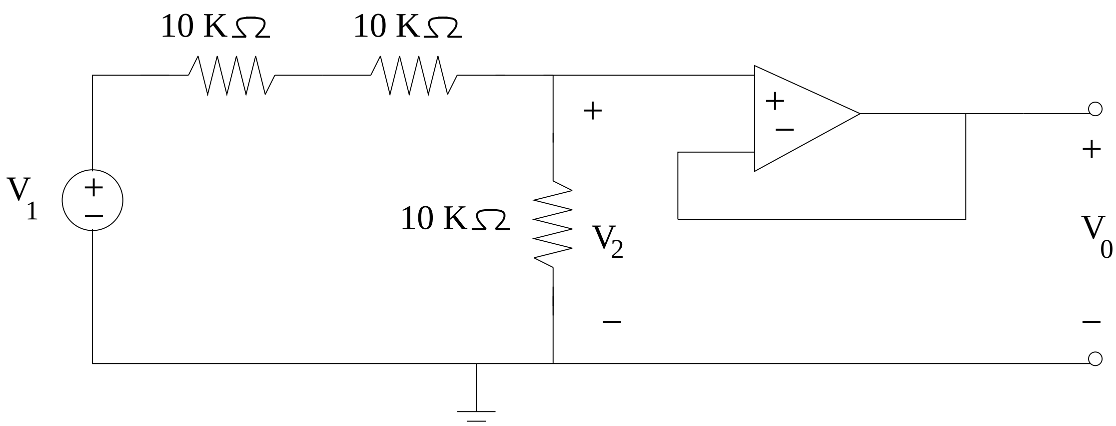
ECE 53a	Quiz #2 SOLUTIONS	Pamela Cosman	2/11/09

Problem 1: This is Bobrow problem 2.31, which was assigned to you as part of homework set 3. The solution set for the homework was already posted.

Problem 2:
(a) This problem was taken directly from quiz 2 from last year. The solution set for that was already posted too. But I repeat the solution here:
In class, I discussed how to use op amps to scale voltages up and down, including both inverting and non-inverting configurations. This problem corresponds to case 4. The configuration we need is:



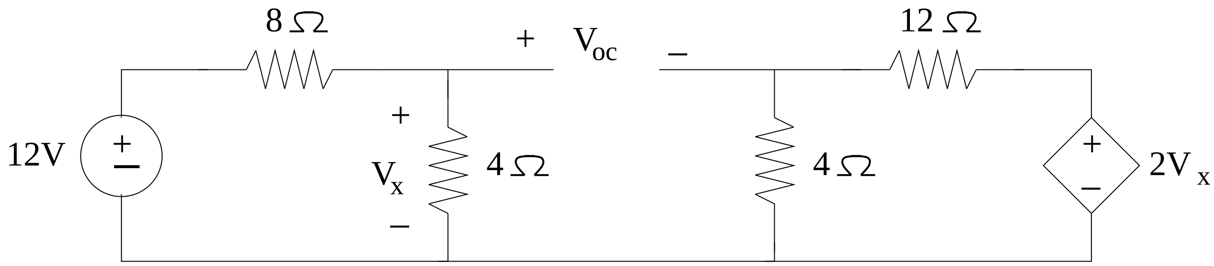
(b) Now the amplifier is no longer an ideal op amp, but rather a finite-gain amplifier with gain A=100.
It is still the case, however, that $V_2 = \frac{V_1}{3}$ where V_1 is the source voltage, because no current goes into the input terminals of the op amp, so the left hand side of the circuit is still doing voltage division.
Now we can write

$$V_0 = 100(\frac{V_1}{3} - V_0) \qquad 3V_0 = 100V_1 - 300V_0$$

$$303V_0 = 100V_1 \qquad V_0 = \frac{100}{303}V_1$$

So the output voltage is now 100/303 of the input voltage, rather than 1/3.
Reminder: in this course, as discussed in class, all the amplifier circuits we consider will have some kind of negative feedback connection (a connection from the output to the inverting input) not positive feedback (a connection from the output to the non-inverting input).

