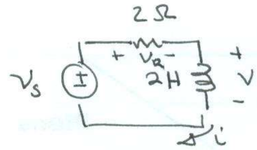
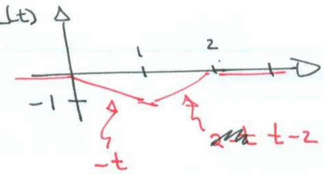
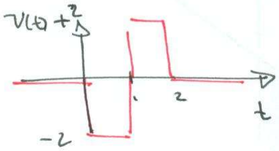
3.2



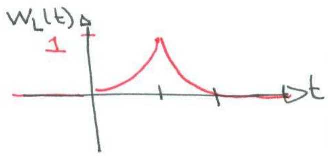


a)



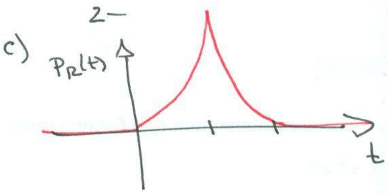
$$v(t) = L\frac{di}{dt} = 2\frac{di}{dt}$$

b)



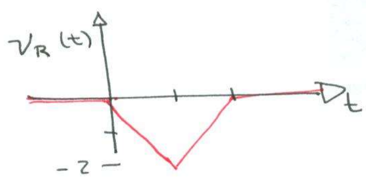
$$W_L(t) = \frac{1}{2}L\,i^2(t) = \frac{1}{2}(2H)\,i^2(t)$$

c)



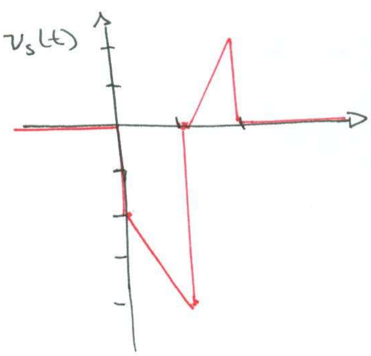
$$P_R(t) = iv = R\,i^2(t) = 2\,i^2(t)$$

d)



$$v_R(t) = iR = 2\,i(t)$$

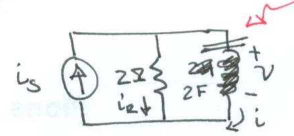
e)

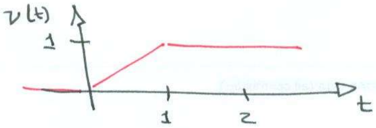


$$v_s(t) = v_R(t) + v_L(t)$$

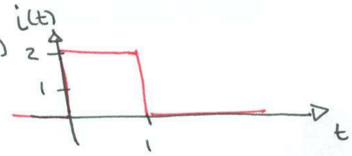
3.8

This is a capacitor!



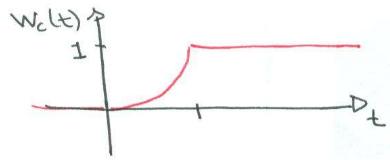


a)



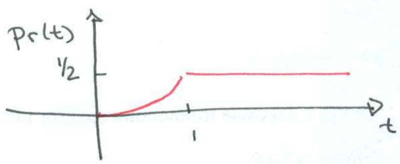
$$i(t) = C\frac{dv}{dt} = 2\frac{dv}{dt}$$

b)



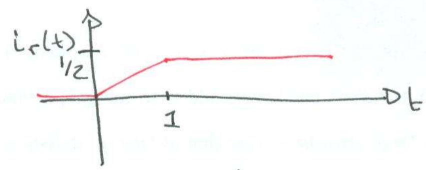
$$W_c(t) = \frac{1}{2}C v^2(t) = \frac{1}{2}(2)\,v^2$$

c)



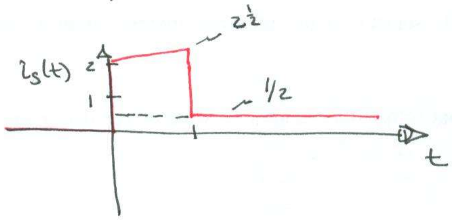
$$p_r(t) = v_R i_R = v_R^2(t)/R = v_c^2/2$$

d)



