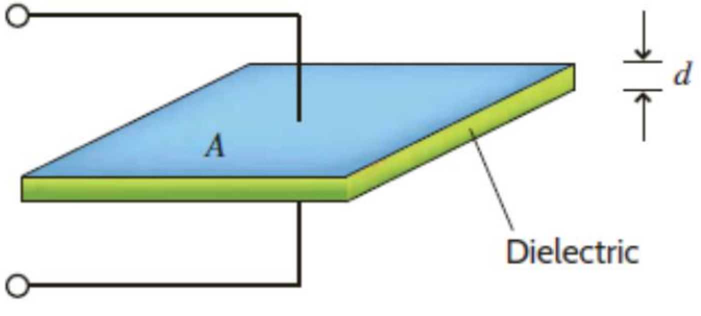
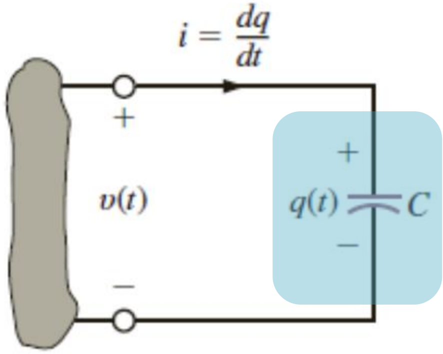
Last Lecture → Capacitor

… a circuit element that consists of two conducting surfaces separated by dielectric material



(a)

Simplified Capacitor



(b)

Symbol

Capacitance (C) → $C = \frac{\varepsilon_0 A}{d}$

permittivity of free space

⇩

Unit → farads (F) = coulombs per volts

$$q = C \cdot v \qquad i = C \cdot \frac{dv}{dt}$$

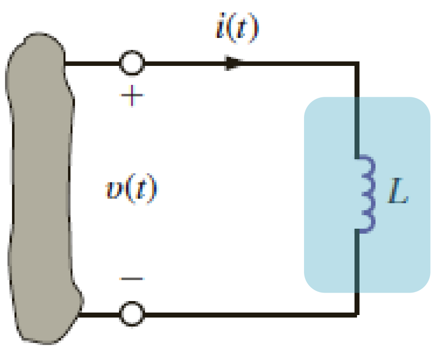
$$v(t) = v(t_0) + \frac{1}{C} \cdot \int_{t_0}^{t} i(x)dx$$

$$p(t) = C \cdot v(t)\frac{dv(t)}{dt}$$

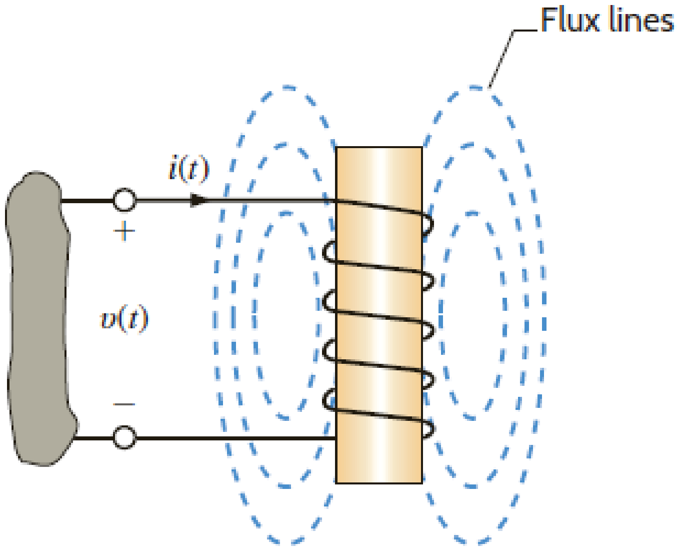
$$w_c(t) = \frac{1}{2} C \cdot v(t)^2$$

Last Lecture → Inductor

… a circuit element that consists of a conducting wire usually in the form of a coil.



Symbol



Simplified Inductor

Inductance (L)

↓

Unit → Henry (H) = 1 volt-second per ampere

$$v = L \cdot \frac{di}{dt}$$

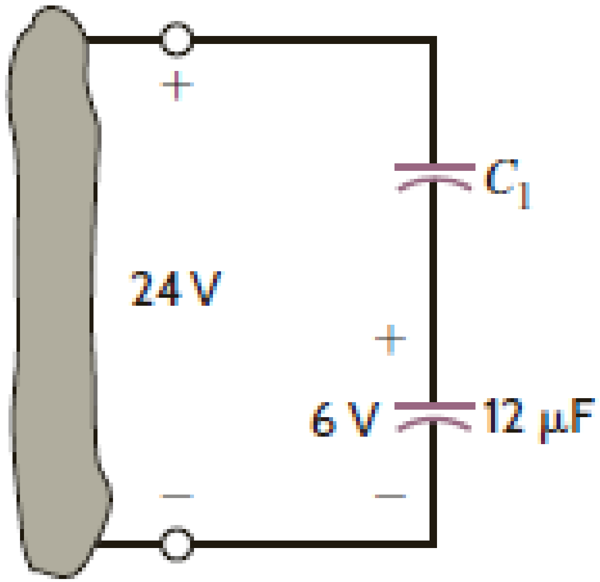
$$i(t) = i(t_0) + \frac{1}{L} \cdot \int_{t_0}^{t} v(x)dx$$

