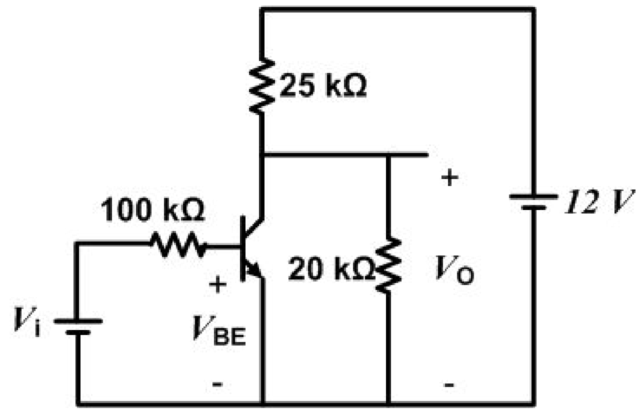
EE411 – Fall 2009, Test 1

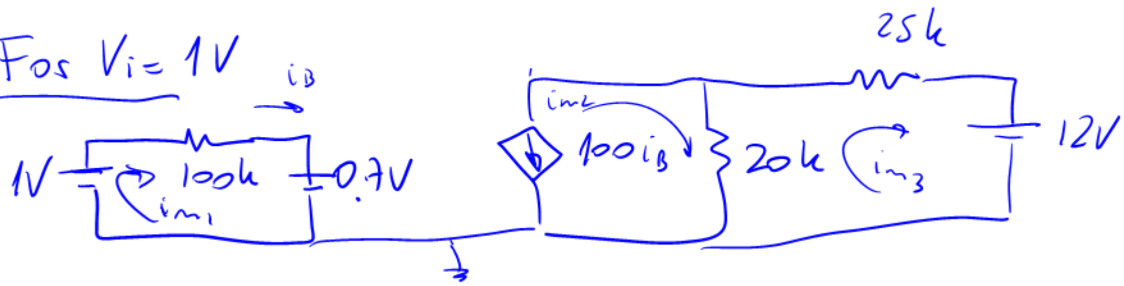
Please, show all your work on the test sheets. A correct answer without supporting work gets no credit. One sheet of notes is permitted. Write your name in all pages. Do not un-staple. You have 60 minutes to complete the test.

Problem 1 (30 points)

For the circuit in the figure below find V_O / V_i for $V_i = 1$ V and $V_i = 0.5$ V. Consider that $\beta = 100$, $V_{BE} = 0.7$ V.



For $V_i = 1V$



#1 $1 - 0.7 = 1.10^5 i_{m_1} \rightarrow i_{m_1} = \frac{0.3}{1.10^5} = 3\mu A$

#2 $i_{m_2} = -100\, i_B = -100\, i_{m_1} = -300\mu A$

#3 $12 + 25000 i_{m_3} + 20000 i_{m_3} - 20000 i_{m_2} = 0$

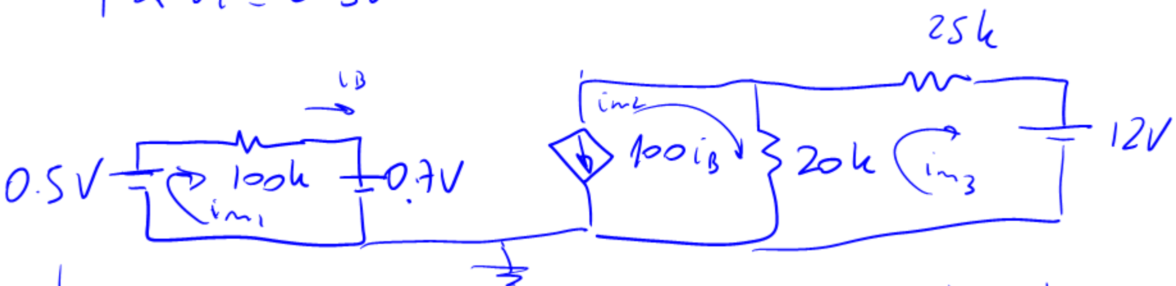
$45000 i_{m_3} = -6 - 12 = -18$

$i_{m_3} = \frac{-18}{45000} = -\frac{2}{5000} = -0.2 \cdot 10^{-3} = -400\mu A$

$V_O = 20000(i_{m_2} - i_{m_3}) = 20{,}000\,\Omega\, 100\mu A = 2\cdot 10^4\, 1\cdot 10^{-4} = 2V$

$\frac{V_O}{V_i} = 2$

For $V_i = 0.5V$



↳ In reality a BJT transistor will not operate appropriately with this input voltage because it is less than 0.7V. But for the sake of completing the calculations let's solve the circuit:

#1 $\quad 0.5 - 0.7 = 100{,}000\, i_{m_1} \rightarrow i_{m_1} = \dfrac{-0.2}{1.10^{5}} = -2\mu A$

#2 $\quad i_{m_2} = -100\, i_B = 200\mu A$

#3 $\quad 12 + 45000\, i_{m_3} - 20000\, i_{m_2} = 0$

$\hookrightarrow i_{m_3} = \dfrac{4 - 12}{45000} = -177.7\mu A$

$V_o = 20000(i_{m_2} - i_{m_3}) = 7.554V$

$\dfrac{V_o}{V_i} = 15.11$

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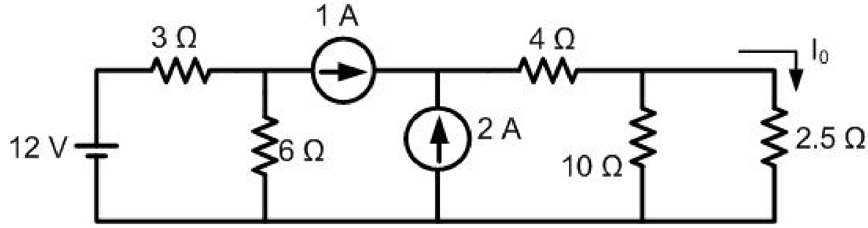
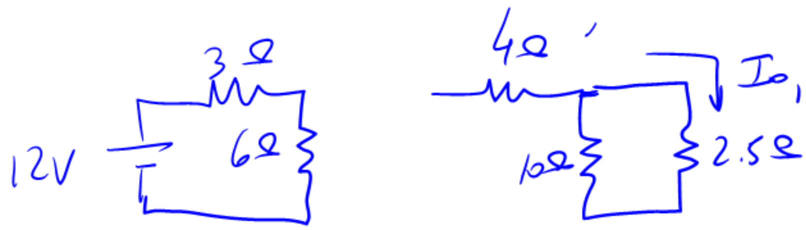
Problem 2 (25 points)

Apply superposition in order to obtain I_0.



a) 12V voltage source on, rest off

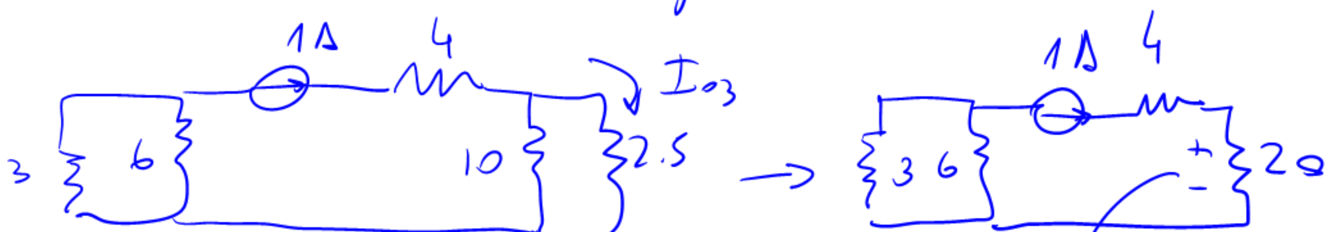


$I_{o1} = 0$

b) 2A current source on, the rest off

$I_{o2} = \frac{4}{2.5} = 1.6A$

c) 1A current source the only one on



$V = 2.1 = 2\,V$

$I_{o3} = \frac{2}{2.5} = 0.8$

$I_o = 1.6 + 0.8 = 2.4A$

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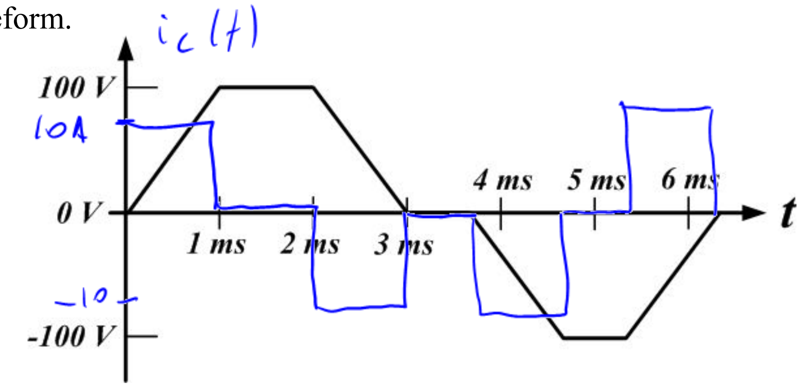
Problem 3 (15 points)