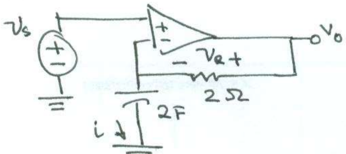
$$i_R(t) = v_R(t)/R = v_c(t)/2$$

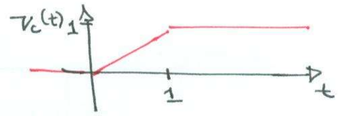
e)



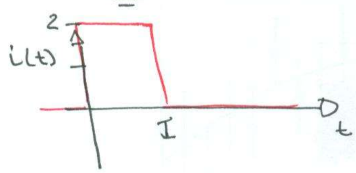
$$i_s(t) = i_R(t) + i_c(t)$$

3.13



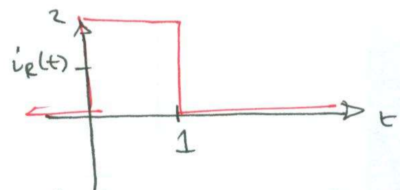


a)



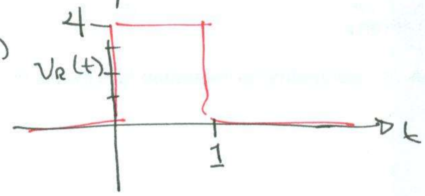
$$i(t) = C\frac{dv}{dt} = 2\frac{dV}{dt}$$

b)



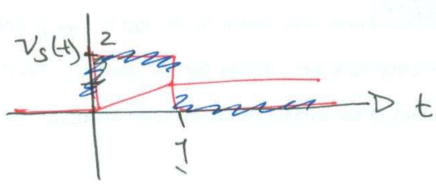
$$i_R(t) = i_c(t)$$

c)



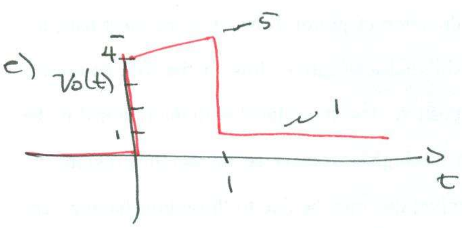
$$v_R(t) = i_R(t)R = 2 i_R$$

d)



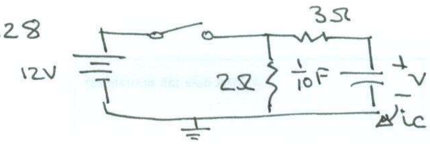
$$v_s(t) = v_c(t)$$

e)



$$v_o(t) = v_c(t) + v_r(t)$$

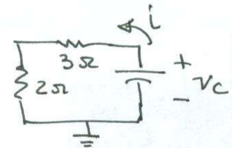
3.28



Switch opens at $t=0$

at $t<0$, $V_c = 12\text{ V}$

at $t>0$



$$v_c + 3i + 2i = 0$$

$$v_c + 5i = 0$$

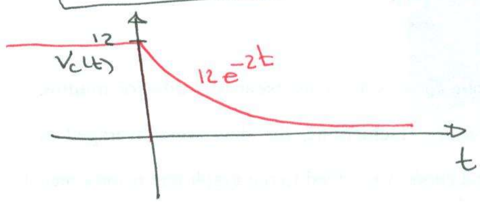
$$i_c = C\frac{dv}{dt} \Rightarrow v_c + 5\left(\frac{1}{10}\frac{dv}{dt}\right) = 0$$

$$\boxed{v_c(t) + \frac{1}{2}\frac{dv}{dt} = 0} \quad \text{or} \quad \boxed{2v_c(t) + \frac{dv}{dt} = 0}$$

