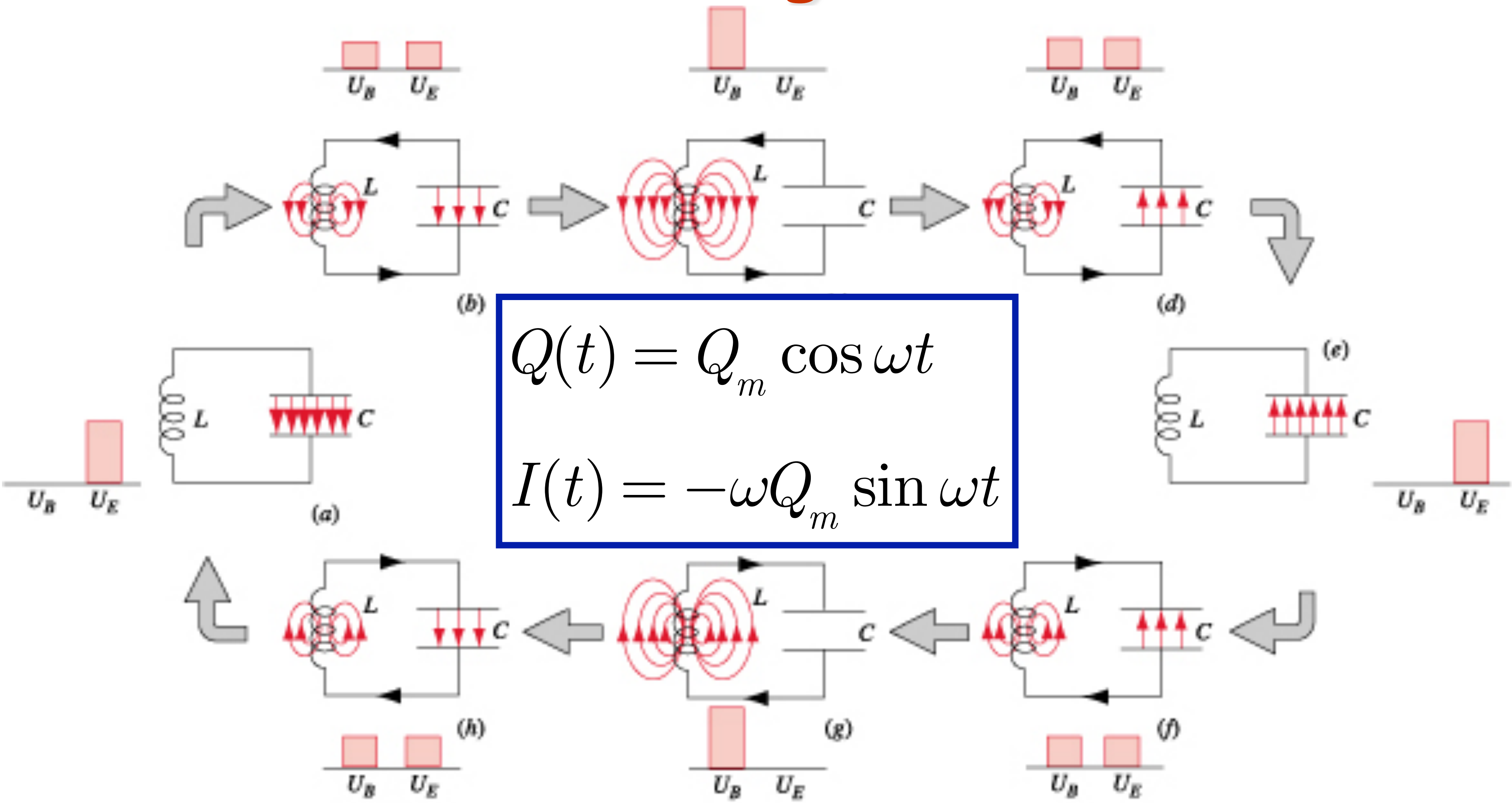


$$U_L = \tfrac{1}{2} L I^2$$

Energy stored in magnetic fields:

Energy density: $$u_B = \frac{\text{Energy}}{\text{unit volume}} = \frac{B^2}{2\mu_o}$$

