EEE109 Assignment 1 Chapter 1, 2, 3 and 5

1. A silicon semiconductor material is to be designed such that the majority carrier electron concentration is $n_o = 7 \times 10^{15}\ \mathrm{cm}^{-3}$.

   (a) Should donor or acceptor impurity atoms be added to intrinsic silicon to achieve this electron concentration?

   (b) What concentration of dopant impurity atoms is required?

   In this silicon material, the minority carrier hole concentration is to be no larger than $p_o = 10^6\ \mathrm{cm}^{-3}$.

   (c) Determine the maximum allowable temperature.

   Hints: Try to use MATLAB to solve the equation, here are two useful functions in MATLAB:
   https://ww2.mathworks.cn/help/symbolic/solve.html
   https://ww2.mathworks.cn/help/symbolic/vpa.html

2. Consider the Zener diode circuit shown in Figure 1. The Zener break-down voltage is $V_Z = 5.6\ \mathrm{V}$ at $I_Z = 0.1\ \mathrm{mA}$, and the incremental Zener resistance is $r_z = 10\ \Omega$.

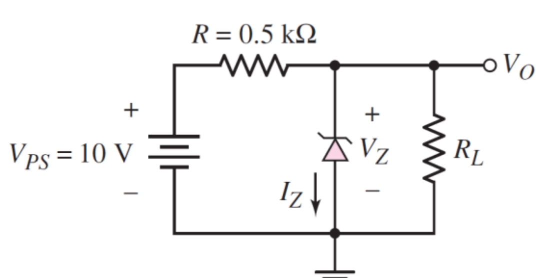

Figure 1

(a) Determine V_O with no load ($R_L = \infty$);

(b) Find the change in the output voltage if V_{PS} changes by ± 1 V;

(c) Find V_O if $V_{PS} = 10$ V and $R_L = 2$ kΩ.

3. For the input shown in Figure 2.1. Assume $V_\gamma = 0.6$ V.

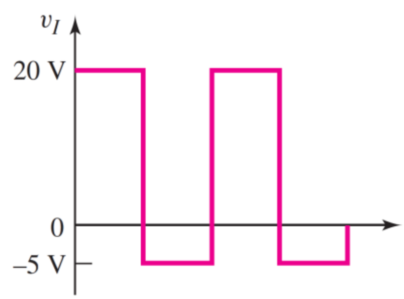

Figure 2.1

(a) Plot v_O for Figure 2.2

(b) Plot v_O for Figure 2.3

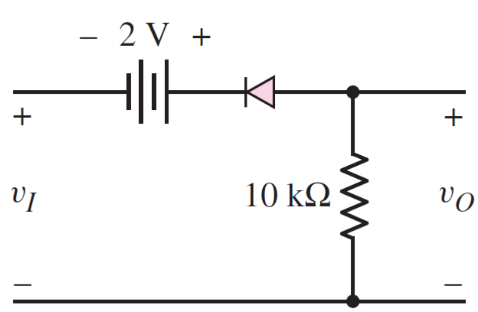

Figure 2.2

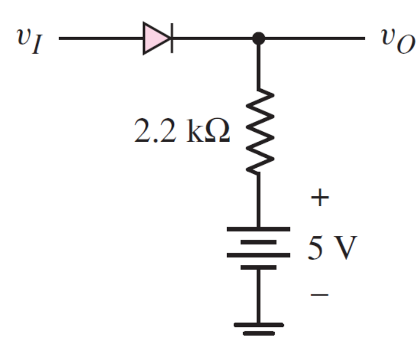

Figure 2.3

4. In the circuit in Figure 3 the diodes have the piecewise linear parameters of $V_\gamma = 0.6$ V and $r_\gamma = 0$.

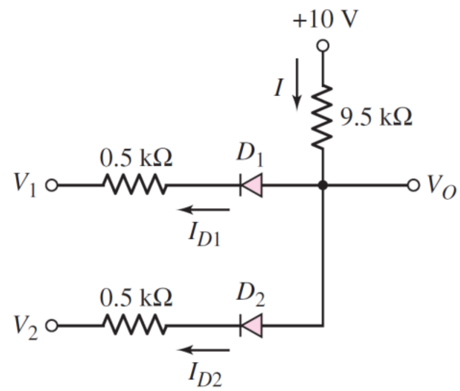

Figure 3

Calculate the output V_O and the diode currents I_{D1} and I_{D2} for the following input conditions:

(a) $V_1 = V_2 = 10$ V;

(b) $V_1 = 10$ V, $V_2 = 0$;

