Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers. Each problem 20 points.

From the text.

(8.5) (a) Ans: \( i(0^-) = 0 \, A, \quad v(0^-) = 0 \, V \)

(b) Ans: \( \frac{di(0^-)}{dt} = 4A/s, \quad \frac{dv(0^-)}{dt} = 0V/s \)

(c) Ans: \( i(\infty) = 2.4A, \quad v(\infty) = 9.6V \)

(8.17) Ans: \( v(t) = \left[ 64.65e^{-4t} - 4.64e^{-37t} \right]u(t) \, V \)

(8.21) Ans: \( v(t) = (18e^{-t} - 2e^{-8t})u(t) \, V \)

(8.25) Work only for \( v(t) \). The switch in this problem is a make before break switch as shown below.

Ans: \( v(t) = e^{-8t}[24 \cos 1.98t + 3.024 \sin 1.98t]u(t) \, V \)
For the circuit below, determine...

(a) \( \lambda'(t^+) \) and \( V(t^+) \)

For \( t = 0^- \):

\[ V(0^-) = 0, \quad \lambda_0(0^-) = 0 \]

\[ \lambda(0^-) = 0, \quad V_c(0^-) = 0 \]

For \( t = 0^+ \):

\[ V(0^+) = 0 \quad \text{because} \quad \lambda_0(0^+) = \lambda_0(0^-) = 0 \]

And \( V = \lambda_0(0^+) = 0 \)

Since \( V(0^+) = V_1(0^+) \)

The voltage across the resistor (at \( t^+ \)) is 0.

\[ V(0^+) = 0 \quad \Rightarrow \quad \lambda'(0^+) = 0 \]

(b) \( \frac{\lambda'(t^+)}{C_1} \) and \( \frac{\partial V(t^+)}{\partial t} \)

\[ \lambda'(t) = \frac{V_0(t)}{R_2} \]

\[ \frac{\lambda'(t)}{C_1} = \frac{1}{C_1} \frac{\partial V(t)}{\partial t} \]
\[ \text{Since } V(t) = V(t) \]
\[ \frac{\partial V(t)}{\partial t} = \frac{\partial V}{\partial t} \]

So,
\[ \frac{\partial V}{\partial t} = \frac{1}{RL} \frac{\partial V}{\partial t} \]

Since
\[ \frac{\partial c}{\partial t} = C \frac{\partial V}{\partial t} \]
\[ \frac{\partial V}{\partial t} = \frac{\partial c}{\partial t} \]

So,
\[ \frac{\partial V(t)}{\partial t} = \frac{\partial c(t)}{\partial t} = \frac{4}{\frac{1}{25}} = 16 \]

The
\[ \frac{\partial V(t)}{\partial t} = \frac{1}{RL} \frac{\partial V(t)}{\partial t} = \frac{1}{4} \times 16 = 4 \text{A/} \]

Next, for \( \frac{\partial V(t)}{\partial t} \)

Now,
\[ V(t) = 6 \frac{\partial V}{\partial t} \]
\[ \frac{\partial V}{\partial t} = 6 \frac{\partial V}{\partial t} \]
8.5.10a

\[ V_L = L \frac{dI}{dt} \]

or

\[ \frac{dI(t)}{dt} = \frac{V_L}{L} \]

We have from (A)

\[ \frac{dV(t)}{dt} = 6 \frac{V(t)}{L} \]

\[ \frac{dV_{10^1}}{dt} = 6 \frac{V_{10^1}}{L} \]

Since

\[ V_L(t) = V(t) + V(10^1) \]

\[ V_L(t) = V(t) - V(10^1) \]

\[ V_L(0^+) = V_{10^1} - V(0^+) \]

\[ \frac{dV_{10^1}}{dt} = 0 \quad \text{and} \quad V(0^+) = 0 \]

\[ V_{10^1} = 0 \]

\[ \frac{dV_{10^1}}{dt} = 0 \]

\[ \frac{dV_{10^1}}{dt} = \frac{6}{L} \frac{V_{10^1}}{L} = 0 \]

(2) As \( t \to \infty \)

\[ \begin{array}{c}
\text{4A} \\
\text{10} \\
\text{10} \\
\text{0} \\
\text{10} \\
\end{array} \]

\[ \text{Ca} \]
6.5 cont.

