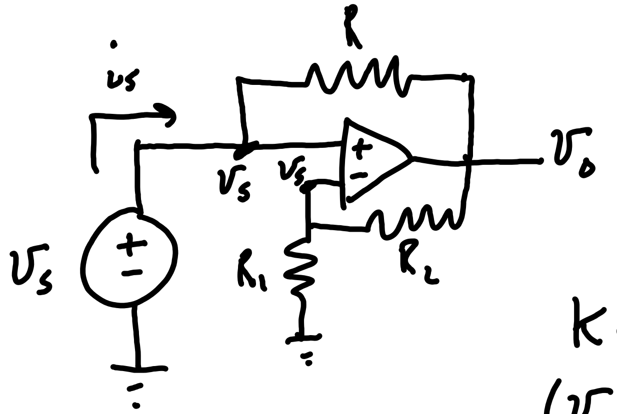
1)



v at "–" terminal is v_s because we have an op-amp with negative feedback.

KCL at "–" terminal:

$$\frac{(v_s - 0)}{R_1} = \frac{v_o - v_s}{R_2}$$

Solving this for v_o:

$$\frac{v_o}{R_2} = \frac{v_s}{R_1} + \frac{v_s}{R_2} \Longrightarrow v_o = v_s\frac{R_2}{R_1} + v_s$$

$$\boxed{v_o = v_s\left(\frac{R_2}{R_1} + 1\right)}$$

b) $\frac{v_s}{i_s} = R_{eq}$ By KCL @ "+" terminal:

$$i_s = \frac{v_s - v_o}{R}$$

substituting above for v_o

$$i_s = \frac{v_s}{R} - \frac{v_s\left(\frac{R_2}{R_1} + 1\right)}{R}$$

$$= \frac{v_s}{R}\left(1 - \frac{R_2}{R_1} - 1\right)$$

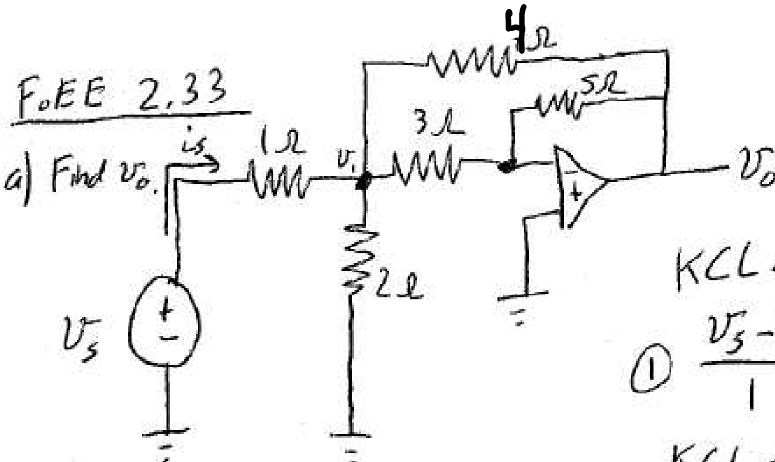
$$= v_s\left(\frac{-R_2}{R R_1}\right)$$

$$\boxed{\text{So, } \frac{v_s}{i_s} = \frac{v_s}{v_s\left(-\frac{R_2}{R R_1}\right)} = \frac{-R R_1}{R_2}}$$

2)

FoEE 2.33

a) Find v_o.



KCL at v_1 yields:

① $\dfrac{v_s - v_1}{1} = \dfrac{v_1}{2} + \dfrac{v_1}{3} + \dfrac{v_1 - v_o}{4}$

KCL at v_- yields

② $\dfrac{v_1}{3} = \dfrac{-v_o}{5} \Rightarrow v_o = -\dfrac{5}{3}v_1$

So, ① becomes $v_s - v_1 = \dfrac{v_1}{2} + \dfrac{v_1}{3} + \dfrac{v_1 - \left(-\frac{5}{3}v_1\right)}{4}$

$12v_s - 12v_1 = 6v_1 + 4v_1 + 3\left(\frac{8}{3}v_1\right) = 18v_1$

$12v_s = 30v_1 \Rightarrow v_1 = \frac{12}{30}v_s = \frac{2}{5}v_s$

Since $\boxed{v_o = -\frac{5}{3}v_1 = \frac{-5}{3}\left(\frac{2}{5}v_s\right) = \frac{-2}{3}v_s}$

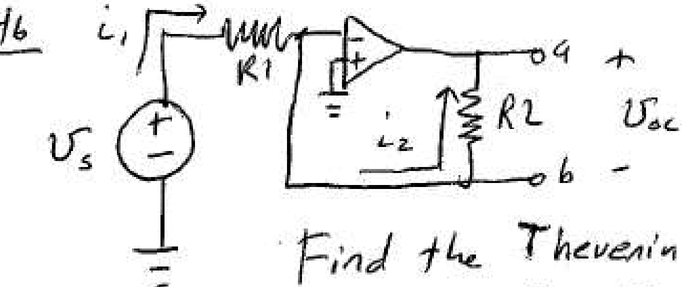
b) Find $\dfrac{v_s}{i_s}$, the resistance as seen by the source.

