Chapter 6, Solution 1.

$$i = C\frac{dv}{dt} = 7.5\left(2e^{-3t} - 6te^{-3t}\right) = \mathbf{15(1 - 3t)e^{-3t}\ A}$$

p = vi = $15(1–3t)e^{-3t} \cdot 2t\ e^{-3t}$ **= $\mathbf{30t(1 - 3t)e^{-6t}}$ W**.

$\mathbf{15(1 - 3t)e^{-3t}}$ A, $\mathbf{30t(1 - 3t)e^{-6t}}$ W

Chapter 6, Solution 2.

$w(t) = (1/2)C(v(t))^2$ or $(v(t))^2 = 2w(t)/C = (20\cos^2(377t))/(50x10^{-6}) = 0.4x10^6\cos^2(377t)$ or $v(t) = \pm632.5\cos(377t)$ V. Let us assume that $v(t) = 632.5\cos(377t)$ V, which leads to $i(t) = C(dv/dt) = 50x10^{-6}(632.5)(-377\sin(377t))$

$$= \mathbf{-11.923\sin(377t)\ A}.$$

Please note that if we had chosen the negative value for v, then i(t) would have been positive.

Chapter 6, Solution 3.

Design a problem to help other students to better understand how capacitors work.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

In 5 s, the voltage across a 40-mF capacitor changes from 160 V to 220 V. Calculate the average current through the capacitor.

Solution

$$i = C\frac{dv}{dt} = 40x10^{-3}\,\frac{220-160}{5} = \mathbf{480\ mA}$$

Chapter 6, Solution 4.

$$v = \frac{1}{C}\int_{o}^{t} idt + v(0)$$

$$= \frac{1}{5}\int_{0}^{t} 4\sin(4t)dt + 1 = \left(-\frac{0.8}{4}\cos(4t)\right)\Bigg|_{0}^{t} + 1 = -0.2\cos(4t) + 0.2 + 1$$

= **[1.2 – 0.2 cos(4t)] V**.

Chapter 6, Solution 5.

$$v = \begin{cases} 5000t, & 0 < t < 2ms \\ 20 - 5000t, & 2 < t < 6ms \\ -40 + 5000t, & 6 < t < 8ms \end{cases}$$

$$i = C\frac{dv}{dt} = \frac{4x10^{-6}}{10^{-3}}\begin{cases} 5, & 0 < t < 2ms \\ -5, & 2 < t < 6ms \\ 5, & 6 < t < 8ms \end{cases} = \underline{\begin{cases} 20\ \text{mA}, & 0 < t < 2ms \\ -20\ \text{mA}, & 2 < t < 6ms \\ 20\ \text{mA}, & 6 < t < 8ms \end{cases}}$$

Chapter 6, Solution 6.

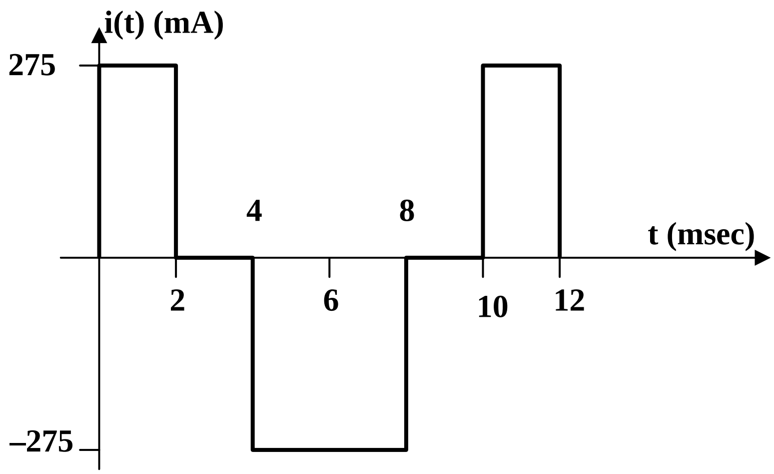
$i = C\frac{dv}{dt} = 55x10^{-6}$ times the slope of the waveform.

For example, for 0 < t < 2,

$$\frac{\text{dv}}{\text{dt}} = \frac{10}{2\text{x}10^{-3}}$$

i = $C\frac{dv}{dt} = (55x10^{-6})\frac{10}{2x10^{-3}} = 275mA$

Thus the current i(t) is sketched below.



Chapter 6, Solution 7.

$$v = \frac{1}{C}\int idt + v(t_o) = \frac{1}{25x10^{-3}}\int_o^t 5tx10^{-3}\,dt + 10$$

$$= \frac{2.5t^2}{25} + 10 = \mathbf{[0.1t^2 + 10]\ V}.$$

Chapter 6, Solution 8.

(a) $i = C\dfrac{dv}{dt} = -100ACe^{-100t} - 600BCe^{-600t}$ (1)

$i(0) = 2 = -100AC - 600BC \longrightarrow 5 = -A - 6B$ (2)

$v(0^+) = v(0^-) \longrightarrow 50 = A + B$ (3)

Solving (2) and (3) leads to

A=61, B=-11

(b) $\text{Energy} = \dfrac{1}{2}Cv^2(0) = \dfrac{1}{2}x4x10^{-3}x2500 = \underline{5\text{ J}}$

(c) From (1),

$$\boldsymbol{i = -100x61x4x10^{-3}e^{-100t} - 600x11x4x10^{-3}e^{-600t} = \underline{-24.4e^{-100t} - 26.4e^{-600t}\ \text{A}}}$$

Chapter 6, Solution 9.

$$v(t) = \frac{1}{1/2}\int_o^t 6\left(1 - e^{-t}\right)dt + 0 = 12\left(t + e^{-t}\right)\Big|_0^t V = 12(t + e^{-t}) - 12$$

$v(2) = 12(2 + e^{-2}) - 12 =$ **13.624 V**

$p = iv = [12\ (t + e^{-t}) - 12]6(1-e^{-t})$

$p(2) = [12\ (2 + e^{-2}) - 12]6(1-e^{-2})$ = **70.66 W**

Chapter 6, Solution 10

$$i = C\frac{dv}{dt} = 5x10^{-3}\frac{dv}{dt}$$

$$v = \begin{cases} 16t, & 0 < t < 1\mu s \\ 16, & 1 < t < 3\ \mu s \\ 64 - 16t, & 3 < t < 4\mu s \end{cases}$$

$$\frac{dv}{dt} = \begin{cases} 16x10^{6}, & 0 < t < 1\mu s \\ 0, & 1 < t < 3\ \mu s \\ -16x10^{6}, & 3 < t < 4\mu s \end{cases}$$

$$\underline{\boldsymbol{i(t)} = \begin{cases} \mathbf{80\,kA,} & \mathbf{0 < \boldsymbol{t} < 1\mu s} \\ \mathbf{0,} & \mathbf{1 < t < 3\ \mu s} \\ \mathbf{-80\,kA,} & \mathbf{3 < t < 4\mu s} \end{cases}}$$

Chapter 6, Solution 11.

$$v = \frac{1}{C}\int_0^t i dt + v(0) = 10 + \frac{1}{4x10^{-3}}\int_0^t i(t)dt$$

For 0<t <2, i(t)=15mA, V(t)= 10+ $v = 10 + \frac{10^3}{4x10^{-3}}\int_0^t 15 dt = 10 + 3.76t$

v(2) = 10+7.5 =17.5

For 2 < t <4, i(t) = –10 mA

$$v(t) = \frac{1}{4x10^{-3}}\int_2^t i(t)dt + v(2) = -\frac{10x10^{-3}}{4x10^{-3}}\int_2^t dt + 17.5 = 22.5 + 2.5t$$

v(4)=22.5-2.5x4 =12.5

For 4<t<6, i(t) = 0, $v(t) = \frac{1}{4x10^{-3}}\int_2^t 0 dt + v(4) = 12.5$

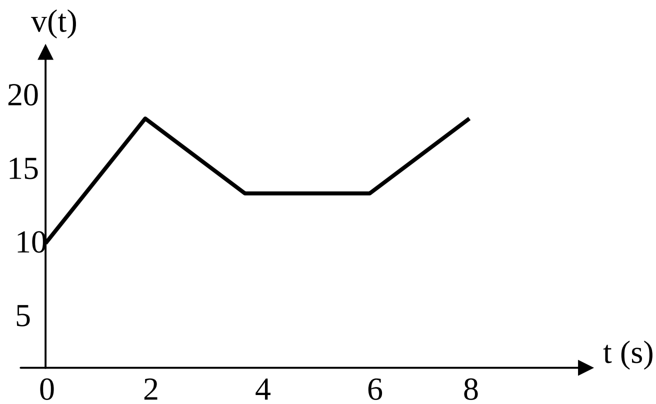
For 6<t<8, i(t) = 10 mA

$$v(t) = \frac{10x10^3}{4x10^{-3}}\int_4^t dt + v(6) = 2.5(t-6) + 12.5 = 2.5t - 2.5$$

Hence,

$$v(t) = \begin{cases} 10 + 3.75t\text{ V}, & 0 < t < 2s \\ 22.5 - 2.5t\text{ V}, & 2 < t < 4s \\ 12.5\text{ V}, & 4 < t < 6s \\ 2.5t - 2.5\text{ V}, & 6 < t < 8s \end{cases}$$

which is sketched below.



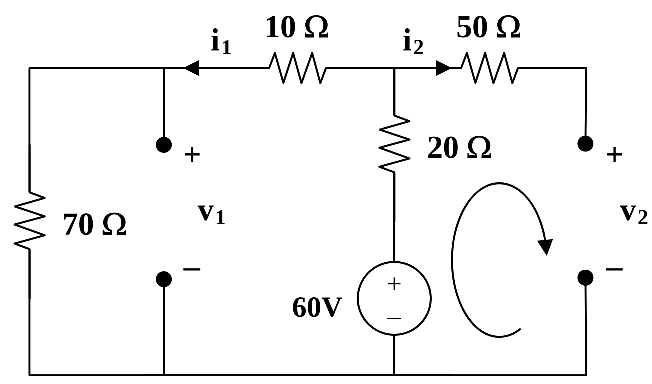
Chapter 6, Solution 12.

$i_R = V/R = (30/12)e^{-2000t} = 2.5\ e^{-2000t}$ and $i_C = C(dv/dt) = 0.1x30(-2000)\ e^{-2000t}$ $= -6000\ e^{-2000t}$ A. Thus, $i = i_R + i_C = -5{,}997.5\ e^{-2000t}$. The power is equal to:

$$vi = \mathbf{-179.925\ e^{-4000t}\ W}.$$

Chapter 6, Solution 13.

