**P3.46.** Starting at $t = 0$, a constant 12-V voltage source is applied to a 2-H inductor. Assume an initial current of zero for the inductor. Determine the current, power, and stored energy at $t_1 = 1$ s.

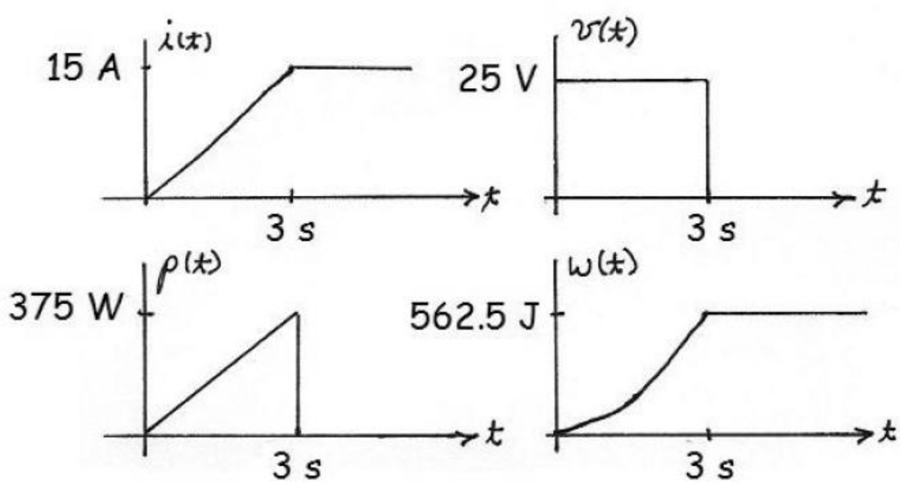
**P3.46**

$$i_L(t_1) = \frac{1}{L}\int_0^{t_1} v_L(t)dt + i_L(0) \qquad i_L(1) = \tfrac{1}{2}\int_0^{1} 12dt + 0 = 6\text{ A}$$

$$p(1) = v_L(1)i_L(1) = 72\text{ W} \qquad w(1) = \tfrac{1}{2}Li_L^2(1) = 36\text{ J}$$

**P3.54.** Before $t = 0$, the current in a 5-H inductance is zero. Starting at $t = 0$, the current is increased linearly with time to 15 A in 3 s. Then, the current remains constant at 15 A. Sketch the voltage, current, power, and stored energy to scale versus time.