Ch. 28: Electromagnetic oscillations

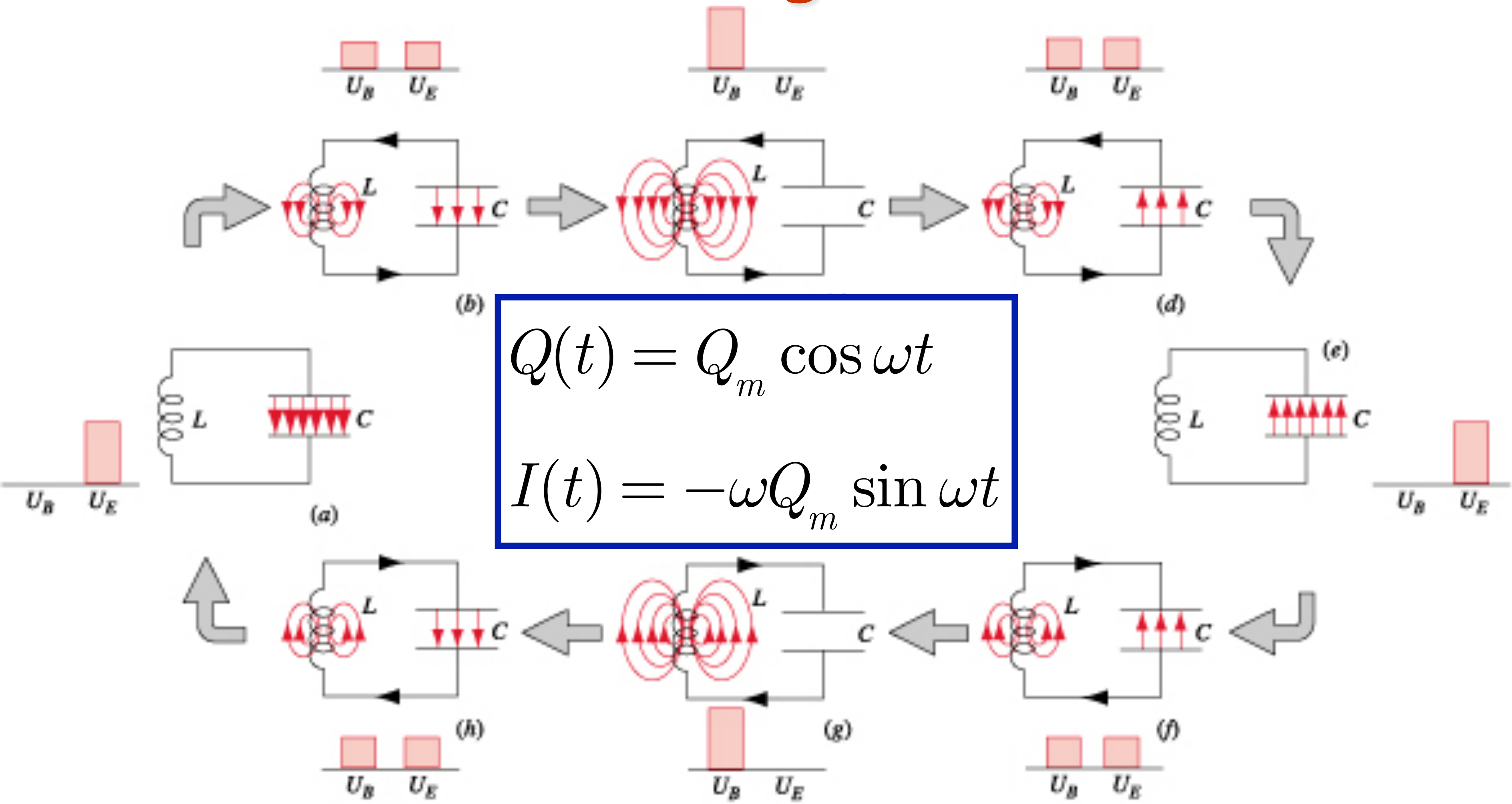


$$Q(t) = Q_m \cos \omega t$$

$$I(t) = -\omega Q_m \sin \omega t$$

$$U = U_B + U_E = \frac{1}{2} L I^2 + \frac{1}{2} \frac{Q^2}{C}$$

