Chapter 7

Capacitor and Inductor

Ideal Inductor

$$v(t) = L\frac{d}{dt}i(t)$$

Magnetic Core

Length l

Area A

N turns of wire
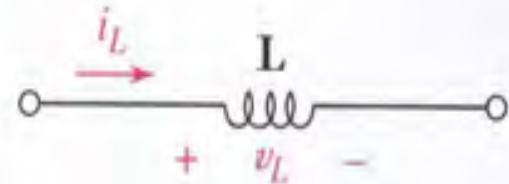
$+$ $v(t)$ $-$

$i(t)$

$$L = \frac{\mu N^2 A}{l}$$

i

$+$

v
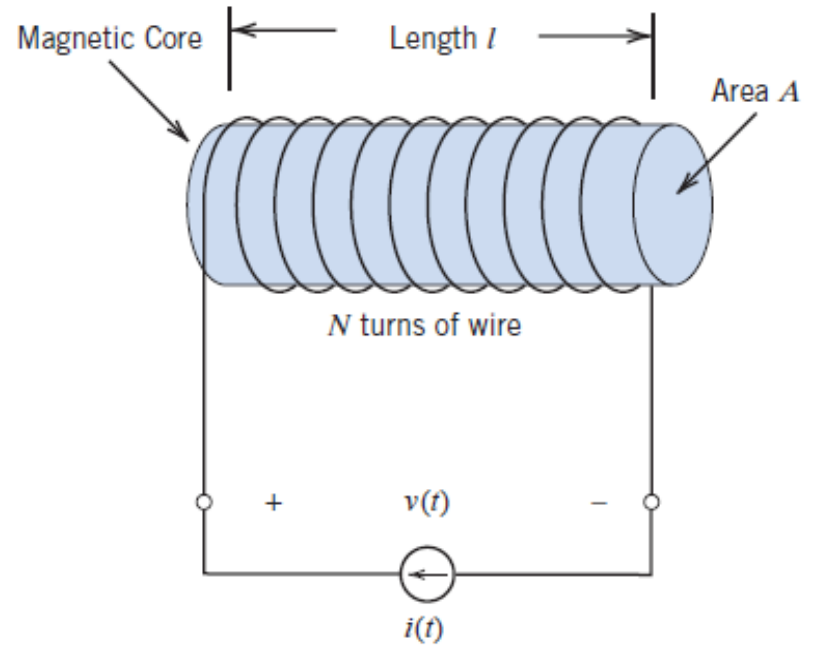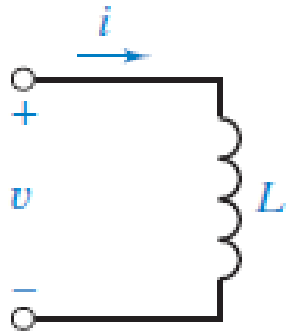
L

$-$

Inductor is used to store energy in electromagnetic field

Inductor is storing energy through charging process
and returning energy through discharging process
Over total cycle ideal inductor never dissipate energy

$$i(t) = \frac{1}{L} \int_{t_0}^{t} v \, dt' + i(t_0)$$

$$I_L(t) = \frac{1}{L} \int_{t_o}^{t} v(\tau).d\tau + i(t_o)$$

$$I_L(t) = \frac{1}{100m} \int_{-0.5}^{t} 2e^{-3\tau} d\tau + 1$$

$$I_L(t) = \frac{-20}{3}(e^{-3\tau} - e^{1.5}) + 1$$

$$I_L(t) = \frac{-20}{3}.e^{-3t} + \frac{20}{3}(4.48) + 1$$

$$I_L(t) = \frac{-20}{3}.e^{-3t} + 30.9A$$

Energy stored in the Inductor is computed by $$w_L(t) = \frac{1}{2}Li^2$$

Important Characteristics of an Ideal Inductor

1. There is no voltage across an inductor if the current through it is not changing with time. An inductor is therefore a *short circuit to dc*.

2. A finite amount of energy can be stored in an inductor even if the voltage across the inductor is zero, such as when the current through it is constant.

3. It is impossible to change the current through an inductor by a finite amount in zero time, for this requires an infinite voltage across the inductor. An inductor resists an abrupt change in the current through it in a manner analogous to the way a mass resists an abrupt change in its velocity.

4. The inductor never dissipates energy, but only stores it. Although this is true for the *mathematical* model, it is not true for a *physical* inductor due to series resistances.

