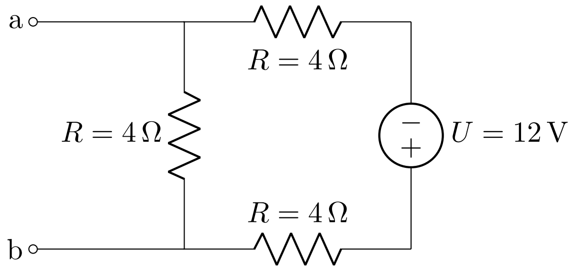
Tutorial Questions: Thevenin/Norton Equivalent, Maximum Power

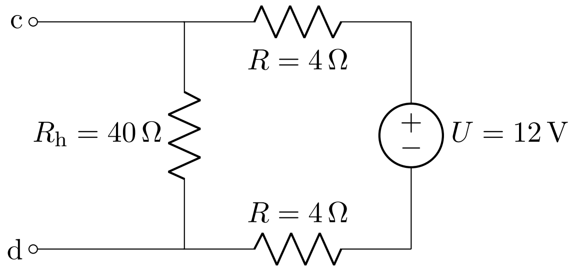
0. Quick, numeric, lab-relevant

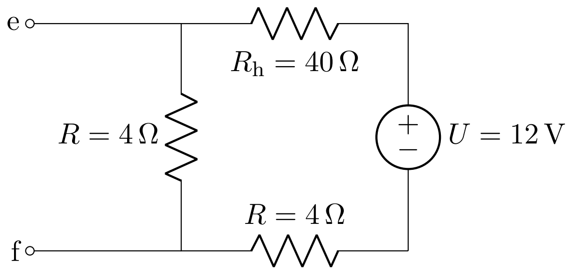
Find two-terminal equivalents (let's suggest Thevenin equivalents) of the following four circuits, between their pairs of letter-marked terminals. Be careful about directions.

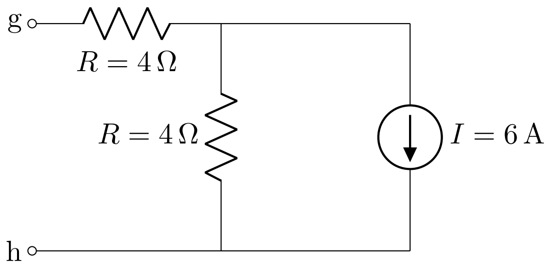
Finding open-circuit voltage then finding equivalent resistance by setting the sources to zero is probably easiest.

Some of the point of this is to get quicker at judging the Thevenin reistance, which is relevant in lab2. (It was relevant in lab1 too, if you think of the dividers' outputs being Thevenin sources loaded by connecting a voltmeter.)







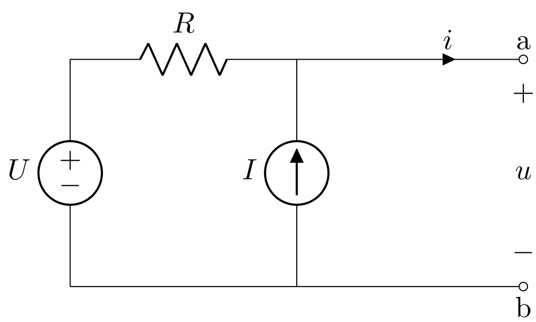


1. By finding u, i relation directly

This circuit came up in the lecture notes (2016) as an example solved by finding short-circuit and open-circuit behaviour.

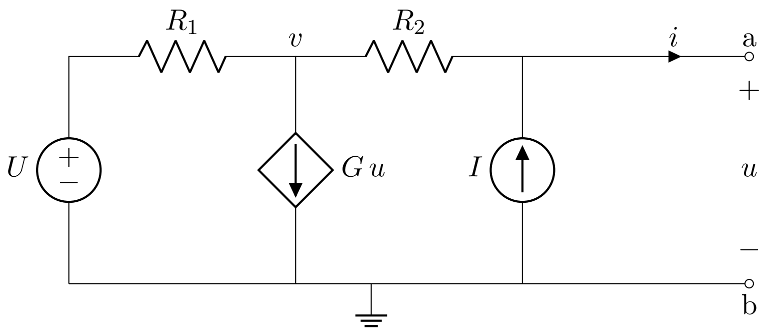
Try it now by the method of finding an equation that relates u and i. This is the first method shown in the notes, but it was shown there on a more complicated circuit.

