Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

EEE 223 Circuit Theory I

Fall 2005-06

Instructors:

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Final EXAMINATION

Jan 27, 2006

Duration : 150 minutes

Number of Problems: 9

Good Luck

STUDENT'S	
NUMBER	
NAME	
SURNAME	
GROUP NO	

Problem		Points	Problem		Points
1		8	6		15
2		8	7		15
3		8	8		15
4		8	9		15
5		8			
TOTAL					100

1. Find the equivalent resistance R_{ab} for the circuit in Fig. P1.

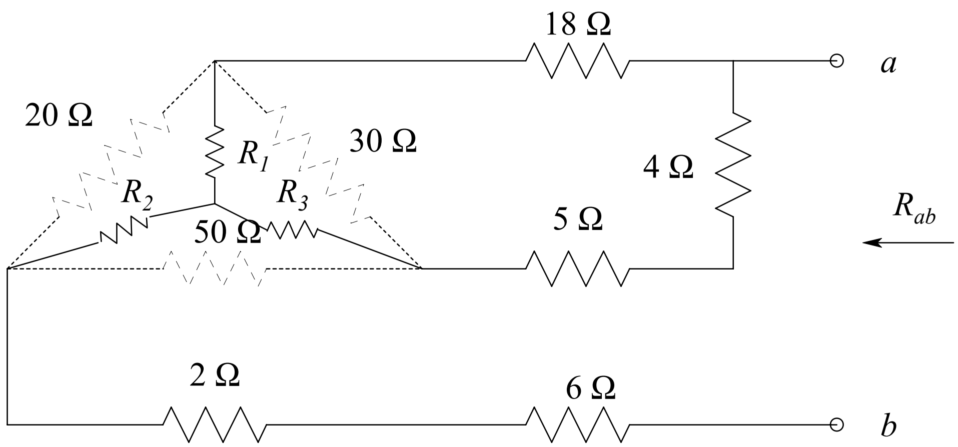


Figure P1

$$R_1 = \frac{20\times30}{20+30+50} = 6\Omega \quad R_2 = \frac{20\times50}{100} = 10\Omega \quad R_3 = \frac{50\times30}{100} = 15\Omega$$

$$R_{ab} = (18+R_1)//(4+5+R_3)+R_2+2+6$$

$$R_{ab} = \underbrace{24//24}_{12}+10+2+6 = 30\Omega$$

2. Convert the circuit in Fig. P2 to current source representation.

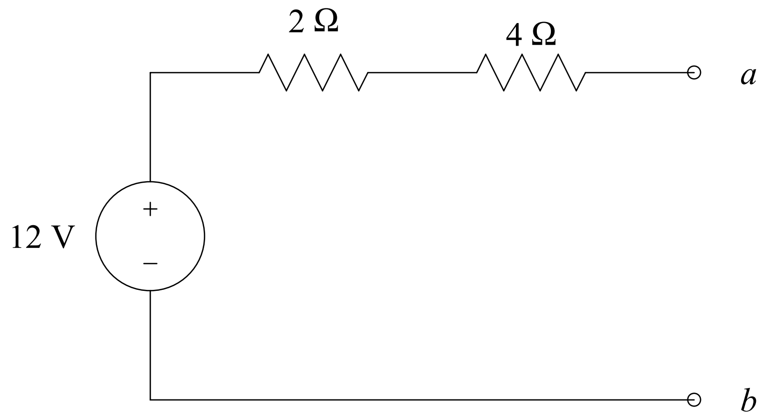
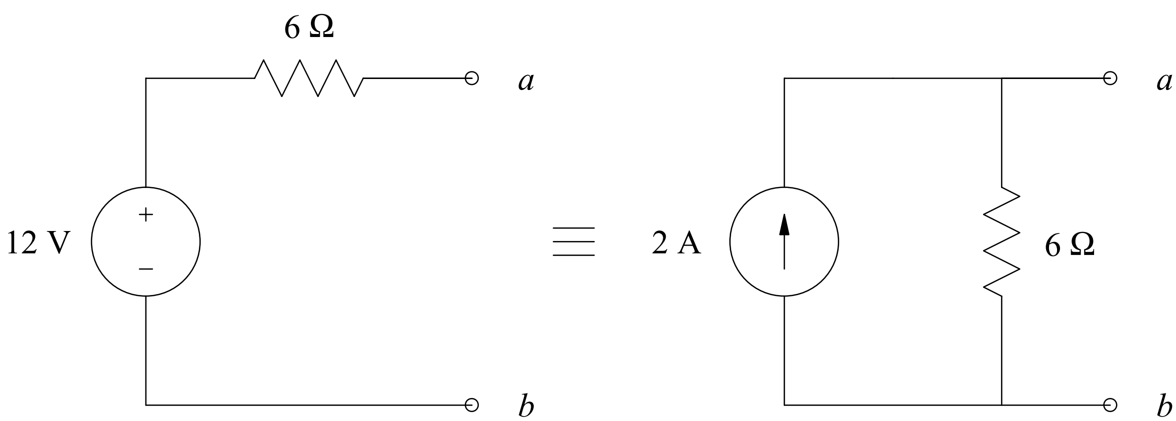


