**Capacitors and Inductors:** So far we have encountered seven types of ideal basic circuit elements. These are two ideal sources (voltage and current), four dependent sources, and the resistor. The last two of the ideal basic circuit elements are the (1) capacitor, and (2) inductor. We will explore the basic properties of each in turn.

One major differences between the capacitor and inductor, compared to the other ideal basic circuit elements that we have encountered so far, is that the voltages and currents associated with them depend, not on the voltages or currents themselves, but depend on the time rates of change of the voltages or currents, i.e. we have to express the equations with time derivatives or integrals.

Also, both capacitors and inductors are energy storage elements. This means that they cannot generate electrical energy but can store it and later release it back into the circuit.

1) **Capacitor:** Consider the capacitor shown below.

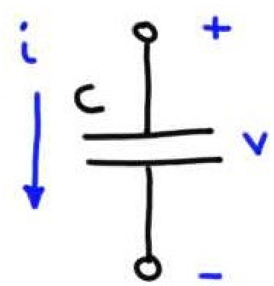



Figure 1. Capacitor

**Answer the following questions about the capacitor:**

a) Write down the equation for the iv-characteristic in differential form:

b) Write down the equation for the iv-characteristic in integral form:

c) Write down an equation for the energy stored by a capacitor:

d) What property of a capacitor MUST be continuous?

**2) Inductor:** Consider the inductor shown below.

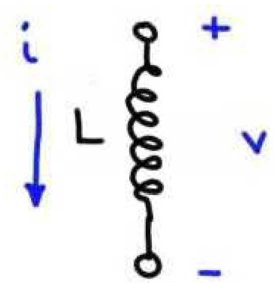



Figure 2. Inductor

**Answer the following questions about the inductor:**

a) Write down the equation for the iv-characteristic in differential form:

b) Write down the equation for the iv-characteristic in integral form:

c) Write down an equation for the energy stored by an inductor:

d) What property of an inductor MUST be continuous?

**Problems:** For a capacitor

1) The capacitor shown in Figure 1 has a value of $0.3\ \mu F$. If the voltage between the terminals is given as $0\ V$ for $t < 0\ s$, and $20e^{-30{,}000t}\cos(60{,}000t)\ V$ for $t \geq 0\ s$, then calculate the following parameters of interest:
   a) The current at $t = 0\ s$, i.e. $i(0)$.
   b) The power associated with the capacitor at $t = \frac{\pi}{40}\ ms$.
   c) The energy store in the capacitor at $t = \frac{\pi}{40}\ ms$.

2) The capacitor shown in Figure 1 has a value of $0.6\ \mu F$. If the current between the terminals is given by $0\ A$ for $t < 0\ s$, and $6\sin(50{,}000t)\ A$ for $t \geq 0\ s$, then calculate the following parameters of interest:
   a) The voltage as a function of time, $v(t)$, for $t \geq 0\ s$.
   b) The maximum power delivered by the capacitor at any given instant in time.
   c) The maximum amount of energy stored in the capacitor at any given instant in time.

**Problems:** For the inductor

1) The inductor in Figure 2 has a value of 8.0 $mH$. If the current in the inductors is 0 $A$ for $t < 0\ s$, and $20e^{-200t} - 10e^{-800t}$ $A$ for $t \geq 0\ s$, then calculate the following parameters of interest:
   a) The voltage at $t = 0\ s$, i.e. $v(0)$.
   b) The instant in time in which the voltage is zero.
   c) The power as a function of time, $p(t)$, for $t \geq 0\ s$.
   d) The maximum power.

2) The voltage in a $200\ mH$ inductor is given by

$$v(t) = \begin{cases} 0\ V\ if\ t < 0\ s \\ 2t + 1\ V\ if\ 0\ s \leq t \leq 2\ s. \\ 0\ if\ t \geq 2\ s \end{cases}$$

   a) Find how the current varies as a function of time between $0\ s \leq t \leq 2\ s$.
   b) What is the maximum power associated with the circuit?
   c) What is the total energy associated with the inductor? Is the energy being stored or delivered by the circuit?

