1. (10 points) **Answer by TRUE or FALSE.**

   (a) An npn transistor having $V_C = 10V$, $V_B = 1.2V$, and $V_E = 1V$ is in cut-off.

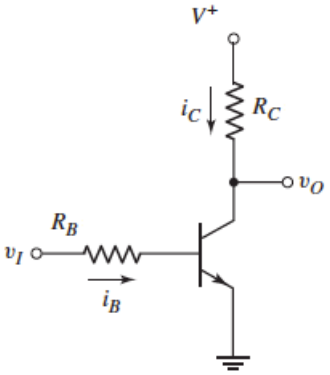
   (b) In the active region, when the collector-emitter voltage increases, the collector current decreases.

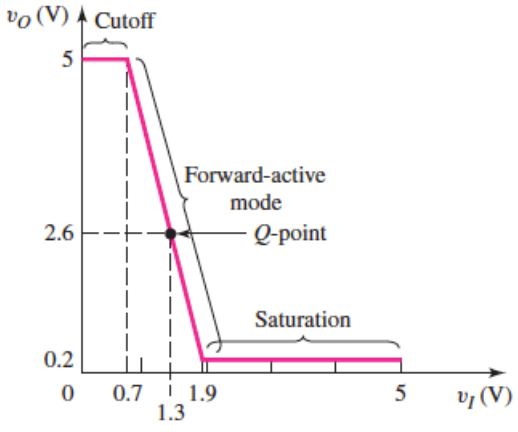
   (c) In saturation mode, a BJT has $I_C \leq \beta I_B$.

   (d) The power dissipated by the zener diode is greater when the load current is less.

   (e) Zener regulators are mostly efficient for applications that require low current to the load.

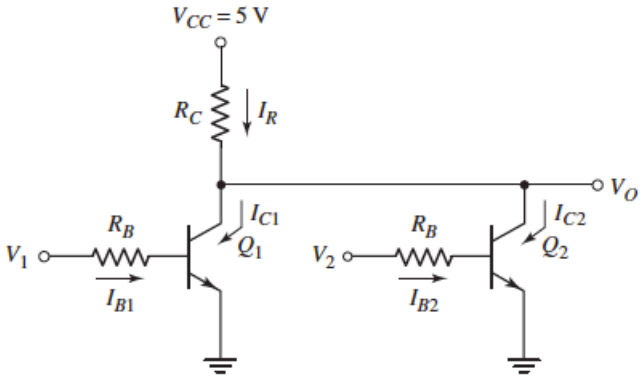
2. (15 points) **Transistor Design.**
Consider the simple transistor circuit shown below along with its voltage characteristics. Let $\beta = 120$ and $I_{C(sat)} = 960\mu A$.





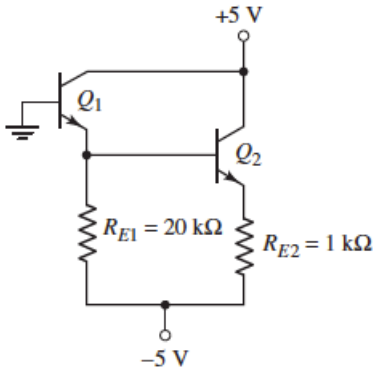
1. (5 pts) What is the transistor's voltage gain?
2. (10 pts) Find R_B and R_C.

3. (25 points) **Digital Gate**
Consider the following two cascaded transistors Q_1 and Q_2 forming a digital logic gate with inputs V_1 and V_2. Let $R_C = 1k\Omega$ and $R_B = 20k\Omega$.
Assume the transistor parameters are: $\beta = 50$, $V_{BE(on)} = 0.7V$ and $V_{CE(sat)} = 0.2V$.
Fill out the following table. What kind of logic gate is that?

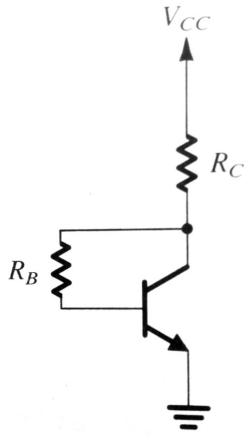


Gate Input	$V_0(V)$	$I_R(mA)$	$I_{B_1}(mA)$	$I_{C_2}(mA)$
$V_1 = 0$, $V_2 = 0$				
$V_1 = 5$, $V_2 = 0$				
$V_1 = 0$, $V_2 = 5$				
$V_1 = 5$, $V_2 = 5$				

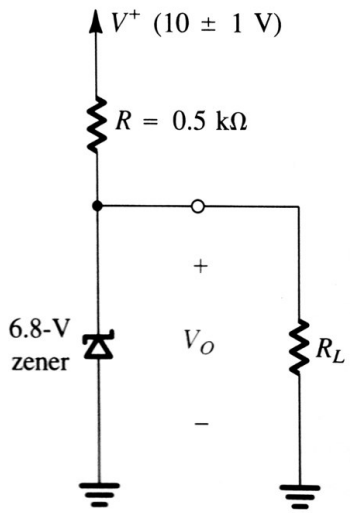
4. (20 points) **Current Gain.**
For each transistor in the following circuit $V_{BE(on)} = 0.7V$, and the current gain is given by β. Find β such that the collector current I_{C1} through Q_1 equals $256\mu A$.



5. (15 points) **Common-Emitter Amplifier Design.**
Design the following circuit to attain an emitter current I_E that is insensitive to variations of β.



6. (15 points) **Zener Circuit.**
The 6.8 V zener diode in the circuit shown below is specified to have $V_Z = 6.8V$ at $I_Z = 5mA$, $R_Z = 20\Omega$, and $I_{ZK} = 0.2mA$. The supply voltage V^+ is nominally 10V but can vary by $\pm 1V$.



1. (5 pts) Find V_0 with no load and with V^+ at its nominal value.
2. (5 pts) Find the change in V_0 resulting from the $\pm 1V$ change in V^+.
3. (5 pts) Find the minimum value of R_L for which the diode still operates in breakdown region.

Bonus (10 points)
Consider the amplifier below, which amplifies the signal from a sensor with an internal resistance of $1K\Omega$. Assume all capacitances to be of very large values. Given an estimate for the amplification factor A_v.