Figure P2



3. Calculate what value of R_L will absorb maximum power and find the maximum power for the circuit in Fig.P3.

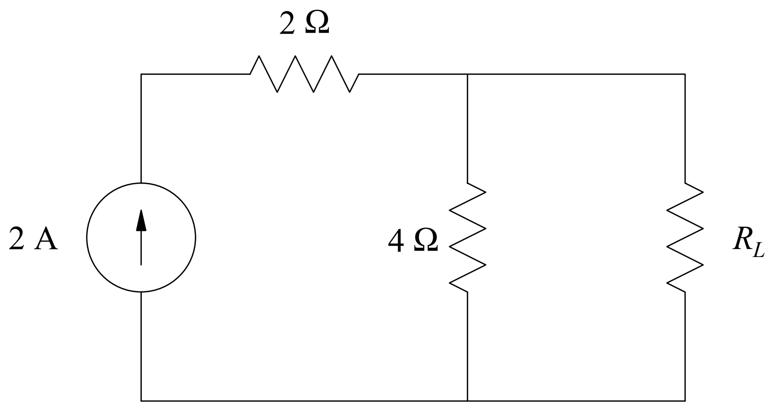
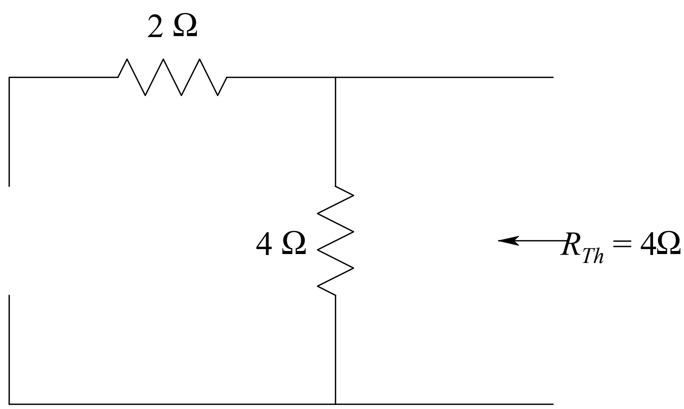


Figure P3

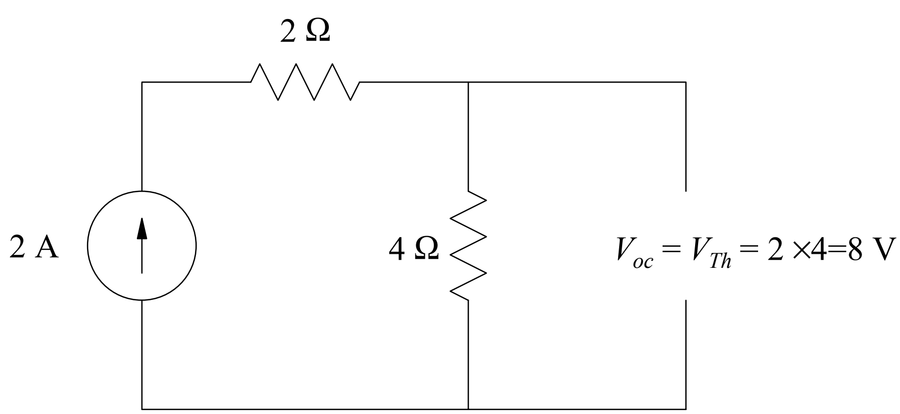
When $R_L = R_{Th}$ it will absorb maximum power. The maximum power absorbed by R_L:

$$P_{\max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{8^2}{4\times 4} = \frac{64}{16} = 4W =$$

In order to find R_{Th}:



V_{Th}:



4. Use superposition to find i for the circuit in Fig.P4.

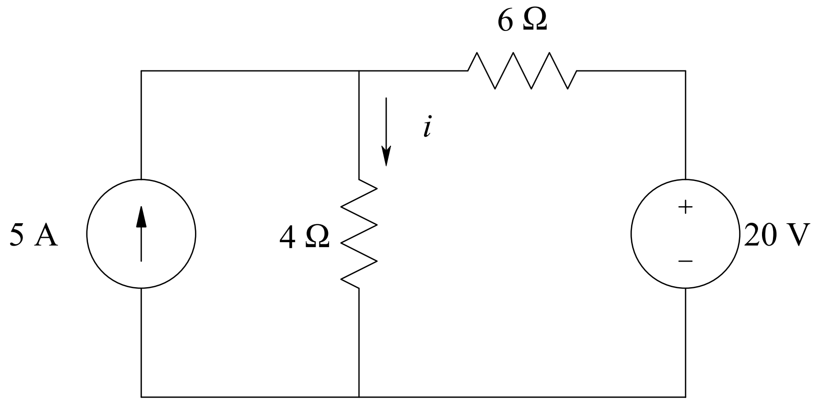
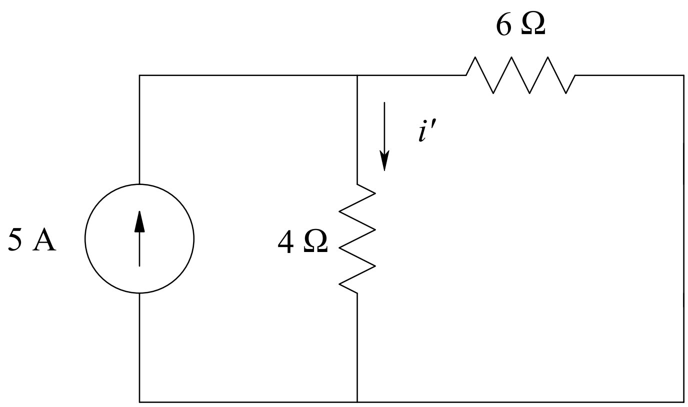
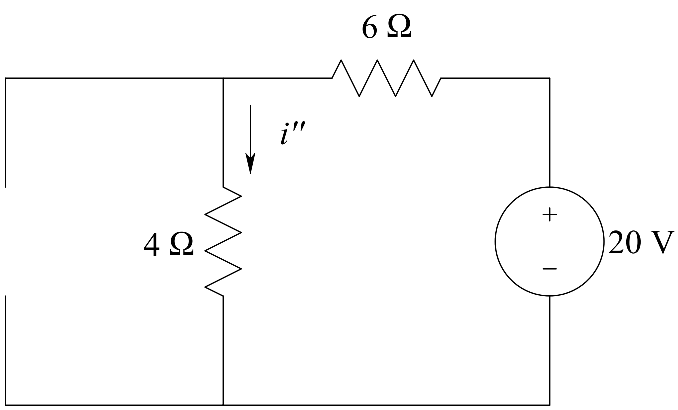