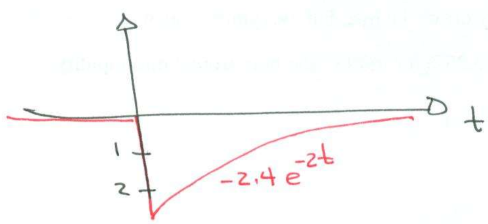
$$v_c(t) = V_0\, e^{-t/t} \qquad \tau = RC = (5\Omega)\left(\tfrac{1}{10}\text{F}\right) = \tfrac{1}{2}\text{ sec}$$

$$V_0 = 12\text{V}$$

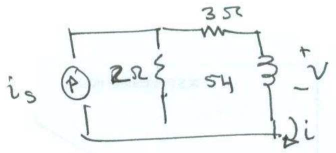
$$\boxed{v_c(t) = 12\, e^{-2t}}$$

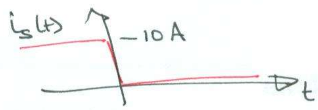


$$i_c(t) = -\frac{V_c(t)}{R} = -\frac{12}{5}\, e^{-2t} = \boxed{-2.4\, e^{-2t}}$$



3.30





after $t=0$

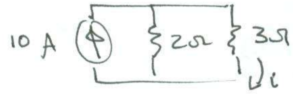
KVL : $i(2\Omega) + i(3\Omega) + L\frac{di}{dt} = 0$

$$5i + 5\frac{di}{dt} = 0$$

$$i(t) + \frac{di}{dt} = 0 \qquad \tau = \frac{L}{R} = \frac{5}{5} = 1 \text{ sec}$$

$$i(t) = I_o e^{-t/\tau}$$

at $t<0$, inductor in open circuit

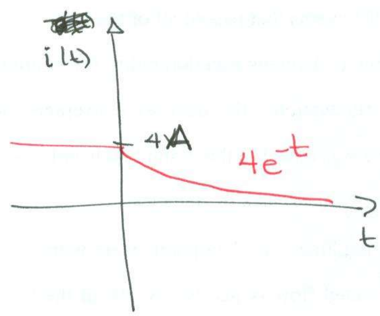


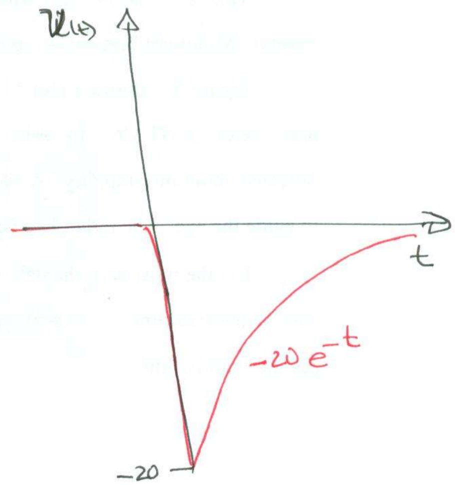
⇒ current divider $I_o = \frac{2\Omega}{2\Omega+3\Omega}\, 10\text{ A}$

$I_o = 4\text{A}$

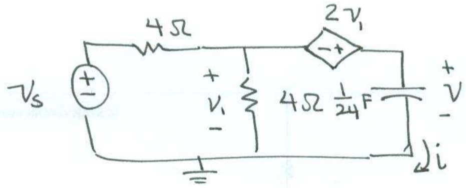
$$i(t) = (4\text{A})\, e^{-t}$$

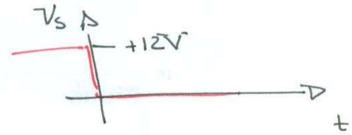
$$v(t) = L\frac{di}{dt} = 5\left((-1)(4\text{A})\, e^{-t}\right) = -20\, e^{-t}$$



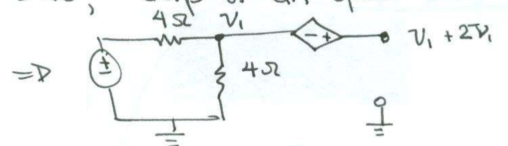


3.34





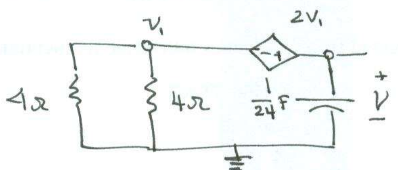
at $t<0$, cap is an open circuit (fully CHARGED)