Under dc conditions, the circuit becomes that shown below:



$i_2 = 0$, $i_1 = 60/(70+10+20) = 0.6$ A

$v_1 = 70i_1 = 42$ V, $v_2 = 60–20i_1 = 48$ V

Thus, $v_1 =$ **42 V**, $v_2 =$ **48 V**.

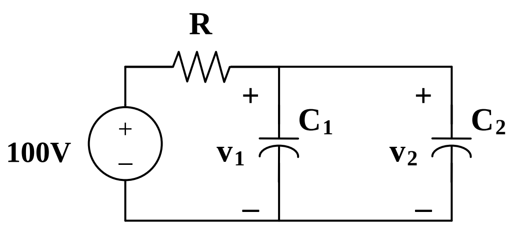
Chapter 6, Solution 14.

20 pF is in series with 60pF = 20*60/80=15 pF
30-pF is in series with 70pF = 30x70/100=21pF
15pF is in parallel with 21pF = 15+21 = **36 pF**

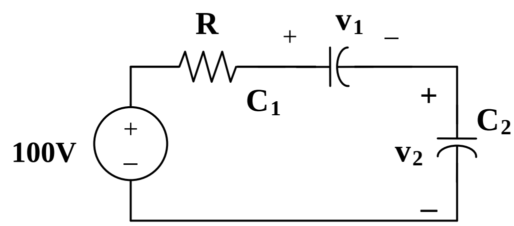
Chapter 6, Solution 15.

Arranging the capacitors in parallel results in circuit shown in Fig. (1) (It should be noted that the resistors are in the circuits only to limit the current surge as the capacitors charge. Once the capacitors are charged the current through the resistors are obviously equal to zero.):

$v_1 = v_2 = 100$



(1)



(2)

$$w_{20} = \frac{1}{2}Cv^2 = \frac{1}{2}x25x10^{-6}x100^2 = \textbf{125 mJ}$$

$$w_{30} = \frac{1}{2}x75x10^{-6}x100^2 = \textbf{375 mJ}$$

(b) Arranging the capacitors in series results in the circuit shown in Fig. (2):

$$v_1 = \frac{C_2}{C_1 + C_2}V = \frac{75}{100}x100 = 75\text{ V},\ v_2 = 25\text{ V}$$

$$w_{25} = \frac{1}{2}x25x10^{-6}x75^2 = \textbf{70.31 mJ}$$

$$w_{75} = \frac{1}{2}x75x10^{-6}x25^2 = \textbf{23.44 mJ}.$$

(a) **125 mJ, 375 mJ (b) 70.31 mJ, 23.44 mJ**

Chapter 6, Solution 16

$$C_{eq} = 14 + \frac{Cx80}{C+80} = 30 \quad \longrightarrow \quad \underline{C = 20\ \mu F}$$

Chapter 6, Solution 17.

(a) 4F in series with 12F = 4 x 12/(16) = 3F
3F in parallel with 6F and 3F = 3+6+3 = 12F
4F in series with 12F = 3F
i.e. C_{eq} = **3F**

(b) C_{eq} = 5 + [6x(4 + 2)/(6+4+2)] = 5 + (36/12) = 5 + 3 = **8F**

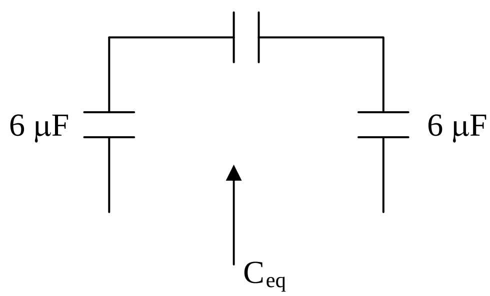
(c) 3F in series with 6F = (3 x 6)/9 = 2F

$$\frac{1}{C_{eq}} = \frac{1}{2} + \frac{1}{6} + \frac{1}{3} = 1$$

C_{eq} = **1F**

Chapter 6, Solution 18.

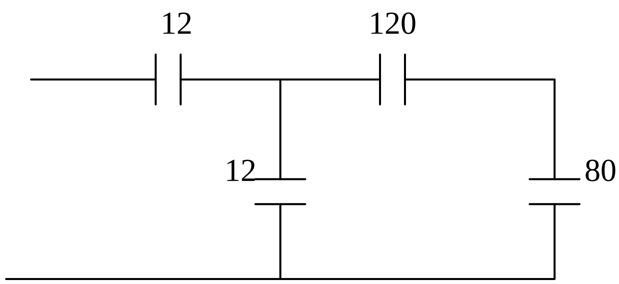
4 μF in parallel with 4 μF = 8μF
4 μF in series with 4 μF = 2 μF
2 μF in parallel with 4 μF = 6 μF
Hence, the circuit is reduced to that shown below.



$$\frac{1}{C_{eq}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{8} = 0.4583 \quad \longrightarrow \quad C_{eq} = \underline{2.1818\ \mu F}$$

Chapter 6, Solution 19.

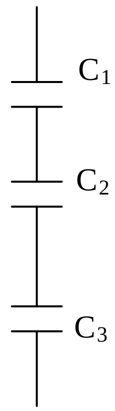
We combine 10-, 20-, and 30- μF capacitors in parallel to get 60 μF. The 60 - μF capacitor in series with another 60- μF capacitor gives 30 μF.
30 + 50 = 80 μF, 80 + 40 = 120 μF
The circuit is reduced to that shown below.



120- μF capacitor in series with 80 μF gives (80x120)/200 = 48
48 + 12 = 60
60- μF capacitor in series with 12 μF gives (60x12)/72 = **10 μF**

Chapter 6, Solution 20.

Consider the circuit shown below.



$$C_1 = 1+1 = 2\mu F$$
$$C_2 = 2+2+2 = 6\mu F$$

$$C_3 = 4x3 = 12\mu F$$

$1/C_{eq} = (1/C_1) + (1/C_2) + (1/C_3) = 0.5 + 0.16667 + 0.08333 = 0.75x10^6$

C_{eq} = **1.3333 μF**.

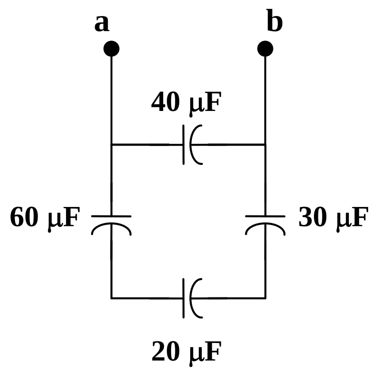
Chapter 6, Solution 21.

$4\mu F$ in series with $12\mu F = (4x12)/16 = 3\mu F$
$3\mu F$ in parallel with $3\mu F = 6\mu F$
$6\mu F$ in series with $6\mu F = 3\mu F$
$3\mu F$ in parallel with $2\mu F = 5\mu F$
$5\mu F$ in series with $5\mu F = 2.5\mu F$

Hence $C_{eq} = \mathbf{2.5\mu F}$

Chapter 6, Solution 22.

Combining the capacitors in parallel, we obtain the equivalent circuit shown below:



Combining the capacitors in series gives C^1_{eq}, where

$$\frac{1}{C^1_{eq}} = \frac{1}{60} + \frac{1}{20} + \frac{1}{30} = \frac{1}{10} \longrightarrow C^1_{eq} = 10\mu F$$

Thus

$$C_{eq} = 10 + 40 = \mathbf{50\ \mu F}$$

Chapter 6, Solution 23.

Using Fig. 6.57, design a problem to help other students better understand how capacitors work together when connected in series and parallel.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

For the circuit in Fig. 6.57, determine:

(a) the voltage across each capacitor,
(b) the energy stored in each capacitor.

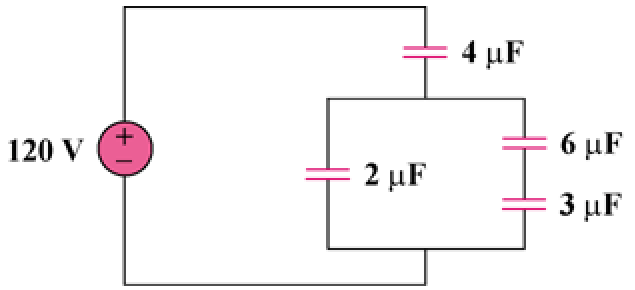


Figure 6.57

Solution

(a) 3μF is in series with 6μF $\quad$ 3x6/(9) = 2μF

$v_{4\mu F}$ = 1/2 x 120 = **60V**

$v_{2\mu F}$ = **60V**

$$v_{6\mu F} = \frac{3}{6+3}(60) = \mathbf{20V}$$

$v_{3\mu F}$ = 60 - 20 = **40V**

(b) Hence w = 1/2 Cv^2

$w_{4\mu F}$ = 1/2 x 4 x 10^{-6} x 3600 = **7.2mJ**

$w_{2\mu F}$ = 1/2 x 2 x 10^{-6} x 3600 = **3.6mJ**

$w_{6\mu F}$ = 1/2 x 6 x 10^{-6} x 400 = **1.2mJ**

$w_{3\mu F}$ = 1/2 x 3 x 10^{-6} x 1600 = **2.4mJ**

Chapter 6, Solution 24.

20μF is series with 80μF = 20x80/(100) = 16μF
14μF is parallel with 16μF = 30μF

(a) $v_{30\mu F}$ = **90V**

$v_{60\mu F}$ = **30V**

$v_{14\mu F}$ = **60V**

$v_{20\mu F} = \dfrac{80}{20+80} x60 = \mathbf{48V}$

$v_{80\mu F}$ = 60 - 48 = **12V**

(b) Since $w = \dfrac{1}{2}Cv^2$

$w_{30\mu F}$ = 1/2 x 30 x 10^{-6} x 8100 = **121.5mJ**
$w_{60\mu F}$ = 1/2 x 60 x 10^{-6} x 900 = **27mJ**
$w_{14\mu F}$ = 1/2 x 14 x 10^{-6} x 3600 = **25.2mJ**
$w_{20\mu F}$ = 1/2 x 20 x 10^{-6} x $(48)^2$ = **23.04mJ**
$w_{80\mu F}$ = 1/2 x 80 x 10^{-6} x 144 = **5.76mJ**

Chapter 6, Solution 25.