$$p(t) = L \cdot i(t)\frac{di(t)}{dt}$$

$$w_L(t) = \frac{1}{2}L \cdot i(t)^2$$

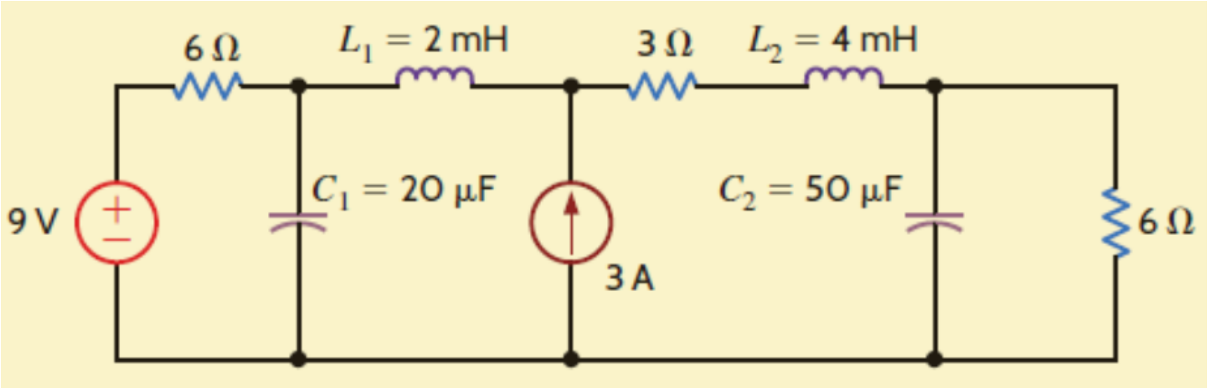
Learning Assessment E6.11

Two initially uncharged capacitors are connected as shown in the circuit below. After a period of time, the voltage reaches the value shown. Determine the value of C_1.

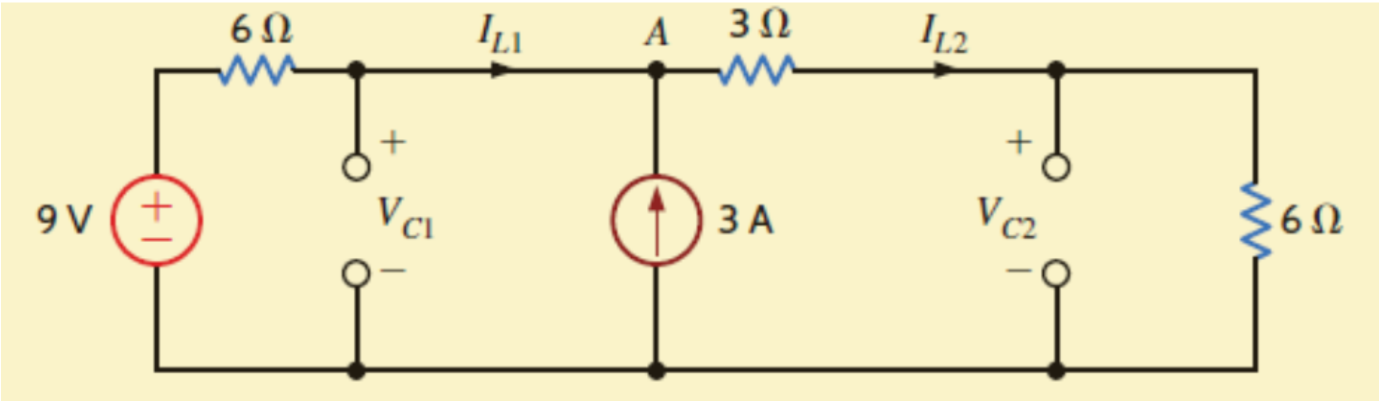


DC Analysis → Example 6.5

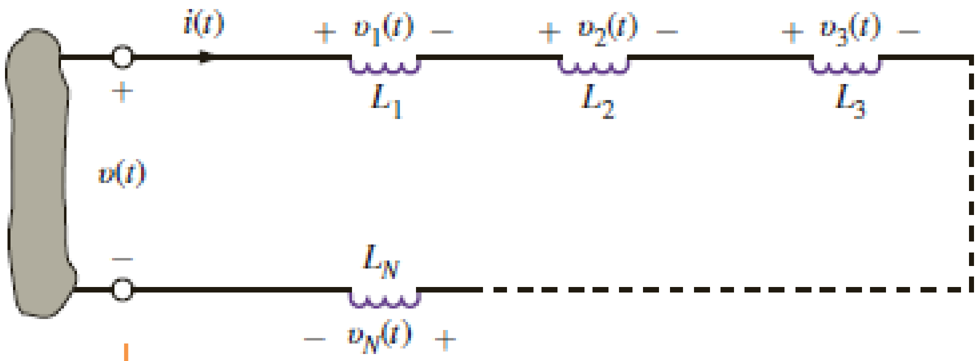
Find the total energy stored in the circuit provided.



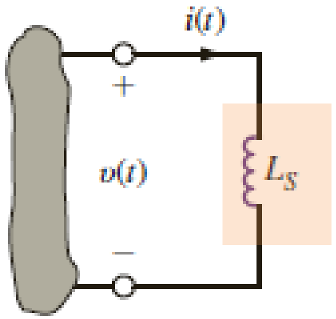
@ DC $V_L = 0$ & $I_C=0$
→ L = short circuit
→ C = open circuit