(c) $V_1 = 10$ V, $V_2 = 5$;

(d) $V_1 = 0, V_2 = 0$;

5. The threshold voltage of each transistor in Figure 4.1-4.3 is $V_{TN} = 0.4\ \text{V}$. Determine the region of operation of the transistor in

(a) Figure 4.1;

(b) Figure 4.2

(c) Figure 4.3

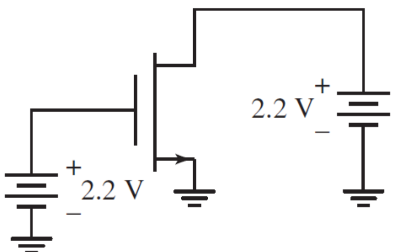

Figure 4.1

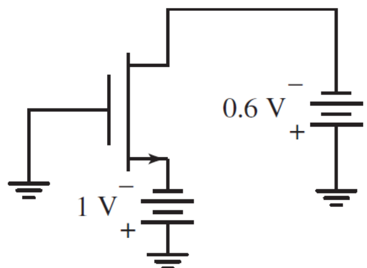

Figure 4.2

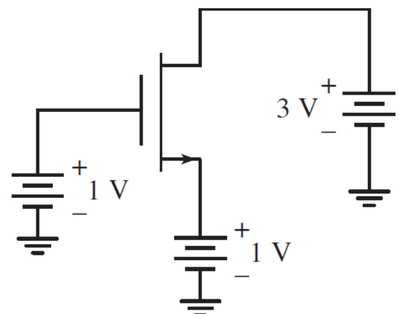

Figure 4.3

6. Calculate the drain current in a PMOS transistor with parameters $V_{TP} = -0.5\ \text{V}, k_p' = 50\ \mu\text{A/V}^2, W = 12\ \mu\text{m}, L = 0.8\ \mu\text{m}$, ($K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$, this equation can be found from the textbook page 136, Equation (3.5(b))) and with applied voltages $V_{SG} = 2\ \text{V}$ and

(a) $V_{SD} = 0.2\ \text{V}$;

(b) $V_{SD} = 0.8\ \text{V}$;

(c) $V_{SD} = 2.2\ \text{V}$;

(d) $V_{SD} = 3.2\ \text{V}$;

7. An npn transistor with $\beta = 80$ is connected in a common-base configuration as shown in Figure 5.

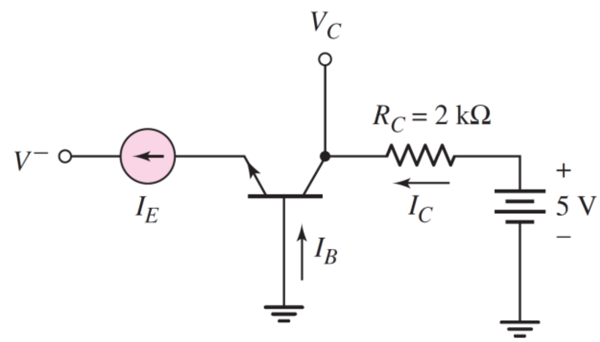

Figure 5

(a) The emitter is driven by a constant-current source with $I_E = 1.2\ \mathrm{mA}$. Determine I_B, I_C, α, and V_C.

(b) Repeat part (a) for $I_E = 0.80\ \mathrm{mA}$.

(c) Repeat parts (a) and for $\beta = 120$.

8. Consider the circuit shown in Figure 6. $V_{EB}(\mathrm{on}) = 0.7\ \mathrm{V}$.

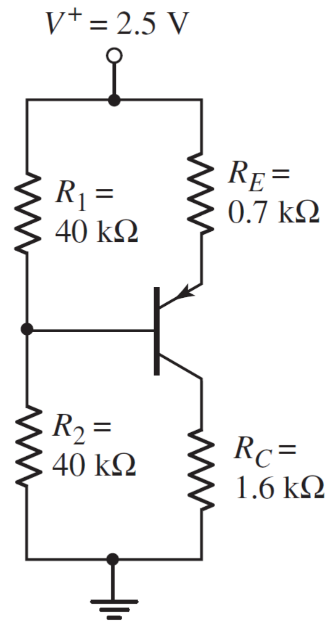

Figure 6

(a) Determine $R_{TH}, V_{TH}, I_{BQ}, I_{CQ},$ and V_{ECQ} for $\beta = 90$.

(b) Determine the percent change in I_{CQ} and V_{ECQ} if β is changed to $\beta = 150$.