School of Engineering
Department of Electrical and Computer Engineering

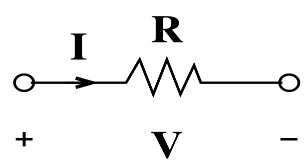
332:221 **Principles of Electrical Engineering I** **Fall 2012**

Quiz 1

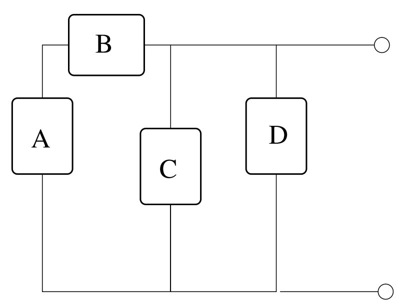
No calculators, no books, no class notes, no nuttin'! Just a pencil/pen, your one side of 8.5×11 ***cheat sheet and you. Final answers must appear in the appropriate box. Show your work outside the box.***

1. *(24 pts)* **Really Basic Stuff:**

   (a) *(2 pts)* $V =$ IR



   (b) *(12 pts)* TRUE/FALSE:



A in series with B: **T** C in series with $A+B$: **F**

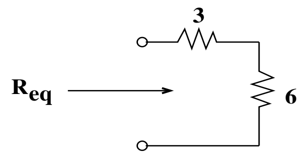
C in parallel with $A+B$: **T** B in parallel with D: **F**

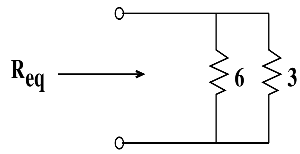
D in parallel with C: **T** A, B and D in series **F**

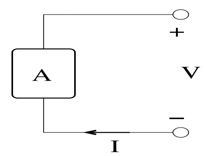
   (c) *(2 pts)* [1] : [3] : [4] : [9] : **X** [12] :

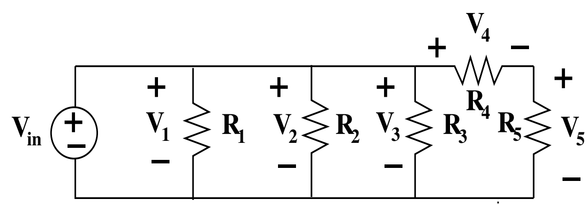
   (d) *(2 pts)* [9] : [6] : [3] : [2] : **X** [1] :

   (e) *(2 pts)* Element A *absorbs* power $P =$ $-VI$



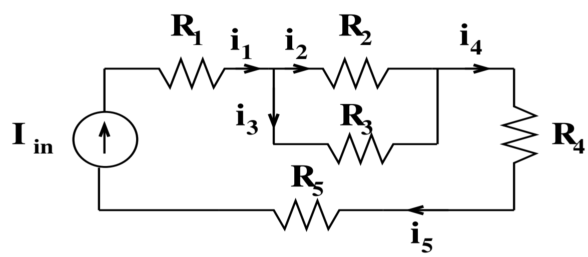






(f) *(2 pts)* What is $V_1 + V_2 + V_3$ in terms of $V_{\mathbf{in}}$? $3V_{\mathbf{in}}$

(g) *(2 pts)*

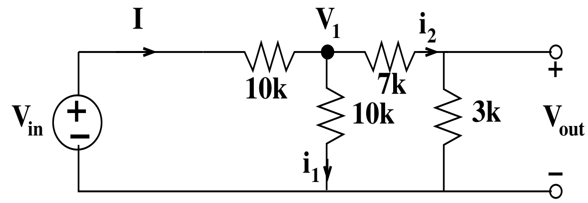


What is $i_4 + i_1$ in terms of $I_{\mathbf{in}}$? $2I_{\mathbf{in}}$

2. *(12 pts)* **Less Basic:**

(a) *(3 pts)* What is i_1 in terms of I? $I/2$

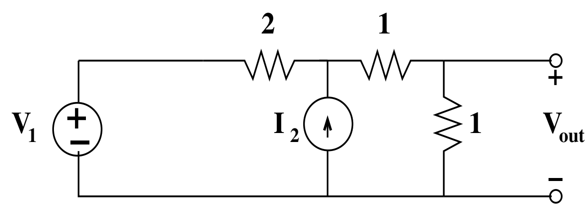
(b) *(3 pts)* What is I in terms of $V_{\mathbf{in}}$? $V_{\mathbf{in}}/15k$



