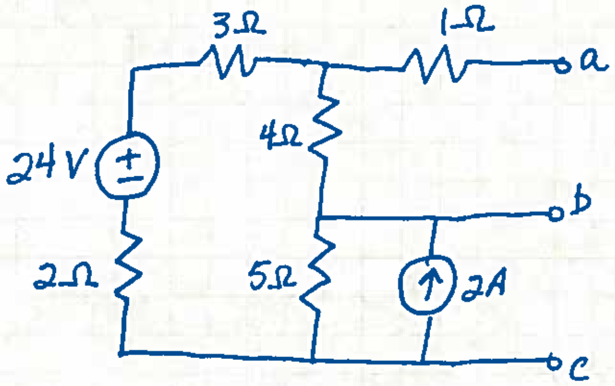
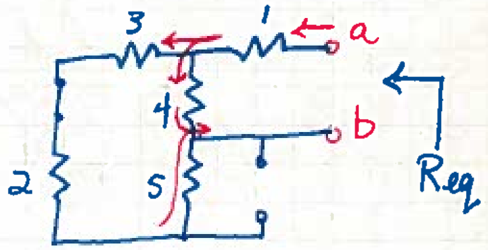
Class Problem - Thevenin Equivalent Circuits

Obj → to demonstrate that the Thevenin equivalent circuit is dependant upon which terminals, or nodes, you specify as the output nodes

Circuit



ⓐ Specifying terminals a-b as the output terminals
This means that "b" is the ground or 0V node, in this situation.



Find R_{Th} • zero out sources
• find Req from "a" to "b"

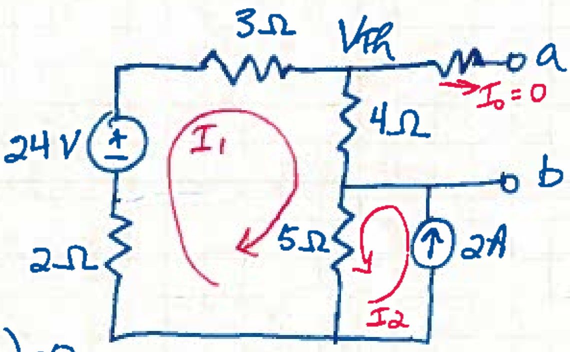
Req starting at node "a", flowing around through all branches and coming back together to flow out "b"
we see $R_{eq} = 1 + (3+2+5) \| 4 = 1 + 10\|4 = 1 + 2.86 = \boxed{3.86\Omega}$

Find V_{Th} • replace all sources, to return to original circuit
• identify which voltage = V_{Th}
• find that voltage using all / any circuit analysis technique that is useful.

- As required for this method (finding a Thevenin equivalent circuit), you must have an open circuit across the specified output terminals ("a"-"b" for now)

- This means no current flows at the output terminals
- So, for this example, no current flows through the 1Ω resistor
- Therefore there is no voltage difference across the 1Ω R
- So, $V_{Th} = V_{a\text{-}b} = V_{\text{across-the-}4\Omega\text{-}R}$

<u>Finding V_{Th}</u>



Using mesh analysis

KVL:

$2I_1 - 24 + 3I_1 + 4I_1 + 5(I_1 + I_2) = 0$

note $I_2 = 2A$

$14I_1 - 24 + 10 = 0$

$14I_1 = 14$ so $I_1 = 1A$

Ohm's law for the 4Ω R, which shares our output nodes (since $I_o = 0$)

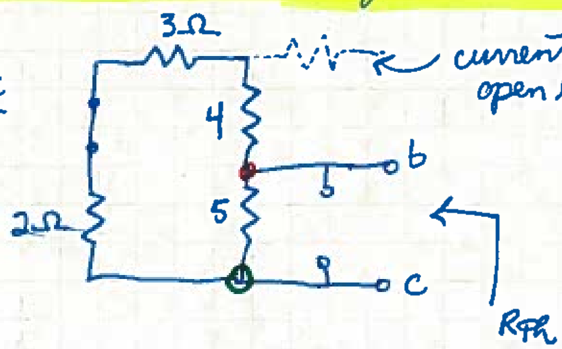
$V_{Th} = IR = (1A)(4\Omega) = 4V$

*Final thevenin equivalent circuit *

This means a load connected to terminals "a-b" above, or to the equivalent at left will not be able to distinguish between them

(b) Thevenin equivalent for terminals b-c

R_{Th} b-c



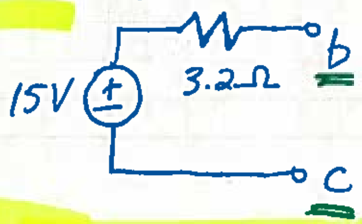
Being an electron that is traveling from "b" to "c" you would immediately encounter a branching or forking path, at the red dot. Hmm, to go through the 4Ω resistor or the 5Ω resistor? But wait, the 4Ω R is in series with a 3Ω + 2Ω R, so in fact the decision is between a 5Ω R and an equivalent of (4+3+2)Ω R.

Flowing along these two branches, you would find they come back together at the common node with the green circle. These branches share 2 nodes: ● & ○

This means the 5Ω R is in parallel with (4+3+2)Ω branch

$$R_{Th} = R_{eq} = \left(\frac{1}{5} + \frac{1}{4+3+2}\right)^{-1} = 3.2\Omega$$

V_{Th} b-c The circuit analysis is the same as for V_{Th} a-b, except now you need to identify which voltage drop = V_{Th} b-c. This is the same as the voltage across the 5ΩR, & the 2A source. Using Ohm's Law for the 5Ω Resistor we find $V_{Th} = IR = (I_1 + I_2)5 = (1+2)5 = 15V$



≠ Thevenin equivalent for terminals a-b.