(a) For the capacitors in series,

$$Q_1 = Q_2 \longrightarrow C_1 v_1 = C_2 v_2 \longrightarrow \frac{v_1}{v_2} = \frac{C_2}{C_1}$$

$$v_s = v_1 + v_2 = \frac{C_2}{C_1} v_2 + v_2 = \frac{C_1 + C_2}{C_1} v_2 \longrightarrow \boldsymbol{v_2 = \frac{C_1}{C_1 + C_2} v_s}$$

Similarly, $\boldsymbol{v_1 = \frac{C_2}{C_1 + C_2} v_s}$

(b) For capacitors in parallel

$$v_1 = v_2 = \frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

$$Q_s = Q_1 + Q_2 = \frac{C_1}{C_2} Q_2 + Q_2 = \frac{C_1 + C_2}{C_2} Q_2$$

or

$$Q_2 = \frac{C_2}{C_1 + C_2}$$

$$Q_1 = \frac{C_1}{C_1 + C_2} Q_s$$

$$i = \frac{dQ}{dt} \longrightarrow \boldsymbol{i_1 = \frac{C_1}{C_1 + C_2} i_s}, \quad \boldsymbol{i_2 = \frac{C_2}{C_1 + C_2} i_s}$$

Chapter 6, Solution 26.

(a) $C_{eq} = C_1 + C_2 + C_3 =$ **35μF**

(b) $Q_1 = C_1 v = 5 \text{ x } 150\mu C =$ **0.75mC**
$Q_2 = C_2 v = 10 \text{ x } 150\mu C =$ **1.5mC**
$Q_3 = C_3 v = 20 \text{ x } 150 =$ **3mC**

(c) $w = \frac{1}{2} C_{eq} v^2 = \frac{1}{2} x35x150^2 \mu J =$ **393.8mJ**

Chapter 6, Solution 27.

If they are all connected in parallel, we get $C_T = 4x4\mu F = 16\mu F$

If they are all connected in series, we get

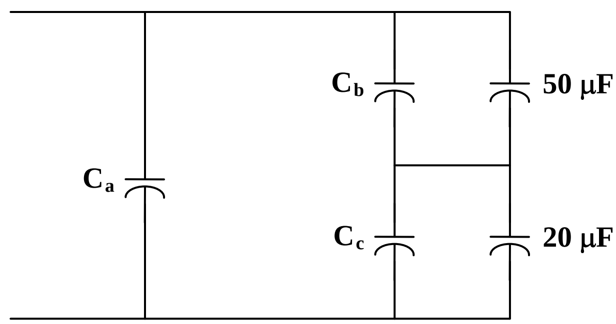
$$\frac{1}{C_T} = \frac{4}{4\mu F} \longrightarrow C_T = 1\mu F$$

All other combinations fall within these two extreme cases. Hence,

C_{min} = **1 μF**, C_{max} = **16 μF**

Chapter 6, Solution 28.

We may treat this like a resistive circuit and apply delta-wye transformation, except that R is replaced by 1/C.



$$\frac{1}{C_a} = \frac{\left(\frac{1}{10}\right)\left(\frac{1}{40}\right) + \left(\frac{1}{10}\right)\left(\frac{1}{30}\right) + \left(\frac{1}{30}\right)\left(\frac{1}{40}\right)}{\frac{1}{30}}$$

$$= \frac{3}{40} + \frac{1}{10} + \frac{1}{40} = \frac{2}{10}$$

$C_a = 5\mu F$

$$\frac{1}{C_b} = \frac{\frac{1}{400} + \frac{1}{300} + \frac{1}{1200}}{\frac{1}{10}} = \frac{2}{30}$$

$C_b = 15\mu F$

$$\frac{1}{C_c} = \frac{\frac{1}{400} + \frac{1}{300} + \frac{1}{1200}}{\frac{1}{40}} = \frac{4}{15}$$

$C_c = 3.75\mu F$

C_b in parallel with $50\mu F = 50 + 15 = 65\mu F$
C_c in series with $20\mu F = 23.75\mu F$
$65\mu F$ in series with $23.75\mu F = \frac{65x23.75}{88.75} = 17.39\mu F$
$17.39\mu F$ in parallel with $C_a = 17.39 + 5 = 22.39\mu F$

Hence C_{eq} = **22.39μF**

Chapter 6, Solution 29.

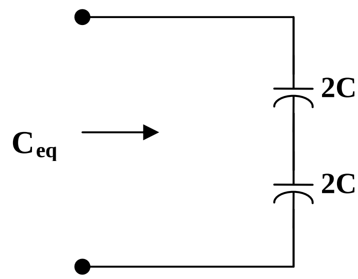
(a) C in series with C = C/(2)

C/2 in parallel with C = 3C/2

$$\frac{3C}{2} \text{ in series with } C = \frac{Cx\frac{3C}{2}}{5\frac{C}{2}} = \frac{3C}{5}$$

$$3\frac{C}{5} \text{ in parallel with } C = C + 3\frac{C}{5} = \mathbf{1.6\ C}$$

(b)



$$\frac{1}{C_{eq}} = \frac{1}{2C} + \frac{1}{2C} = \frac{1}{C}$$

C_{eq} = **1 C**

Chapter 6, Solution 30.

$$v_o = \frac{1}{C}\int_o^t idt + i(0)$$

For 0 < t < 1, i = 90t mA,

$$v_o = \frac{10^{-3}}{3x10^{-6}}\int_o^t 90tdt + 0 = 15t^2 kV$$

$v_o(1) = 15$ kV

For 1< t < 2, i = (180 – 90t) mA,

$$v_o = \frac{10^{-3}}{3x10^{-6}}\int_1^t (180 - 90t)dt + v_o(1)$$

$= [60t - 15t^2]\Big|_1^t + 15kV$

$= [60t - 15t^2 - (60–15) + 15]$ kV $= [60t - 15t^2 - 30]$ kV

$$\boldsymbol{v_o(t) = \begin{cases} 15t^2 kV, & 0 < t < 1 \\ [60t - 15t^2 - 30]kV, & 1 < t < 2 \end{cases}}$$

Chapter 6, Solution 31.

$$i_s(t) = \begin{bmatrix} 30tmA, & 0 < t < 1 \\ 30mA, & 1 < t < 3 \\ -75 + 15t, & 3 < t < 5 \end{bmatrix}$$

C_{eq} = 4 + 6 = 10μF

$$v = \frac{1}{C_{eq}} \int_o^t idt + v(0)$$

For 0 < t < 1,

$$v = \frac{10^{-3}}{10x10^{-6}} \int_o^t 30t\ dt + 0 = 1.5t^2\ \text{kV}$$

For 1 < t < 3,

$$v = \frac{10^3}{10} \int_1^t 20dt + v(1) = [3(t-1) + 1.5]kV$$

$$= [3t - 1.5]kV$$

For 3 < t < 5,

$$v = \frac{10^3}{10} \int_3^t 15(t-5)dt + v(3)$$

$$= \left[1.5\frac{t^2}{2} - 7.5t\right]\Big|_3^t + 7.5kV = [0.75t^2 - 7.5t + 23.25]kV$$

$$\boldsymbol{v(t) = \begin{bmatrix} 1.5t^2 kV, & 0 < t < 1s \\ [3t - 1.5]kV, & 1 < t < 3s \\ [0.75t^2 - 7.5t + 23.25]kV, & 3 < t < 5s \end{bmatrix}}$$

$$i_1 = C_1 \frac{dv}{dt} = 6x10^{-6} \frac{dv}{dt}$$

$$\boldsymbol{i_1 = \begin{bmatrix} 18tmA, & 0 < t < 1s \\ 18mA, & 1 < t < 3s \\ [9t - 45]mA, & 3 < t < 5s \end{bmatrix}}$$

$$i_2 = C_2 \frac{dv}{dt} = 4x10^{-6} \frac{dv}{dt}$$

$$i_2 = \begin{cases} 12t\,mA, & 0 < t < 1s \\ 12\,mA, & 1 < t < 3s \\ [6t - 30]\,mA, & 3 < t < 5s \end{cases}$$

Chapter 6, Solution 32.

(a) C_{eq} = (12x60)/72 = 10 μF

$$v_1 = \frac{10^{-3}}{12x10^{-6}}\int_0^t 50e^{-2t}dt + v_1(0) = \underline{-2083e^{-2t}\ \Big|_0^t} + 50 = \underline{-2083e^{-2t} + 2133V}$$

$$v_2 = \frac{10^{-3}}{60x10^{-6}}\int_0^t 50e^{-2t}dt + v_2(0) = \underline{-416.7e^{-2t}\ \Big|_0^t} + 20 = \underline{-416.7e^{-2t} + 436.7V}$$

(b) At t=0.5s,

$$v_1 = -2083e^{-1} + 2133 = 1366.7, \qquad v_2 = -416.7e^{-1} + 436.7 = 283.4$$

$$w_{12\mu F} = \frac{1}{2}x12x10^{-6}x(1366.7)^2 = \underline{11.207\text{ J}}$$

$$w_{20\mu F} = \frac{1}{2}x20x10^{-6}x(283.4)^2 = \underline{803.2\text{ mJ}}$$

$$w_{40\mu F} = \frac{1}{2}x40x10^{-6}x(283.4)^2 = \underline{1.6063\text{ J}}$$

Chapter 6, Solution 33

Because this is a totally capacitive circuit, we can combine all the capacitors using the property that capacitors in parallel can be combined by just adding their values and we combine capacitors in series by adding their reciprocals. However, for this circuit we only have the three capacitors in parallel.

3 F + 2 F = 5 F (we need this to be able to calculate the voltage)

$C_{Th} = C_{eq} = 5+3+2 = 10$ F

The voltage will divide equally across the two 5 F capacitors. Therefore, we get:

$$V_{Th} = \mathbf{15\ V}, \quad C_{Th} = \mathbf{10\ F}.$$

15 V, **10 F**

Chapter 6, Solution 34.

$i = 10e^{-t/2}$

$$v = L\frac{di}{dt} = 10x10^{-3}(10)\left(\frac{1}{2}\right)e^{-t/2}$$

$= -50e^{-t/2}$ mV

$v(3) = -50e^{-3/2}$ mV = **–11.157 mV**

$p = vi = -500e^{-t}$ mW

$p(3) = -500e^{-3}$ mW = **–24.89 mW**.

Chapter 6, Solution 35.

$$v = L\frac{di}{dt} \quad \longrightarrow \quad L = \frac{v}{di/dt} = \frac{160x10^{-3}}{\frac{(100-50)x10^{-3}}{2x10^{-3}}} = \underline{6.4\ \text{mH}}$$

Chapter 6, Solution 36.