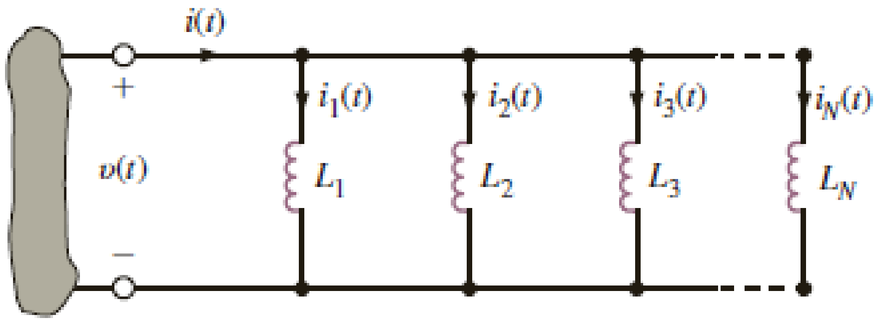
Series \ Parallel Inductors



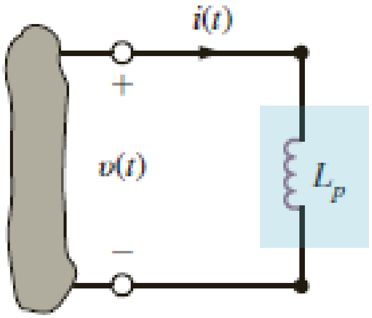
$$v(t) = v_1(t) + v_2(t) + \cdots + v_N(t)$$
$$= L_1 \frac{di(t)}{dt} + L_2 \frac{di(t)}{dt} + \cdots + L_N \frac{di(t)}{dt}$$
$$= [L_1 + L_2 + \cdots + L_N] \frac{di(t)}{dt}$$



$$L_s = L_1 + L_2 + \cdots + L_N$$

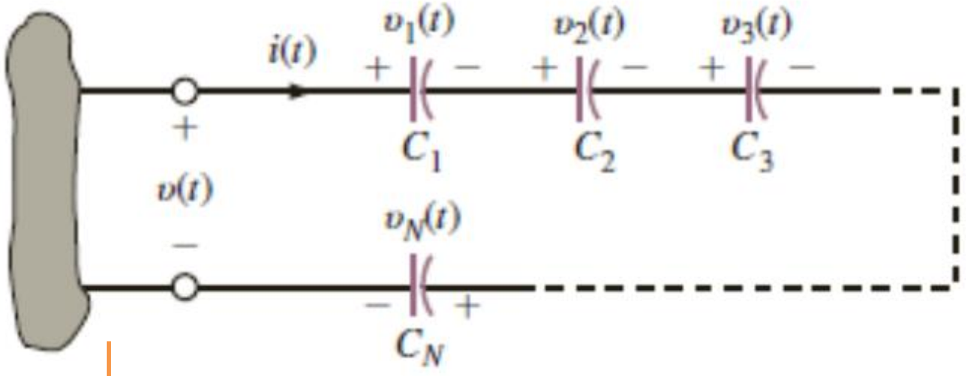


$$i(t) = i_1(t) + i_2(t) + \cdots +$$
$$= \frac{1}{L_1} v(t)dt + \frac{1}{L_2} v(t)dt + \cdots + \frac{1}{L_N} v(t)dt$$
$$= \left[\frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_N}\right] v(t)dt$$

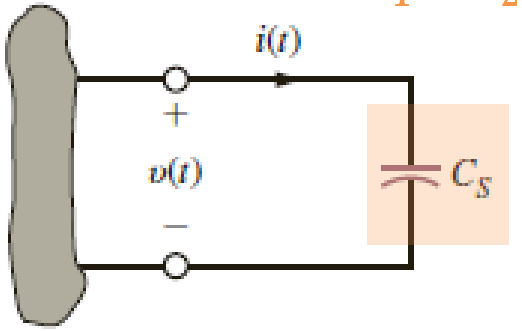


$$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_N}$$

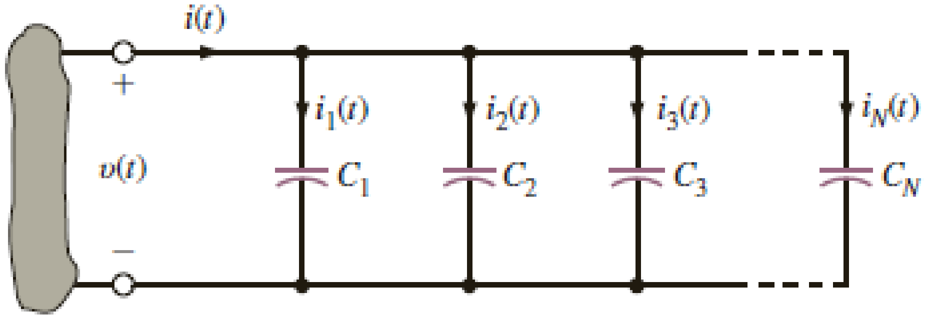
Series \ Parallel Capacitors



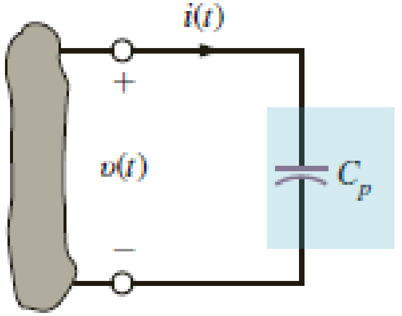
$$v(t) = v_1(t) + v_2(t) + \cdots + v_N(t)$$
$$= \frac{1}{C_1} i(t)dt + \frac{1}{C_2} i(t)dt + \cdots + \frac{1}{C_N} i(t)dt$$
$$= \left[\frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}\right] i(t)dt$$