Since $v_1 = \frac{-3}{5}v_o$ and $v_o = -\frac{2}{3}v_s \Rightarrow v_1 = \frac{2}{5}v_s$ (also found here.)

$i_s = \dfrac{v_s - v_1}{1} = \dfrac{v_s - \frac{2}{5}v_s}{1} = \frac{3}{5}v_s$

$\boxed{\text{So, } \dfrac{v_s}{i_s} = \dfrac{v_s}{3/5\, v_s} = \dfrac{5}{3}\,\Omega}$

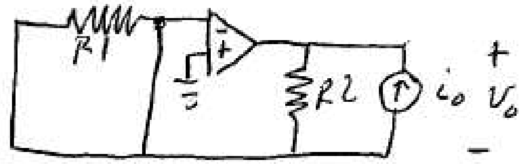
3) FoEE 2.46



Find the Thevenin Equivalent at a&b.

First, we need v_{oc}: $i_1 = i_2 = \frac{v_s}{R_1} = \frac{-v_{oc}}{R2} \Rightarrow v_{oc} = -\frac{R2}{R_1} v_s$

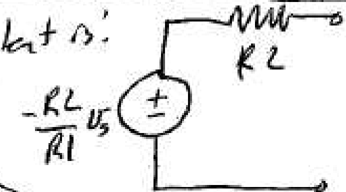
As suggested in the problem statement, we'll apply a current source at a/b and calculate the resulting voltage. When we do this, we still need to short v_s!



here, $v_o = i_o R2$

So, $R_o = \frac{v_o}{i_o} = R2$

∴ the Thevenin Equivalent is:



4) **3.5** For the circuit shown in Fig. P3.5, suppose that $i(t)$ is described by the function given in Fig. P3.1b. Sketch (a) $v_R(t)$, (b) $v_L(t)$, and (c) $v(t)$.

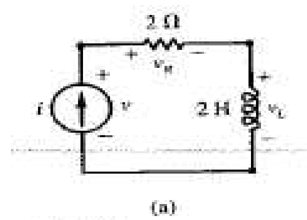
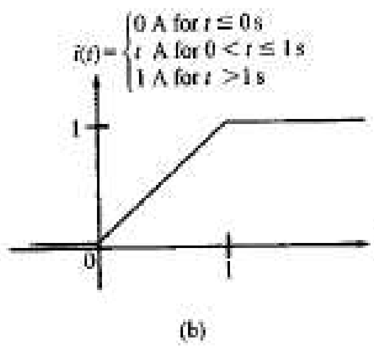
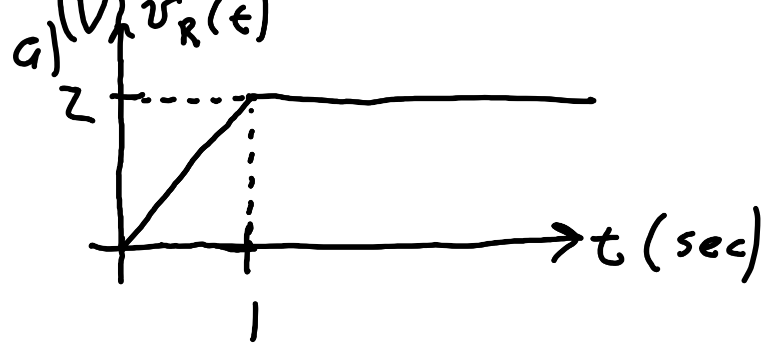