Design a problem to help other students to better understand how inductors work.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

The current through a 12-mH inductor is $i(t) = 30te^{-2t}$ A, $t \geq 0$. Determine: (a) the voltage across the inductor, (b) the power being delivered to the inductor at t = 1 s, (c) the energy stored in the inductor at t = 1 s.

Solution

(a) $v = L\dfrac{di}{dt} = 12x10^{-3}(30e^{-2t} - 60te^{-2t}) = \underline{(0.36 - 0.72t)e^{-2t}\ \text{V}}$

(b) $p = vi = (0.36 - 0.72x1)e^{-2}x30x1e^{-2} = 0.36x30e^{-4} = \underline{-0.1978\ \text{W}}$

(c) $\text{w} = \dfrac{1}{2}\text{Li}^2 = 0.5\text{x}12\text{x}10^{-3}(30\text{x}1\text{xe}^{-2})^2 =$ **98.9 mJ**.

Chapter 6, Solution 37.

$$v = L\frac{di}{dt} = 12x10^{-3}\,x4(100)\cos 100t$$

$$= \mathbf{4.8\ cos\ (100t)\ V}$$

$$p = vi = 4.8 \text{ x } 4 \sin 100t \cos 100t = 9.6 \sin 200t$$

$$w = \int_o^t pdt = \int_o^{11/200} 9.6 \sin 200t$$

$$= -\frac{9.6}{200}\cos 200t\Big|_o^{11/200} \text{ J}$$

$$= -48(\cos\pi - 1)\text{mJ} = \mathbf{96\ mJ}$$

Please note that this problem could have also been done by using (½)Li^2.

Chapter 6, Solution 38.

$$v = L\frac{di}{dt} = 40x10^{-3}\left(e^{-2t} - 2te^{-2t}\right)dt$$

$$= \mathbf{40(1-2\mathit{t})\mathit{e}^{-2\mathit{t}}\mathit{mV}\,,\mathit{t} > 0}$$

Chapter 6, Solution 39

$$v = L\frac{di}{dt} \longrightarrow i = \frac{1}{L}\int_0^t idt + i(0)$$

$$i = \frac{1}{200x10^{-3}}\int_0^t (3t^2 + 2t + 4)dt + 1$$

$$= 5(t^3 + t^2 + 4t)\Big|_0^t + 1$$

i(t) = **[5t^3 + 5t^2 + 20t + 1] A**

Chapter 6, Solution 40.

$$i = \begin{cases} 5t, & 0 < t < 2ms \\ 10, & 2 < t < 4ms \\ 30 - 5t, & 4 < t < 6ms \end{cases}$$

$$v = L\frac{di}{dt} = \frac{5x10^{-3}}{10^{-3}}\begin{cases} 5, & 0 < t < 2ms \\ 0, & 2 < t < 4ms \\ -5, & 4 < t < 6ms \end{cases} = \begin{cases} 25, & 0 < t < 2ms \\ 0, & 2 < t < 4ms \\ -25, & 4 < t < 6ms \end{cases}$$

At t = 1ms, v = **25 V**
At t = 3ms, v = **0 V**
At t = 5ms, v= **–25 V**

Chapter 6, Solution 41.

$$i = \frac{1}{L}\int_0^t v dt + C = \left(\frac{1}{2}\right)\int_o^t 20\left(1 - e^{-2t}\right)dt + C$$

$$= 10\left(t + \frac{1}{2}e^{-2t}\right)\Big|_o^t + C = 10t + 5e^{-2t} - 4.7A$$

Note, we get C = –4.7 from the initial condition for i needing to be 0.3 A.

We can check our results be solving for v = Ldi/dt.

$v = 2(10 – 10e^{–2t})V$ which is what we started with.

At t = l s, $i = 10 + 5e^{-2} – 4.7 = 10 + 0.6767 – 4.7 =$ **5.977 A**

$w = \frac{1}{2} L\, i^2 =$ **35.72J**

Chapter 6, Solution 42.

$$i = \frac{1}{L}\int_o^t vdt + i(0) = \frac{1}{5}\int_o^t v(t)dt - 1$$

For $0 < t < 1$, $i = \frac{10}{5}\int_0^t dt - 1 = 2t - 1$ A

For 1 < t < 2,   i = 0 + i(1) = 1A

For 2 < t < 3, $i = \frac{1}{5}\int 10dt + i(2) = 2t\Big|_t^2 + 1$

= 2t - 3 A

For 3 < t < 4,   i = 0 + i(3) = 3 A

For 4 < t < 5, $i = \frac{1}{5}\int_4^t 10dt + i(4) = 2t\Big|_4^t + 3$

= 2t - 5 A

Thus,

$$\boldsymbol{i(t) = \begin{cases} 2t - 1A, & 0 < t < 1 \\ 1A, & 1 < t < 2 \\ 2t - 3A, & 2 < t < 3 \\ 3A, & 3 < t < 4 \\ 2t - 5, & 4 < t < 5 \end{cases}}$$

Chapter 6, Solution 43.

$$w = L\int_{-\infty}^{t} i\,dt = \frac{1}{2}Li^2(t) - \frac{1}{2}Li^2(-\infty)$$

$$= \frac{1}{2}x80x10^{-3}x\left(60x10^{-3}\right)^2 - 0$$

= **144 μJ**.

Chapter 6, Solution 44.

(a) $v_L = L\dfrac{di}{dt} = 100x10^{-3}(-400)x50x10^{-3}e^{-400t} = \underline{-2e^{-400t}\ \text{V}}$

(b) Since R and L are in parallel, $v_R = v_L = \underline{-2e^{-400t}\ \text{V}}$

(c) **No**

(d) $w = \dfrac{1}{2}Li^2 = 0.5x100x10^{-3}(0.05)^2 =$ **125 μJ**.

Chapter 6, Solution 45.

$$i(t) = \frac{1}{L}\int_o^t v(t) + i(0)$$

For 0 < t < 1, v = 5t

$$i = \frac{1}{10x10^{-3}}\int_o^t 5t\,dt + 0$$

$$= 250t^2 \text{ A}$$

For 1 < t < 2, v = -10 + 5t

$$i = \frac{1}{10x10^{-3}}\int_1^t (-10 + 5t)dt + i(1)$$

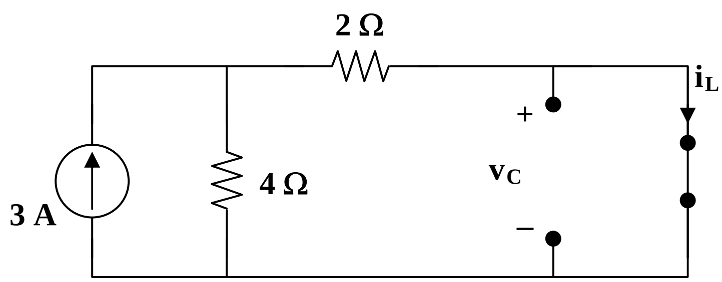
$$= \int_1^t (0.5t - 1)dt + 0.25\text{kA}$$

$$= [1 - t + 0.25t^2]\text{ kA}$$

$$\boldsymbol{i(t) = \begin{cases} 250t^2\ A, & 0 < t < 1s \\ [1 - t + 0.25t^2]\,kA, & 1 < t < 2s \end{cases}}$$

Chapter 6, Solution 46.

Under dc conditions, the circuit is as shown below:



By current division,

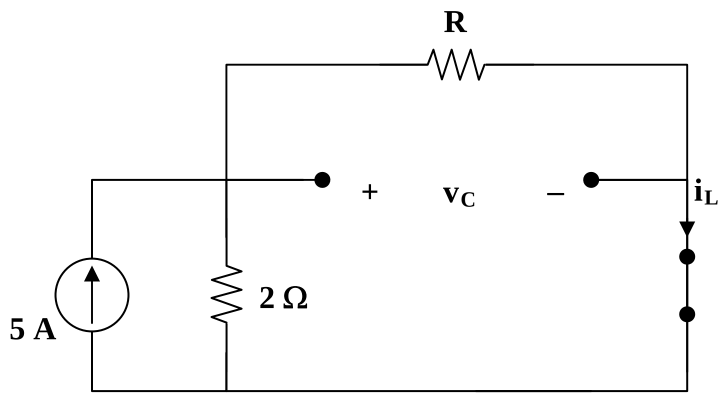
$$i_L = \frac{4}{4+2}(3) = \mathbf{2A}, \quad v_c = \mathbf{0V}$$

$$w_L = \frac{1}{2} L\, i_L^2 = \frac{1}{2}\left(\frac{1}{2}\right)(2)^2 = \mathbf{1J}$$

$$w_c = \frac{1}{2} C\, v_c^2 = \frac{1}{2}(2)(v) = \mathbf{0J}$$

Chapter 6, Solution 47.

Under dc conditions, the circuit is equivalent to that shown below:



$$i_L = \frac{2}{R+2}(5) = \frac{10}{R+2}, \quad v_c = Ri_L = \frac{10R}{R+2}$$

$$w_c = \frac{1}{2}Cv_c^2 = 80x10^{-6}x\frac{100R^2}{(R+2)^2}$$

$$w_L = \frac{1}{2}Li_1^2 = 2x10^{-3}x\frac{100}{(R+2)^2}$$

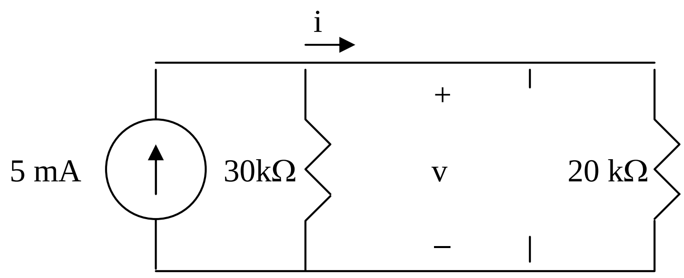
If $w_c = w_L$,

$$80x10^{-6}x\frac{100R^2}{(R+2)^2} = \frac{2x10^{-3}x100}{(R+2)^2} \longrightarrow 80 \text{ x } 10^{-3}R^2 = 2$$

$$R = \mathbf{5\Omega}$$

Chapter 6, Solution 48.

Under steady-state, the inductor acts like a short-circuit, while the capacitor acts like an open circuit as shown below.