$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}$$



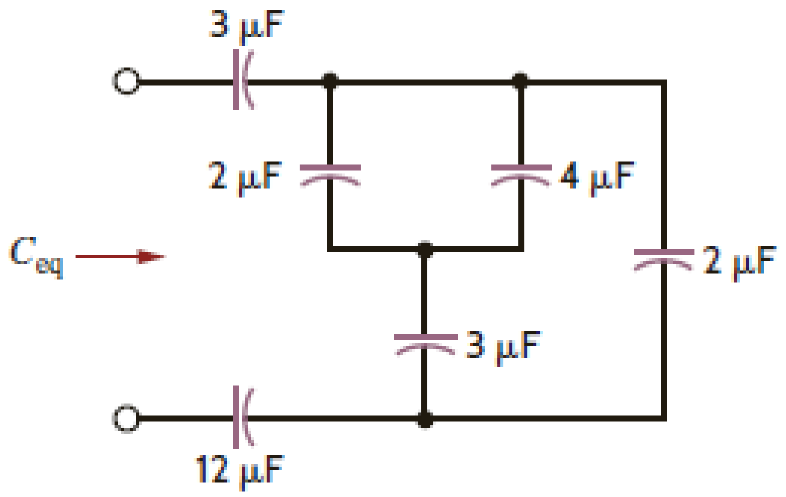
$$i(t) = i_1(t) + i_2(t) + \cdots + i_N$$
$$= C_1 \frac{dv(t)}{dt} + C_2 \frac{dv(t)}{dt} + \cdots + C_N \frac{dv(t)}{dt}$$
$$= [C_1 + C_2 + \cdots + C_N] \frac{dv(t)}{dt}$$



$$C_p = C_1 + C_2 + \cdots + C_N$$

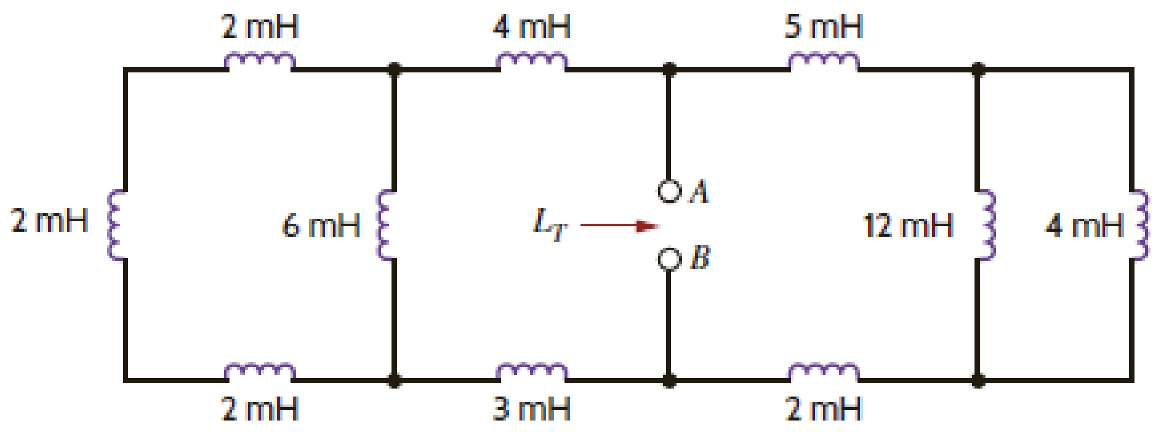
Learning Assessment E6.12

Compute the equivalent capacitance of the network provided.



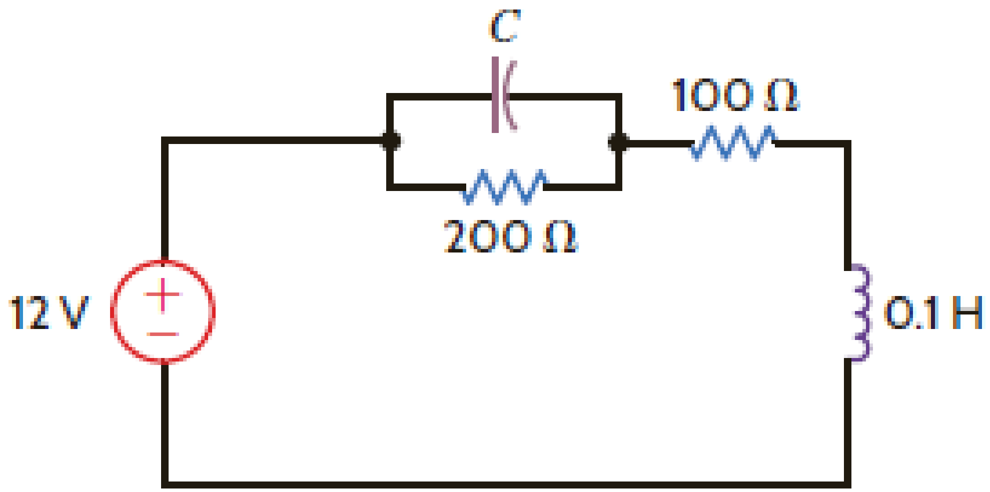
Learning Assessment E6.15

Find L_T in the network provided.