The figure shows the voltage waveform for a 100 μF capacitor. Sketch the capacitor current waveform.



$$i_c = C\frac{dV_c}{dt}$$

$0 \leq t \leq 1ms \rightarrow i_c = 100 \times 10^{-6} \frac{100}{1.10^{-3}} = 10A$

$1 \leq t \leq 2ms \rightarrow i_c = 0$

⋮ the rest follows the same idea

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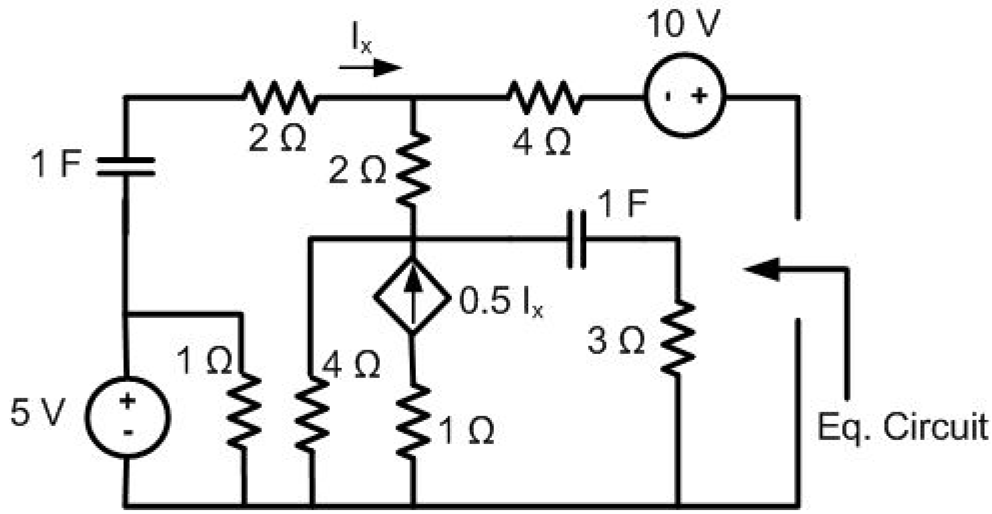
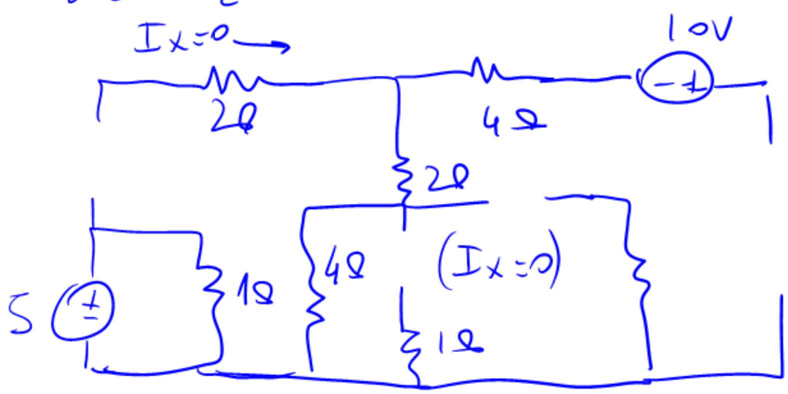
Problem 4 (30 points)

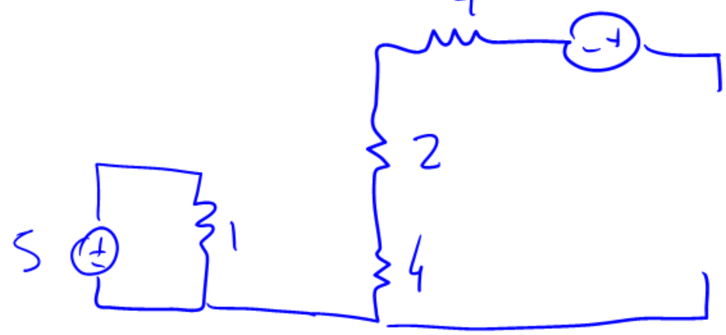
Find the Thevenin and Norton equivalents for the circuit in the next figure under dc conditions.



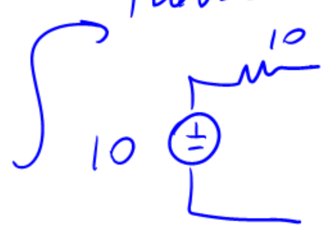
Since in dc $i_c = 0$ then the circuit is



Thus, the simplified circuit is



Thevenin:



Norton

$I_N = \frac{V_{TH}}{R} = \frac{10}{10}$