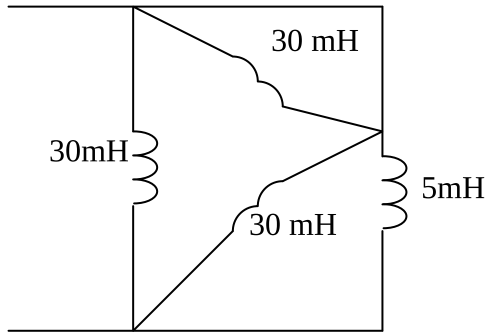
Using current division,

$$i = (30k/(30k+20k))(5mA) = \mathbf{3\ mA}$$

$$v = 20ki \ = \mathbf{60\ V}$$

Chapter 6, Solution 49.

Converting the wye-subnetwork to its equivalent delta gives the circuit below.



30//0 = 0, 30//5 = 30x5/35=4.286

$$L_{eq} = 30 // 4.286 = \frac{30x4.286}{34.286} = \underline{3.75 \text{ mH}}$$

Chapter 6, Solution 50.

16mH in series with 14 mH = 16+14=30 mH
24 mH in series with 36 mH = 24+36=60 mH
30mH in parallel with 60 mH = 30x60/90 = **20 mH**

Chapter 6, Solution 51.

$$\frac{1}{L} = \frac{1}{60} + \frac{1}{20} + \frac{1}{30} = \frac{1}{10} \qquad\qquad L = 10 \text{ mH}$$

$$L_{eq} = 10 \| (25 + 10) = \frac{10x35}{45}$$

$$= \mathbf{7.778 \text{ mH}}$$

Chapter 6, Solution 52.

Using Fig. 6.74, design a problem to help other students better understand how inductors behave when connected in series and when connected in parallel.

Although there are many ways to work this problem, this is an example based on the same kind of problem asked in the third edition.

Problem

Find L_{eq} in the circuit of Fig. 6.74.

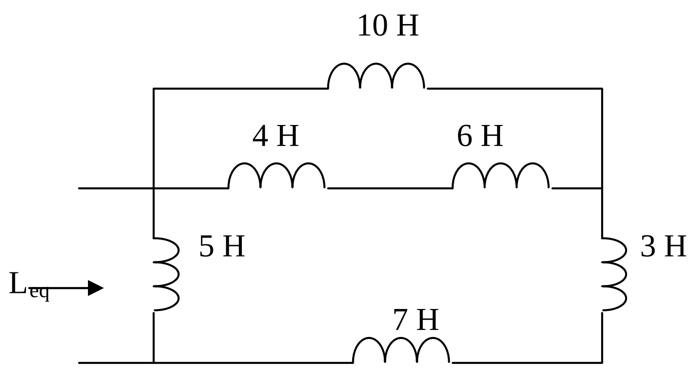


Figure 6.74 For Prob. 6.52.

Solution

$$L_{eq} = 5//(7+3+10//(4+6)) == 5//(7+3+5)) = \frac{5x15}{20} = \underline{3.75 \text{ H}}$$

Chapter 6, Solution 53.

$$L_{eq} = 6 + 10 + 8 \| \left[5 \| (8 + 12) + 6 \| (8 + 4) \right]$$

$$= 16 + 8 \| (4 + 4) = 16 + 4$$

L_{eq} = **20 mH**

Chapter 6, Solution 54.

$$L_{eq} = 4 + (9+3)\|\left(10\|0 + 6\|12\right)$$

$$= 4 + 12\|(0+4) = 4 + 3$$

$$L_{eq} = \mathbf{7H}$$

Chapter 6, Solution 55.

(a) L//L = 0.5L, L + L = 2L

$$L_{eq} = L + 2L // 0.5L = L + \frac{2Lx0.5L}{2L + 0.5L} = \underline{1.4L} = \mathbf{1.4\ L}.$$

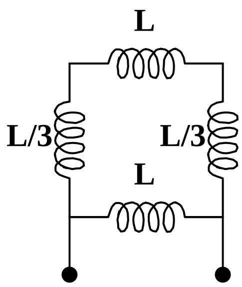
(b) L//L = 0.5L, L//L + L//L = L

$$L_{eq} = L//L = \mathbf{500\ mL}$$

Chapter 6, Solution 56.

$$L \| L \| L = \frac{1}{\frac{3}{L}} = \frac{L}{3}$$

Hence the given circuit is equivalent to that shown below:



$$L_{eq} = L \left\| \left(L + \frac{2}{3}L \right) = \frac{L x \frac{5}{3} L}{L + \frac{5}{3} L} = \frac{\mathbf{5}}{\mathbf{8}} \boldsymbol{L} \right.$$

Chapter 6, Solution 57.

$$\text{Let } v = L_{eq}\frac{di}{dt} \qquad (1)$$

$$v = v_1 + v_2 = 4\frac{di}{dt} + v_2 \qquad (2)$$

$$i = i_1 + i_2 \longrightarrow i_2 = i - i_1 \qquad (3)$$

$$v_2 = 3\frac{di_1}{dt} \text{ or } \frac{di_1}{dt} = \frac{v_2}{3} \qquad (4)$$

and

$$-v_2 + 2\frac{di}{dt} + 5\frac{di_2}{dt} = 0$$

$$v_2 = 2\frac{di}{dt} + 5\frac{di_2}{dt} \qquad (5)$$

Incorporating (3) and (4) into (5),

$$v_2 = 2\frac{di}{dt} + 5\frac{di}{dt} - 5\frac{di_1}{dt} = 7\frac{di}{dt} - 5\frac{v_2}{3}$$

$$v_2\left(1 + \frac{5}{3}\right) = 7\frac{di}{dt}$$

$$v_2 = \frac{21}{8}\frac{di}{dt}$$

Substituting this into (2) gives

$$v = 4\frac{di}{dt} + \frac{21}{8}\frac{di}{dt}$$

$$= \frac{53}{8}\frac{di}{dt}$$

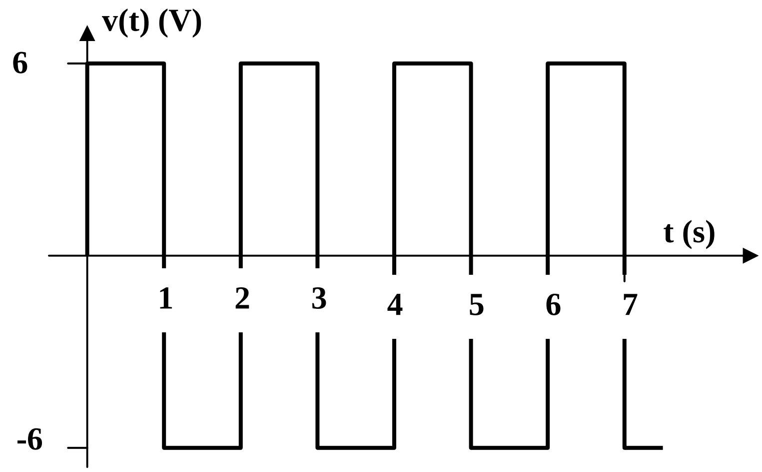
Comparing this with (1),

$$L_{eq} = \frac{53}{8} = \mathbf{6.625\ H}$$

Chapter 6, Solution 58.

$$v = L\frac{di}{dt} = 3\frac{di}{dt} = 3 \text{ x slope of i(t).}$$

Thus v is sketched below:



Chapter 6, Solution 59.

(a) $v_s = (L_1 + L_2)\dfrac{di}{dt}$

$$\frac{di}{dt} = \frac{v_s}{L_1 + L_2}$$

$$v_1 = L_1\frac{di}{dt}, \quad v_2 = L_2\frac{di}{dt}$$

$$\boldsymbol{v_1 = \frac{L_1}{L_1 + L_2} v_s, \; v_L = \frac{L_2}{L_1 + L_2} v_s}$$

(b) $v_i = v_2 = L_1\dfrac{di_1}{dt} = L_2\dfrac{di_2}{dt}$

$$i_s = i_1 + i_2$$

$$\frac{di_s}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt} = \frac{v}{L_1} + \frac{v}{L_2} = v\frac{(L_1 + L_2)}{L_1 L_2}$$

$$i_1 = \frac{1}{L_1}\int v\,dt = \frac{1}{L_1}\int \frac{L_1 L_2}{L_1 + L_2}\frac{di_s}{dt}\,dt = \boldsymbol{\frac{L_2}{L_1 + L_2} i_s}$$

$$i_2 = \frac{1}{L_2}\int v\,dt = \frac{1}{L_2}\int \frac{L_1 L_2}{L_1 + L_2}\frac{di_s}{dt}\,dt = \boldsymbol{\frac{L_1}{L_1 + L_2} i_s}$$

Chapter 6, Solution 60

$$L_{eq} = 3 // 5 = \frac{15}{8}$$

$$v_o = L_{eq}\frac{di}{dt} = \frac{15}{8}\frac{d}{dt}\left(4e^{-2t}\right) = \underline{-15e^{-2t}}$$

$$i_o = \frac{I}{L}\int_0^t v_o(t)dt + i_o(0) = 2 + \frac{1}{5}\int_0^t(-15)e^{-2t}dt = 2 + 1.5e^{-2t}\Big|_0^t$$

i_o = **(0.5 + 1.5e^{-2t}) A**

Chapter 6, Solution 61.

(a) $L_{eq} = 20//(4+6) = 20x10/30 = \underline{6.667\ \text{mH}}$

Using current division,

$$i_1(t) = \frac{10}{10+20} i_s = \underline{e^{-t}\ \text{mA}}$$

$$i_2(t) = \underline{2e^{-t}\ \text{mA}}$$

(b) $v_o = L_{eq}\dfrac{di_s}{dt} = \dfrac{20}{3}x10^{-3}(-3e^{-t}x10^{-3}) = \underline{-20e^{-t}\ \mu\text{V}}$

(c) $w = \dfrac{1}{2}Li_1^2 = \dfrac{1}{2}x20x10^{-3}xe^{-2}x10^{-6} = \underline{1.3534\ \text{nJ}}$

Chapter 6, Solution 62.