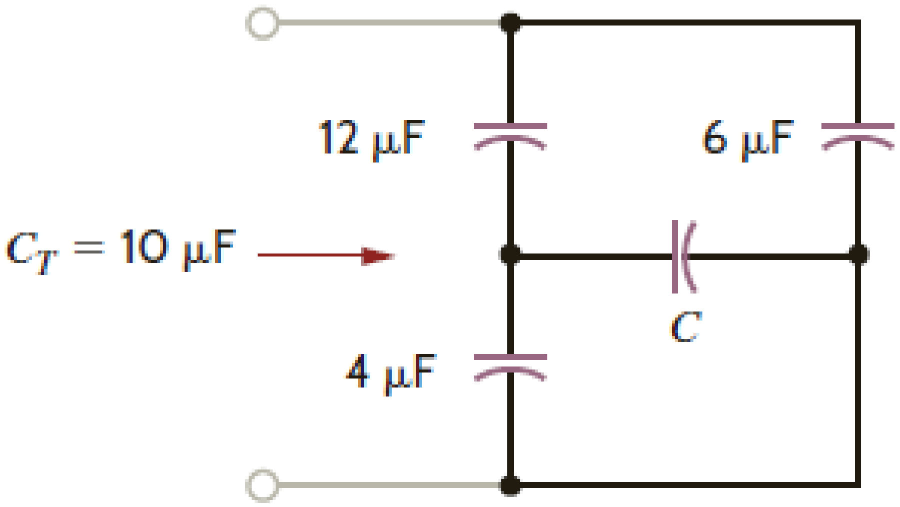
Problem 6.38

Find the value of C if the energy stored in the capacitor equals the energy stored in the inductor.



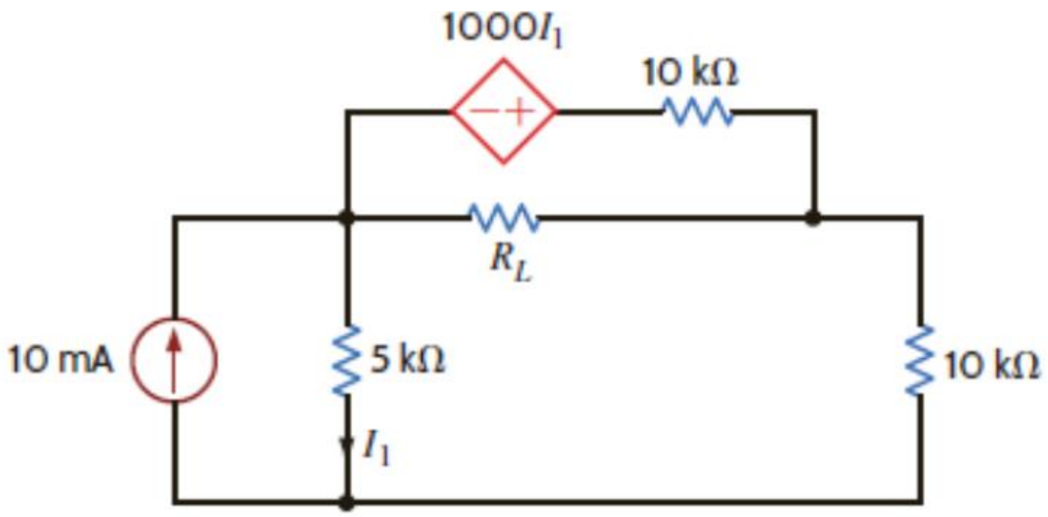
Problem 6.57

If the total capacitance of the provided network is 10μF, find the value of C.



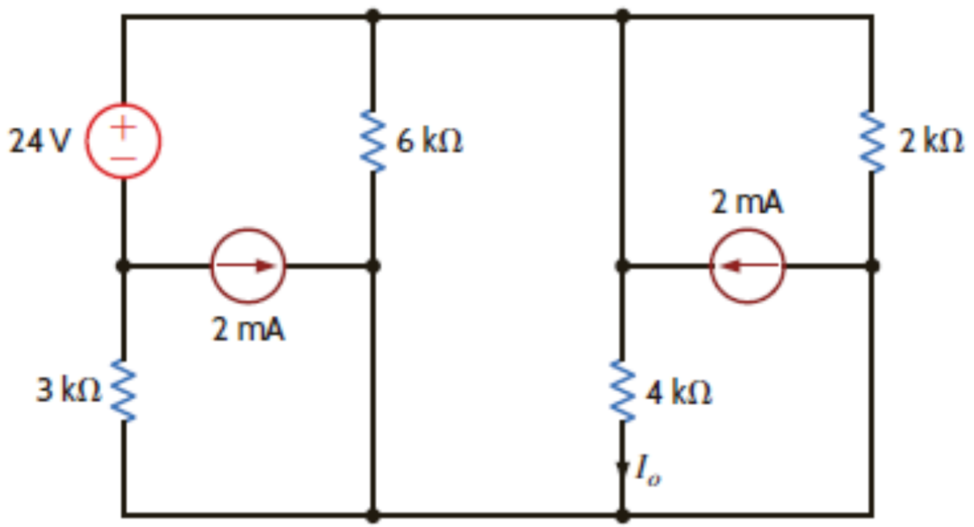
Problem → P5.124

For the given network find the value of R_L for maximum power transfer and the maximum power that can be transferred to this load.



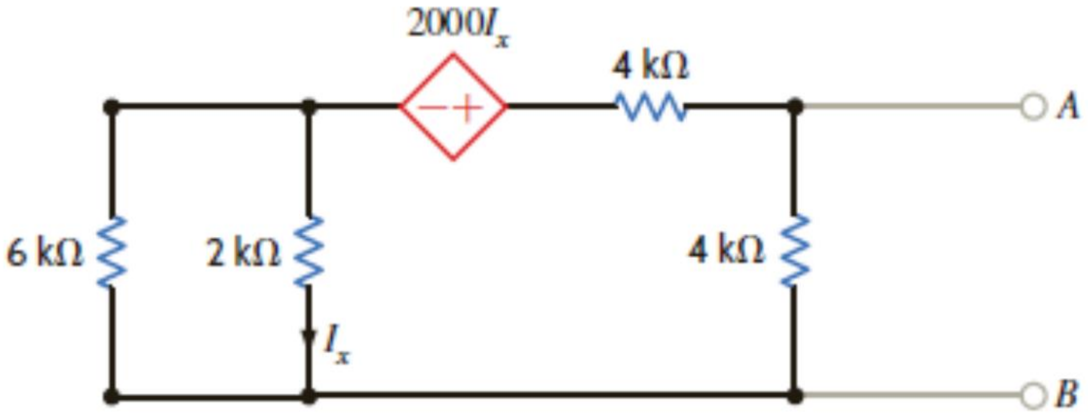
Problem → P5.106

Using source transformation, find I_0 in the circuit provided.



