Eastern Mediterranean University
"For Your International Career"

Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EENG223 – Circuit Theory I

Final Exam
Spring 2014-15

02 July 2015
Duration: 120 minutes

Instructor: M. K. Uyguroğlu

STUDENT'S	
NUMBER	
NAME	SOLUTIONS
SURNAME	
GROUP NO.	

Problem		**Points**
1		20
2		20
3		20
4		20
5		20
TOTAL		100

Problem 1

The mesh equations for the circuit shown in Fig.P1 are

$$\begin{bmatrix} 8 & -2 & -5 \\ -2 & 5 & -3 \\ -5 & -3 & 18 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 3 \\ 3 \\ 0 \end{bmatrix}$$

Given $V_3 = 5\,\mathrm{V}$, find R_1, R_2, R_3, R_4, R_5, and V_1, V_2.

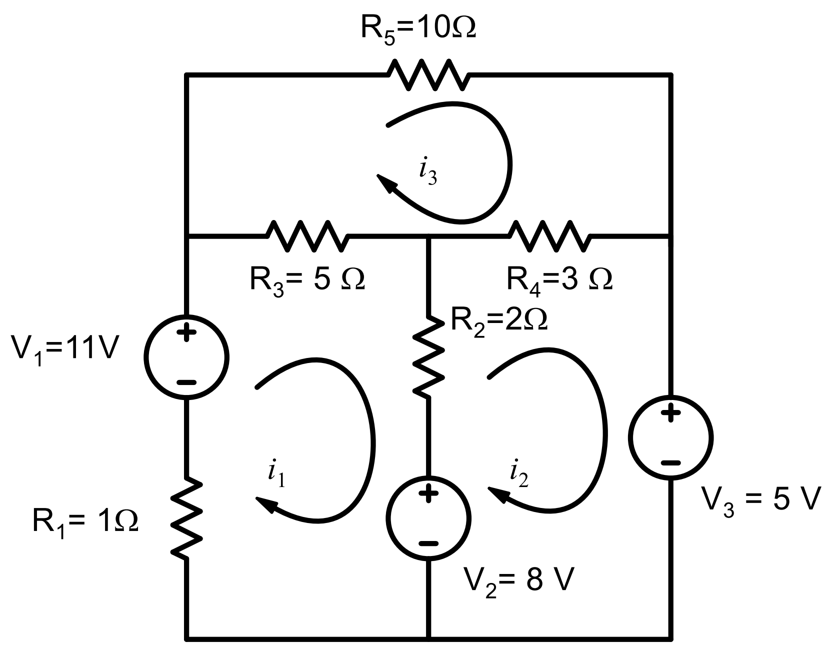


Figure P1

Problem 2

Using nodal anlaysis find i_x in the circuit shown in Fig.P2.

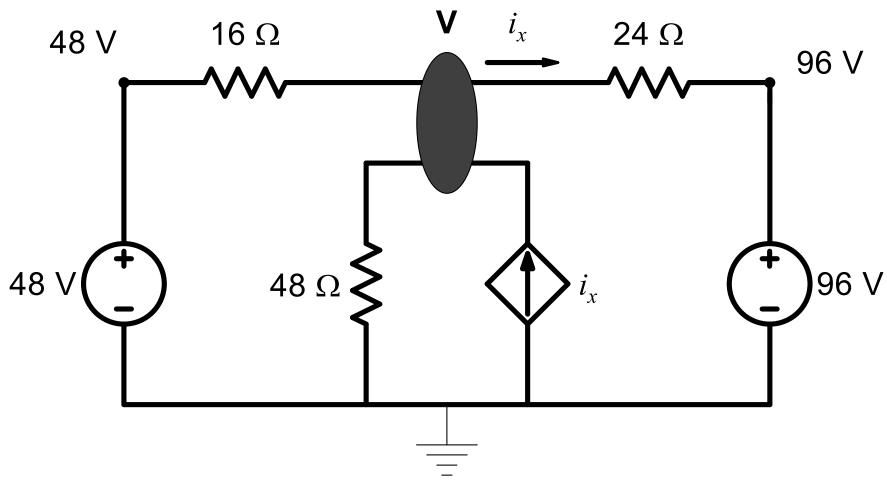


Figure P2

KCL at V:

$$\frac{V-48}{16}+\frac{V-96}{24}+\frac{V}{48}=i_x=\frac{V-96}{24}$$

$$\left(\frac{1}{16}+\frac{1}{48}\right)V=\frac{48}{16}=3$$

Multiply both sides of the equation by 48 yields:

$$4V=3(48)\Rightarrow V=36\text{ V}$$

Therefore

$$i_x=\frac{36-96}{24}=-\frac{60}{24}=-2.5\text{ A}$$

Problem 3

Determine the current i_0 for the circuit shown in Fig.P3.