(a) $L_{eq} = 25 + 20 // 60 = 25 + \dfrac{20x60}{80} = 40 \text{ mH}$

$$v = L_{eq}\frac{di}{dt} \longrightarrow i = \frac{1}{L_{eq}}\int v(t)dt + i(0) = \frac{10^{-3}}{40x10^{-3}}\int_0^t 12e^{-3t}dt + i(0) = -0.1(e^{-3t} - 1) + i(0)$$

Using current division and the fact that all the currents were zero when the circuit was put together, we get,

$$i_1 = \frac{60}{80}i = \frac{3}{4}i, \quad i_2 = \frac{1}{4}i$$

$$i_1(0) = \frac{3}{4}i(0) \longrightarrow 0.75i(0) = -0.01 \longrightarrow i(0) = -0.01333$$

$$i_2 = \frac{1}{4}(-0.1e^{-3t} + 0.08667) \text{ A} = \text{ - 25e}^{\text{-3t}} + 21.67 \text{ mA}$$

$$\boldsymbol{i_2(0) = -25 + 21.67 = \underline{-3.33 \text{ mA}}}$$

(b) $\boldsymbol{i_1 = \dfrac{3}{4}(-0.1e^{-3t} + 0.08667) \text{ A} = \underline{\text{ - 75e}^{\text{-3t}} + 65 \text{ mA}}}$

$$\boldsymbol{i_2 = \underline{\text{ - 25e}^{\text{-3t}} + 21.67 \text{ mA}}}$$

Chapter 6, Solution 63.

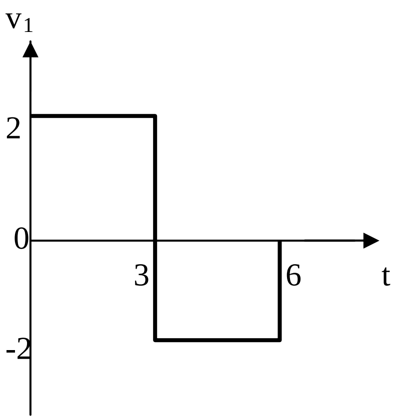
We apply superposition principle and let

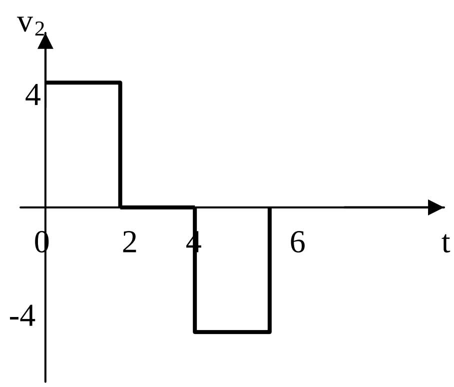
$$v_o = v_1 + v_2$$

where v_1 and v_2 are due to i_1 and i_2 respectively.

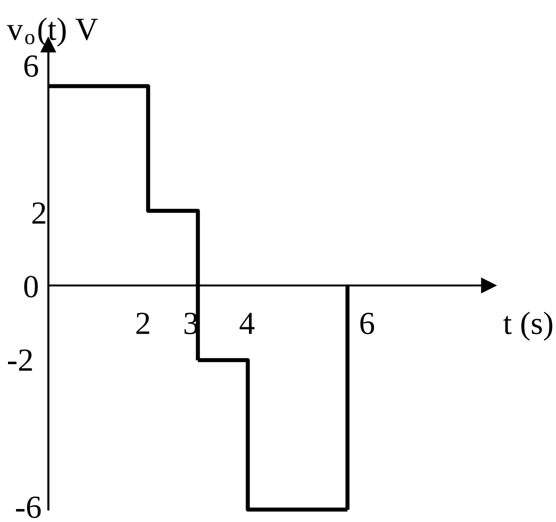
$$v_1 = L\frac{di_1}{dt} = 2\frac{di_1}{dt} = \begin{cases} 2, & 0 < t < 3 \\ -2, & 3 < t < 6 \end{cases}$$

$$v_2 = L\frac{di_2}{dt} = 2\frac{di_2}{dt} = \begin{cases} 4, & 0 < t < 2 \\ 0, & 2 < t < 4 \\ -4, & 4 < t < 6 \end{cases}$$





Adding v_1 and v_2 gives v_o, which is shown below.



Chapter 6, Solution 64.

(a) When the switch is in position A,

$i = -6 = i(0)$

When the switch is in position B,

$i(\infty) = 12/4 = 3, \qquad \tau = L/R = 1/8$

$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$$

$$i(t) = \mathbf{(3 - 9e^{-8t})\ A}$$

(b) $-12 + 4i(0) + v = 0$, i.e. $v = 12 - 4i(0) =$ **36 V**

(c) At steady state, the inductor becomes a short circuit so that

$$v = \mathbf{0\ V}$$

Chapter 6, Solution 65.

(a) $w_5 = \frac{1}{2}L_1 i_1^2 = \frac{1}{2}x5x(4)^2 = \mathbf{40\ J}$

$w_{20} = \frac{1}{2}(20)(-2)^2 = \mathbf{40\ J}$

(b) $w = w_5 + w_{20} = \mathbf{80\ J}$

(c) $i_1 = \frac{1}{L_1}\int_0^t -50e^{-200t}dt + i_1(0) = \frac{1}{5}\left(\frac{1}{200}\right)\left(50e^{-200t}x10^{-3}\right)\Big|_0^t + 4$

$= \mathbf{[5x10^{-5}(e^{-200t} - 1) + 4]\ A}$

$i_2 = \frac{1}{L_2}\int_0^t -50e^{-200t}dt + i_2(0) = \frac{1}{20}\left(\frac{1}{200}\right)\left(50e^{-200t}x10^{-3}\right)\Big|_0^t - 2$

$= \mathbf{[1.25x10^{-5}\ (e^{-200t} - 1) - 2]\ A}$

(d) $i = i_1 + i_2 = \mathbf{[6.25x10^{-5}\ (e^{-200t} - 1) + 2]\ A}$

Chapter 6, Solution 66.

If v=i, then

$$i = L\frac{di}{dt} \longrightarrow \frac{dt}{L} = \frac{di}{i}$$

Integrating this gives

$$\frac{t}{L} = \ln(i) - \ln(C_o) = \ln\left(\frac{i}{C_o}\right) \rightarrow i = C_o e^{t/L}$$

$i(0) = 2 = C_o$

$$i(t) = 2e^{t/0.02} = \mathbf{2e^{50t}\ A}.$$

Chapter 6, Solution 67.

$$v_o = -\frac{1}{RC}\int v_i\,dt, \text{ RC} = 50 \text{ x } 10^3 \text{ x } 0.04 \text{ x } 10^{-6} = 2 \text{ x } 10^{-3}$$

$$v_o = \frac{-10^3}{2}\int 10\sin 50t\ dt$$

v_o = **100cos(50t) mV**

Chapter 6, Solution 68.

$$v_o = -\frac{1}{RC}\int vi\,dt + v(0),\ RC = 50 \text{ x } 10^3 \text{ x } 100 \text{ x } 10^{-6} = 5$$

$$v_o = -\frac{1}{5}\int_o^t 10dt + 0 = -2t$$

The op amp will saturate at $v_o = \pm 12$

$$-12 = -2t \longrightarrow \mathbf{t = 6s}$$

Chapter 6, Solution 69.

RC = 4 x 10^6 x 1 x 10^{-6} = 4

$$v_o = -\frac{1}{RC}\int v_i dt = -\frac{1}{4}\int v_i dt$$

For 0 < t < 1, v_i = 20, $v_o = -\frac{1}{4}\int_o^t 20dt =$ -5t mV

For 1 < t < 2, v_i = 10, $v_o = -\frac{1}{4}\int_1^t 10dt + v(1) = -2.5(t-1) - 5$

= -2.5t - 2.5mV

For 2 < t < 4, v_i = - 20, $v_o = +\frac{1}{4}\int_2^t 20dt + v(2) = 5(t-2) - 7.5$

= 5t - 17.5 mV

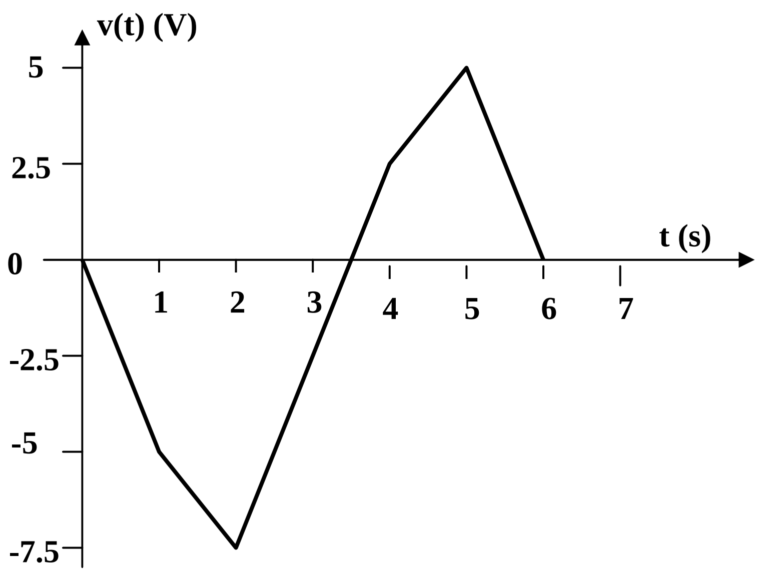
For 4 < t < 5m, v_i = -10, $v_o = \frac{1}{4}\int_4^t 10dt + v(4) = 2.5(t-4) + 2.5$

= 2.5t - 7.5 mV

For 5 < t < 6, v_i = 20, $v_o = -\frac{1}{4}\int_5^t 20dt + v(5) = -5(t-5) + 5$

= - 5t + 30 mV

Thus v_o(t) is as shown below:



Chapter 6, Solution 70.

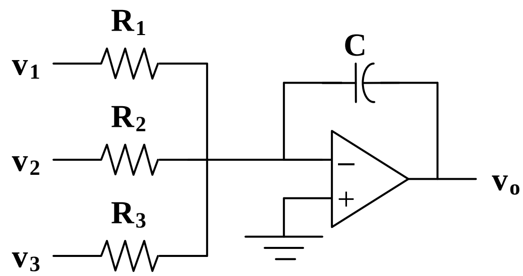
One possibility is as follows:

$$\frac{1}{RC} = 50$$

Let R = 100 kΩ, $\boldsymbol{C = \frac{1}{50x100x10^3} = 0.2\mu F}$

Chapter 6, Solution 71.

By combining a summer with an integrator, we have the circuit below:



$$v_o = -\frac{1}{R_1C}\int v_1 dt - \frac{1}{R_2C}\int v_2 dt - \frac{1}{R_2C}\int v_2 dt$$

For the given problem, C = **2μF**,

$R_1C = 1 \longrightarrow R_1 = 1/(C) = 10^6/(2) =$ **500 kΩ**
$R_2C = 1/(4) \longrightarrow R_2 = 1/(4C) = 500\text{k}\Omega/(4) =$ **125 kΩ**
$R_3C = 1/(10) \longrightarrow R_3 = 1/(10C) =$ **50 kΩ**

Chapter 6, Solution 72.