(c) *(3 pts)* What is V_1 in terms of V_{in}? $V_{\mathbf{in}}/3$

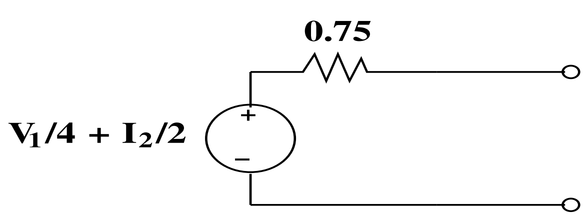
(d) *(3 pts)* What is V_{out} in terms of V_{in}? $V_{\mathbf{in}}/10$

3. *(14 pts)* **Multiple Approaches (courtesy of Jackie):**

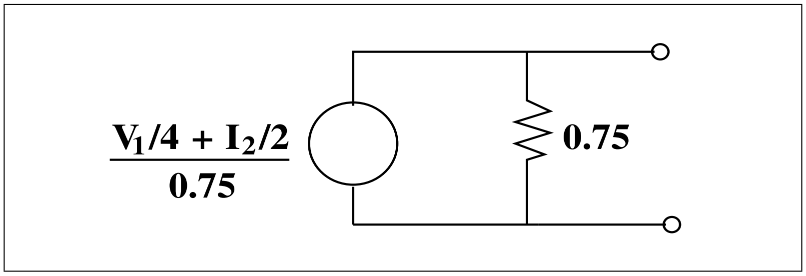


(a) *(6 pts)* What is V_{out} in terms of V_1 and I_2? $V_{\mathbf{out}} = \frac{V_{\mathbf{1}}}{4} + \frac{I_{\mathbf{2}}}{2}$

(b) *(4 pts))* Sketch and label the Thevenin equivalent as seen from V_{out}.



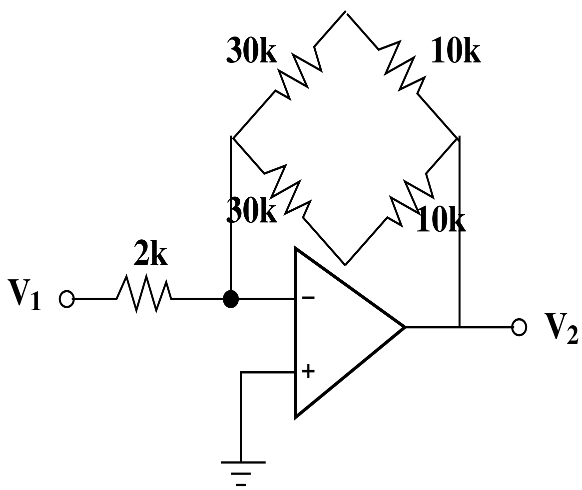
(c) *(4 pts))* Sketch and label the Norton equivalent as seen from V_{out}.



4. *(15 pts)* **Basic Amplifiers and Chuck's Bridges:**

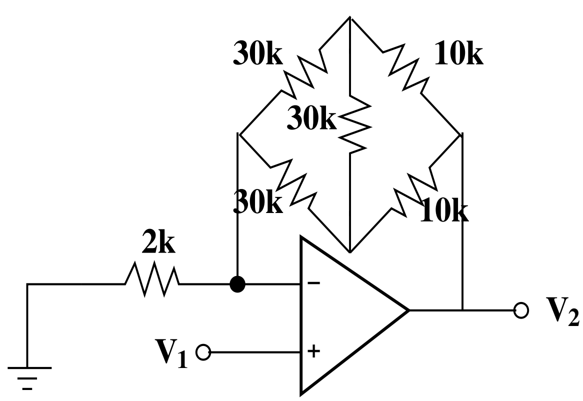
The op-amps in this problem are ideal.