We get v_1 FROM voltage division, $v_1 = \frac{4}{4+4} 12 = 6V$

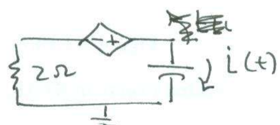
$$v(t<0) = 6V + 2(6V) = 18V$$

for $t>0$



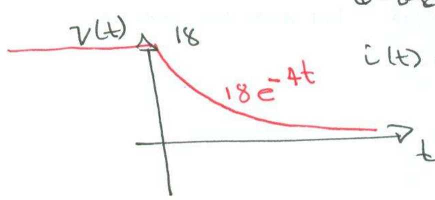
$v(t) = 3v_1(t)$

$R_{11} = \frac{(4)(4)}{4+4} = 2\,\Omega$



$$\overbrace{i(t)(2\Omega)}^{v_1(t)} + 2v_1 - v(t) = 0$$

$$6\,i(t) - v(t) = 0$$

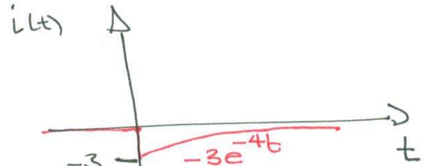


$$i(t) = -C\frac{dv}{dt}$$

$$6\left(-\frac{1}{24}\frac{dv}{dt}\right) - v(t) = 0$$

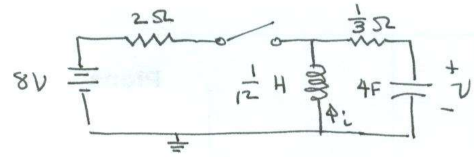
$$4v(t) + \frac{dv}{dt} = 0$$

$$v(t) = 18\,e^{-4t}$$



$$i(t) = -3e^{-4t}$$

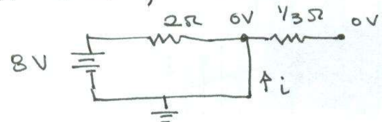
3.57



switch opens at $t=0$

find $v(t)$ and $i(t)$

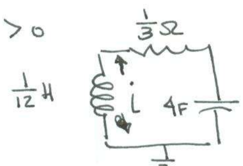
for $t<0$, Inductor is short circuit, capacitor is open circuit



$v(t<0) = 0V$

$i(t<0) = -\frac{8V}{2\Omega} = -4A$

for $t>0$



SERIES RLC

$$\alpha = \frac{R}{2L} = \frac{\frac{1}{3}\Omega}{2\,\frac{1}{12}H} = 2$$

$$\omega_n = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{1}{12}4}} = \frac{1}{\sqrt{1/3}} = \sqrt{3} \simeq 1.7$$

$\alpha > \omega_n \Rightarrow$ overdamped

$$S_1 = -\alpha - \sqrt{\alpha^2 - \omega_n^2}$$
$$= -2 - \sqrt{4-3} = -2 - \sqrt{1} = -3$$
$$S_2 = -\alpha + \sqrt{\alpha^2 - \omega_n^2} = -2 + 1 = -1$$

$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$ @ $t=0 \Rightarrow A_1 + A_2 = 0V$

$A_1 = -A_2$

$$i(t) = C\frac{dV}{dt} = 4\left(A_1 s_1 e^{s_1 t} + A_2 s_2 e^{s_2 t}\right)$$
$$= -12 A_1 e^{s_1 t} - 4 A_2 e^{s_2 t}$$

@ $t=0$ $-12A_1 - 4A_2 = -4$

$12A_1 + 4(-A_1) = 4$

$8_1 A_1 = 1 \Rightarrow A_1 = \frac{1}{2}$

$A_2 = -\frac{1}{2}$

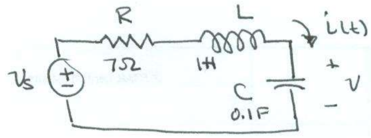
for $t>0$

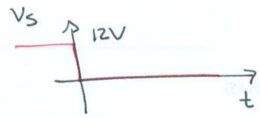
$$\boxed{v(t) = \frac{1}{2}e^{-3t} - \frac{1}{2}e^{-t}}$$

$$\boxed{i(t) = -6e^{-3t} + 2e^{-t}}$$

For those who use −8V source, all signs change.

