Signature: Solution Key

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM #2
ELEE 2335
OCTOBER 26, 1985

INSTRUCTIONS:

1. Fill in the information required on the upper left of this page.

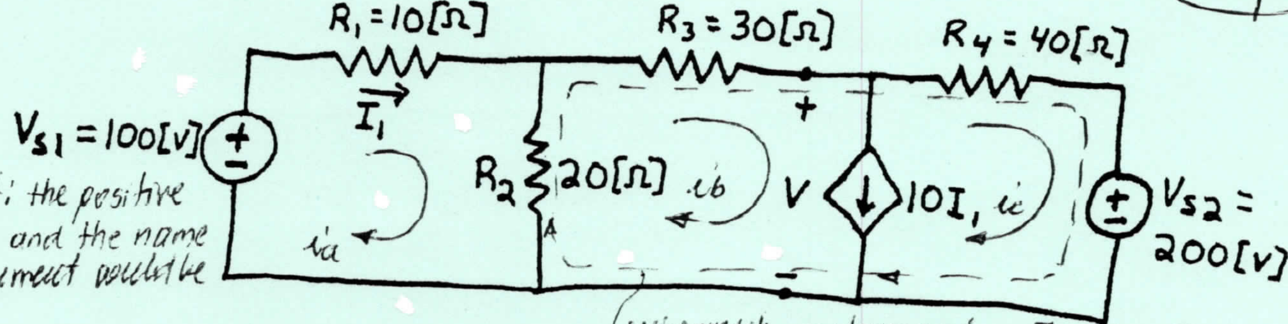
2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary, but indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless necessary work is shown. Show all of your units explicitly. Units in exam questions are placed within square brackets.

3. If your answers and work are not in ink, there will be no provision for changing your grade once the exam is returned to you. Do not use red ink.

1. 30
2. 20
3. 25
4. 25

1. Apply the mesh-current method to the following circuit to determine the value of V.

30pct



comment: the positive direction and the name of mesh current would be different.

supermesh contour and positive direction

Solution: $n=5$; $n_e=3$; $b=7$; $b_e=5$

\# of independent kirchhoff's voltage law: $b_e-(n_e-1)=5-(3-1)=3$ (+3)

mesh a: $(R_1+R_2)\,i_a - R_2 i_b = V_{S1}$ (5p)

mesh b+c (supermesh): $-R_2 i_a + (R_2+R_3) i_b + R_4 i_c = -V_{S2}$ (5p)

dependent current source: $i_b - i_c = 10 i_1 = 10 i_a$ (5p)

$$\rightarrow \begin{cases} 30 i_a - 20 i_b = 100 & (1) \\ -20 i_a + 50 i_b + 40 i_c = -200 & (2) \\ 10 i_a - i_b + i_c = 0 & (3) \end{cases}$$

comment: could be also solved by matrix method.

from (1): $i_b = 1.5 i_a - 5$;

replaced in (2)+(3):

$$\begin{cases} -20 i_a + 75 i_a - 250 + 40 i_c = -200 \\ 10 i_a - 1.5 i_a + 5 + i_c = 0 \end{cases}$$

↓

$$\begin{cases} 55 i_a + 40 i_c = 50 & (2') \\ 8.5 i_a + i_c = -5 & (3') \end{cases}$$

from (3'): $i_c = -5 - 8.5 i_a$

replaced on (2'):

$55 i_a - 200 - 340 i_a = 50$

↓

$285 i_a = 250$

↓

$i_a = -0.8771929\,[A]$

↓

$i_c = 2.4561403\,[A]$

$i_b = -6.3157894\,[A]$

$V = R_4 i_c + V_{S2} = 40 * 2.4561403 + 200$ (5p)

$\boxed{V = 298.24561\,[V]}$

(10p)

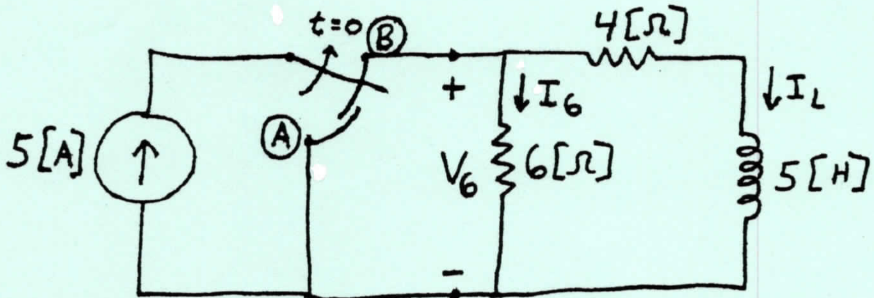
* math mistake : -2 pct
* units : -3 pct.

