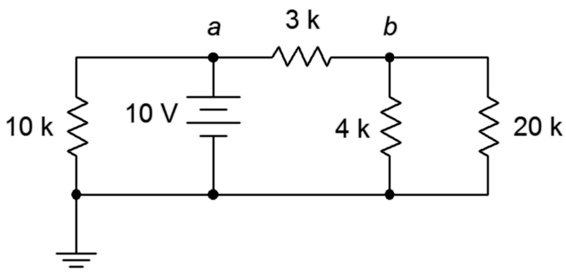
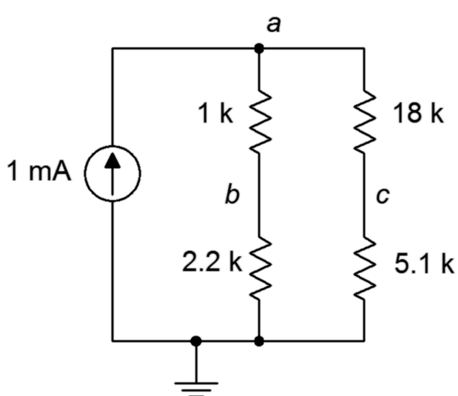
DC Circuits   Self Test: Series-Parallel and Dependent Sources

Answers are on the final pages

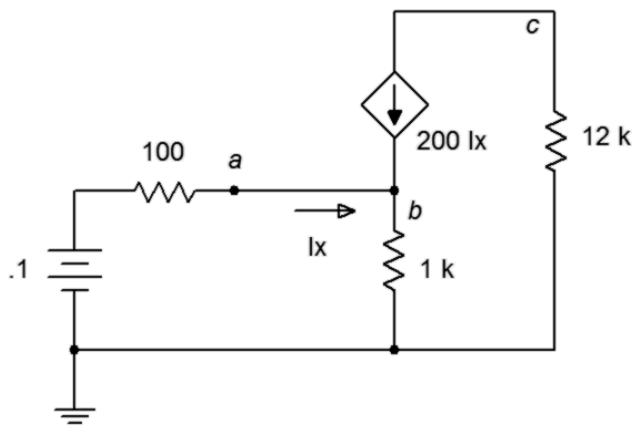
1. For the circuit below, find voltage V_{ab}. Also find the current through the 20 k.



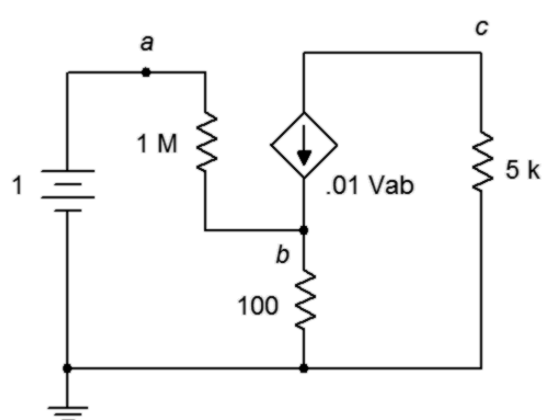
2. For the circuit below, find voltage V_{bc} Also find the current through the 1 k.



