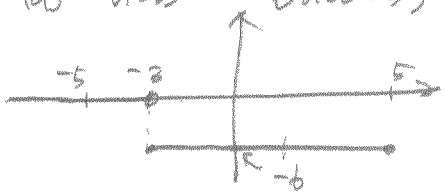
1 U&M 5.1 (a), (c), (e)

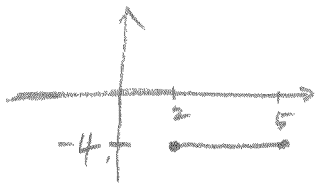
(a) $v(t) = -6u(t+3)$



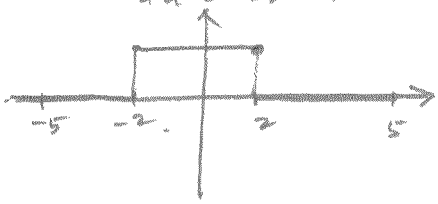
(c) $v_3(t) = 4u(t+2) - 4u(t-2)$

① $4u(t+2)$

② $-4u(t-2)$

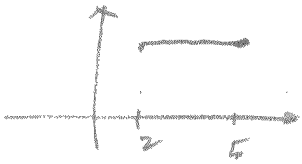


① + ② → $4u(t+2) - 4u(t-2)$

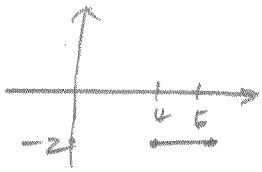


(e) $v_5(t) = 8u(t-2) - 2u(t-4)$.

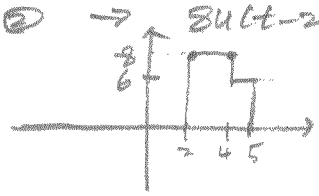
① $8u(t-2)$



② $-2u(t-4)$



① + ② → $8u(t-2) - 2u(t-4)$



2. USM 5.8 c, d $\qquad C = 0.2\,mF$

(c) $V_3(t) = 15\,u(-t) + 15e^{-0.5t}u(t)$ V.

$$i_3(t) = C\frac{dV_3(t)}{dt} = 0.2\times10^{-3}\times\left[0\times u(-t) + 15\times(-0.5)e^{-0.5}u(t)\right]$$

$$= 0.2\times10^{-3}\times(-7.5)\times e^{-0.5}u(t)$$
$$= -1.5\times e^{-0.5t}u(t)\times10^{-3}$$
$$= -1.5e^{-0.5t}u(t)\ mA.$$

$$p(t) = V_3(t)\,i_3(t)$$
$$= \left[15u(-t) + 15e^{-0.5t}u(t)\right]\cdot\left[-1.5e^{-0.5t}u(t)\times10^{-3}\right]$$
$$= 15\times(-1.5)\times e^{-0.5t}\times e^{-0.5t}u(t)\times10^{-3}$$
$$= -22.5e^{-t}\times10^{-3}\,u(t)$$
$$= -22.5e^{-t}u(t)\ mW$$

(f) $u(t)\times u(-t) = 0$
$u(t)\times u(t) = u(t)$.
$u(-t)\times u(-t) = u(-t)$.

$$w(t) = \frac{1}{2}CV_3^2(t) = \frac{1}{2}\times(0.2\times10^{-3})\times\left(15u(-t) + 15e^{-0.5t}u(t)\right)^2$$

$$= 0.1\times10^{-3}\times\left(225u(-t) + 225e^{-t}u(t)\right)$$
$$= \left[22.5u(-t) + 22.5e^{-t}u(t)\right]\times10^{-3}$$
$$= \left(22.5u(-t) + 22.5e^{-t}u(t)\right)\ mJ.$$