**Networks of Capacitors:**

1) How do you add capacitors in series? Draw a diagram and give an equation for the equivalent capacitance, $C_{eq}$.

2) How do you add capacitors in parallel? Draw a diagram and give an equation for the equivalent capacitance, $C_{eq}$.

Find the equivalent capacitance with respect to terminals a and b.

**Networks of Inductors:**

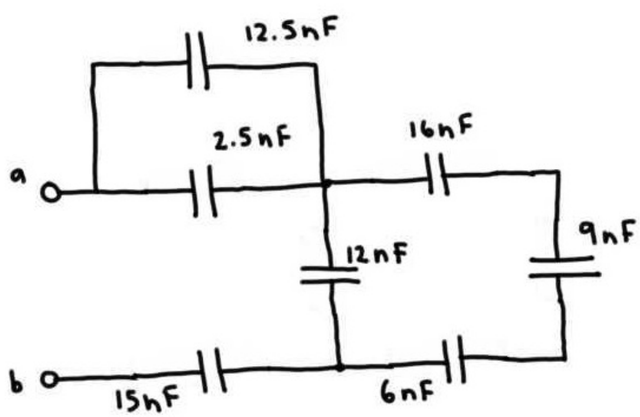
1) How do you add inductors in series? Draw a diagram and give an equation for the equivalent inductance, $L_{eq}$.

2) How do you add inductors in parallel? Draw a diagram and give an equation for the equivalent inductance, $L_{eq}$.

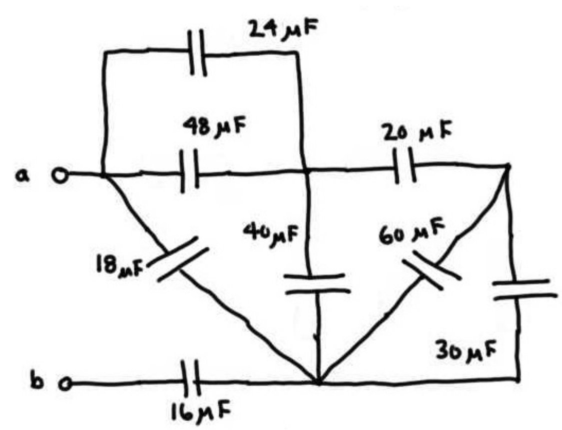
**Equivalent Capacitance and Inductance:**

Find the equivalent capacitance with respect to terminals a and b for the following networks:

a)

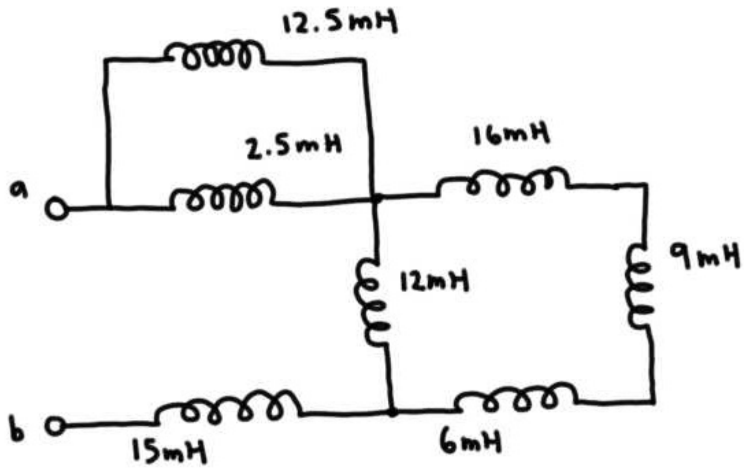



b)



Find the equivalent inductance with respect to terminals a and b for the following networks:

a)




b)