The output of the first op amp is

$$v_1 = -\frac{1}{RC}\int v_i\, dt = -\frac{1}{10x10^3 x2x10^{-6}}\int_o^t v_i dt = -\frac{100t}{2}$$

$$= -50t$$

$$v_o = -\frac{1}{RC}\int v_i\, dt = -\frac{1}{20x10^3 x0.5x10^{-6}}\int_o^t (-50t)dt$$

$$= 2500t^2$$

At t = 1.5ms,

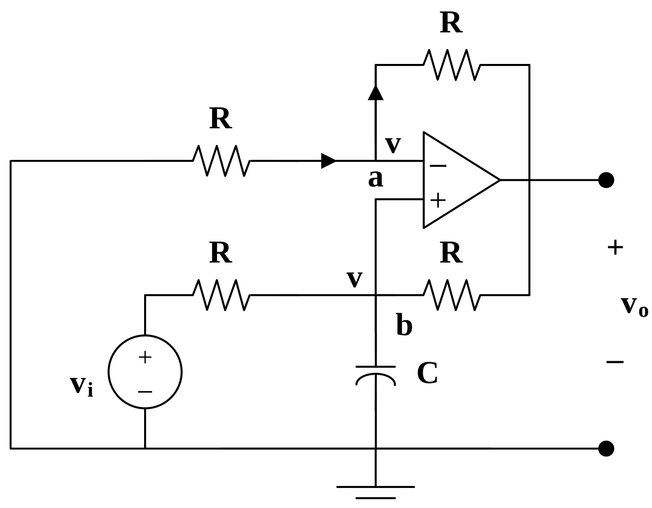
$$v_o = 2500(1.5)^2 x10^{-6} = \mathbf{5.625\ mV}$$

Chapter 6, Solution 73.

Consider the op amp as shown below:

Let $v_a = v_b = v$

At node a, $\frac{0-v}{R} = \frac{v-v_o}{R} \longrightarrow \mathbf{2v - v_o = 0}$ (1)



At node b, $\frac{v_i - v}{R} = \frac{v - v_o}{R} + C\frac{dv}{dt}$

$$v_i = 2v - v_o + RC\frac{dv}{dt} \quad (2)$$

Combining (1) and (2),

$$v_i = v_o - v_o + \frac{RC}{2}\frac{dv_o}{dt}$$

or

$$v_o = \frac{2}{RC}\int v_i \, dt$$

showing that the circuit is a noninverting integrator.

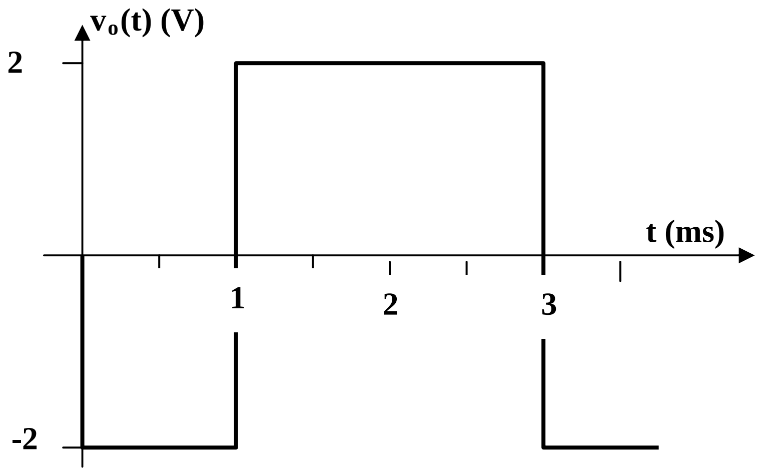
Chapter 6, Solution 74.

RC = 0.01 x 20 x 10^{-3} sec

$$v_o = -RC\frac{dv_i}{dt} = -0.2\frac{dv}{dt}\,m\sec$$

$$v_o = \begin{cases} -2V, & 0 < t < 1 \\ 2V, & 1 < t < 3 \\ -2V, & 3 < t < 4 \end{cases}$$

Thus $v_o(t)$ is as sketched below:



Chapter 6, Solution 75.

$$v_0 = -RC\frac{dv_i}{dt}, \quad RC = 250x10^3\,x10x10^{-6} = 2.5$$

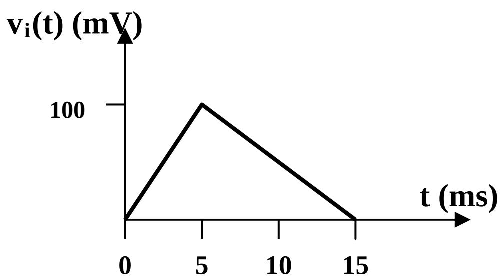
$$v_o = -2.5\frac{d}{dt}(12t) = \mathbf{-30\ mV}$$

Chapter 6, Solution 76.

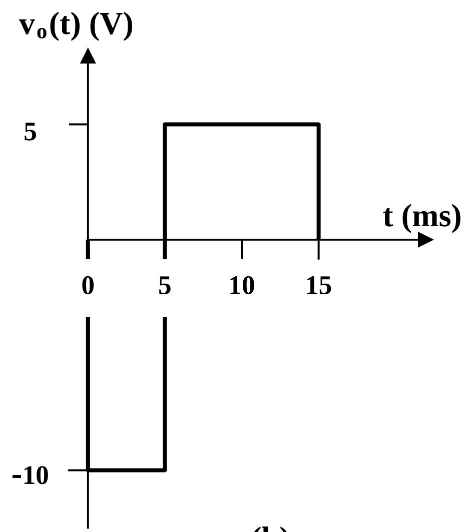
$$v_o = -RC\frac{dv_i}{dt},\ RC = 50 \text{ x } 10^3 \text{ x } 10 \text{ x } 10^{-6} = 0.5$$

$$v_o = -0.5\frac{dv_i}{dt} = \begin{cases} -10, & 0 < t < 5 \\ 5, & 5 < t < 15 \end{cases}$$

The input is sketched in Fig. (a), while the output is sketched in Fig. (b).



(a)



(b)

Chapter 6, Solution 77.

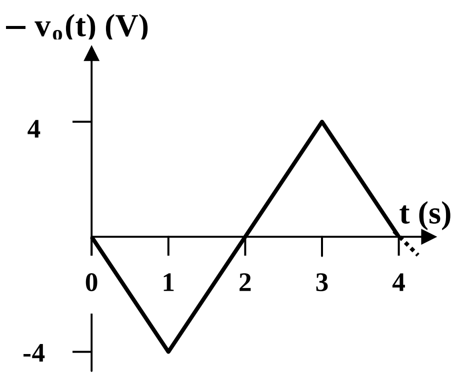
$i = i_R + i_C$

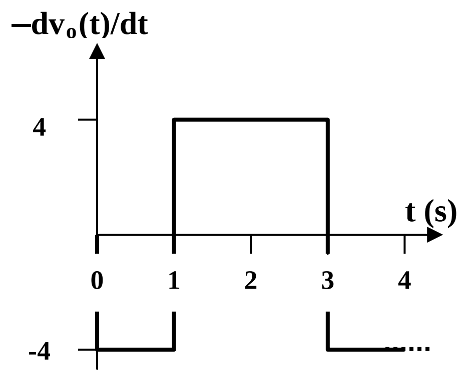
$$\frac{v_i - 0}{R} = \frac{0 - v_0}{R_F} + C\frac{d}{dt}(0 - v_o)$$

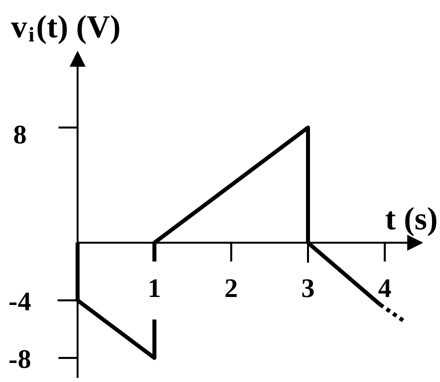
$$R_F C = 10^6 x 10^{-6} = 1$$

Hence $v_i = -\left(v_o + \frac{dv_o}{dt}\right)$

Thus v_i is obtained from v_o as shown below:



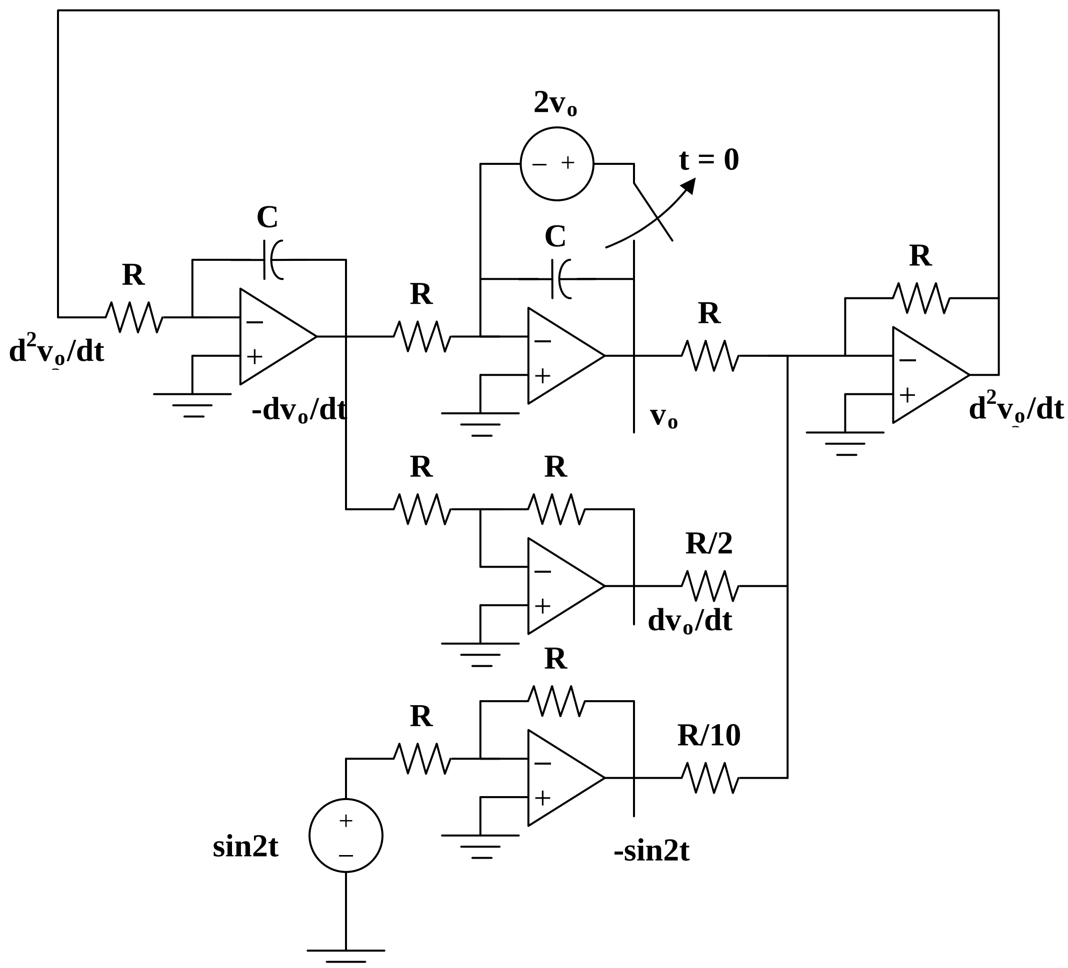




Chapter 6, Solution 78.