(d) $$i_4(t) = C\frac{dV_4(t)}{dt} = (0.2\times10^{-3})\times\left(-15\times(-0.5)\times e^{-0.5t}\right)u(t)$$

$$= 1.5e^{-0.5t}\times10^{-3}\times u(t)$$
$$= 1.5e^{-0.5t}u(t)\ (mA)$$

$$p(t) = V_4(t)\,i_4(t) = 15\left[1-e^{-0.5t}\right]u(t)\cdot\left[1.5e^{-0.5t}\times10^{-3}\times u(t)\right]$$
$$= \left(22.5e^{-0.5t} - 22.5e^{-t}\right)\times u(t)\times10^{-3}$$
$$= 22.5e^{-0.5t}\left[1-e^{-0.5t}\right]u(t)\ (mW)$$

$$w(t) = \frac{1}{2}CV_4^2(t) = \frac{1}{2}\times(0.2\times10^{-3})\times\left\{15\left[1-e^{-0.5t}\right]u(t)\right\}^2$$
$$= 0.1\times10^{-3}\times225\times\left(1-2e^{-0.5t}+e^{-t}\right)\times u(t)$$
$$= 22.5\times\left(1-2e^{-0.5t}+e^{-t}\right)u(t)\times10^{-3}$$
$$= 22.5\times\left(1-2e^{-0.5t}+e^{-t}\right)u(t)\ (mJ)$$

3. U&M 5.13

(a) $v(t) = (60 - 40e^{-5t})\ V$

$\downarrow$

$t \to 0 \Rightarrow v(0) = 60 - 40 = 20 \rightarrow$ same with initial voltage

$\Rightarrow$ There is no instantaneous change in $v(t)$

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

Let's check $\frac{dv(t)}{dt} = \frac{d}{dt}(60 - 40e^{-5t}) = 0 - 40 \times (-5)e^{-5t}$

$= 200e^{-5t}$

$i(t) = C \times 200e^{-5t} = 0.2 \times 10^{-3} \times 200\, e^{-5t} = 0.04\, e^{-5t}$

Before the switch is open, $i(0) = 0$

$i(t)$ as $t \to 0 \Rightarrow i(0+) = 0.04\, e^{-5 \times 0} = 0.04\, e^{0} = \underline{0.04\ A}$

So, switch action results current $0A \rightarrow 0.04A$.

(c) $w(0) = \frac{1}{2}Cv^2(0) = \frac{1}{2} \times 0.2 \times 10^{-3} \times (20)^2 = \frac{1}{2} \times 0.2 \times 10^{-3} \times 400$

$= 40 \times 10^{-3}\ (J) = 40\ (mJ)$.

(d) $v(\infty) = 60 - 40e^{-5 \times \infty} = 60 - 40 \times 0 = 60V$.

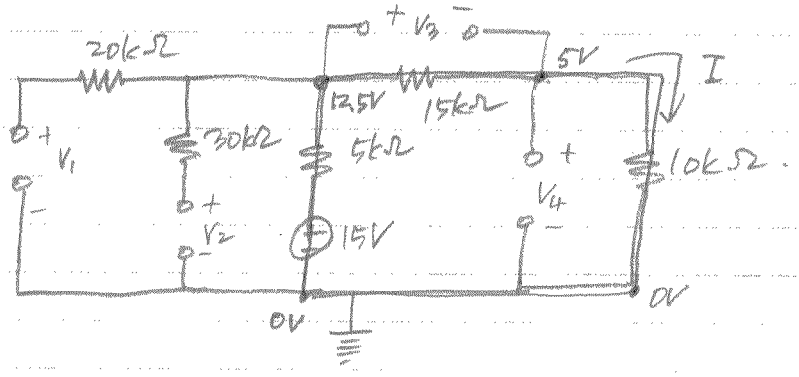
$w(\infty) = \frac{1}{2}Cv(\infty)^2 = \frac{1}{2} \times 0.2 \times 10^{-3} \times (60)^2$

$= 0.1 \times 10^{-3} \times 3600 = 360 \times 10^{-3} = 360\ (mJ)$.

4. U&M 5.14

DC condition → capacitor = open circuit

⇒



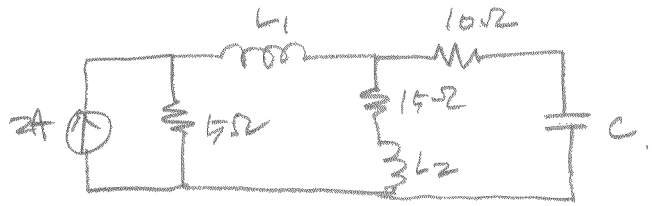
Red part is the part that current flows.