3. For the circuit below, find the voltage across the 12 k.

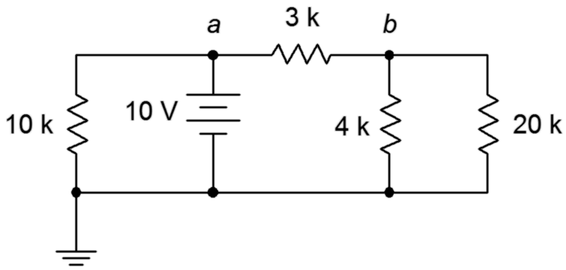


4. For the circuit below, find the voltage across the 5 k.



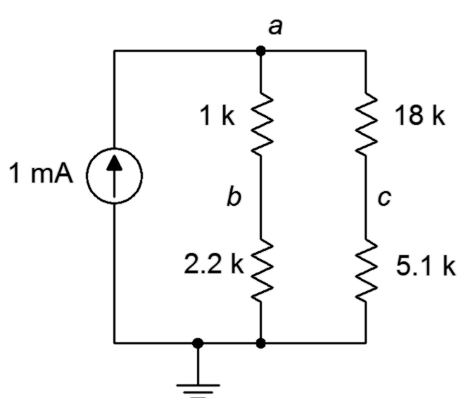
Answers

1. For the circuit below, find voltage V_{ab}. Also find the current through the 20 k.



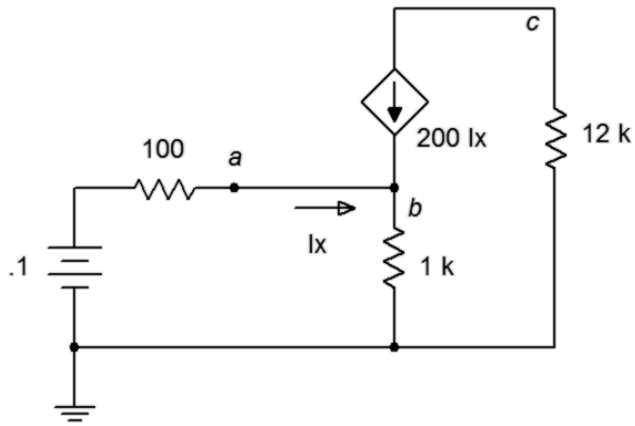
By definition, Vab = Va-Vb. By inspection, Va = 10 V. Vb may be found via a voltage divider between the 3 k and the 4 k||20 k combo. 4 k||20 k = 3.333 k
Vb = 10V*3.333 k/(3.333 k + 3 k) = 5.263 V
Thus, Vab = 4.737 V
Knowing Vb, the current through the 20 k is found via Ohm's law.
I = Vb/20 k = 5.263 V/20 k = .2631 mA

2. For the circuit below, find voltage V_{bc} Also find the current through the 1 k.



By definition, Vbc = Vb-Vc. These can be found via Ohm's law once the currents are known. The currents may be determined via current divider rule and KCL. Treat each series pair as a single resistance (3.2 k left, 23.1 k right)
I_{left} = 1 mA * 23.1 k/(23.1 k + 3.2 k) = .8783 mA (I of 1 k, also)
I_{right} = 1 mA - .8783 mA = .1217 mA
Vb = .8783 mA * 2.2 k = 1.932 V
Vc = .1217 mA * 5.1 k = .6207 V
Vbc = 1.932 V - .6207 V = 1.311 V

3. For the circuit below, find the voltage across the 12 k.



Using nodal analysis, define the currents at node b.
$Ix + 200Ix = I_{1k}$

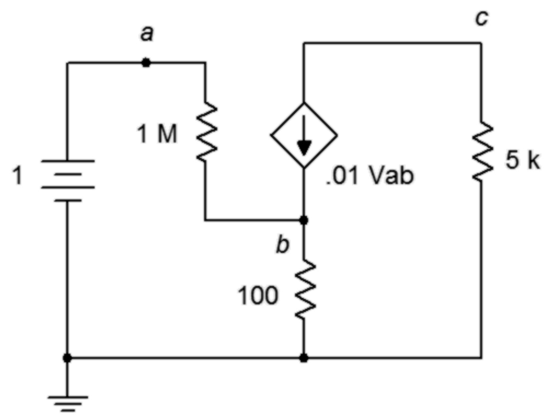
Ix is the current flowing through point a. Also, Va = Vb.
Further, note that Ix = (.1-Vb)/100.

Expand:
201(.1-Vb)/100 = Vb/1 k
.201 = Vb(201/100 + 1/1 k)
Vb = 99.9502735 mV
Therefore Ix = (100 mV – 99.9502735 mV)/100 = .497265 uA
And finally, V of 12 k = 12 k * 200 * .497265 uA = 1.193 V

Crosschecking: I Of 1 k = Vb / 1 k = 99.9502735 uA
Ix + 200*Ix = 99.950265 uA so KCL checks within round-off error.

FYI: the circuit above is a simplified amplifier using a bipolar junction transistor. The amplification factor is approximately equal to the ratio the right and middle resistors.

4. For the circuit below, find the voltage across the 5 k.



Using nodal analysis, define the currents at node b.
$I_{1M} + .01Vab = I_{100}$

Note that $I_{1M} = (1-Vb)/1$ M, and that $Vab = 1 - Vb$.

Expand:
(1-Vb)/1 M + .01(1 – Vb) = Vb/100
1/1 M – Vb/1 M + .01 - .01Vb = Vb/100
.010001 = Vb(1/1M + .01 + 1/100)
Vb = .5200024999 V
Therefore, Vab = 1 V - .500024999 V = .499975 V
The VCCS = .01 * .499975 V = 4.99975 mA
Therefore, V of 5 k = 24.999 volts.

You can also crosscheck KCL at node b but make sure that you leave many digits of precision because I_{1M} is very small compared to the other currents (roughly .5 uA).

FYI: This circuit is a simplified amplifier using an FET (field effect transistor). The amplification factor is approximately equal to the transconductance (here, .01) times the 5 k, the result then divided by the quantity 1 plus the product of transconductance times the 100 ohm. This works out to 25 for this circuit (i.e., 1 volt times 25 yields 25 volts).