Find the Norton equivalent of this circuit between terminals a-b. Check whether you agree with the solution in the notes.



2. By short-circuit current and open-circuit voltage

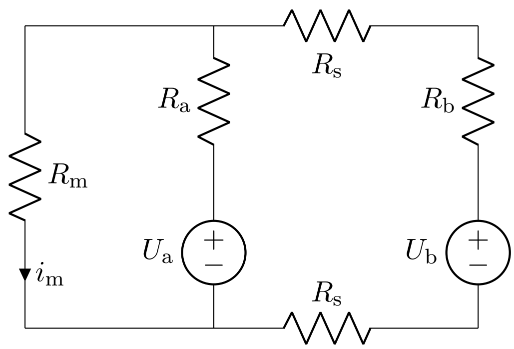
This circuit also came up in the notes, as the first example. Try doing that again to find the Thevenin equivalent at a-b, but this time use the method of finding $i_{\rm sc}$ and $u_{\rm oc}$.



3. Homework 3, task 'Q1'

This was solved in the homework (3, nodal analysis), and was suggested for the previous tutorial (4a) as a superposition question.

Now, to simplify the algebra, assume $U_{\rm a} = U_{\rm b} = U$ and $R_{\rm a} = R_{\rm b} = R_{\rm s} = R$. (We like keeping the different names in order to distinguish the components if writing solutions: but use just U and R as the components' values in your equations.)



What value of $R_{\rm m}$ (as a function of U and R) will result in the highest possible power being delivered to $R_{\rm m}$?

What is the delivered power to $R_{\rm m}$ in this case?

(Are you interested enough to go and find the numeric values from HW3, to put in here?)

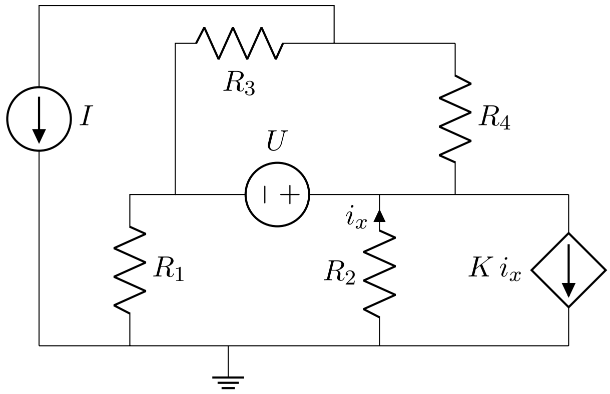
Suggestion: first, find the Thevenin equivalent of everything except for $R_{\rm m}$, seen at the terminals where $R_{\rm m}$ connects. Use the direct method for finding the equivalent resistance by setting all (independent) sources to zero.

4. A dependent source

And here's another familiar circuit, that came up in the superposition questions.

This time, for simplicity of equations, let's define R, and let $R_1 = R_2 = R_3 = R_4 = R$.

Find what value of source I should be chosen in order to maximize the power supplied *to* this current source from the rest of the circuit.



Suggestion:
Mark the two terminals (e.g. a-b or x-y) where the source I connects to the rest of the circuit. Find a Norton (or Thevenin) equivalent of everything except I, at those terminals. From that, find what value I is needed for maximum power transfer.
Redrawing might help a bit. You might see a way to combine R_2 and $K\,i_x$ into a single resistor (e.g. R_{2k}), because of this special situation where the current controlling the dependent source is the current in a resistor in parallel with that source. Then you might see each of the resistor pairs $R_{1|2k}$ and $R_{3|4}$ as a divider.