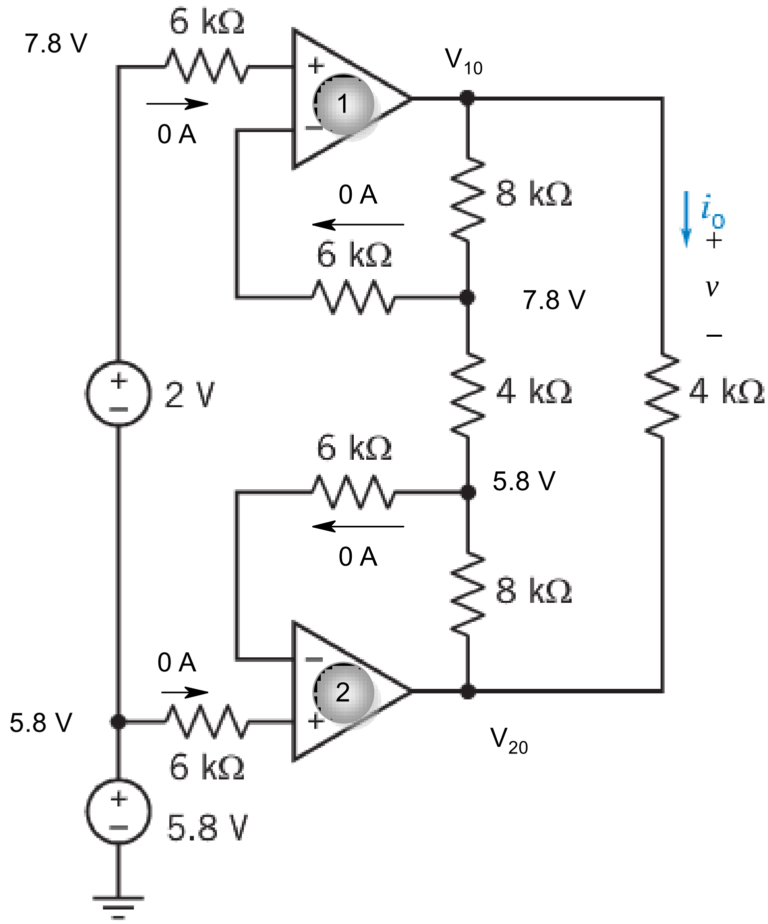


Figure P3

KCL at inverting terminal of OP AMP (1)

$$\frac{7.8-5.8}{4k}+\frac{7.8-V_{10}}{8k}=0$$

Multiply both sides by $8k$.

$$4+7.8=V_{10} \Rightarrow V_{10}=11.8 \text{ V}$$

KCL at inverting terminal of OP AMP (2)

$$\frac{5.8-7.8}{4k}+\frac{5.8-V_{20}}{8k}=0$$

Multiply both sides by $8k$.

$$-4+5.8=V_{20} \Rightarrow V_{20}=1.8 \text{ V}$$

$$i_0=\frac{11.8-1.8}{4k}=2.5mA$$

Problem 4
The circuit shown in Fig. P4 is under dc conditions before the switch closes at time t = 0. Determine v(t) for t > 0.

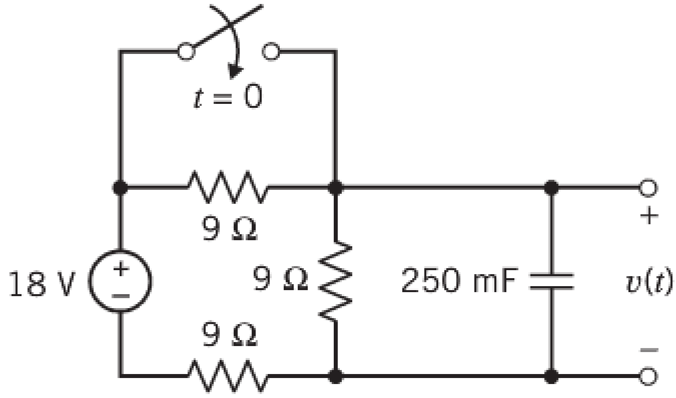
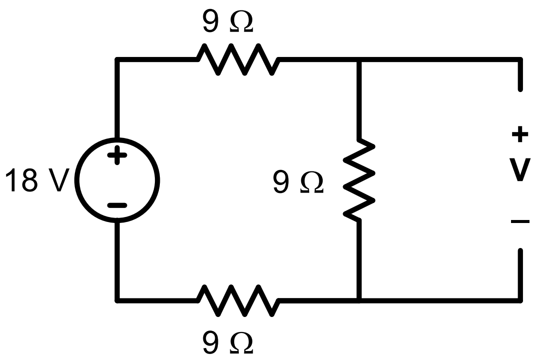


