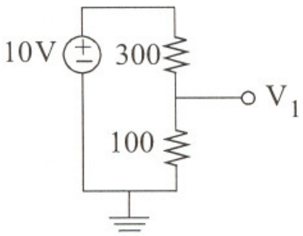
EE42/100 Fall 2005 Midterm 1A.

Problem 1 – Short Answers (20 points)

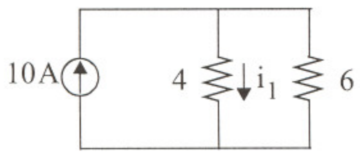
[2 pts.] (a)



$10 \cdot \frac{100}{100+300} = 2.5V$

V_1 = 2.5V

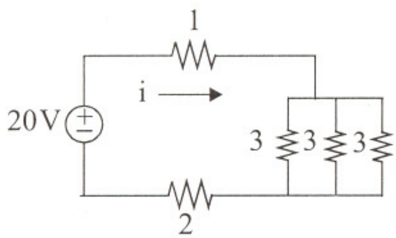
[2pts.] (b)



$10 \cdot \frac{6}{4+6} = 6\text{amps}$

i_1 = 6A

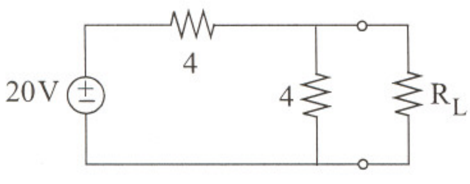
[2 pts.] (c)



$\frac{20V}{1+3/3+2} = 5\text{amps}$

i = 5A

[4 pts.] (d)



For what value of R_L is power in R_L maximized?

R_L = 2Ω

2Ω

Thev Equiv

What is the maximum power dissipated in R_L?

12.5 watts

$i = \frac{10V}{4\Omega}$, $P = i^2R$

$P = \frac{100}{16} \cdot 2 = 12.5\text{watts}$

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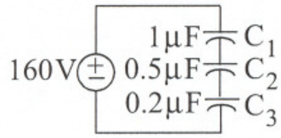
Problem 1 (cont.)

[6 pts.] (e)



Determine charge (q) and voltage across each capacitor.

$q_1 = 2\times10^{-5}C$	$q_2 = 2\times10^{-5}C$	$q_3 = 2\times10^{-5}C$
$V_1 = 20V$	$V_2 = 40V$	$V_3 = 100V$

$q_1 = q_2 = q_3$

$C_1V_1 = C_2V_2 = C_3V_3$

$V_1 + V_2 + V_3 = 160V$

$q\cdot\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right) = 160V$

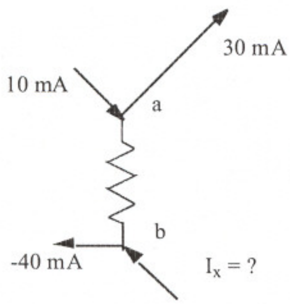
$q = \frac{160V}{10^6(1+2+5)} = 20\times10^{-6}C$

[4 pts.] (f) Short Question

Here is a circuit fragment – a 100-ohm resistor imbedded in a very large circuit that provides the currents shown here. Find the unknown current I_x and the voltage V_{ab} across the resistor.

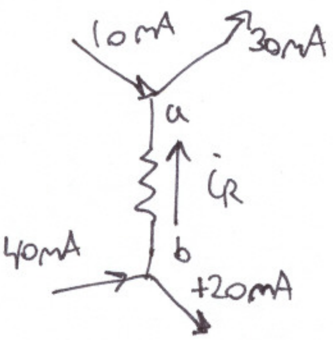
I_x = ____________

V_{ab} = ____________



$10mA - 30mA - (-40mA) + I_x = 0$

$I_x = -20mA$



$i_R = 20mA$

$V_{ab} = -100 \cdot 20mA$

$= -2V$

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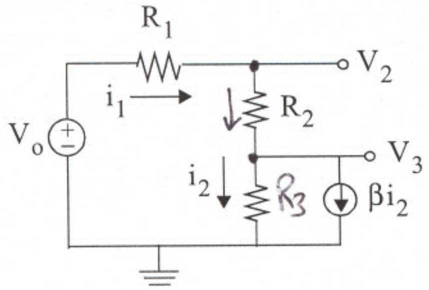
Problem 2 (20 points)



V_0, R_1, R_2, R_3, β are known.