Figure P4



By using current division

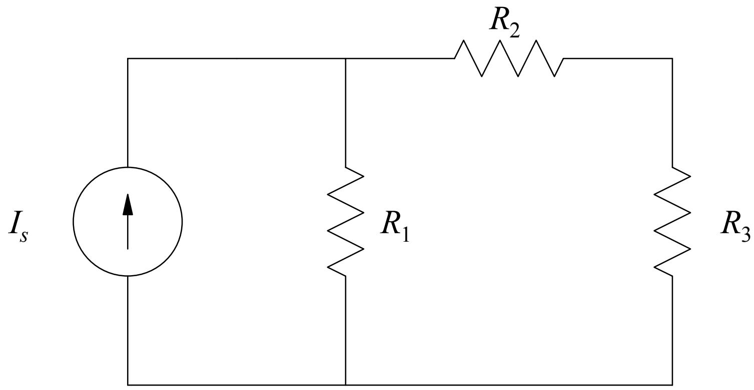
$$i' = \frac{5\times 6}{6+4} = 3\,A$$



$$i'' = \frac{20}{6+4} = 2\,A$$

$$i = i' + i'' = 3 + 2 = 5\,A$$

5. (a)Use current division principle to find the current flowing through R_3 for the circuit in Fig.P5(a).



$$i_{R_3} = I_s \frac{R_1}{R_1 + R_2 + R_3}$$

Figure 5(a)

(b) Use voltage division principle to find the voltage across R_3 for the circuit in Fig.P5(b).

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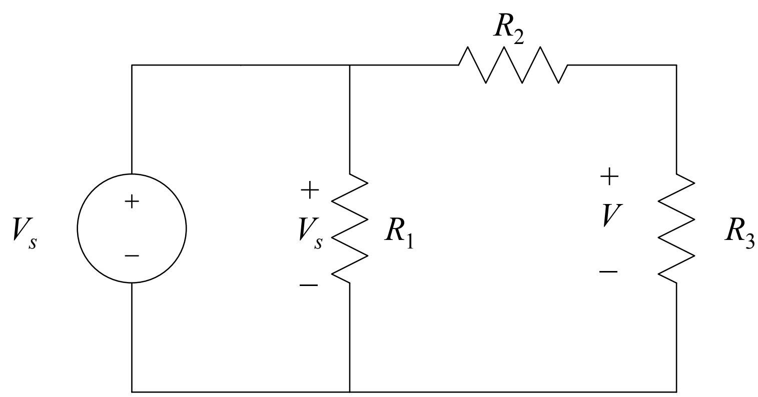
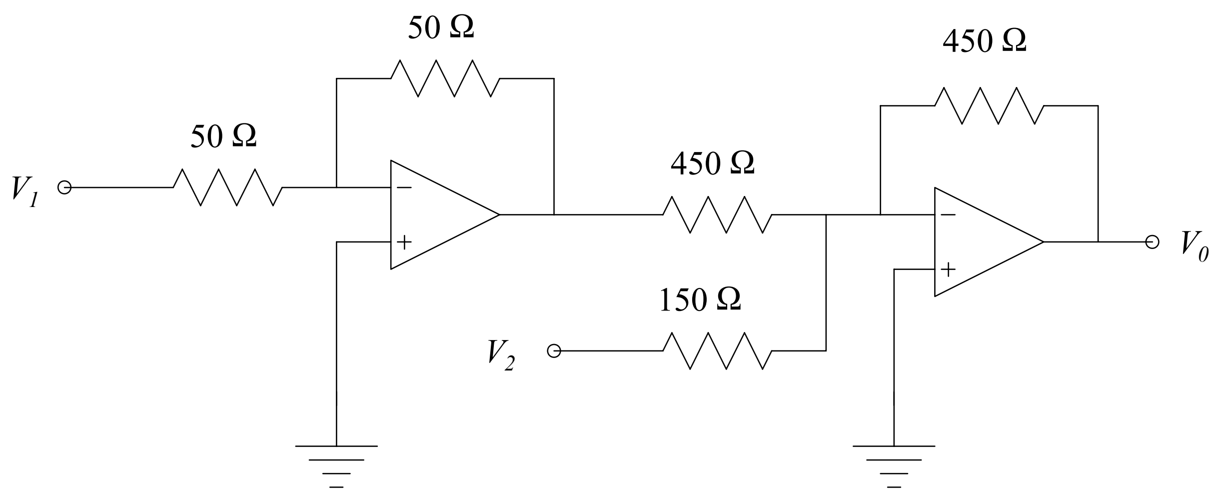