2. Assume that the switch in the network given below has been in position A for a very long time. The switch is moved to position B at t=0. Determine the following quantities:

a) $I_L(t)$, for $t \geq 0$.

b) $I_6(t)$, for $t \geq 0$.

c) $V_6(t)$, for $t \geq 0$.



$I_L(@\, t=0) = 0$

$I_L(@\, t\to\infty) = \frac{6}{10}\times 5 = 3A$

$i_L(t) = Ae^{-t/\tau} + B$; $\tau = \frac{5}{10} = .5$

$0 = A + B$

$3 = B$

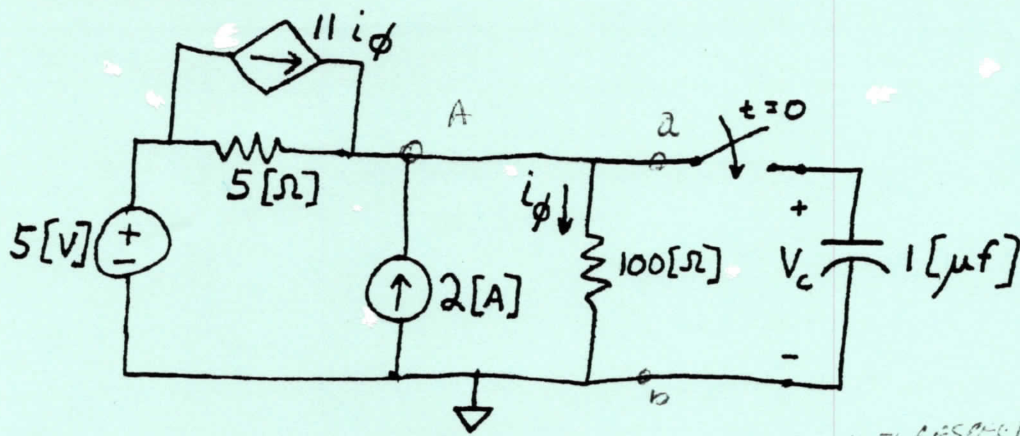
a) $\therefore\ i_L(t) = 3(1-e^{-2t})$ AMPS

b) $I_6 + I_L = 5$; $I_6 = 5 - I_L$

$i_6(t) = 5 - 3 + 3e^{-2t} = 2 + 3e^{-2t}$ AMPS

c) $V_6 = 6\times I_6 = 12 + 18e^{-2t}$ VOLTS

3. In the network given the energy stored in the capacitor for t<0 is zero. At t=0, the switch is closed. Determine the value of $V_C(t)$ for all time after the switch is closed.



CONVERT CIRCUIT TO THEVENIN EQUIVALENT CKT WITH RESPECT TO TERMINALS ab

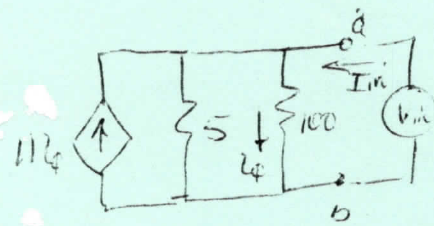
$\frac{V_A-5}{5} - 11 i_\phi - 2 + \frac{V_A}{100} = 0$; $i_\phi = \frac{V_A}{100}$

$\frac{V_A}{5} - 1 - \frac{11V_A}{100} - 2 + \frac{V_A}{100} = 0$

$20V_A - 100 - 11V_A - 200 + V_A = 0$

$10V_A = 300$

$\therefore \; V_A = 30V = V_{TH}$

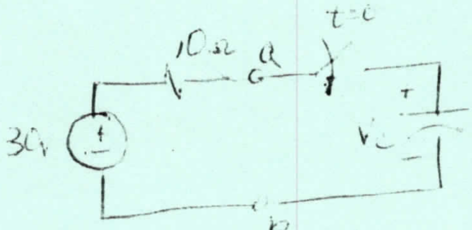


$I_{in} = i_\phi + \frac{V_{in}}{5} - 11i_\phi = \frac{V_{in}}{5} - 10i_\phi$

$i_\phi = \frac{V_{in}}{100}$

$\therefore \; I_{in} = \frac{V_{in}}{5} - \frac{10V_{in}}{100} = \frac{2V_{in}}{10} - \frac{V_{in}}{10} = \frac{V_{in}}{10}$

