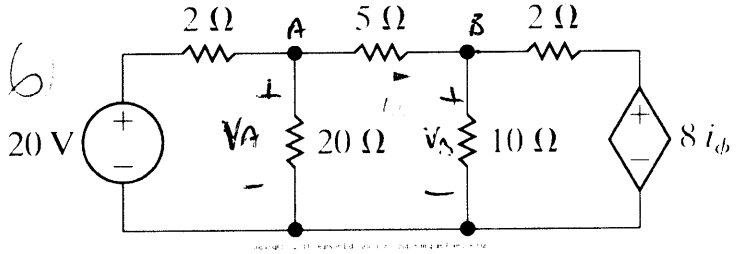
ECEN 2632 - Fall 2013 Test #2 **100 points** **NAME** KEY

(Please show ALL of your work and label the circuits to achieve maximum credit)

1. [25 POINTS] Use the node-voltage method to determine the current through the 5 Ω resistor (i_ϕ). Label your nodes on the circuit



i) $\frac{V_A - 20}{2} + \frac{V_A - V_B}{5} + \frac{V_A}{20} = 0$ 6

$10V_A - 200 + 4V_A - 4V_B + V_A = 0$

$15V_A - 4V_B = 200$

ii) $\frac{V_B - V_A}{5} + \frac{V_B}{10} + \frac{V_B - 8I_\phi}{2} = 0$ 8

iii) $I_\phi = \frac{V_A - V_B}{5}$

$2V_B - 2V_A + V_B + .5V_B - 40\left(\frac{V_A - V_B}{5}\right) = 0$

$8V_B - 2V_A - 8V_A + 8V_B = 0$

$16V_B - 10V_A = 0$

$V_A = 1.6V_B = 16V$

$15(1.6)V_B - 4V_B = 200$

$24V_B - 4V_B = 20$

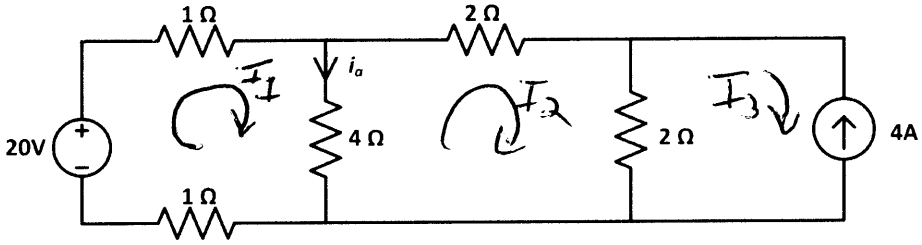
$20V_B = 200$

$V_B = 10V$

$I_\phi = \frac{16 - 10}{5} = \frac{6}{5}$

$I_\phi = 1.2\ A$

2. [25 POINTS] Use Mesh-current analysis to determine the current i_a. Show your mesh loops on the figure.