Ch. 28: Electromagnetic oscillations



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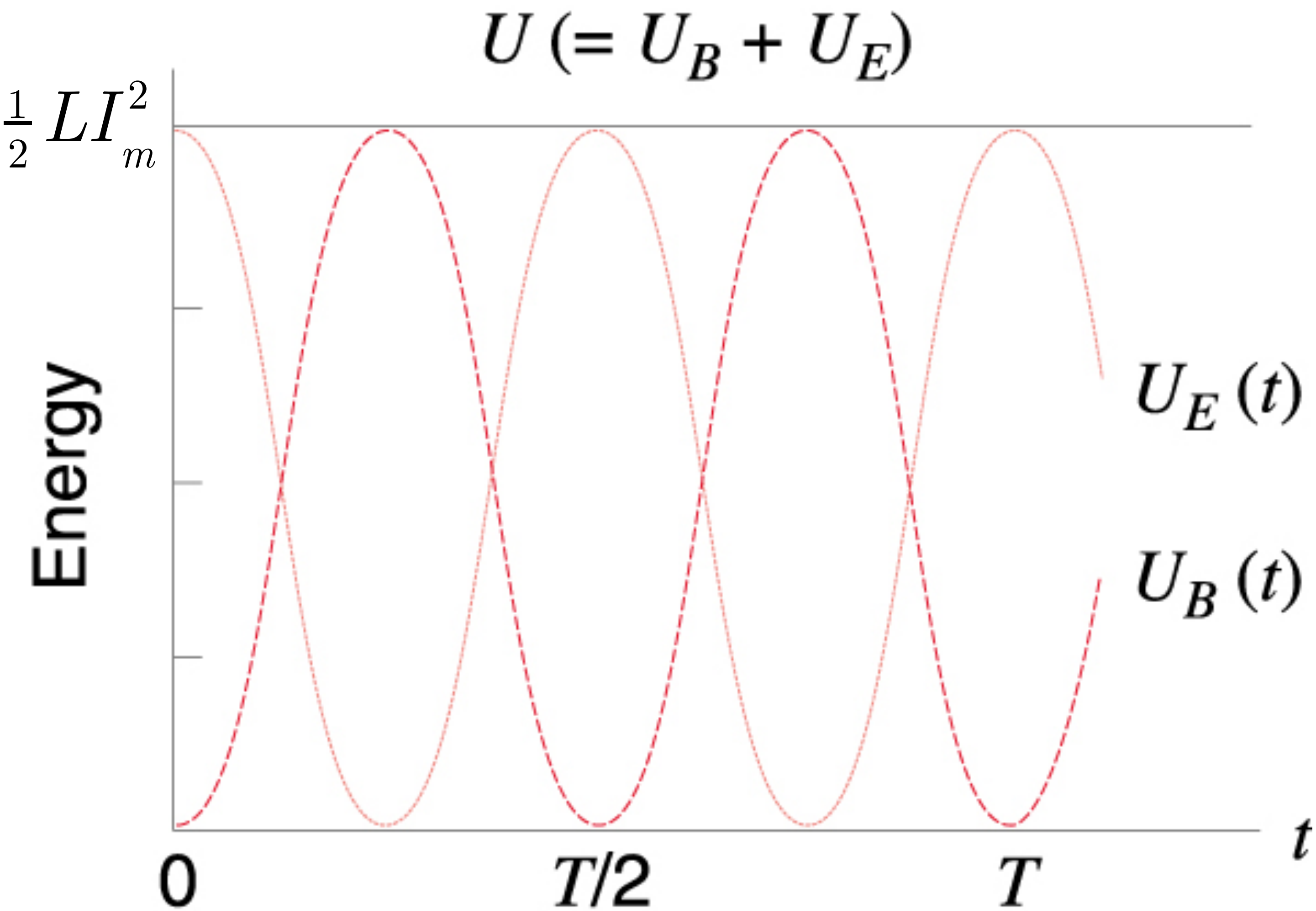
$$\omega = \sqrt{\frac{1}{LC}}$$