$$\frac{d^2 v_o}{dt} = 10\sin 2t - \frac{2dv_o}{dt} - v_o$$

Thus, by combining integrators with a summer, we obtain the appropriate analog computer as shown below:

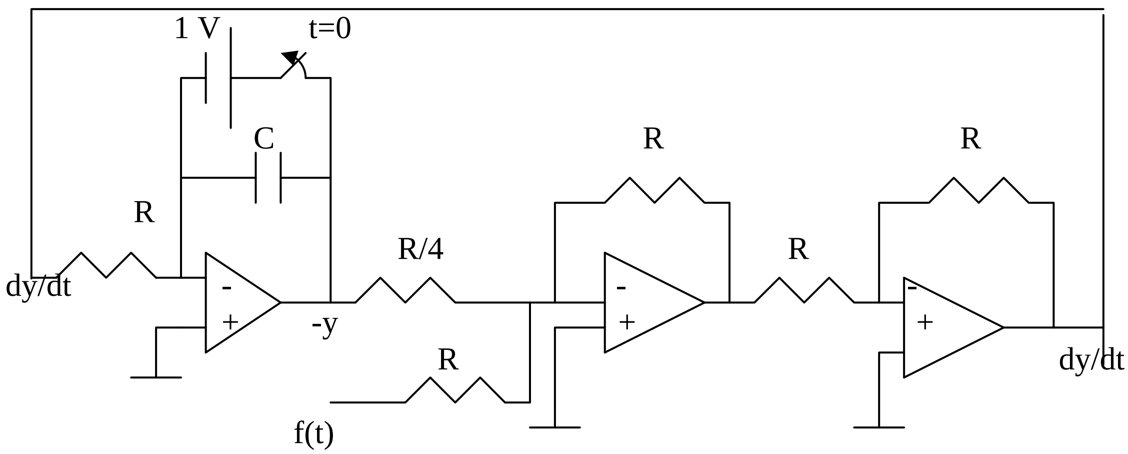


Chapter 6, Solution 79.

We can write the equation as

$$\frac{dy}{dt} = f(t) - 4y(t)$$

which is implemented by the circuit below.



Chapter 6, Solution 80.

From the given circuit,

$$\frac{d^2 v_o}{dt^2} = f(t) - \frac{1000\text{k}\Omega}{5000\text{k}\Omega} v_o - \frac{1000\text{k}\Omega}{200\text{k}\Omega} \frac{dv_o}{dt}$$

or

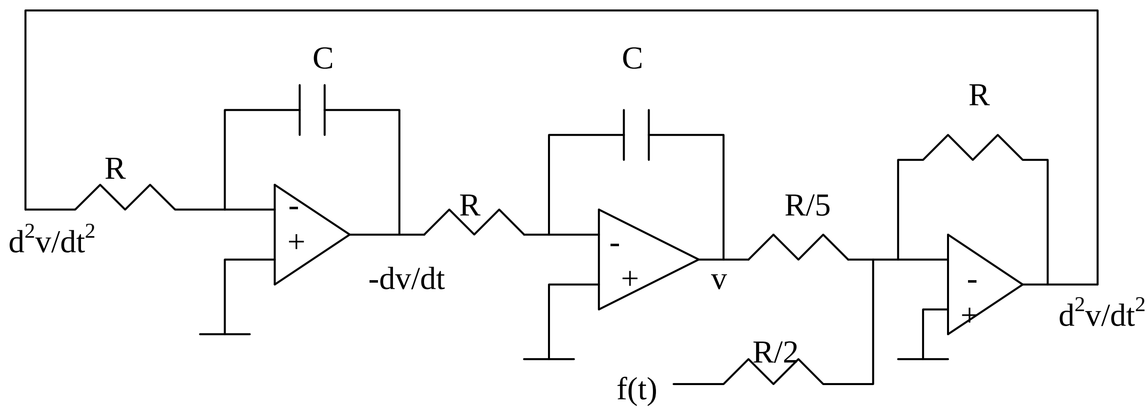
$$\boldsymbol{\frac{d^2 v_o}{dt^2} + 5\frac{dv_o}{dt} + 2v_o = f(t)}$$

Chapter 6, Solution 81

We can write the equation as

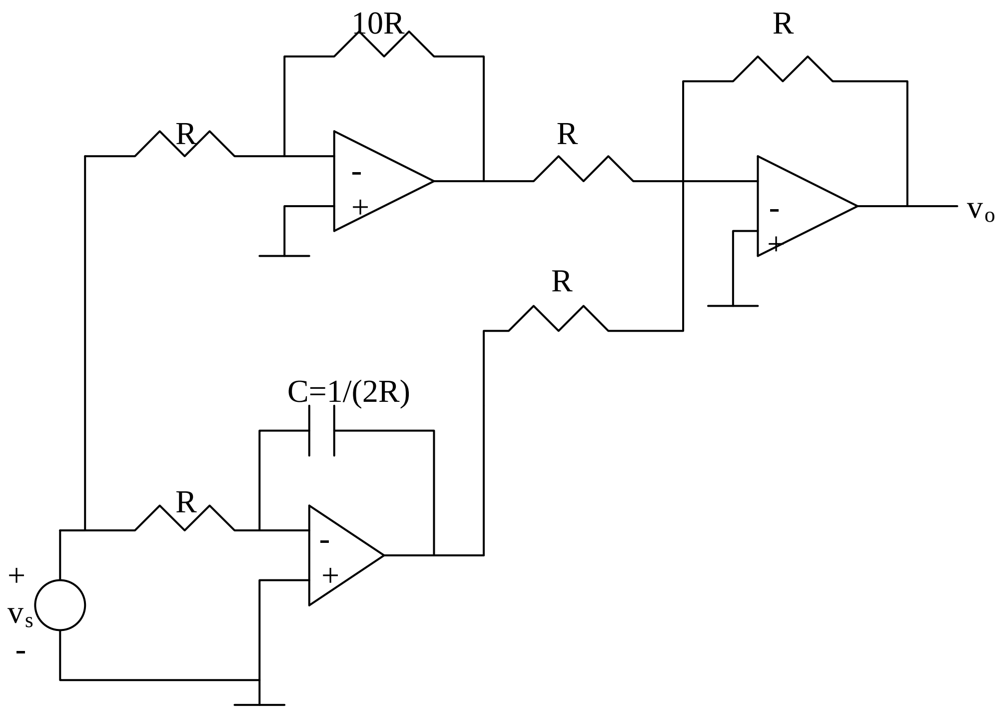
$$\frac{d^2v}{dt^2} = -5v - 2f(t)$$

which is implemented by the circuit below.



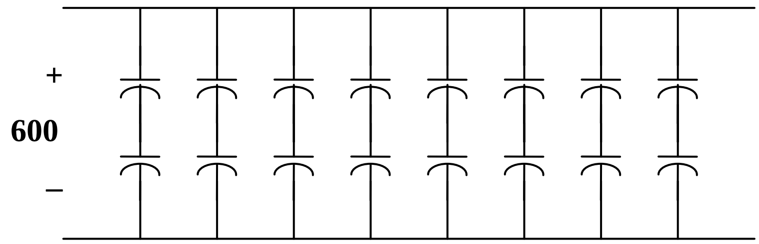
Chapter 6, Solution 82

The circuit consists of a summer, an inverter, and an integrator. Such circuit is shown below.



Chapter 6, Solution 83.

Since two 10μF capacitors in series gives 5μF, rated at 600V, it requires 8 groups in parallel with each group consisting of two capacitors in series, as shown below:



Answer: **8 groups in parallel with each group made up of 2 capacitors in series.**

Chapter 6, Solution 84.

v = L(di/dt) = $8x10^{-3}x5x2\pi\sin(\pi t)\cos(\pi t)10^{-3} = 40\pi\sin(2\pi t)$ μV

p = vi = $40\pi\sin(2\pi t)5\sin^2(\pi t)10^{-9}$ W, at t=0 p = **0W**

$$w = \frac{1}{2}Li^2 = \frac{1}{2}x8x10^{-3}x[5\sin^2(\pi/2)x10^{-3}]^2 = 4x25x10^{-9} = \underline{100\ \text{nJ}}$$

= **100 ηJ**

Chapter 6, Solution 85.

It is evident that differentiating i will give a waveform similar to v. Hence,

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

$$i = \begin{bmatrix} 4t, 0 < t < 1ms \\ 8 - 4t, 1 < t < 2ms \end{bmatrix}$$

$$v = L\left[\frac{di}{dt} = \begin{bmatrix} 4000L, 0 < t < 1ms \\ -4000L, 1 < t < 2ms \end{bmatrix}\right]$$

But, $$v = \begin{bmatrix} 5V, 0 < t < 1ms \\ -5V, 1 < t < 2ms \end{bmatrix}$$

Thus, $4000L = 5 \longrightarrow L = 1.25$ mH in a **1.25 mH inductor**

Chapter 6, Solution 86.

$$v = v_R + v_L = Ri + L\frac{di}{dt} = 12x2te^{-10t} + 200x10^{-3}x(-20te^{-10t} + 2e^{-10t}) = \underline{(0.4 - 20t)e^{-10t}\ \text{V}}$$