Fig. P3.5

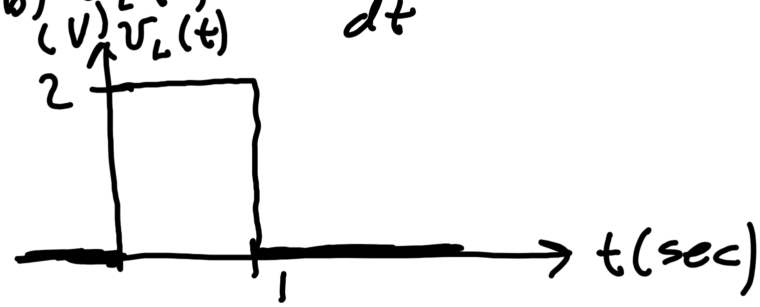


i is the same all around the loop. So, $v_R(t) = i \cdot 2\,\Omega$

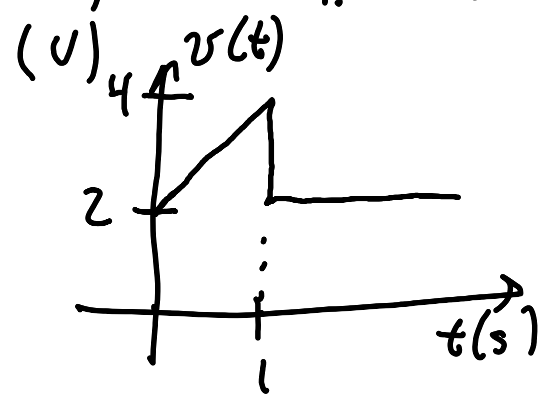
a)



b) $v_L(t) = L \frac{di(t)}{dt}$



c) $v(t) = v_R(t) + v_L(t)$



5)

3.9 For the op-amp circuit shown in Fig. P3.9, suppose that $v(t)$ is described by the function given in Fig. P3.7*b*. Sketch (a) $i(t)$, (b) $i_R(t)$, (c) $v_R(t)$, (d) $v_s(t)$, and (e) $v_o(t)$.

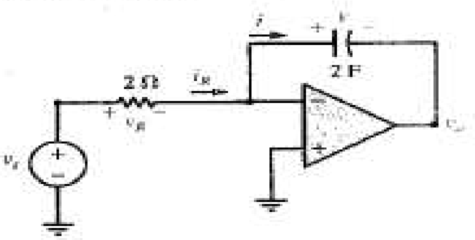
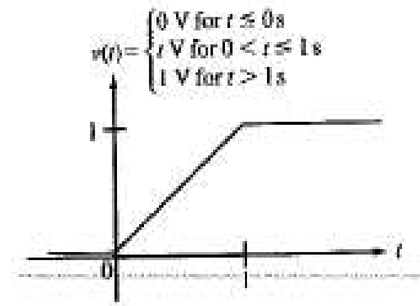
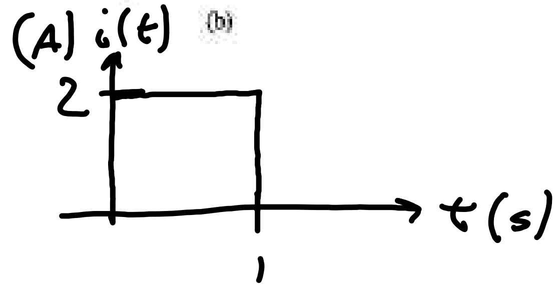


Fig. P3.9



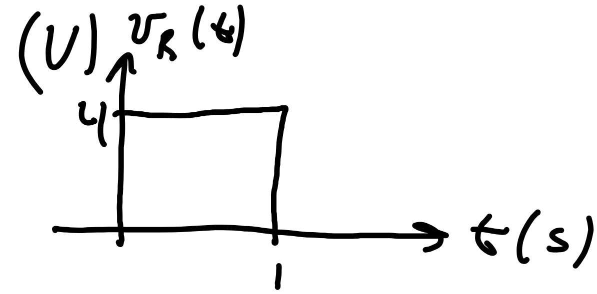
(b)

a) $i(t) = C\dfrac{dv}{dt} = 2 \cdot \dfrac{dv}{dt}$



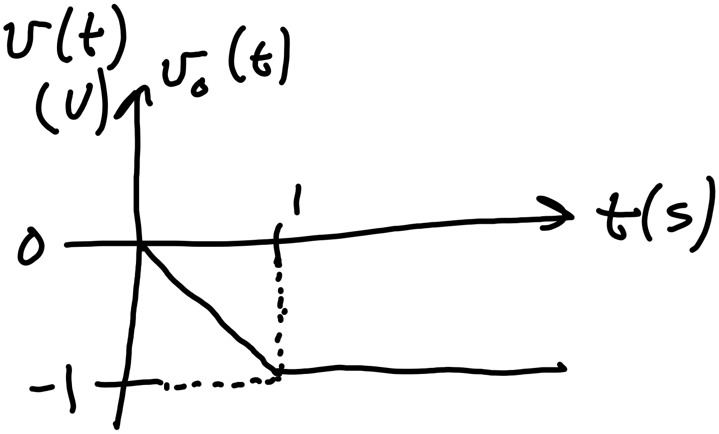
b) $i_R(t) = i(t) \longrightarrow$ plot same as (a)