[10 pts.] (a) Write (but do not solve) a minimum set of equations that could be solved for unknowns V_2 and V_3 using Kirchhoff's Current Law, KCL. (Equations in box for full credit.)

at V_2: $\frac{V_0 - V_2}{R_1} - \frac{(V_2 - V_3)}{R_2} = 0$

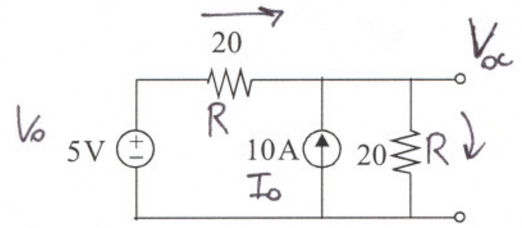
at V_3: $\frac{V_2 - V_3}{R_2} - \frac{V_3}{R_3} - \beta \frac{V_3}{R_3} = 0$

[10 pts.] (b) Write (but do not solve) a minimum set of equations that could be solved for unknowns i_1, i_2 using Kirchhoff's Voltage Law (KVL). (Equations in box for full credit.)

$V_0 - i_1 R_1 - i_1 R_2 - i_2 R_3 = 0$ (KVL around loop)

$i_1 - i_2 - \beta i_2 = 0$ (KCL at node 2)

Problem 3 – Equivalent Circuits (20 points)

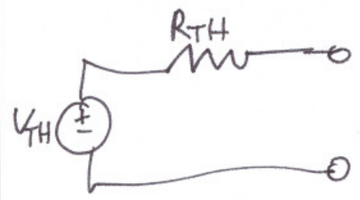


$$\frac{V_0 - V_{oc}}{R} + I_0 - \frac{V_{oc}}{R} = 0$$

$$V_0 + I_0 R = 2V_{oc}$$

$$V_{oc} = \frac{V_0 + I_0 R}{2} \qquad I_{sc} = \frac{V_0}{R} + I_0$$

[2 pts.] (a) Draw the Thévenin equivalent circuit.



$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{\frac{1}{2}(V_0 + I_0 R)}{\frac{1}{R}\cdot(V_0 + I_0 R)} = R/2$$

$$V_{TH} = V_{oc} = \frac{5 + 200}{2} = 102.5V$$

[14 pts.] (b) R_{TH} = 10Ω V_{TH} = 102.5V

[2 pts.] (c) Draw the Norton equivalent circuit.

[2 pts.] (d) In general, if you know V_{TH} and R_{TH}, how do you determine R_N and I_N?

R_N = R_{TH} I_N = V_{TH}/R_{TH}

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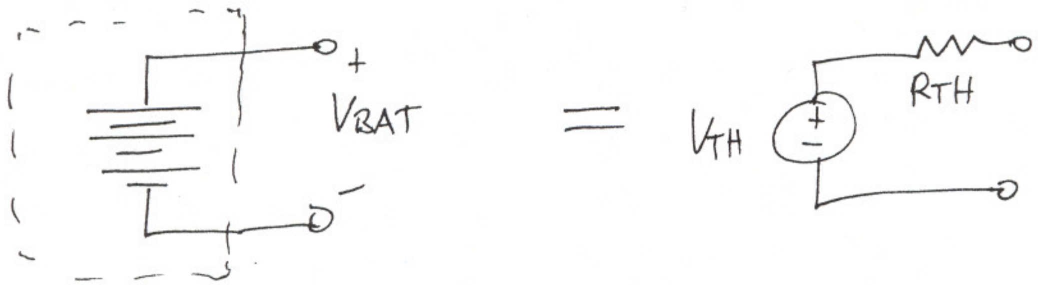
Problem 4 – Lab Related Question (18 points)

Suppose you buy a strange-looking battery at the Berkeley Surplus Center and want to find its Thévenin equivalent circuit experimentally. You have a multimeter with voltage, current and resistance scales, and you also have one resistor R, one capacitor C, and one inductor L. Incidentally, you don't want to short circuit the battery – it would be bad for it!

