ECE 255 Spring 2019

Homework 1

Due 5:00 PM Monday, Jan 14 in MSEE 180 Dropbox

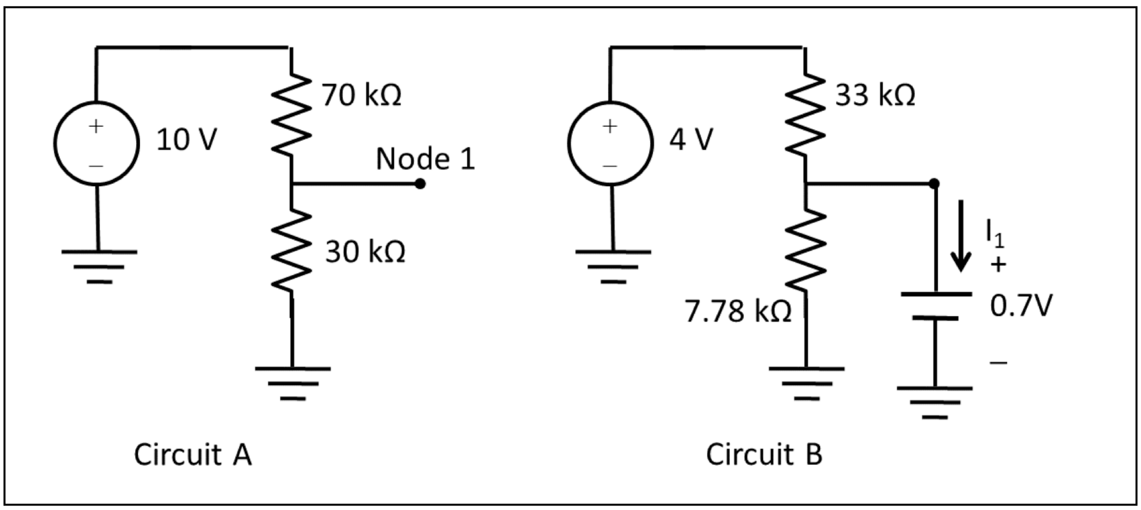
1) (Review Problem) Consider the voltage source and resistor networks shown in Figure A.

1a) For the circuit shown in Fig A, find the Thevenin equivalent network between node 1 and ground.

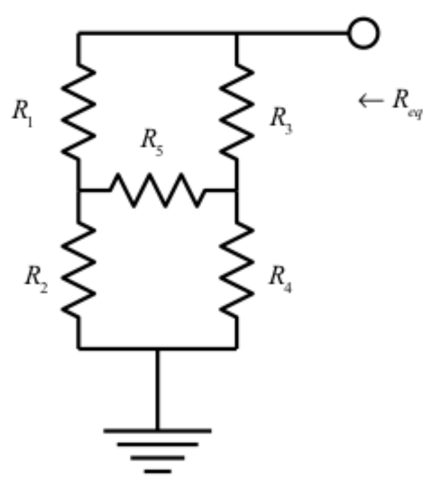
1b) For the circuit shown in Fig A, what is the open-circuit voltage between node 1 and ground (i.e. voltage on node 1 for circuit shown in figure)?

1c) For the circuit shown in Fig. A, suppose that we connect a load resistor of 21 kΩ between node 1 and ground. What is the voltage across this resistor?

1d) For the circuit shown in Fig B, what is the current I1?



2) (Review Problem) Consider the circuit below



HW1 Problem 2 (continued)

2a) Assume that $R_1 = R_2 = R_3 = R_4 = R_5 = 1\ \text{k}\Omega$ and find the Thevenin equivalent resistance, R_{eq}. (Hint: If you see what's going on, you can solve this problem by inspection.)

2b) Assume that $R_1 = 2\ \text{k}\Omega$ and all other resistors are unchanged. Find the Thevenin equivalent resistance, R_{eq}.

3) The intrinsic carrier concentration, n_i, is an important parameter for a semiconductor. An approximate expression for n_i is

$$n_i = BT^{3/2}e^{-E_G/2k_BT},$$

where the temperature, T, is in Kelvin, the bandgap, E_G in Joules, and $k_B = 1.38\times10^{-23}$ J/K is Boltzmann's constant.

3a) Assuming that $B = 4.87\times10^{15}\ \text{cm}^{-3}\text{K}^{-3/2}$ and that $E_G = 1.12\ \text{eV}$ for silicon, compute n_i at room temperature (27 ^{o}C), -55 ^{o}C and +125 ^{o}C (the lowest and highest temperatures represent the military specification for the range of temperatures over which electronics must operate). Note that we are ignoring the small but important temperature dependence of the bandgap.

3b) For operation at high temperatures, wide bandgap semiconductors are needed. Repeat prob. 3a) for gallium nitride (GaN) assuming that $E_G = 3.4$ eV and $B = 1.85\times10^{15}\ \text{cm}^{-3}\text{K}^{-3/2}$ and that T = +125 ^{o}C.

4) Consider a Si at two different temperatures: 1) room temperature, 300 K and 2) an elevated temperature of 700 K. Assuming that $n_i(300\ \text{K}) = 1.0\times10^{10}\ \text{cm}^{-3}$ and $n_i(700\ \text{K}) = 2.9\times10^{16}\ \text{cm}^{-3}$, calculate the equilibrium electron and hole concentrations (n and p) for each of the following cases. Assume that the dopants are fully ionized.

4a) intrinsic material ($N_D = N_A = 0$)

4b) $N_D = 1.00\times10^{13}\ \text{cm}^{-3}$ $N_A = 0$

4c) $N_D = 5.00\times10^{16}\ \text{cm}^{-3}$ $N_A = 0$

4d) $N_D = 0$ $N_A = 5.00\times10^{16}\ \text{cm}^{-3}$

4e) $N_D = 1.00\times10^{18}\ \text{cm}^{-3}$ $N_A = 3.00\times10^{18}\ \text{cm}^{-3}$