c) $v_R(t) = i_R(t) \cdot 2$



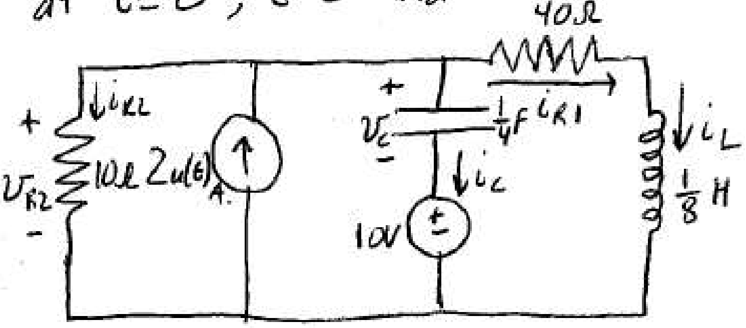
d) $v_s(t) = v_R(t) \longrightarrow$ plot same as (c)

e) $v_o(t) = -v_c(t) = -v(t)$

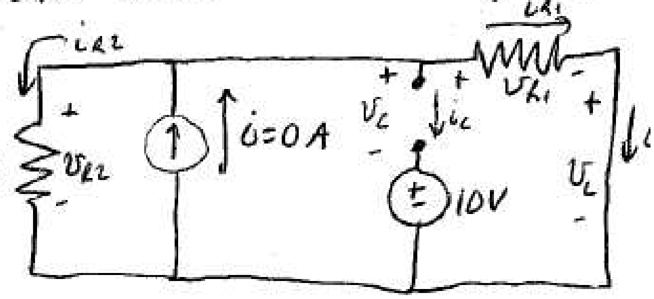


6)

We are asked to analyze the following circuit at $t=0^-$, $t=0^+$ and $t=\infty$.



At $t=0^-$ we have a DC circuit with no current going up through the current source:



In the DC case, the capacitor is an open circuit and the inductor is a short circuit.

Since no current can flow through an open circuit $\boxed{i_C(0^-)=0A}$

With no current from the current source and no current allowed to flow from the 10V source, all currents are 0 A before $t=0$. So $\boxed{i_{R2}(0^-)=0A}$, $\boxed{i_{R1}(0^-)=0A}$ and $\boxed{i_L(0^-)=0A}$. Ohm's law tells us that $\boxed{v_{R1}(0^-)=0V}$ and $\boxed{v_{R2}(0^-)=0V}$ Since no voltage can drop across a short circuit, $\boxed{v_L(0^-)=0V}$. Finally KVL around the right-most loop gives us: $10+v_C=v_{R1}+v_L$

So, $\boxed{v_C(0^-)=-10V}$

At $t=0^+$, our elements are back in our circuit, the current source is out putting 2 A and we know that the current across the inductor and the voltage across the capacitor can't change.

So, $\boxed{v_C(0^+)=-10V}$, $\boxed{i_L(0^+)=0\ A}$

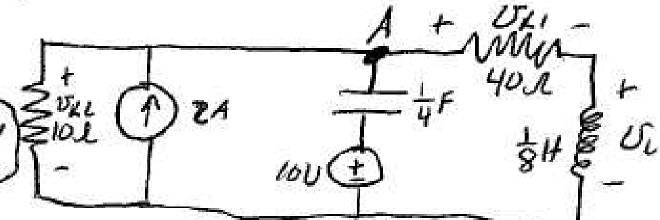
Since $i_{R1}(0^+)=i_L(0^+)$; $\boxed{i_{R1}(0^+)=0A}$ By Ohm's law $\boxed{v_{R1}(0^+)=0V}$

By KVL (same as before)

$$10 + v_C = v_{R1} + v_L.$$

So, $10 + {-10} = 0 + v_L$ $\therefore$ $\boxed{v_L(0^+) = 0V}$

At $t=0^+$ we have this circuit:



$v_{R2}(0^+) = v_{R1}(0^+) + v_L(0^+)$ ⟵ KVL around outside loop.