3-63





for $t < 0$, capacitor in open circuit $\Rightarrow$ $I_0 = 0\,A$
$V_0 = 12V$

for $t > 0$:

$$\alpha = \frac{R}{2L} = \frac{7\Omega}{2H} = \frac{7}{2} = 3.5$$

$$\omega_n = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1/10}} = \sqrt{10} = 3.16$$

$\alpha > \omega_n \Rightarrow$ overdamped

$$s_1 = -\alpha - \sqrt{\alpha^2 - \omega_n^2} = -3.5 - 1.5 = -5$$

$$s_2 = -3.5 + 1.5 = -2$$

$$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$i(t) = C\frac{dv}{dt} = \frac{1}{10} s_1 A_1 e^{s_1 t} + \frac{1}{10} s_2 A_2 e^{s_2 t}$$

To determine A_1 and A_2 apply the Boundary Conditions @ $t=0$

voltage: $A_1 + A_2 = V_0 = 12\,V$

current $-\frac{5}{10} A_1 - \frac{2}{10} A_2 = 0$

$$A_1 = -\frac{2}{5} A_2$$

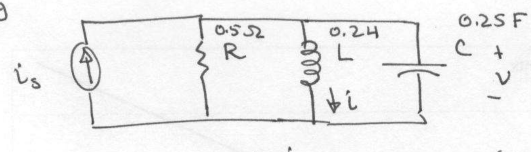
$$-\frac{2}{5} A_2 + A_2 = 12\,V \Rightarrow \frac{3}{5} A_2 = 12\,V \Rightarrow A_2 = 20$$

$$A_1 = -8$$

$$\boxed{v(t) = -8e^{-5t} + 20e^{-2t}}$$

$$\boxed{i(t) = +4e^{-5t} - 4e^{-2t}}$$

3.69



$i_s(t) = 2u(t)$

find $i(t)$, $v(t)$

at $t<0$; $i(t<0) = 0$, $v(t<0) = 0$

for $t>0$, for a parallel RLC circuit

$$\frac{d^2i}{dt^2} + \frac{1}{RC}\frac{di}{dt} + \frac{1}{LC}i = \frac{I}{LC}u(t)$$

$$\frac{d^2i}{dt^2} + 8\frac{di}{dt} + 20i = 40\,u(t)$$

$2\alpha = 8$, $\omega_n^2 = 20$

$\alpha = 4$, $\omega_0 = \sqrt{20} = 4.47$ ⇒ underdamped

$\omega_d = \sqrt{\omega_n^2 - \alpha^2} = \sqrt{20-16} = 2$ rad/sec

$$i(t) = 2 + e^{-4t}(A_1 \cos\omega_d t + A_2 \sin\omega_d t)$$

$$v(t) = L\frac{di}{dt} = \frac{1}{5}\Big[(-4e^{-4t})(A_1\cos\omega_d t + A_2\sin\omega_d t) + (e^{-4t})(-2A_1\sin\omega_d t + 2A_2\cos\omega_d t)\Big]$$

Apply conditions @ $t=0$

$i(t=0) = 0 = 2 + (A_1)$ ⇒ $A_1 = -2$

$v(t=0) = 0 = \frac{1}{5}\big[(-4)(-2) + (1)(2A_2)\big]$

$-8 = 2A_2$ ⇒ $A_2 = -4$

$$\boxed{i(t) = 2 + e^{-4t}(-2\cos 2t - 4\sin 2t)}$$

$$v(t) = \frac{1}{5}\Big[e^{-4t}\big(\underbrace{(-8+8)}_{0}\cos 2t + (16+4)\sin 2t\big)\Big]$$

$$\boxed{v(t) = 4e^{-4t}\sin 2t}$$