Figure 5(b)

$$V = V_s \frac{R_3}{R_2 + R_3}$$

6. Given signals V_1 and V_2, cascade an inverting op-amp with an inverting summer to have an output

$$V_0 = V_1 - 3V_2$$



7. Find v_0 in the circuit in Fig. P7.

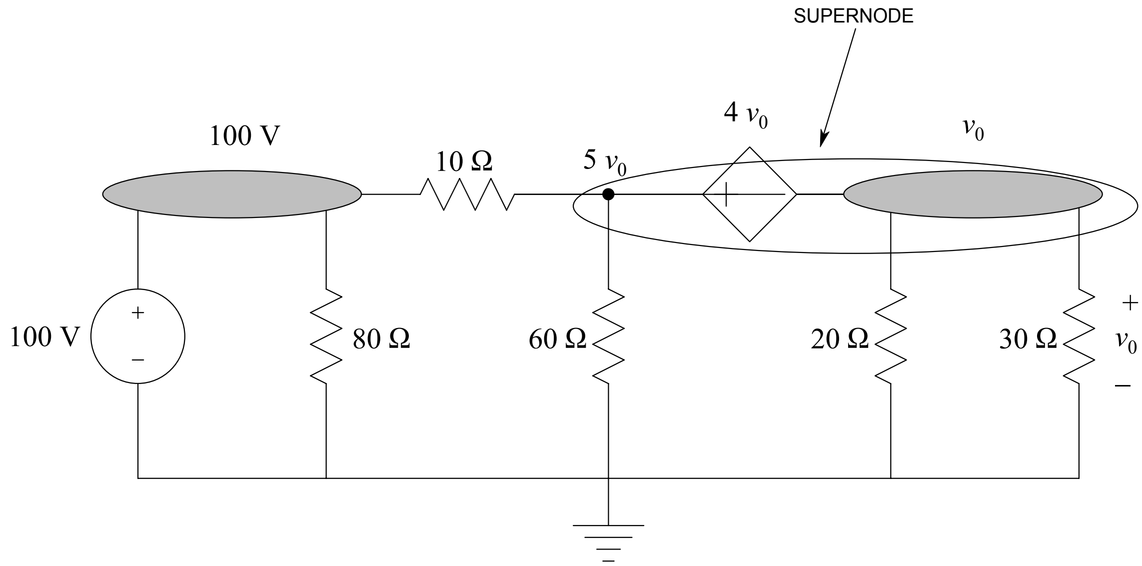


Figure P7

KCL at the SUPERNODE:

$$\frac{5v_0 - 100}{10} + \frac{5v_0}{60} + \frac{v_0}{20} + \frac{v_0}{30} = 0$$

multiply both sides by 60 yields:

$$30v_0 - 600 + 5v_0 + 3v_0 + 2v_0 = 0$$

$$40v_0 = 600$$

$$\boxed{v_0 = 15\text{ V}}$$

8. The switch in the circuit in Fig. P8 has been in position 1 for a long time before moving to position 2 at $t = 0$. Find $i(t)$ for $t \geq 0$.

