HW#1, Electronic Circuit, Spring semester 2020

March 20, 2020

Due: 23:55, March 25 (Wednesday night)

We have 8 problems.

In your answer file, specify both the **SOLUTION PROCEDURE** and the **FINAL SOLUTION**. Of course, for some problems (like P4 in this HW#1), you may provide only the solution.

1. Consider the crystalline silicon. The position vector of any silicon atom can be written as either $\left(\frac{j+k}{2}, \frac{i+k}{2}, \frac{i+j}{2}\right) a$ or $\left(\frac{j+k}{2}+\frac{1}{4}, \frac{i+k}{2}+\frac{1}{4}, \frac{i+j}{2}+\frac{1}{4}\right) a$ in the Cartesian coordinate system. In this problem, i, j, and k are arbitrary integers and a is 0.543 nm. Calculate the mass density of silicon. Your answer should have a unit of (atoms/cm^3).

2. Assume that the intrinsic carrier density of silicon follows the following formula:

$$n_i = 5.2 \times 10^{15}\, T^{1.5} \exp\left(-\frac{E_g}{2k_B T}\right) (\#/\mathrm{cm}^3)$$

In this expression, T is the absolute temperature in K, $E_g = 1.12$ eV, and $k_B = 8.617 \times 10^{-5}$ eV/K. At 300 K, the intrinsic carrier density is about 1X10^{10} cm^{-3}. Estimate the intrinsic carrier density at 400 K.

3. Consider a silicon cube, whose volume is given by 10 nm X 10 nm X 10 nm. When the sample is n-type doped with a doping density of 10^{20} cm^{-3}, estimate the number of electrons in the sample. Of course, in this problem, the electrons represent the ones found in the conduction band.

4. Draw the circuit schematic for the following netlist.

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v1 batt 0 1.5
rchar batt anode 1e6
cchar anode 0 1e-9
rpcss anode cathode 21
rload cathode 0 50
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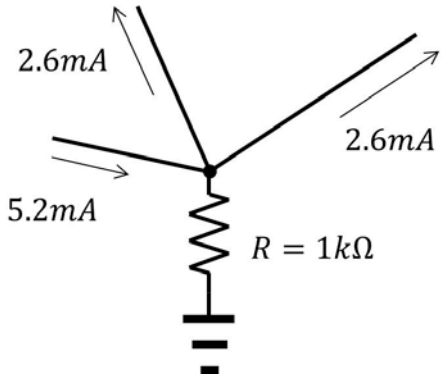
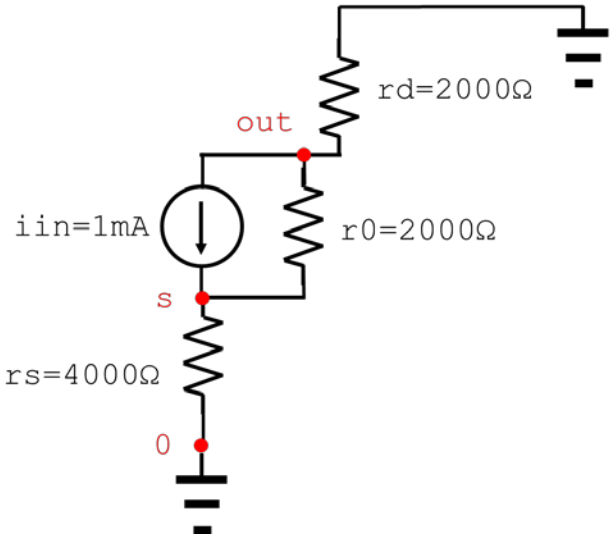
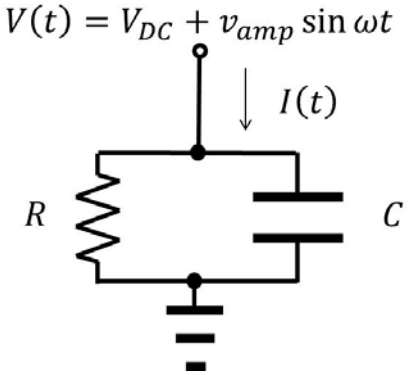
5. Calculate the node voltage.



6. We have introduced the following example in the Lecture 2. Calculate the node voltages.



7. Consider a circuit shown below. When the voltage source is given by $V(t) = V_{DC} + v_{amp} \sin \omega t$, calculate the current, $I(t)$.



8. Consider a circuit shown below. Calculate the current, $I_{ans}(t)$.