Given the waveform of the current in a 3 H inductor as shown in Fig. 7.15a, determine the inductor voltage and sketch it.
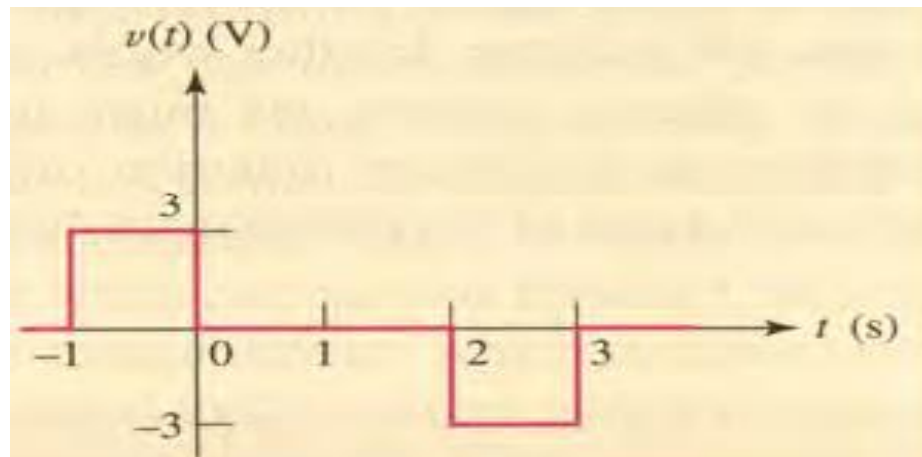

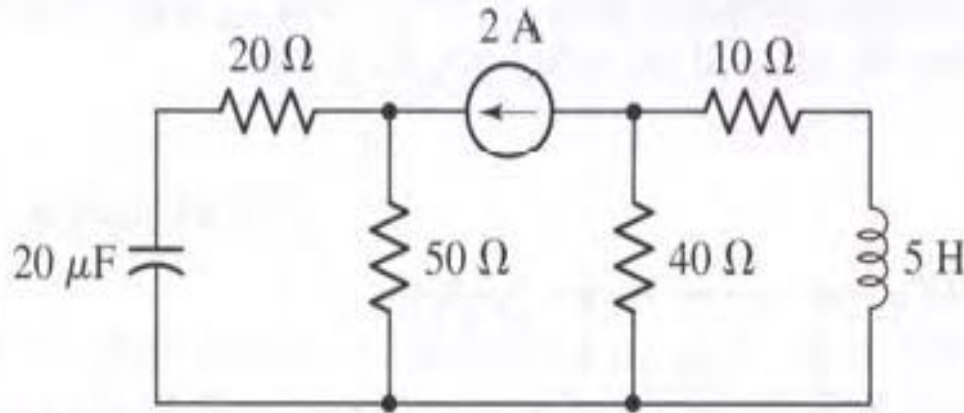i(t) (A)
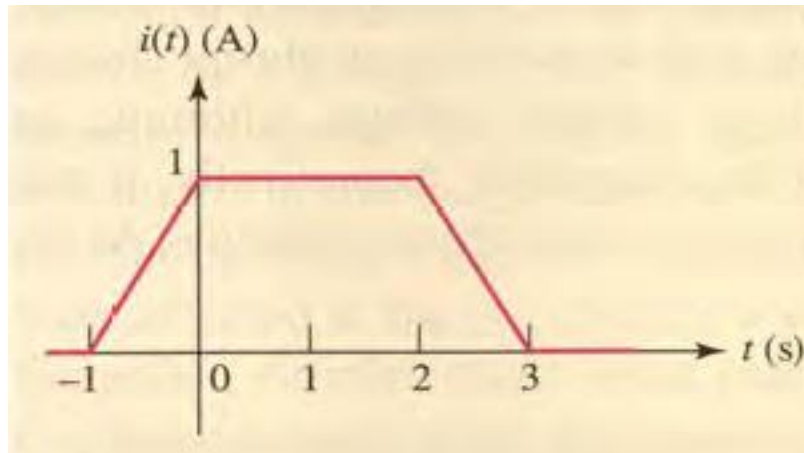
$v_L = 3.slope$

$m_1 = 1 \rightarrow v_L = 3v$

$m_2 = 0 \rightarrow v_L = 0v$

$m_3 = -1 \rightarrow v_L = -3v$

Solution

v(t) (V)

Find total energy stored in the following circuit

$$V_c = 50(2) = 100\,v$$

$$CDR$$

$$I_L = \frac{-2(40)}{10+40} = \frac{-80}{50} = -1.6A$$

$$Wc = \frac{1}{2}(20\mu)(100)^2 = 0.1\,Joule$$

$$W_L = \frac{1}{2}(5)(-1.6)^2 = 6.4\,Joule$$

$$W_T = W_c + W_L = 6.5\,Joule$$