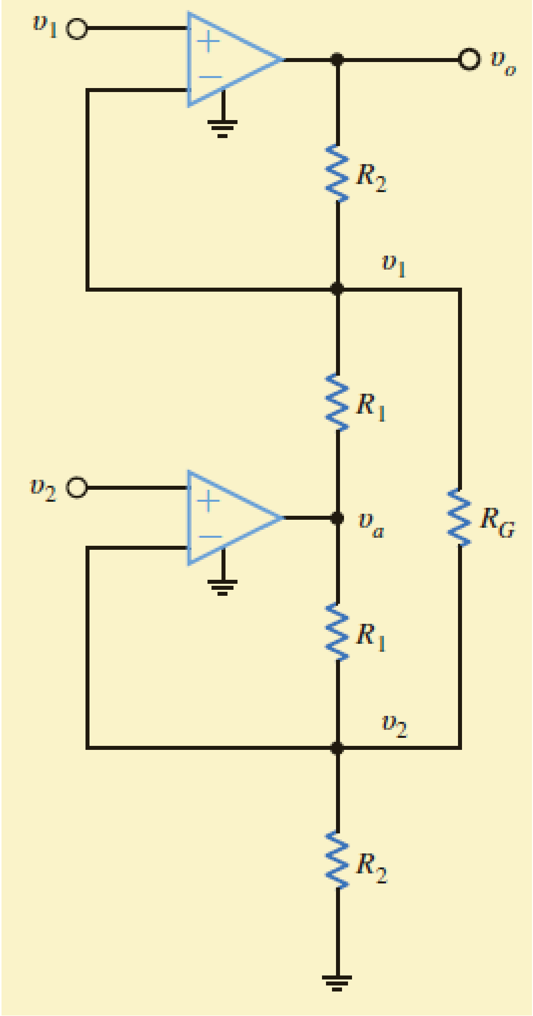
Problem → P5.87

Find the Thevenin's equivalent circuit of the provided network at terminals A-B.



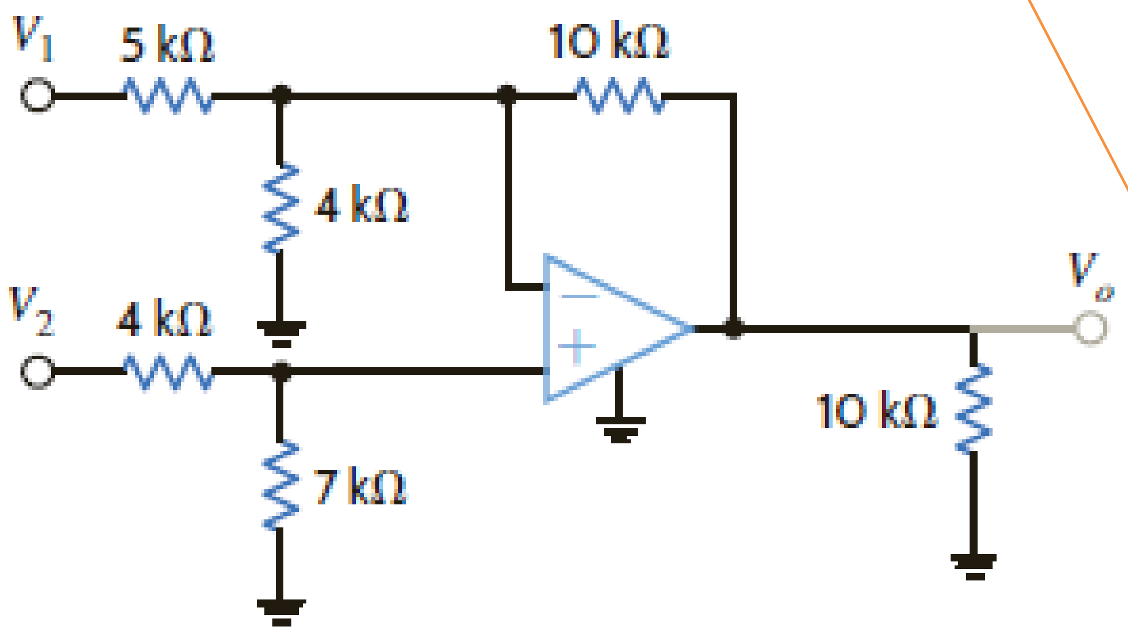
Example 4.5

The circuit shown is a precision differential voltage-gain device. It is used to provide a single-ended input for an analog-to-digital converter. Derive an expression for the output of the circuit in terms of the two inputs.



Learning Assessment – E4.5

Assuming ideal op-amp behavior find Vo in terms of V_1 and V_2. If V_1=V_2=4 find V_0. If the op-amp power supplies are ±15V and V_2=2V, what is the allowable range of V_1?