**P3.54**



**P3.62.** Find the equivalent inductance for each of the series and parallel combinations shown in Figure P3.62.

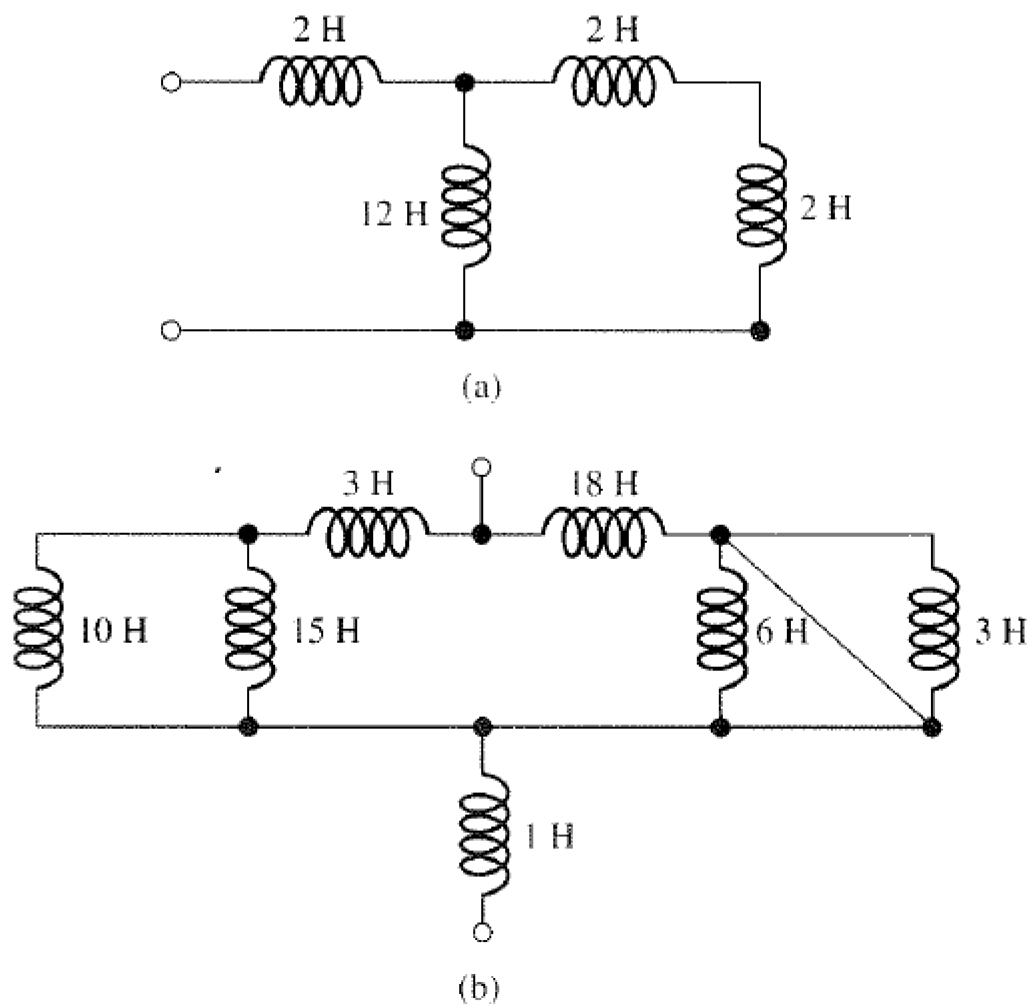



Figure P3.62

**P3.62** (a) $L_{eq} = 5\,\text{H}$.

(b) The 6 H inductor and 3 H inductor have no effect because they are in parallel with a short circuit. Thus, $L_{eq} = 7\,\text{H}$.

**P3.63.** Suppose that we need to combine (in series or in parallel) an unknown inductance $L$ with a second inductance of 4 H to attain an equivalent inductance of 7 H. Should $L$ be placed in series or in parallel with the original inductance? What value is required for $L$?

**P3.63** We need to place $L = 3$ H in series with the original 4-H inductance.

***P4.3.** The initial voltage across the capacitor shown in Figure P4.3 is $v_C(0+) = -10$ V. Find an expression for the voltage across the capacitor as a function of time. Also, determine the time $t_0$ at which the voltage crosses zero.

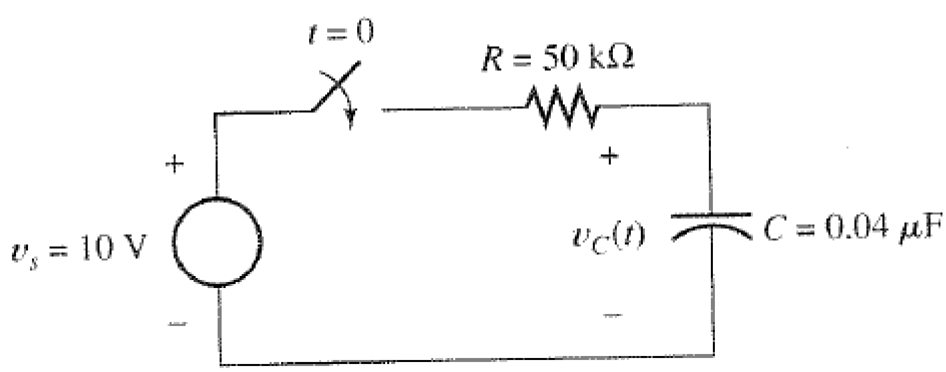



Figure P4.3

**P4.3*** The solution is of the form of Equation 4.17:

$$v_C(t) = V_s + K_2 \exp(-t/RC) = 10 + K_2 \exp(-t/(2\times 10^{-3}))$$

in which $K_2$ is a constant to be determined. At $t = 0+$, we have

$$v_C(0+) = -10 = 10 + K_2$$

Solving, we find that $K_2 = -20$ and the solution is

$$v_C(t) = 10 - 20\exp(-t/(2\times 10^{-3}))\ \text{V}$$

Setting the voltage equal to zero at time $t_0$ and solving we obtain:

$$0 = 10 - 20\exp(-t_0/(2\times 10^{-3}))$$

$$1/2 = \exp(-t_0/(2\times 10^{-3}))$$

$$-\ln(2) = -t_0/(2\times 10^{-3})$$

$$t_0 = 2\ln(2) = 1.386\ \text{ms}$$

***P4.5.** At $t = 0$, a charged 10-$\mu$F capacitance is connected to a voltmeter, as shown in Figure P4.5. The meter can be modeled as a resistance. At $t = 0$, the meter reads 50 V. At $t = 30$ s,

the reading is 25 V. Find the resistance of the voltmeter.