(a) *(5 pts)* Please determine V_2 as a function of V_1.



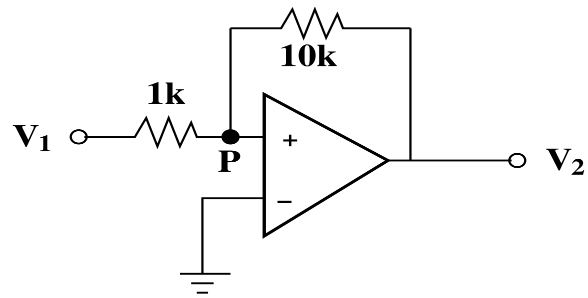
$V_2 = -10V_1$

(b) *(10 pts)* Please determine V_2 as a function of V_1. HINT: THINK FIRST (you too,



Chuck)!

$V_2 = 11V_1$

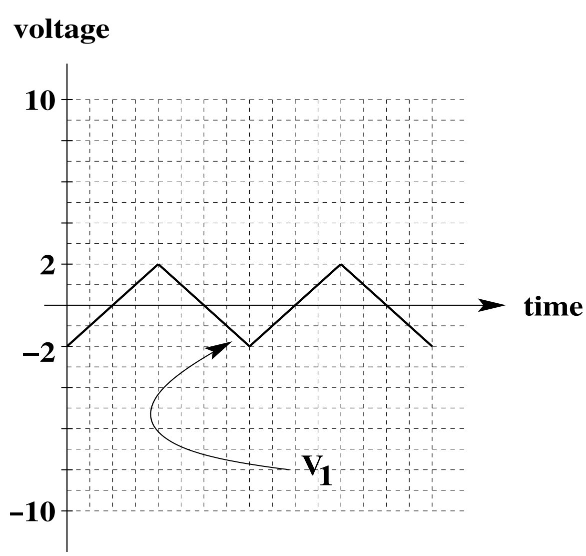


5. *(15 pts)* **Positive Feedback for Evan:**

(a) *(5 pts)* Assume the ideal op-amp in the figure has a supply voltage of $\pm 10V$. Assume V_2 is initially at $-10V$ and V_1 is initially at $-2V$. Describe in words what happens to V_2 as V_1 is raised continuously from $-2V$ to $2V$ HINT: Note the polarity of the op-am inputs and pay close attention to the potential of node P.