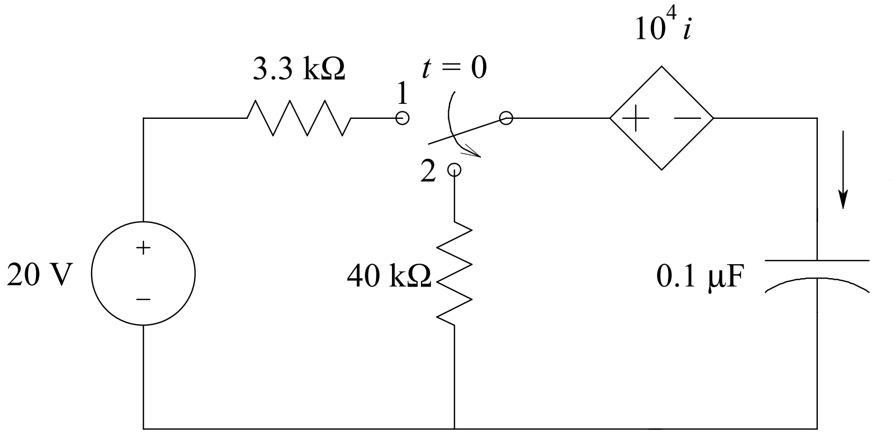
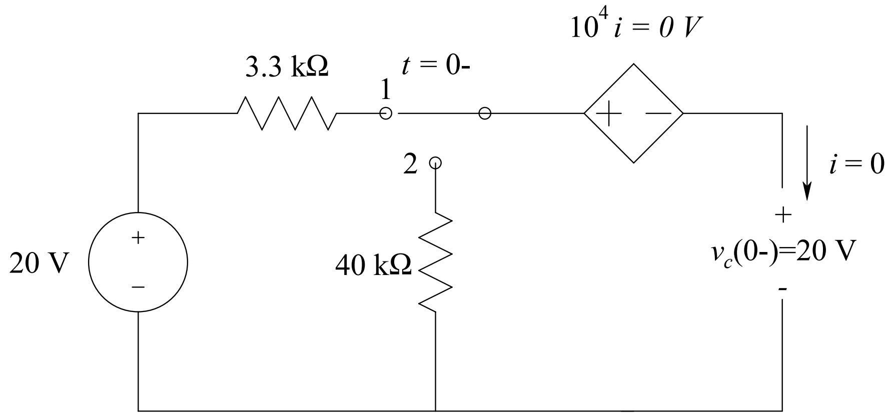


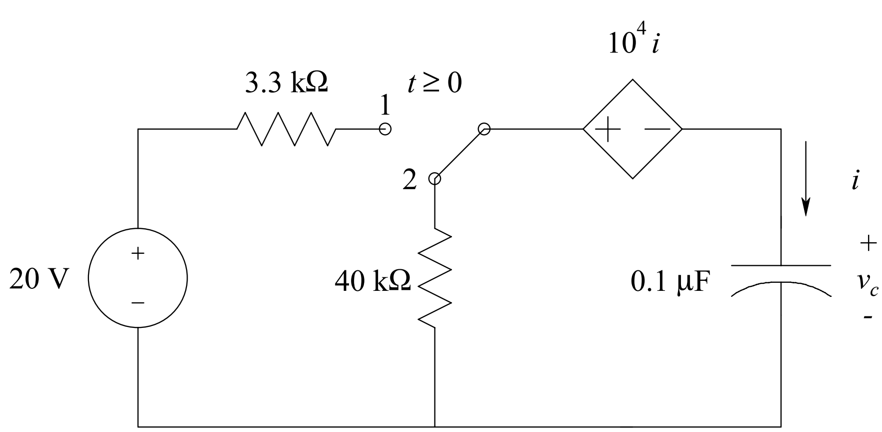
Figure P8

at $t = 0-$



for $t \geq 0$

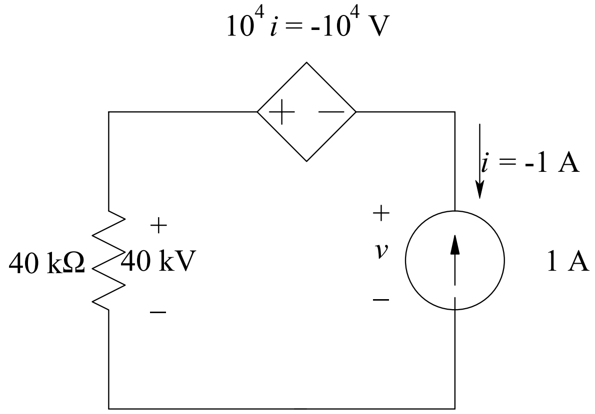
$v_c(0-) = v_c(0+) = 12$ V



$i = 0.1\times10^{-6}\dfrac{dv_c}{dt}$ and $v_c = \underbrace{v_c(0)}_{20\text{ V}}e^{-\frac{t}{\tau}}$

$\tau = R_{eq}C$

In order to find the equivalent resistance R_{eq} seen by the capacitor, a test source is needed to connect .