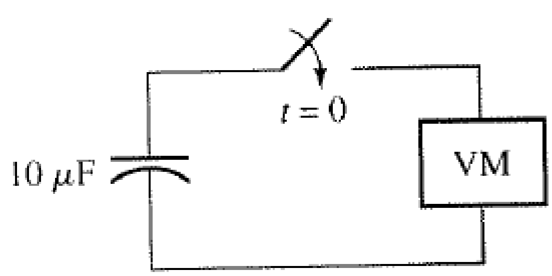



Figure P4.5

**P4.5*** This is a case of a capacitance discharging through a resistance. The voltage is given by Equation 4.8:

$$v_C(t) = V_i \exp(-t/RC)$$

At $t = 0$, we have $v_C(0) = 50 = V_i$. At $t = 30$, we have $v_C(30) = 25$. Thus, we can write $25 = 50\exp(-30/RC)$. Dividing by 50 and taking the natural logarithm of both sides, we obtain $-\ln(2) = -30/RC$. Rearranging, we have $R = \dfrac{30}{C\ln(2)} = 4.328\ \text{M}\Omega$.

***P4.33.** The circuit shown in Figure P4.33 is operating in steady state with the switch closed prior to $t = 0$. Find $i(t)$ for $t < 0$ and for $t \geq 0$.

**P4.33*** In steady state with the switch closed, we have $i(t) = 0$ for $t < 0$ because the closed switch shorts the source.

In steady state with the switch open, the inductance acts as a short circuit and the current becomes $i(\infty) = 1\ A$. The current is of the form

$$i(t) = K_1 + K_2 \exp(-Rt/L) \text{ for } t \geq 0$$

in which $R = 20\ \Omega$, because that is the Thévenin resistance seen looking back from the terminals of the inductance with the switch open. Also, we have

$$i(0+) = i(0-) = 0 = K_1 + K_2$$

$$i(\infty) = 1 = K_1$$

Thus, $K_2 = -1$ and the current (in amperes) is given by

$$i(t) = 0 \quad \text{for } t < 0$$

$$= 1 - \exp(-20t) \quad \text{for } t \geq 0$$

**P4.39.** The circuit shown in Figure P4.39 is operating in steady state with the switch closed prior to $t = 0$. Find expressions for $i_L(t)$ for $t < 0$ and for $t \geq 0$. Sketch $i_L(t)$ to scale versus time.

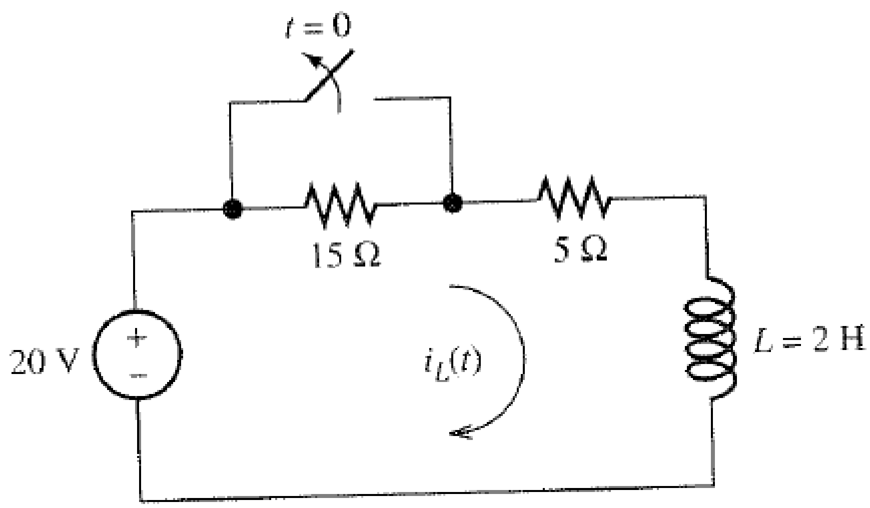



Figure P4.39

**P4.39** In steady state, the inductor acts as a short circuit. With the switch closed, the steady-state current is $(20\text{ V})/(5\,\Omega) = 4\ A$. With the switch opened, the current eventually approaches $i_L(\infty) = (20\text{ V})/(20\,\Omega) = 1\ A$. For $t > 0$, the current has the form

$$i_L(t) = K_1 + K_2\exp(-Rt/L)$$

where $R = 20\,\Omega$, because that is the resistance with the switch open. Now, we have

$$i_L(0+) = i_L(0-) = 4 = K_1 + K_2 \qquad i_L(\infty) = 1 = K_1$$

Thus, we have $K_2 = 3$. The current is

$$\begin{aligned} i_L(t) &= 4 && t < 0 \text{ (switch closed)} \\ &= 1 + 3\exp(-10t) && t \ge 0 \text{ (switch open)} \end{aligned}$$