The inductor looks like a short circuit.
The capacitor looks like an open circuit.

From the circuit

\[ I(\infty) = \frac{4 \times 4}{6+4} \cdot \frac{8}{10} = \frac{84}{10} = 8.4 \text{ A} \]

\[ V(\infty) = \left( \frac{4 \times 4}{10} \right) \times 6 = 9.6 \text{ V} \]

\[ V(\infty) = 9.6 \text{ V} \]
S.17 Switch in the following circuit moves instantaneously from A to B at t = 0.
Find \( V(t) \) for \( t > 0 \).

\[
\begin{align*}
\text{For } t < 0, \text{ the current through the inductor is zero, } \frac{dv}{dt} = 0. \\
V(0^-) = 15 \text{ V, } V(0^+) = 60 \text{ V} \\
\end{align*}
\]

\[
\begin{align*}
\text{For } t > 0, \\
\end{align*}
\]

\[
R \frac{di}{dt} + L \frac{dv}{dt} + V(t) = 0 
\] (1)
\[ V'(t) = C \frac{\partial V}{\partial t} \]  
(12)

Substitute (12) into (6)

\[ RC \frac{\partial V}{\partial t} + L \frac{\partial^2 V}{\partial t^2} + V(t) = 0 \]

\[ \frac{\partial^2 V}{\partial t^2} + R \frac{\partial V}{\partial t} + \frac{V(t)}{L} = 0 \]

With numbers

\[ R = 10 \Omega, \quad L = 0.25 H, \quad C = 0.04 F \]

\[ \frac{\partial^2 V}{\partial t^2} + 40 \frac{\partial V}{\partial t} + 100 V(t) = 0 \]

Solve Eq.

\[ s^2 + 40 s + 100 = 0 \]

\[ (s + 37.32)(s + 2.68) = 0 \]

\[ V(t) = A_1 e^{-37.32 t} + A_2 e^{-2.68 t} \]  
(14)

\[ V(0^+) = V(0^-) = 60 V \]

From Eq (2)

\[ \frac{\partial V(0^+)}{\partial t} = \frac{\partial V(0^-)}{\partial t} = 0 \]

\[ \frac{\partial^2 V(0^+)}{\partial t^2} = 0 \]  
(15)
Using (4) in (3) gives
\[
\mathbf{v}_0 = \mathbf{A}_1 + \mathbf{A}_2
\]
Using (5) in \( \frac{\mathbf{v}_0}{2t} \)
\[
\frac{\mathbf{v}_0}{2t} = \begin{bmatrix} -37.32A_1, e^{-37.32t} & -2.68 e^{-2.68t} \end{bmatrix}
\]
\[
\mathbf{v}_0 = -37.32A_1, -2.68 A_2
\]
\[
\begin{bmatrix} 1 & 1 \\ -27.32 & 2.48 \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \end{bmatrix} = \begin{bmatrix} \mathbf{v}_0 \end{bmatrix}
\]
\[
A_1 = -4.16, \quad A_2 = 64.64
\]
\[
\mathbf{v}(t) = \begin{bmatrix} -4.16 e^{-37.32t} + 64.64 e^{-2.68t} \end{bmatrix}
\]
Calculate V10 when t > 0 in the following circuit.

For t < 0, determine V10.

\[ V_{10} = \frac{24 \times 24}{12 + 24} = 16 \text{ V} \]

\[ I(0^-) = 0 \text{ A} \]
The equation for the above is

$$\frac{d^2V}{dt^2} + \frac{R}{L} \frac{dV}{dt} + \frac{V_{WH}}{LC} = 0$$

where \( R = 20 \) \( \Omega \), \( L = 3 \) \( H \), \( C = \frac{1}{27} \) \( F \)

$$\frac{d^2V}{dt^2} + 10 \frac{dV}{dt} + 9 \frac{V_{WH}}{C} = 0$$

\( s^2 + 10s + 1 = 0 \)

\( (s + 9)(s + 1) = 0 \)

