3.1 L and C Elements:

Capacitor:

A capacitor is a passive element designed to store energy in its electric field. Besides resistors, capacitors are the most common electrical components. Capacitors are used extensively in electronics, communications, computers, and power systems. For example, they are used in the tuning circuits of radio receivers and as dynamic memory elements in computer systems.

Statement:

Capacitance is the ratio of the charge on one plate of a capacitor to the voltage difference between the two plates, measured in farads (F).

In many practical applications, the plates may be aluminum foil while the dielectric may be air, ceramic, paper, or mica.

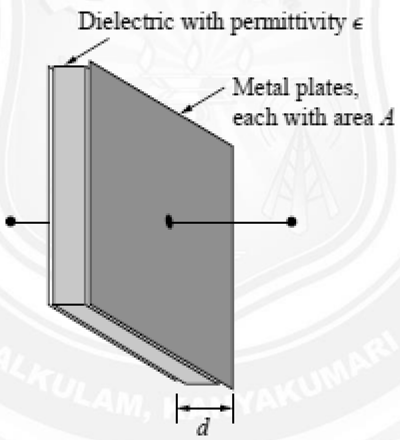

Fig. 3.1.1 Capacitor.

[Source: "Fundamentals of Electric Circuits" by charles K. Alexander, page: 202]

The capacitor is said to store the electric charge. The amount of charge stored, represented by q, is directly proportional to the applied voltage v so that

$$q = Cv$$

where C, the constant of proportionality, is known as the *capacitance* of the capacitor. The unit of capacitance is the farad (F)

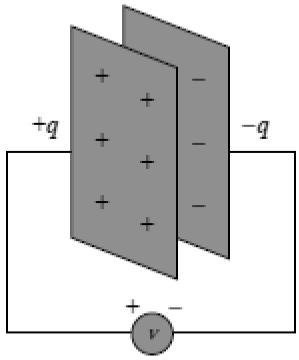

Fig. 3.1.2 Two plates of capacitor.

[Source: "Fundamentals of Electric Circuits" by charles K. Alexander, page: 202]

Problem 1:

The voltage across a 5-μF capacitor is $v(t) = 10 \cos 6000t$ V. Calculate the current throughit.

Solution:

By definition, the current is

$$i(t) = C\, dv/dt$$

$$= 5 \times 10^{-6}\, d/dt\, (10 \cos 6000t)$$

$$= -5 \times 10^{-6} \times 6000 \times 10 \sin 6000t$$

$$= -0.3 \sin 6000t \text{ A}$$

Inductor:

An inductor is a passive element designed to store energy in its magnetic field. Inductors find numerous applications in electronic and power systems. They are used in power supplies, transformers, radios, TVs, radars and electric motors.

Any conductor of electric current has inductive properties and may be regarded as an inductor. But in order to enhance the inductive effect, a practical inductor is usually formed into a cylindrical coil with many turns of conducting wire.

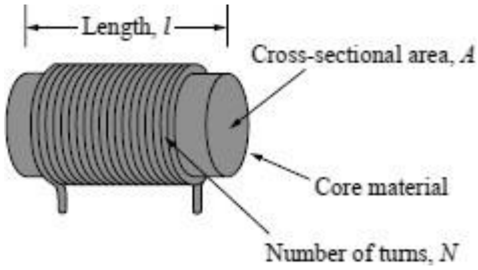

Fig. 3.1.3 Inductor.

[Source: "Fundamentals of Electric Circuits" by charles K. Alexander, page: 212]

If current is allowed to pass through an inductor, it is found that the voltage across the inductor is directly proportional to the time rate of change of the current. Using the passive sign convention,

$$v = L\, di/dt$$

where L is the constant of proportionality called the inductance of the inductor. The unit of inductance is the henry (H)

Statement:

Inductance is the property whereby an inductor exhibits opposition to the change of current flowing through it, measured in henrys (H).

Problem 2:

The current through a 0.1-H inductor is $i(t) = 10te^{-5t}$ A. Find the voltage across the inductor and the energy stored in it.

Solution:

Since $v = L\,di/dt$ and $L = 0.1$ H,

$$v = 0.1\frac{d}{dt}(10te^{-5t}) = e^{-5t} + t(-5)e^{-5t} = e^{-5t}(1 - 5t) \text{ V}$$

The energy stored is

$$w = \frac{1}{2}Li^2 = \frac{1}{2}(0.1)100t^2e^{-10t} = 5t^2e^{-10t} \text{ J}$$