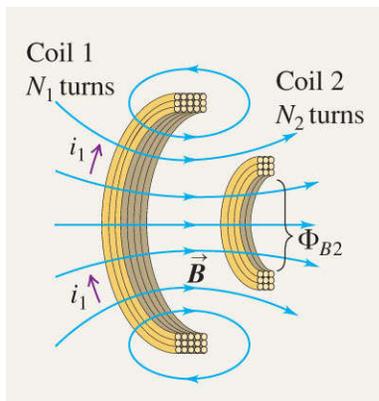


University Physics, 13/e
Young/Freedman
Chapter 30 Summary

1. **Mutual inductance:** When a changing current i_1 in one circuit causes a changing magnetic flux in a second circuit, an emf \mathcal{E}_2 is induced in the second circuit. Likewise, a changing current i_2 in the second circuit induces an emf \mathcal{E}_1 in the first circuit. If the circuits are coils of wire with N_1 and N_2 turns, the mutual inductance M can be expressed in terms of the average flux Φ_{B2} through each turn of coil 2 caused by the current i_1 in coil 1, or in terms of the average flux Φ_{B1} through each turn of coil 1 caused by the current i_2 in coil 2. The SI unit of mutual inductance is the henry, abbreviated H. (See Examples 30.1 and 30.2.)

$$\mathcal{E}_2 = -M \frac{di_1}{dt} \quad \text{and} \quad \mathcal{E}_1 = -M \frac{di_2}{dt} \quad (30.4)$$

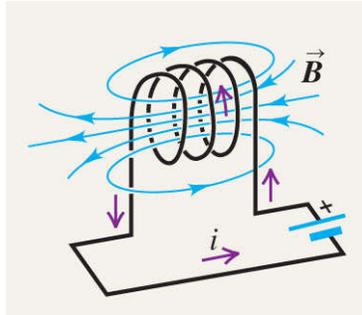
$$M = \frac{N_2 \Phi_{B2}}{i_1} = \frac{N_1 \Phi_{B1}}{i_2} \quad (30.5)$$



2. **Self-inductance:** A changing current i in any circuit causes a self-induced emf \mathcal{E} . The inductance (or self-inductance) L depends on the geometry of the circuit and the material surrounding it. The inductance of a coil of N turns is related to the average flux Φ_B through each turn caused by the current i in the coil. An inductor is a circuit device, usually including a coil of wire, intended to have a substantial inductance. (See Examples 30.3 and 30.4.)

$$\varepsilon = -L \frac{di}{dt} \quad (30.7)$$

$$L = \frac{N\Phi_B}{i} \quad (30.6)$$

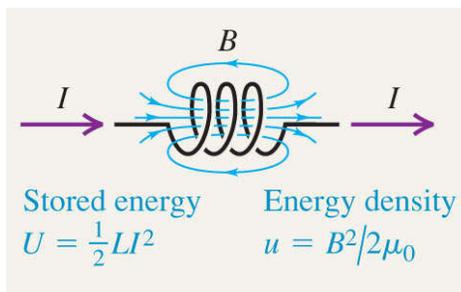


3. **Magnetic-field energy:** An inductor with inductance L carrying current I has energy U associated with the inductor's magnetic field. The magnetic energy density u (energy per unit volume) is proportional to the square of the magnetic field magnitude. (See Example 30.5.)

$$U = \frac{1}{2} LI^2 \quad (30.9)$$

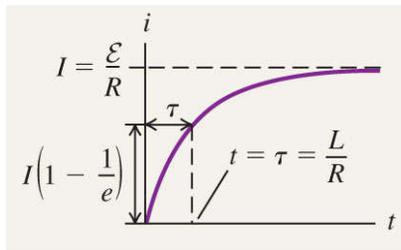
$$u = \frac{B^2}{2\mu_0} \quad (\text{in vacuum}) \quad (30.10)$$

$$u = \frac{B^2}{2\mu} \quad (\text{in a material with magnetic permeability } \mu) \quad (30.11)$$



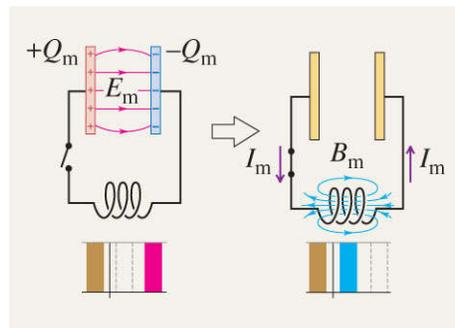
4. **R-L circuits:** In a circuit containing a resistor R , an inductor L , and a source of emf, the growth and decay of current are exponential. The time constant t is the time required for the current to approach within a fraction $1/e$ of its final value. (See Examples 30.6 and 30.7.)

$$\tau = \frac{L}{R} \quad (30.16)$$



5. **L-C circuits:** A circuit that contains inductance L and capacitance C undergoes electrical oscillations with an angular frequency ω that depends on L and C . This is analogous to a mechanical harmonic oscillator, with inductance L analogous to mass m , the reciprocal of capacitance $1/C$ to force constant k , charge q to displacement x , and current i to velocity v_x . (See Examples 30.8 and 30.9.)

$$\omega = \sqrt{\frac{1}{LC}} \quad (30.22)$$



6. **L-R-C series circuits:** A circuit that contains inductance, resistance, and capacitance undergoes damped oscillations for sufficiently small resistance. The frequency ω' of damped oscillations depends on the values of L , R , and C . As R increases, the damping increases; if R is greater than a certain value, the behavior becomes overdamped and no longer oscillates. (See Example 30.10.)

$$\omega' = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}} \quad (30.29)$$