$I = 15V / 30k\Omega = 0.5mA$ → We can calculate voltage drop across the resistances.

So,

$$\boxed{\begin{aligned} V_1 &= 12.5V \\ V_2 &= 12.5V \\ V_3 &= 12.5 - 5 = 7.5V \\ V_4 &= 5V. \end{aligned}}$$

5. UBM 5.28.

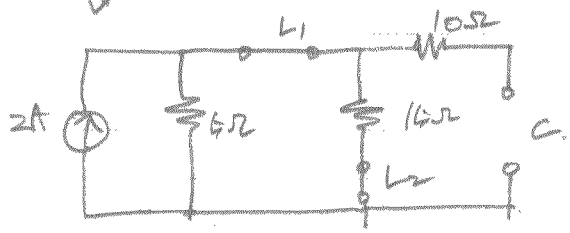


DC condition

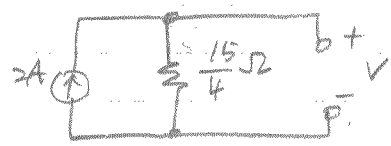
C → open circuit

L → short circuit

→ $V_{L1} = V_{L2} = 0$



→



then $V = 2A \times \frac{15}{4}\Omega = \frac{15}{2} = 7.5V$

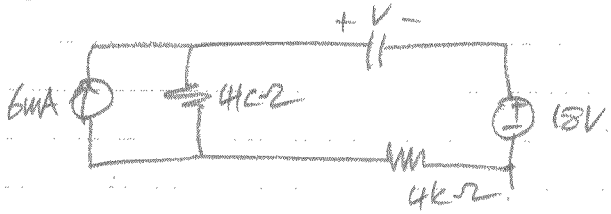
So, $V_{L1} = V_{L2} = 0$

$V_o = 7.5V$

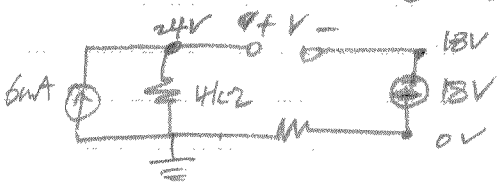
$V_{L1} = V_{L2} = 0$ because Inductor is short circuit in DC condition

6. 4th-M 5.39

① $t < 0$. → switch at position n

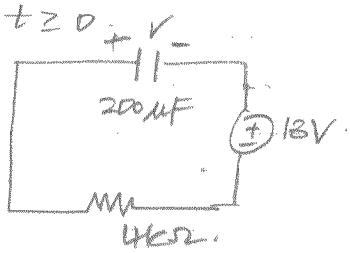


DC condition ⇒ C = open circuit



$V = 24 - 18 = 6V.$

② $t \geq 0$



$V(0) = 6V.$

(KVL)

$Ri + V + 18 = 0$

$RC\frac{dv}{dt} + v + 18 = 0.$

$\frac{dv}{dt} + \frac{1}{RC}v = \frac{-18}{RC}.$

$\Rightarrow V(t) = V(\infty) + [V(0) - V(\infty)]e^{-t/RC}.$

$\Rightarrow V(\infty) = 18V$

$V(0) = 6V$

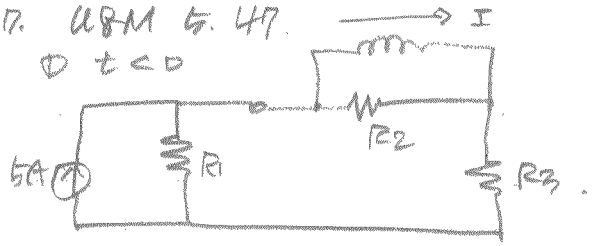
$RC = 4\times10^{3} \times 200\times10^{-6} = 800\times10^{-3} = 0.8 = \frac{4}{5}$