Ch. 28: Electromagnetic oscillations

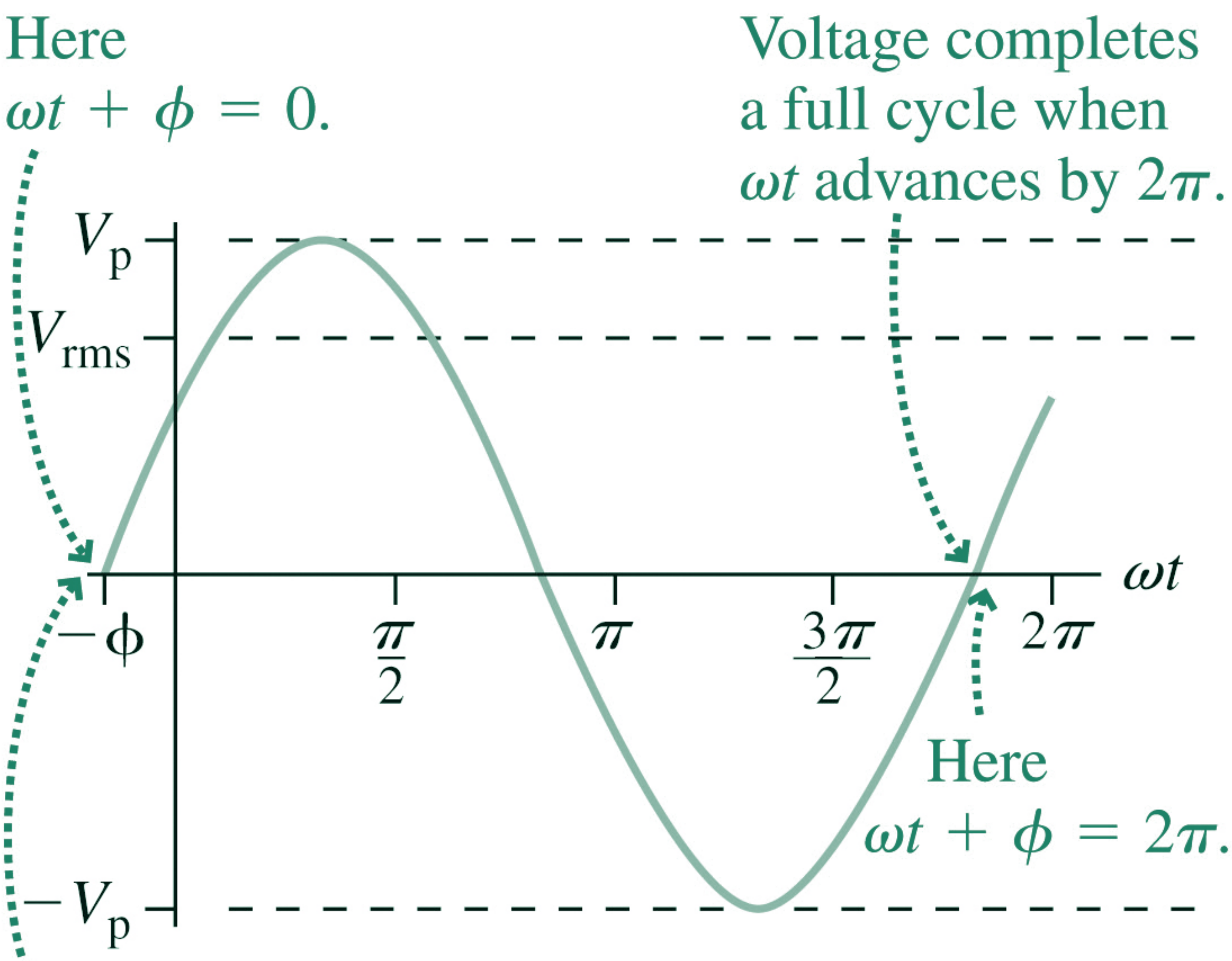
$$\frac{Q_m^2}{2C} = \tfrac{1}{2} L I_m^2$$



$$U = U_B + U_E = \frac{1}{2} L I^2 + \frac{1}{2}\frac{Q^2}{C}$$

Ch. 28: Alternating Current

$$V(t) = V_P \sin\left(\omega t + \phi_V\right); \qquad I(t) = I_P \sin\left(\omega t + \phi_I\right)$$



Sine curve starts at $\omega t = -\pi/6$ or -30^o

Angular frequency:

$$\omega = 2\pi f$$

In this example:

$\phi_V = +\pi/6$ or 30^o

Root-Mean-Square:

$$V_{rms} = \frac{V_P}{\sqrt{2}}$$

$$I_{rms} = \frac{I_P}{\sqrt{2}}$$