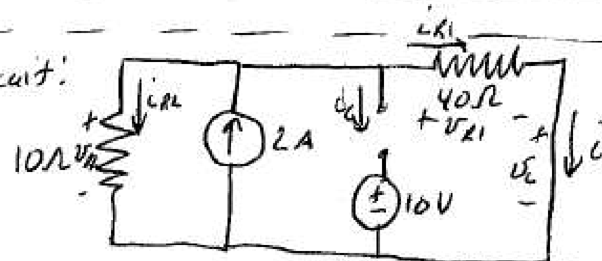
So, $\boxed{v_{R2}(0^+) = 0V}$, so, by Ohm's law, $\boxed{i_{R2}(0^+) = 0A}$

That leaves 2 Amps of current (from the current source) that has to flow somewhere ⟶ KCL at node A we see that:

$$i_{R2} - 2 + i_C + i_{R1} = 0$$

at $t=0^+$ this is: $0 - 2 + i_C + 0 = 0$ so, $\boxed{i_C(0^+) = 2A}$

At $t=\infty$ we have the following circuit:



We can use DC replacements because the circuit has stabilized.

Again, no current can flow through an open circuit, so $\boxed{i_C(\infty) = 0A}$

Since there can be no voltage drop over a short: $\boxed{v_L(\infty) = 0V}$

Using KCL: $2 = i_{R2} + i_{R1}$ ①

Using KVL: $v_{R2} = v_{R1} + v_L$, adding Ohm's Law: $10 i_{R2} = 40 i_{R1}$ ②

Combining ① & ② we see that $10(2 - i_{R1}) = 40 i_{R1}$

So, $20 = 50 i_{R1} \Rightarrow$ $\boxed{i_{R1}(\infty) = 0.4A}$

$\boxed{\therefore i_{R2}(\infty) = 1.6A}$ From Ohm's Law: $\boxed{v_{R1}(\infty) = 16V}$

and $\boxed{v_{R2}(\infty) = 16V}$

Since, $i_L(\infty) = i_{R1}(\infty)$, $\boxed{i_L(\infty) = 0.4A}$

Finally, by KVL: $10 + v_C(\infty) = v_{R1}(\infty) + v_L(\infty)$

$10 + v_C(\infty) = 16$ $\therefore$ $\boxed{v_C(\infty) = 6V}$

The chart for #1 is shown below:

	$t=0^-$	$t=0^+$	$t=\infty$
$i_L(t)$	0 A	0 A	0.4 A
$i_C(t)$	0 A	2 A	0 A
$i_{R1}(t)$	0 A	0 A	0.4 A
$i_{R2}(t)$	0 A	0 A	1.6 A
$v_L(t)$	0 V	0 V	0 V
$v_C(t)$	-10 V	-10 V	6 V
$v_{R1}(t)$	0 V	0 V	16 V
$v_{R2}(t)$	0 V	0 V	16 V

7. (0 points) FoEE 2.28 **2.28** For the op-amp circuit shown in Fig. P2.28, find (a) v_o, and (b) i_o.

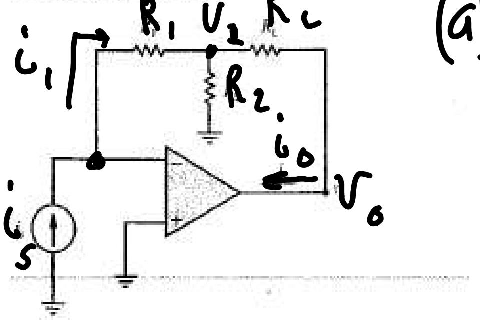


Fig. P2.28

(a) KCL at v_-: $i_s = \dfrac{0 - v_2}{R_1} \Rightarrow v_2 = -i_s R_1$

KCL at v_2: $\dfrac{0 - v_2}{R_1} = \dfrac{v_2}{R_2} + \dfrac{v_2 - v_o}{R_L}$

$$\frac{--i_s R_1}{R_1} = \frac{-i_s R_1}{R_2} + \frac{-i_s R_1 - v_o}{R_L}$$

$$i_s\left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_L}\right)R_L = -v_o$$

So, $v_o = -i_s R_L\left(1 + \dfrac{R_1}{R_2} + \dfrac{R_1}{R_L}\right)$

(b) $i_o = \dfrac{v_2 - v_o}{R_L}$

$$= \frac{-i_s R_1 + i_s R_L\left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_L}\right)}{R_L}$$

$$= i_s\left[-\frac{R_1}{R_L} + 1 + \frac{R_1}{R_2} + \frac{R_1}{R_L}\right]$$

$$i_o = i_s\left[\frac{R_1}{R_2} + 1\right]$$

8. (0 points) FoEE 2.45

2.45 Find the Thévenin equivalent of the op-amp circuit shown in Fig. P2.45. (*Hint:* To find R_o, apply a current source i_o and calculate the resulting voltage v_o.)