\( v(t) = (A_1 e^{-9t} + A_2 e^{-t}) v_{WH} \) \( v(t) \)

\( v(0) = v(0) = 16 \) \( V \)

\( i(0^+) = \frac{dv(10^{-})}{dt} \)

\( i(10^+) = i(10^-) = 0 \)

$$\frac{dv(10^+)}{dt} = 0$$ \( i(t) \)
\[ \begin{align*}
8.21 \text{ cont.} \\
\text{Using (2) in (1) gives} \quad A_1 + A_2 &= 16 \\
\text{Using (3) in (1) gives} \quad -9A_1 - A_2 &= 0
\end{align*} \]

\[
\begin{bmatrix}
1 & 1 \\
-9 & 1
\end{bmatrix}
\begin{bmatrix}
A_1 \\
A_2
\end{bmatrix} =
\begin{bmatrix}
16 \\
0
\end{bmatrix}
\]

\[ A_1 = -2, \quad A_2 = 18 \]

\[
\text{\therefore \quad } V(14) = \int \left( -2e^{-9t} + 18e^{-t} \right) \, \text{d}t
\]
For the following circuit, determine $V_o(t)$ for $t \geq 0$.

For $t \leq 0$

\[ V_o(0^-) = \frac{20 \times 3}{4 + 2} = 24V = V_o(0^+) \quad (1) \]
\[ i(0^-) = \frac{30}{8} = 3.75A = i(0^+) = -i(0^+) \quad (2) \]

For $t > 0$

Parallel RLC
The d.e. for the parallel RLC is
\[ \frac{d^2 V_0}{dt^2} + \frac{1}{RC} \frac{dV_0}{dt} + \frac{V_0}{LC} = 0 \]  
(3)

Going to complex
\[ \frac{V_0}{R} + \frac{1}{LC} + C \frac{dV_0}{dt} = 0 \]  
(4)

\[ R = 8 \Omega, \quad L = 1H, \quad C = 0.25 \mu F \]
\[ s^2 + \frac{1}{RC} s + \frac{1}{LC} = 0 \]
\[ s^2 + 0.5s + \frac{1}{0.25} = 0 \]
\[ (s + 0.25 + j \omega_c)(s + 0.25 - j \omega_c) = 0 \]

\[ V_0(t) = e^{-0.25t} \left( B_1 e^{0.25t} + B_2 e^{-0.25t} \right) \]  
(5)

\[ V_0(0^+) = V_0(0) = 2 + \frac{2}{3} \]  
(form 15)

\[ C \frac{d(V_0(t))}{dt} = -\frac{2}{3} - \frac{V_0(t)}{R} \]  
(form 14)

\[ C \frac{d(V_0(t))}{dt} = 3 - \frac{2}{3} = 0 \]  
(17)

\[ \frac{dV_0(t)}{dt} = 0 \]

We know \( i(t) = 3 \) \( \Rightarrow V_0(t) = 3 \)
\[ i_0(t) = 0 \quad i_0 = C \frac{dV_0(t)}{dt} = 0 \]
From (5) using (4)

\[ 24 = 2_{1}\cos B + 2_{2}\sin B = B_{1} \]

\[ B_{1} = 24 \]

\[ y(t) = e^{-0.25t}\left[ 2_{1}\cos 1.98t + 2_{2}\sin 1.98t \right] \]

Take \( \frac{\partial y}{\partial t} \)

\[ \frac{\partial y}{\partial t} = e^{-0.25t}\left[ -1.98\times 2_{1}\sin 1.98t + 1.98\times 2_{2}\cos 1.98t \right] - 0.25e^{-0.25t}\left[ 2_{1}\cos 1.98t + 2_{2}\sin 1.98t \right] \]

Evaluate (5) at \( t = 0 \) using \( \frac{\partial y(0)}{\partial t} = 0 \)

\[ 2_{2} = \frac{0.25 \times 24}{1.98} = \frac{6}{1.98} = 3.03 \]

\[ v_{e}(t) = e^{-0.25t}\left[ 2_{1}\cos 1.98t + 3.03\sin 1.98t \right] \]