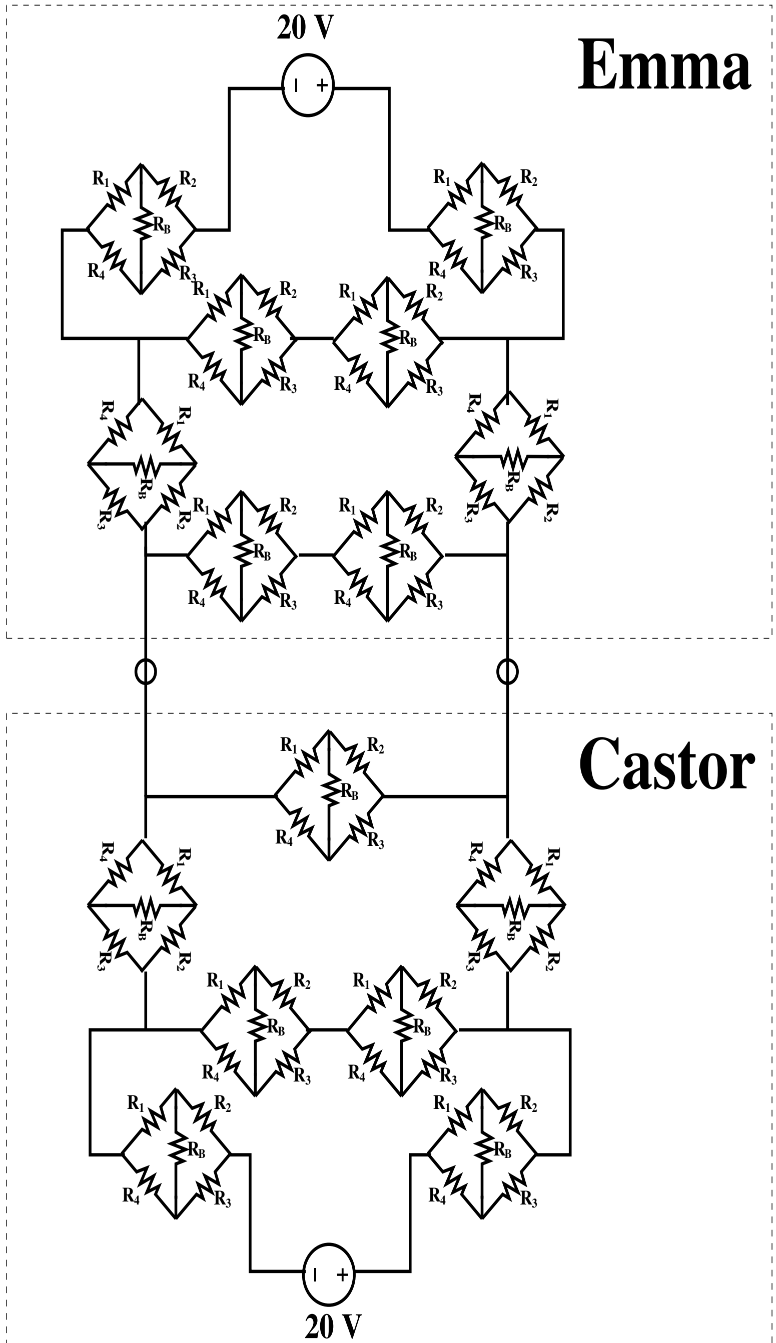
Voltage divider between V_1 and V_2 through the resistors Output will stay pinned at $-10V$ until $V_1 = 1V$ at which point the op-amp input will have zero volts and its output will snap to zero volts (ideally). But that raises P above zero so the output snaps to $10V$ and stays there as V_1 is further increased.

(b) *(10 pts)* Suppose $V_2 = -10$ at $t = 0$ and V_1 follows the time course shown. Please plot V_2 as a function of time on the same axes.



Starts at -10 and snaps up to 10 when $V_{in} = 1$, then back down again when V_{in} exceeds -1 volt. Repeat.

6. *(20 pts)* **Emma The Electrical Engineer and the Battling Circuits:**



Once again, Emma the Electrical Engineer (a Rutgers ECE alum!) finds herself battling her arch nemesis, Dr. Castor Canadensis, a particularly diabolical (and well-educated) beaver. Emma has designed a circuit as labeled. As you know, resistors dissipate energy. The resistor R_B in each bridge element provides a specific amount of heat to an associated reaction chamber. Each reaction chamber brews a trial drug which Emma's boss (a big pharma concern) is developing to pacify troublesome beavers for capture and disposal.

Castor gets wind of the project and attaches his own circuit as shown to Emma's circuit, hoping to disrupt the brews by transferring power to Emma's circuit (the brews "denature" if they get too hot).

(a) *(5 pts)* $R_1 = 1k$, $R_2 = 10k$, $R_3 = 40k$, $R_4 = 3k$ and $R_B = 100k$. Does Castor's circuit achieve his objective? (Yes/No):

No

(b) *(15 pts)* Why?/Why not?

All we care about is whether power flows from top to bottom or from bottom to top. Each bridge is a one-port resistive network with a given (and identical in this case since the bridges are identical) resistance, R. Likewise, Emma's and Castor's networks are identical from the voltage source through the six closest bridges. These identical subnetworks can be reduced to identical Thevenin equivalents.

So, the specific resistance values DO NOT MATTER.

The difference is that Emma's network is loaded with a resistance $2R$ while Castor's is loaded with R. Thus, the Thevenin equivalent for Castor's COMPLETE network will have a LOWER EQUIVALENT VOLTAGE than Emma's (voltage divider to calculate the open circuit voltage). When those networks are linked, current will flow from Emma's to Castor's network (through the positive terminal) and power is supplied to Castor's network.

And yes, the equivalent resistance of Castor's and Emma's network is different. But it's the difference in voltages that trumps when considering power.