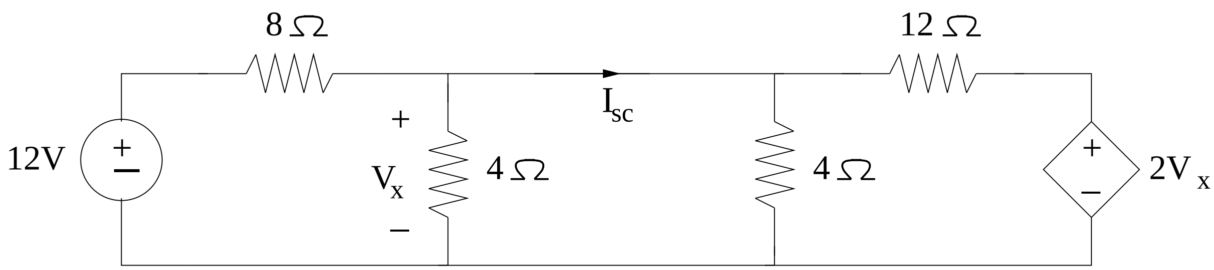
Problem 3:
To find the Thevenin equivalent circuits across those terminals, first we open circuit it and find V_{oc}:



On the left we have 12V across 12Ω so the current there is 1A. So $V_x = 4$V.
Because $V_x = 4$V, on the right hand side we have an 8V source across 16 Ω, so the current going around there is 0.5 A.
That means the drop across the 4Ω resistor on the right is 2A.

$$v_{oc} = 4V - 2V = 2V$$

Next, we can find the short circuit current:



Writing KCL for the node V_x where the defined branch current I_{sc} originates:

$$\frac{12 - V_x}{8} = I_{sc} + \frac{V_x}{4}$$

We can also write KCL for the node where the defined branch current I_{sc} terminates:

$$I_{sc} = \frac{V_x}{4} + \frac{V_x - 2V_x}{12}$$

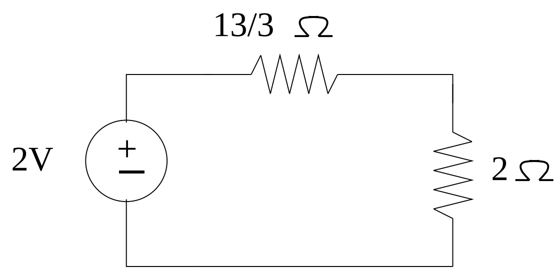
We can solve these two equations to get

$$I_{sc} = \frac{6}{13}$$

Then

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{2}{6/13} = \frac{13}{3}$$

We can now draw out the little Thevenin circuit with the load resistor re-attached:



from which we get the current is

$$I_o = \frac{2}{13/3 + 2} = \frac{6}{19}$$

Problem 4:
This is an example which I did completely in lecture.

$$i(t) = C\frac{dV_c(t)}{dt} = 2\frac{dV_c(t)}{dt} = \begin{cases} 0 & \text{for} \quad t \leq 0 \\ 2 & \text{for} \quad 0 < t \leq 1 \\ 0 & \text{for} \quad t > 1 \end{cases}$$

Because no current goes into the input terminals of the op amp, $I_R(t) = i(t)$.
By Ohm's Law,

$$V_R(t) = 2I_R(t) = 2i(t)$$

which was given above.
Because this is an ideal op amp, the two input terminals are at the same voltage, therefore $V_s(t) = V_R(t)$
Lastly, the output voltage is

$$V_o(t) = V_c(t) + V_R(t) = \begin{cases} 0 & \text{for} \quad t \leq 0 \\ t+4 & \text{for} \quad 0 < t < 1 \\ 1 & \text{for} \quad t > 1 \end{cases}$$