$R_{TH} = \frac{V_{in}}{I_{in}} = 10\Omega$



$V_c(t) = Ae^{-t/\tau} + B$; $\tau = RC = 10\times1\times10^{-6} = 1\times10^{-5}$

$V_c(0^+) = 0$; $V_c(\infty) = 30V$

$0 = A + B$

$30 = B$

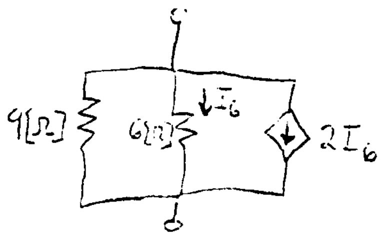
$\therefore \; V_c(t) = -30e^{-1\times10^5 t} + 30$

$= 30(1-e^{-1\times10^5 t})$

-2 pts - no units

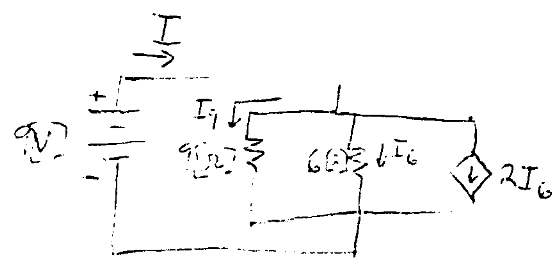
4. A circuit component can be modelled by 3 elements in parallel, a 6 ohm resistor, a 9 ohm resistor, and a dependent current source. The current in the dependent current source is twice the current in the 6 ohm resistor, and is in the same polarity. In other words, positive current in the source leaves the same node as positive current in the 6 ohm resistor.

a) Draw the equivalent circuit for this component.



6pts

b) Using any polarity, connect a 9 Volt battery to the two terminals of this component. Draw the circuit diagram that would result.



3pts

c) Solve for the current in the 9 Volt battery.

$I = ?$

8 pts

$$I = I_9 + I_6 + 2I_6$$

$$I_9 = \frac{9[V]}{9[\Omega]} = 1[A] \qquad I_6 = \frac{9[V]}{6[\Omega]} = 1.5[A]$$

$$I = 1[A] + 1.5[A] + 3[A] = \boxed{5.5[A]}$$

d) Find the simplest possible equivalent circuit for this component.

Note that the current in the dependent current source is twice that in the 6[Ω] resistor for any applied voltage. Thus, the current in the dependent source is proportional to the voltage across it, and it behaves as a resistor. The value will be half of 6[Ω] or 3[Ω]

8pts

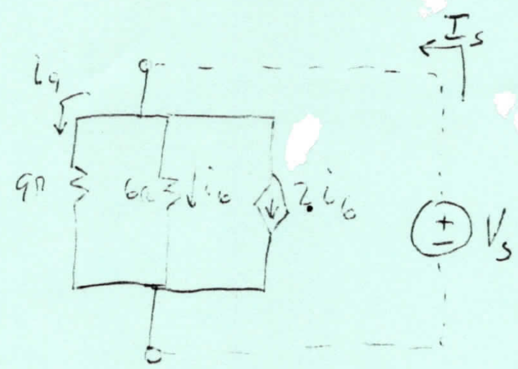
Thus, the component behaves as

$$R = 9[\Omega] \parallel 6[\Omega] \parallel 3[\Omega] \cong \boxed{1.6\ [\Omega]}$$

We can also find this using Thevenin's Theorem. [see next page]

ROOM FOR EXTRA WORK

4d) Optional method:



$$\boxed{V_{OC} = V_{TH} = 0}$$

since there are no independent sources.

If we apply a test source V, then

$$I_s = 3i_6 + i_9$$

$$i_6 = \frac{V_s}{6}$$

$$i_9 = \frac{V_s}{9}$$

$$I_s = \frac{3V_s}{6} + \frac{V_s}{9} = \left(\frac{9+2}{18}\right) V_s$$

$$\boxed{\frac{V_s}{I_s} = \frac{18}{11}\,\Omega} = R_{TH}$$