$\Rightarrow V(t) = 18 + [6 - 18]e^{-\frac{5}{4}t}$

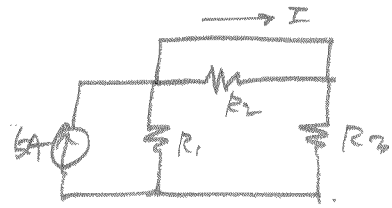
$= 18 - 12e^{-\frac{5}{4}t}.$

7. 4&M 5.47

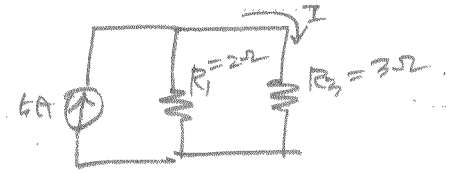
① $t < 0$



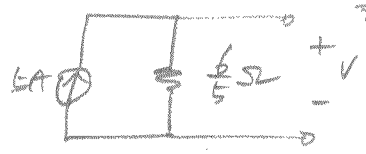
DC condition $\Rightarrow$



$\Rightarrow$



$\Rightarrow$



$\frac{1}{2} + \frac{1}{3} = \frac{5}{6}$

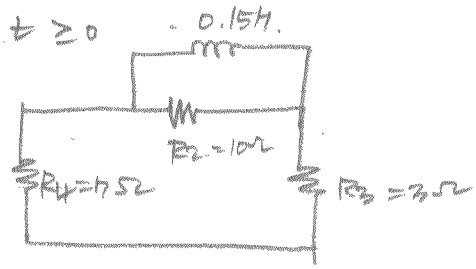
Votage difference = 6V $\Rightarrow$ current goes through R_3

$$\Rightarrow \frac{\text{Voltage difference}}{R_3} = \frac{6}{3} = 2A$$

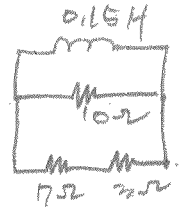
$\Rightarrow$ Current goes through $L = 2A$

$\Rightarrow L(0) = 2A$

② $t \geq 0$



$\rightarrow$



$\rightarrow$

natural responce

$$Ri + L\frac{di}{dt} = 0 \rightarrow \frac{di}{dt} + \frac{R}{L} i = 0 \rightarrow i(t) = i(0)e^{-\frac{R}{L}t}$$

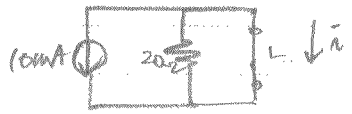
$i(0) = 2A$ $\quad \frac{R}{L} = \frac{5\Omega}{0.15} = \frac{1}{0.03} = \frac{100}{3}$

$$\Rightarrow \boxed{i(t) = 2e^{-\frac{100}{3}t}}$$

8. K&M 5.53.

① $t < 0$

DC condition

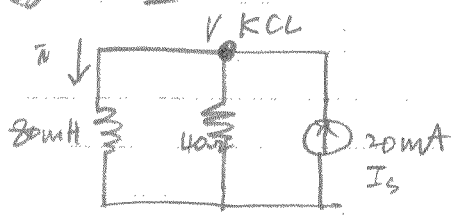


DC condition → L 看 short circuit.

$i(0) = -10\,mA$

(check the direction of current!)

② $t \geq 0$



$$I_s = \frac{V}{R} + i(t)$$

$$= L\frac{di}{dt} \times \frac{1}{R} + i$$

$$\Rightarrow \frac{di}{dt} + \frac{R}{L} i = \frac{R}{L} I_s$$

$$i(t) = i(\infty) + [i(0) - i(\infty)]\, e^{-t/\tau} \qquad \tau = \frac{L}{R}$$

$$i(\infty) = 20mA, \quad i(0) = -10\,mA, \quad \tau = \frac{L}{R} = \frac{80 \times 10^{-3}}{40} = 2 \times 10^{-3}$$

$$\frac{1}{\tau} = 500$$

$$i(t) = 20 \times 10^{-3} + [-10 \times 10^{-3} - 20 \times 10^{-3}]\, e^{-500t}$$

$$= (20 - 30e^{-500t}) \times 10^{-3}$$

$$= [20 - 30e^{-500t}]\ (mA)$$