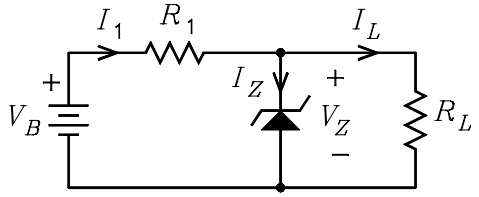
ECE 3040 Microelectronic Circuits Quiz 4
June 9, 2004

Professor Leach Name_____

Instructions. Print your name in the space above. The quiz is closed-book and closed-notes. The quiz consists of 2 problems. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials _____

1. The figure shows a Zener diode regulator circuit. It is given that $V_B = 45\,\text{V}$, $V_Z = 24\,\text{V}$, $I_Z = 5\,\text{mA}$, $r_z = 20\,\Omega$, and $R_L = 12\,\text{k}\Omega$.



   (a) In the large signal model of the Zener diode, what is the voltage V_{Z0}?

$$V_Z = V_{Z0} + I_Z r_z \Longrightarrow V_{Z0} = V_Z - I_Z r_z = 23.9\,\text{V}$$

   (b) What are the values of I_L and I_1?

$$I_L = \frac{V_Z}{R_L} = 2\,\text{mA} \qquad I_1 = I_Z + I_L = 7\,\text{mA}$$

   (c) What is the required value of R_1?

$$R_1 = \frac{V_B - V_Z}{I_1} = 3\,\text{k}\Omega$$

   (d) Calculate the power dissipated in R_1, in the Zener diode, and in R_L.

$$P_{R_1} = I_1^2 R_1 = 147\,\text{mW} \qquad P_Z = V_Z I_Z = 120\,\text{mW} \qquad P_{R_L} = I_L^2 R_L = 48\,\text{mW}$$

   (e) If the load current doubles, calculate the decrease in the voltage across the Zener diode.

$$\Delta I_L = 2\,\text{mA} \qquad \Delta V_Z = -\Delta I_L\,(r_z \| R_1) = -39.7\,\text{mV}$$

2. (a) Draw and label a diagram that illustrates the basic construction of the n-channel enhancement-mode MOSFET. (See the notes or book for the diagram.)
   (b) What must done for an inversion layer to form in the MOSFET, and where is it in the device? **Answer:** Apply a voltage to the gate which sets up an electric field in the substrate that induces the inversion layer. The inversion layer forms directly below the gate region.
   (c) What is meant by the threshold voltage of a MOSFET? **Answer:** The gate-to-source voltage above which drain-to-source current flows.
   (d) Explain how the phenomenon called pinchoff relates to the current versus voltage characteristic of the MOSFET. **Answer:** When the device is pinched off, the drain current remains approximately constant as the drain-to-source voltage is increased.