KVL around the loop:

$-40k + (-10^4) + v = 0$

$v = 50\text{kV}$

$R_{eq} = \dfrac{v}{1} = 50\text{k}\Omega$

Therefore

$$\tau = 50\times10^3\times0.1\times10^{-6} = 5\times10^{-3}$$

$$v_c = 20e^{-200t}\text{ V}$$

$$i = 0.1\times10^{-6}\frac{d}{dt}\left(20e^{-200t}\right) = 0.1\times10^{-6}\left(-4000e^{-200t}\right) = -0.4e^{-200t}\text{ mA}$$

9. The switch in the circuit in Fig. P9 has been open for a long time before closing at $t = 0$. Find $v(t)$ for $t \geq 0$.

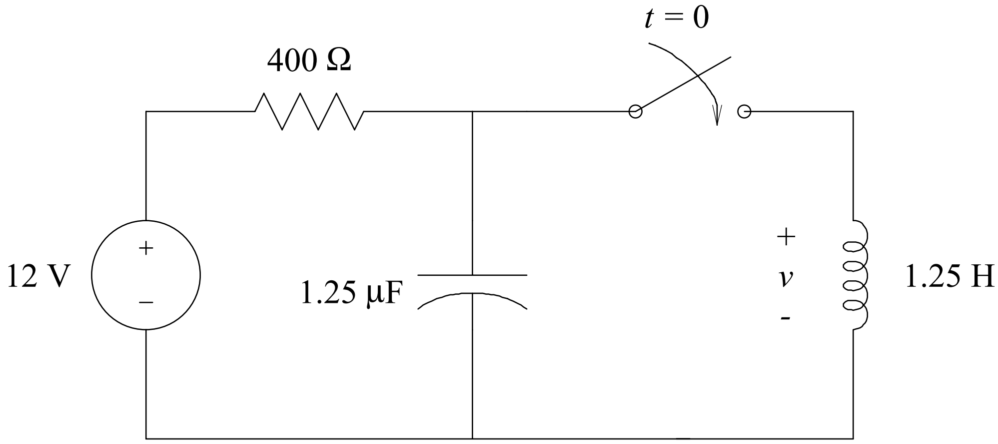
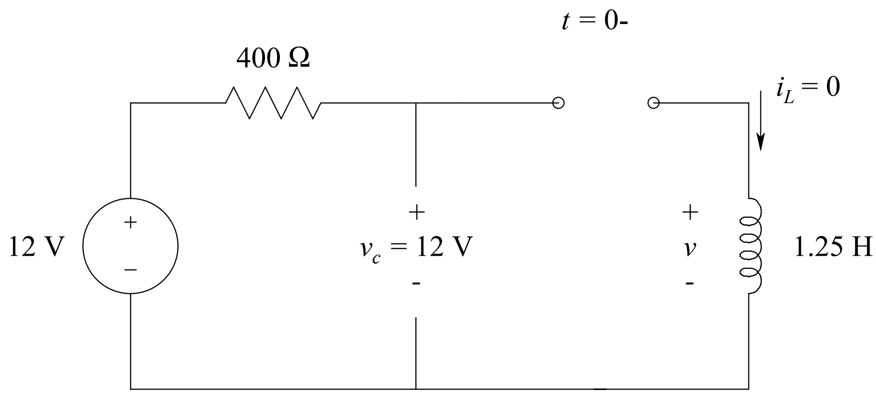