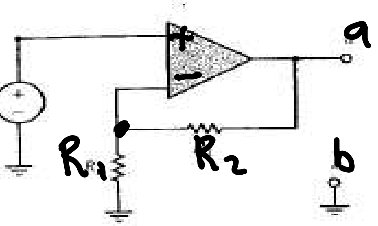


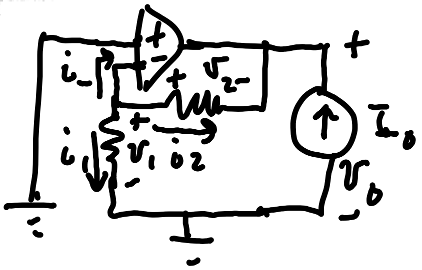
Fig. P2.45

KCL at v_-: $\frac{v_s}{R_1} = \frac{v_o - v_s}{R_2}$

So, $v_{oc} = v_s\left(\frac{1}{R_1} + \frac{1}{R_2}\right)R_2$

$$v_{oc} = v_s\left(1 + \frac{R_2}{R_1}\right)$$

To find Req:



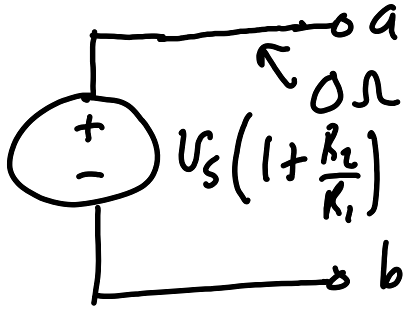
$v_- = 0$ V so, $i_1 = 0$.

Since $i_- = 0$ $i_2 = 0$.

$\therefore v_2 = 0$

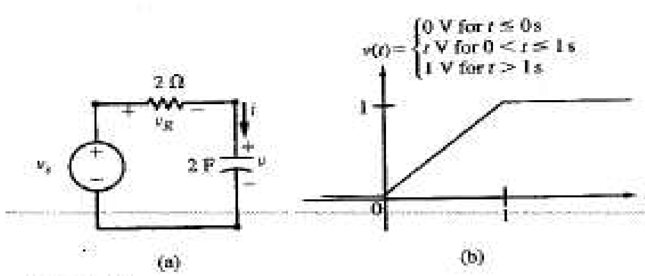
$\therefore v_o = 0$ $\therefore$ Req = 0.

Thevenin Eq.:

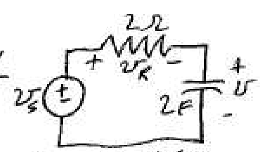


9. (0 points) FoEE 3.7

3.7 For the circuit shown in Fig. P3.7*a*, suppose that $v(t)$ is described by the function given in Fig. P3.7*b*. Sketch (a) $i(t)$, (b) $w_C(t)$, (c) $p_R(t)$, (d) $v_R(t)$, and (e) $v_s(t)$.



5) FoEE 3.7



$$v(t) = \begin{cases} 0\,V & \text{for } t \le 0 \\ t\,V & 0 < t \le 1 \\ 1\,V & t > 1 \end{cases}$$

a) $i(t) = 2\frac{dv}{dt} = \begin{cases} 0 & t \le 0 \\ 2 & 0 < t \le 1 \\ 0 & t > 1 \end{cases}$

b) $w_c(t) = \frac{1}{2} 2 v^2(t) = \begin{cases} 0 & t \le 0 \\ t^2 & 0 < t \le 1 \\ 1 & t > 1 \end{cases}$

c) $p_R(t) = Ri^2(t) = 2i^2(t) = \begin{cases} 0 & t \le 0 \\ 8 & 0 < t \le 1 \\ 0 & t > 1 \end{cases}$

d) $v_R(t) = Ri(t) = 2i(t) = \begin{cases} 0 & t \le 0 \\ 4 & 0 < t \le 1 \\ 0 & t > 1 \end{cases}$

e) $v_s(t) = v_R(t) + v(t) = \begin{cases} 0 & t \le 0 \\ 4 + t & 0 < t \le 1 \\ 1 & t > 1 \end{cases}$