Figure P4

$at\, t = 0^-$
(since the circuit is under dc conditions, capacitor acts like open circuit)



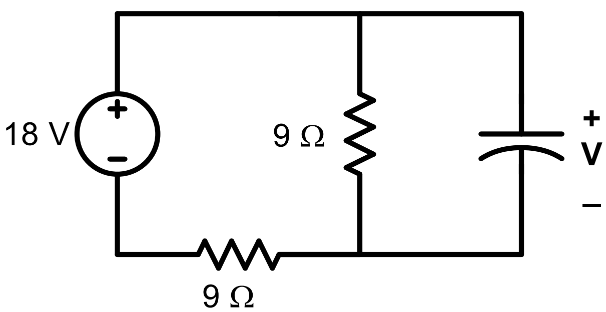
Using voltage division principle

$$V(0-) = 18\frac{9}{27} = 6 \text{ V}$$

Since the capacitor voltage cannot change instantaneously,

$$V(0^-) = V(0^+) = 6 \text{ V}$$

For $t > 0$



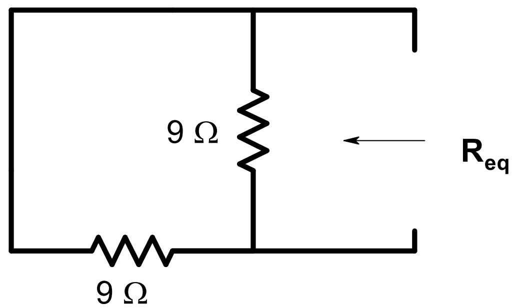
Since the circuit contains a dc source:

$V(t) = V(\infty) + \left[V(0) - V(\infty)\right]e^{-\frac{t}{\tau}}$

Where

$\tau = R_{eq}C$

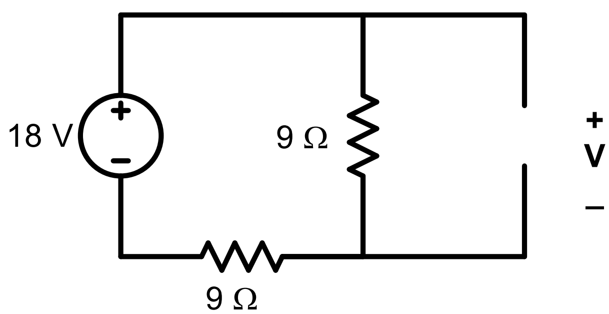
R_{eq} is the equivalent resistance seen by the capacitor by setting the independent source values to zero.



$R_{eq} = 9//9 = 4.5\Omega$

$\tau = 4.5 \times 250 \times 10^{-3} = \frac{4.5}{4} = 1.125\,\text{sec}.$

At $t = \infty$, the circuit will ve under dc conditions again.



Using voltage division principle

$V(\infty) = 18\frac{9}{18} = 9\text{ V}$

Therefore

$V(t) = 9 + \left[6 - 9\right]e^{-0.89t}$

$V(t) = 9 - 3e^{-0.89t}\,V$

Problem 5

Suppose that the switch in Fig. P5 has been closed for a long time and is opened at $t = 0$. Find:

(a) $i(0+)$ and $v(0+)$

(b) $\dfrac{di(0+)}{dt}$

(c) $i(t)$ for $t > 0$

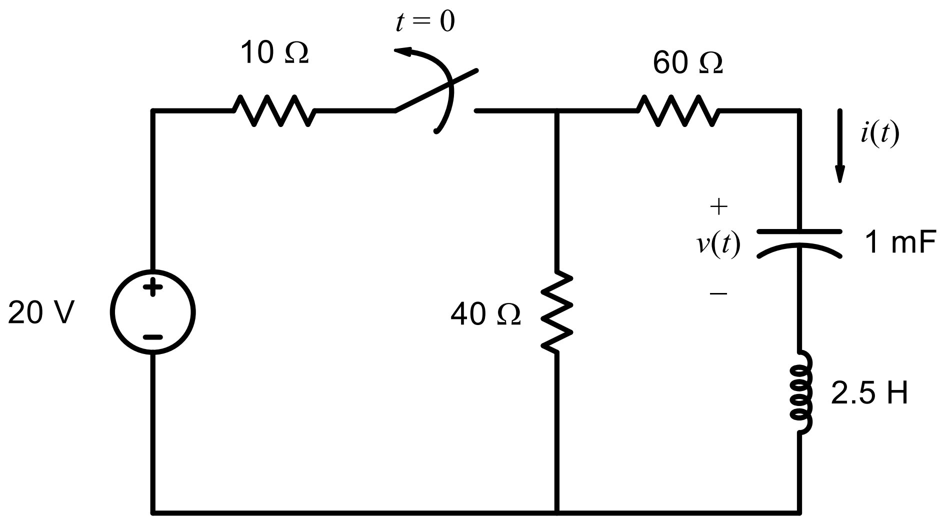
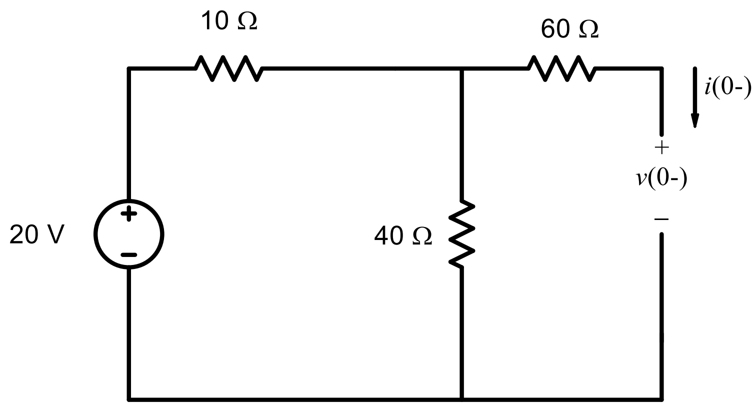


Figure P5

(a) At $t = 0-$, the circuit is under dc conditions and inductor acts like short circuit and capacitor acts like open circuit.



It is obvious that

$i(0-) = 0$ and $v(0-)$ is the voltage across $40\,\Omega$ resistor.

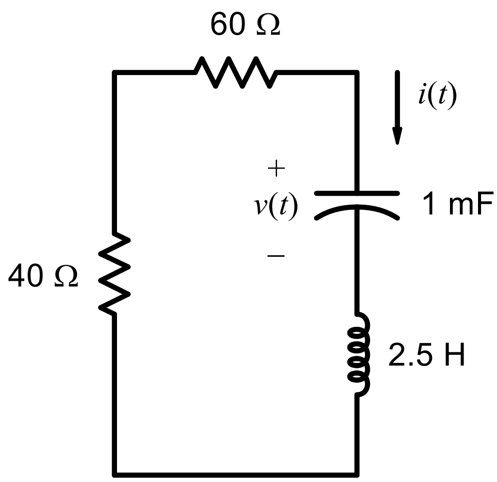
Therefore, using voltage division principle

$$v(0-) = 20\frac{40}{40+10} = 16\text{ V}$$

Since the capacitor voltage and inductor current cannot change instantaneously,

$v(0+) = v(0-) = 16$ V
$i(0+) = i(0-) = 0$

For $t > 0$



(b) If we write KVL around the loop:

$$2.5\frac{di}{dt} + 40i + 60i + v = 0$$

$$2.5\frac{di}{dt} + 100i + v = 0 \text{..........(1)}$$

and

$$i = 1\times10^{-3}\frac{dv}{dt} \text{...............(2)}$$

If we write Eqn.(1) at $t = 0+$

$$2.5\frac{di(0+)}{dt} + 100i(0+) + v(0+) = 0$$

$$\frac{di(0+)}{dt} = -\frac{16}{2.5} = -6.4\,A/s$$

(c) From Eqn.(1):

$$v = -2.5\frac{di}{dt} - 100i \text{.........(3)}$$

Substitution of Eqn.(3) into (2) yields:

$$i = -2.5\times10^{-3}\frac{d^2i}{dt^2} - 100\times10^{-3}\frac{di}{dt}$$

If we multiply both sides of the equation by 400 and rearrange it, we can obtain:

$$\frac{d^2i}{dt^2} + 40\frac{di}{dt} + 400i = 0$$

Characteristic equation is

$$s^2 + 40s + 400 = 0$$

$$(s+20)(s+20) = 0$$

Which implies that

$s_{1,2} = -20$ real and equal natural frequencies. (Critically damped case)

$$i(t) = e^{-20t}\left(A_1 + A_2 t\right)$$

$$i(0) = 0 = A_1$$

$$\frac{di}{dt} = -20e^{-20t}\left(A_1 + A_2 t\right) + A_2 e^{-20t}$$

$$\frac{di(0)}{dt} = -6.4 = -20A_1 + A_2$$

$$A_2 = -6.4$$

$$i(t) = -6.4te^{-20t}\ A$$