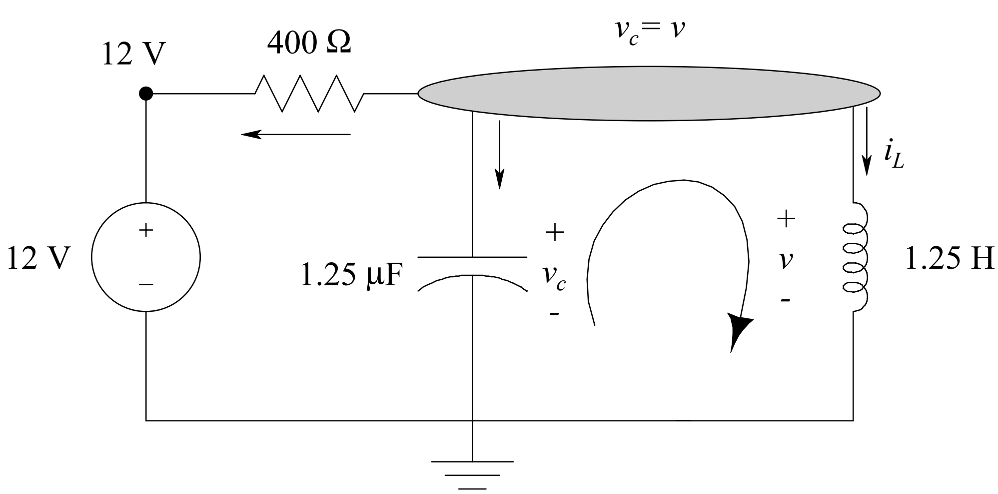
Figure P9

at $t = 0-$



$v_c(0-) = 12\text{ V} \quad i_L(0-) = 0\,A$

for $t \geq 0$



KCL at node v_c:

$$\frac{v_c-12}{400}+1.25\times10^{-6}\frac{dv_c}{dt}+i_L=0 \qquad (1)$$

KVL around the loop:

$$-v_c+1.25\frac{di_L}{dt}=0 \qquad (2)$$

If Eq. (1) is written at $t=0+$ then $\frac{dv_c}{dt}(0+)=0$.

From Eq.(1)

$$i_L=-\frac{v_c-12}{400}-1.25\times10^{-6}\frac{dv_c}{dt}i_L \qquad (3)$$

Substitute Eq.3) into (2) yields:

$$-v_c+1.25\frac{d}{dt}\left(-\frac{v_c-12}{400}-1.25\times10^{-6}\frac{dv_c}{dt}\right)=0$$

$$1.25^2\times10^{-6}\frac{d^2v_c}{dt^2}+\frac{1.25}{400}\frac{dv_c}{dt}+v_c=0$$

or multiply both sides by $\frac{10^6}{1.25^2}$

$$\frac{d^2v_c}{dt^2}+\frac{10^6}{500}\frac{dv_c}{dt}+\frac{10^6}{1.25^2}v_c=0 \Rightarrow \boxed{\frac{d^2v_c}{dt^2}+2000\frac{dv_c}{dt}+640000v_c=0}$$

characteristic equation:

$$s^2+2000s+640000=0$$

$$s_{1,2}=\frac{-2000\mp\sqrt{2000^2-4\times640000}}{2}=-1000\mp600$$

The natural frequencies are

$$\left.\begin{aligned}s_1&=-400\\ s_2&=-1600\end{aligned}\right\}\text{real and distinct natural frequencies } \Rightarrow \text{OVERDAMPED case}$$

$$v_c(t)=A_1e^{-400t}+A_2e^{-1600t}$$

$$v_c(0)=A_1+A_2=12..................................(4)$$

$$\frac{d}{dt}v_c(t)=-400A_1e^{-400t}-1600A_2e^{-1600t}$$

$$\frac{d}{dt}v_c(0)=-400A_1-1600A_2=0...............(5)$$

Multipy Eq.(4) by 400 and add to Eq.(5) gives:

$$-1200A_2=4800$$

$$\boxed{A_2=-4}$$

Substitute the value of A_2 into Eq.(4) yields:

$$\boxed{A_1=16}$$

Therefore

$$v(t)=v_c(t)=16e^{-400t}-4e^{-1600t}\ \text{V}$$