I) $-20 + I_1 + 4(I_1 - I_2) + I_1 = 0$

$6I_1 - 4I_2 = 20$

II) $4(I_2 - I_1) + 2I_2 + 2(I_2 - I_3) = 0$

$-4I_1 + 8I_2 - 2I_3 = 0$

III) $I_3 = -4A$

$6I_1 - 4I_2 = 20$

$-4I_1 + 8I_2 = -8$

$\Rightarrow$ $12I_1 - 8I_2 = 40$

$-4I_1 + 8I_2 = -8$

$8I_1 = 32$

$I_1 = 4A$

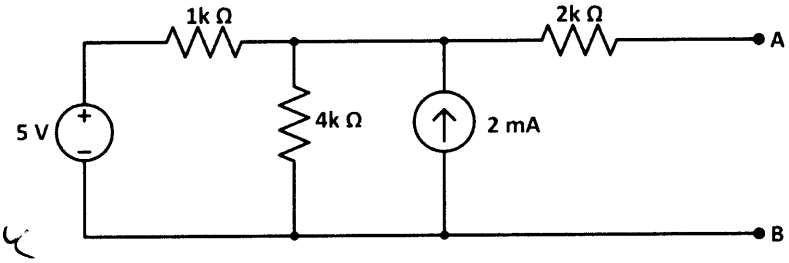
$-4I_2 = 20 - 6(4)$

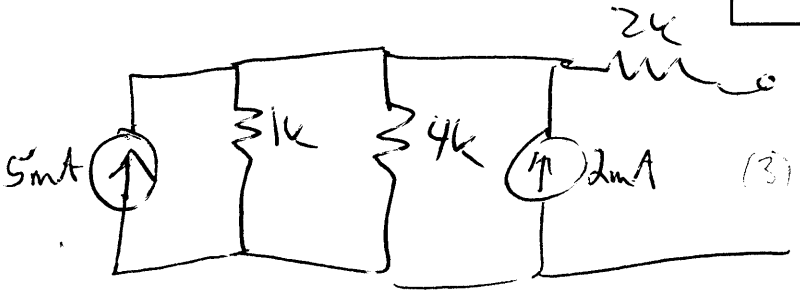
$I_2 = \frac{-4}{-4} = 1A$

$i_a = I_1 - I_2$

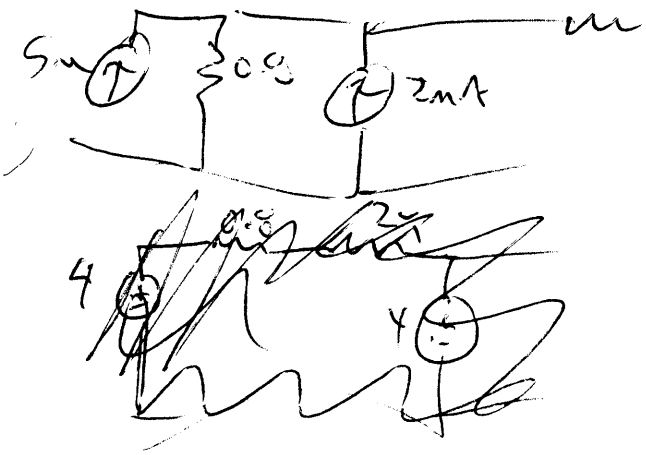
$i_a = 4 - 1 = 3A$

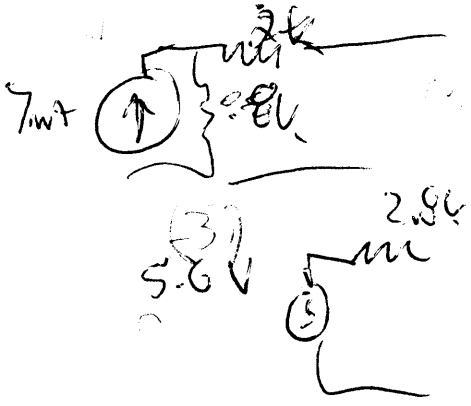
3. [25 POINTS] Find the Thevenin and Norton equivalent circuits with respect to terminals A-B.



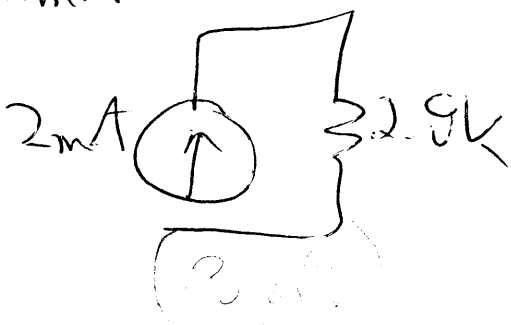


$1k \parallel 4k = 0.8k$





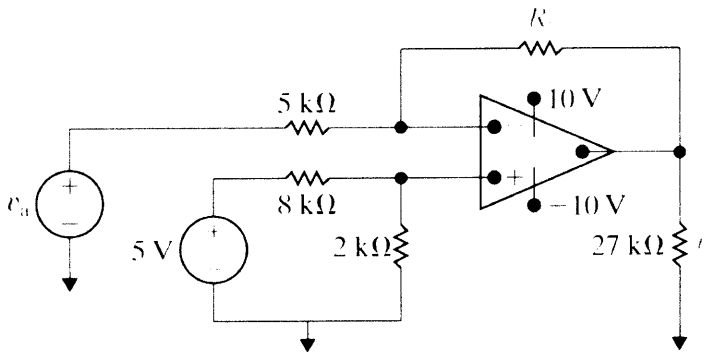
$\frac{5.6}{2.8k} = 2mA$



4. [25 POINTS]Given that this is an ideal Op-amp and $R_f = 20k\Omega$ and v_a = 1V

   a) Find v_o

   b) What is the range of v_a that allows the op amp to operate in its linear range?



$V_p = V_N \qquad i_p = i_n = 0$

$$V_o - \left(\frac{2k}{10k}\right) 5 = 1\,V$$

$$\frac{V_N - V_A}{5k} + \frac{V_N - V_o}{20k} + \cancel{i_n}^{\,0} = 0$$

$$4V_N - 4V_A + V_N - V_o = 0$$

$$V_o = 5V_N - 4V_A$$

$$V_o = 5 - 4 = 1\,V$$

b) $10 = 5 - 4V_A$

$-4V_A = 5$

$V_A = -\frac{5}{4} = -1.25$

$-10 = 5 - 4V_A$

$-15 = -4V_A$

$V_A = \frac{15}{4} = 3.75$

$-1.25\,V \leq V_A \leq 3.75\,V$