→ **Superposition: Inverting Amp. / Non-Inverting Amp.**

$$V_0{}' = -V_1\left[\frac{10k}{5k}\right] = -2\cdot V_1$$

$$V_0{}'' = V_2\left[\frac{7k}{11k}\right]\left[1+\frac{10k}{4k//5k}\right] = 3.5\cdot V_2$$

$$\therefore V_0 = -2\cdot V_1 + 3.5\cdot V_2$$

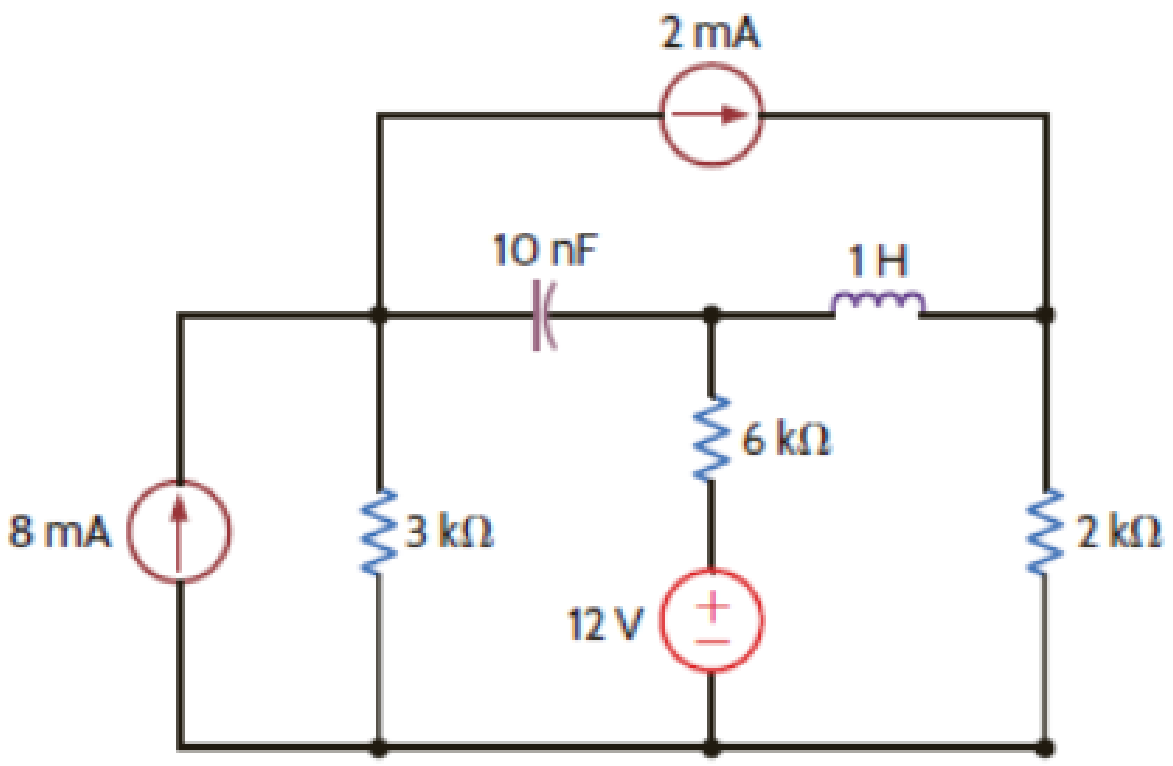
$$-15V \le V_0 \le 15V$$

$$\therefore V_0 = -2\cdot V_1 + 3.5\cdot V_2 \le 15$$

$$\therefore V_0 = -2\cdot V_1 + 3.5\cdot V_2 \ge -15$$

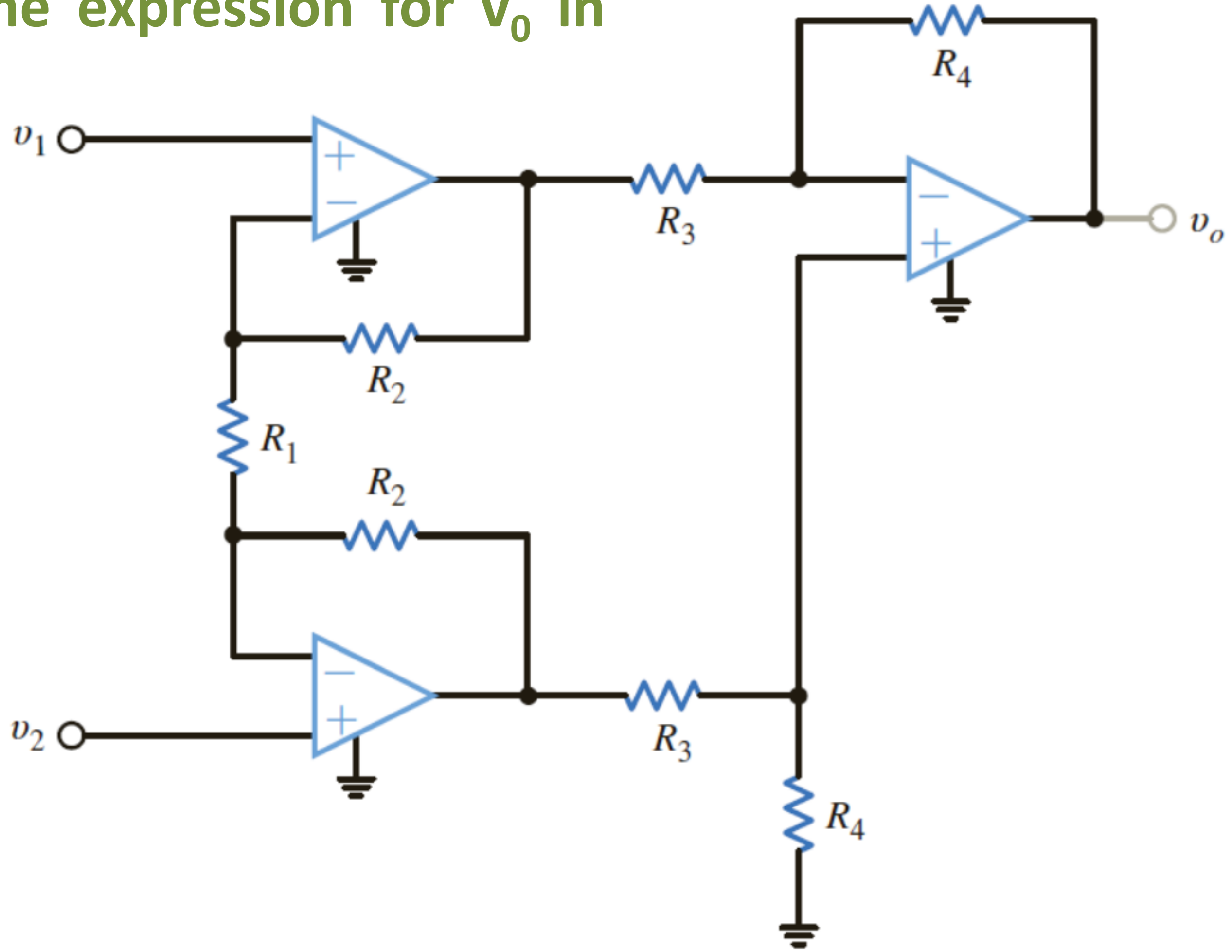
Learning Assessment E6.10

For the provided circuit find the energy stored in the capacitor and the inductor.



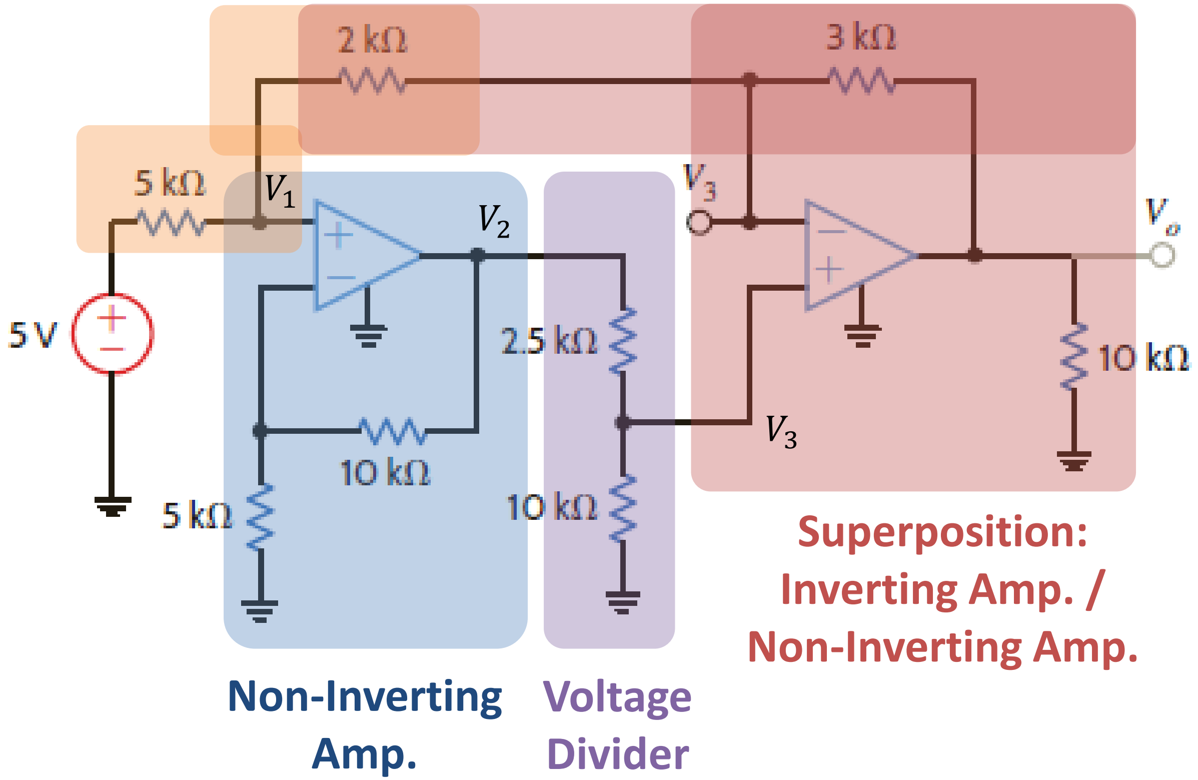
Problem 4.43

Assuming ideal op-amp behavior, find the expression for v_0 in terms of (v_2-v_1).



Learning Assessment – E4.6

Assuming ideal op-amp behavior find V_0 and V_3 in the provided circuit.



$$V_2 = \left[1 + \frac{10k}{5k}\right] V_1 = 3 \cdot V_1$$

$$V_3 = \left[\frac{10k}{10k + 2.5k}\right] V_2 = \frac{4}{5} \cdot V_2 = \frac{12}{5} \cdot V_1$$

$$V_0 = \left[1 + \frac{3k}{2k}\right] V_3 - \left[\frac{3k}{2k}\right] V_1$$

$$= \frac{5}{2} \cdot V_3 - \frac{3}{2} \cdot V_1 = 6 \cdot V_1 - \frac{3}{2} \cdot V_1 = \frac{9}{2} \cdot V_1$$

$$V_1 = \left[\frac{2k}{7k}\right] 5 + \left[\frac{5k}{7k}\right] V_3 = \frac{10}{7} + \frac{12}{7} \cdot V_1$$

$$\therefore V_1 = -2V$$

$$\therefore V_0 = -9V$$

$$\therefore V_3 = -4.8V$$