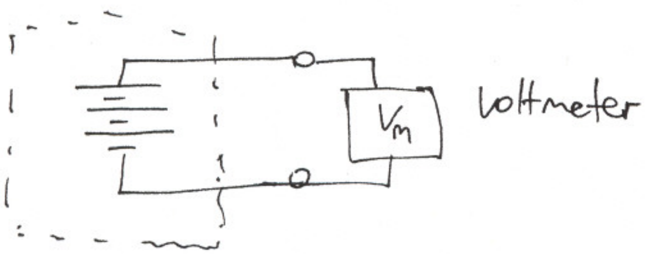
a) How can you find V_{Th} safely?

b) How can you find R_{Th} safely?

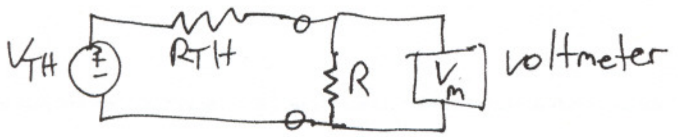
Draw the circuits showing how you'd connect the meter, the battery and any other components, and write any equations you will use in the process,



a) Open circuit voltage $V_{BAT} \equiv V_{TH}$. So just use multimeter voltage scale.



b) We know $R_{TH} = \dfrac{V_{TH}}{I_{SC}}$, but we don't want to measure short circuit current. We can use known R + voltmeter to find R_{TH}:

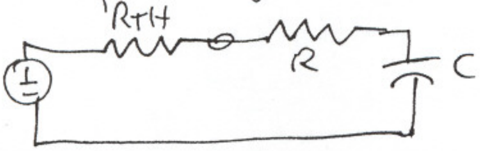


$V_m = V_{TH} \cdot \dfrac{R}{R + R_{TH}}$, $R_{TH} + R = \dfrac{V_{TH}}{V_m} \cdot R$

$R_{TH} = R\left(\dfrac{V_{TH}}{V_m} - 1\right)$

[if you use a capacitor w/o R you instantaneously short V_{BAT}].

Could use



$\tau = (R + R_{TH})C$

$R_{TH} = \tau/C - R$

Problem 5 – RL Circuit

An RL circuit with a voltage source and a very fast-acting switch is shown. the values of the components are: $V_s = 2\text{ V}$; $R_1 = 20\Omega$; $R_2 = 980\Omega$; $L = 0.1\text{ H}$. At time $t = 0$, a long time after the switch has closed, the switch opens.

[2 pts.] (a) What is the current i_L that is flowing at time $t = -2\text{s}$?

$i_L(-2) =$ 0.1A

$\frac{V_s}{R_1} = \frac{2}{20} = 0.1\text{amp}$

[2 pts.] (b) What is the time constant for the RL circuit?

$\tau =$ 10^{-4}sec

after switch opens $\tau = L/(R_1+R_2)$

$= \frac{0.1}{20+980} = 10^{-4}\text{sec}$

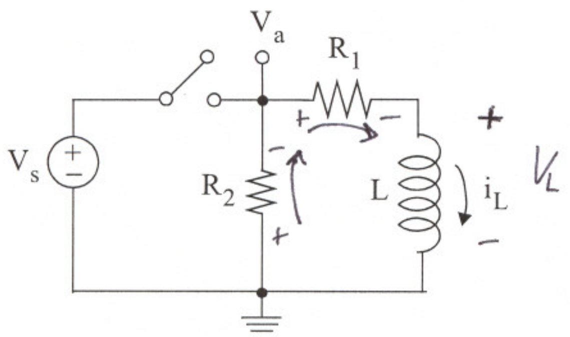
[6 pts.] (c) Write KVL for time $t = 0^+$.

for inductor, current can not change instantaneously. $V_L = L\frac{di}{dt}$

$-i_L R_2 - i_L R_1 - V_L = 0$

[4 pts.] (d) Find the voltage $V_a(t = 0+)$.

$= -i_L R_2 = -(0.1)980 = -98V$



$v_a(t = 0^+) =$ $-98V$

[8 pts.] (e) Determine $v_a(t)$ for $t > 0$.

$v_a(t) =$ $-98e^{-t\cdot 10^4\text{sec}^{-1}}$

$V_a(t) = V_{af} + [V_a(0^+) - V_{af}]e^{-t/\tau}$

$\lim_{t\to\infty} V_a(t) = 0$

$V_a(t) = V_a(t=0^+)e^{-tR/L}$

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