

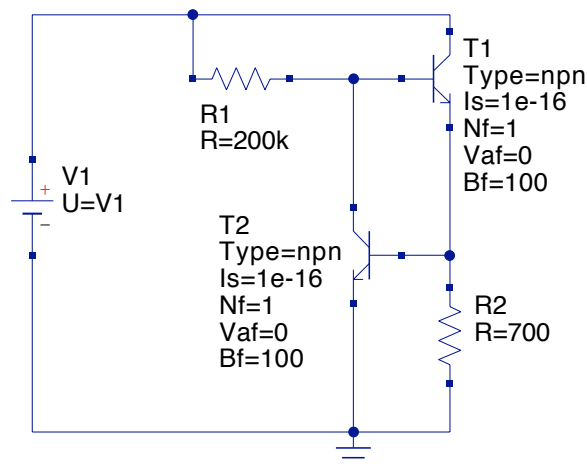
Physics 262

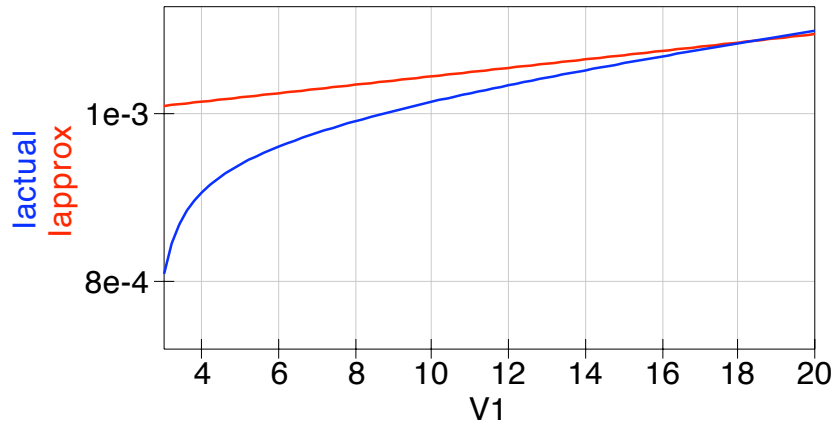
Homework #6

Show your work.

For design problems, work to within 5% of specifications.

1. H&H exercise 1.27 (p.46).
2. The circuit pictured below is designed to draw a nearly constant current for any applied voltage, V_1 . Most of the current flows through the collector of transistor T1 and resistor R2. The current through R2 cannot exceed that required to reach the diode drop T2, because T2 turns on and diverts the base current from T1. The plot shows the result you will derive (red) compared to a simulation using the full Ebers-Moll transistor model (blue). The agreement is reasonable above 4 V input.
 - (a) Calculate the currents I_1 and I_2 through resistors R1 and R2 in terms of V_1 . Assume $V_{BE} = 0.7\text{V}$ on both transistors. *Hint: Each can be worked out by a simple application of KVL.*
 - (b) Calculate the total current through the circuit in terms of V_1 and the transistor β (assume the transistors are identical). *Hint: Assume both transistors are active. Use multiple applications of KCL. There are a bunch of currents, so eliminate unknowns quickly to reduce the number of equations.*
 - (c) Show that in the limit $\beta \rightarrow \infty$, the total current is just $I_1 + I_2$.





3. Line regulation for a power supply depends on building a voltage reference that is as independent of the input voltage as possible. Zener diodes are a great help here, but even the Zener changes its voltage slightly in response to changes in current.
 - (a) Calculate dI/dV , the rate of change of the current with respect to the applied voltage, for a Zener whose current is limited only by a series 10 k resistor.
 - (b) Suppose we use the circuit of problem 2 in series with a Zener diode to regulate the current into the Zener. Estimate dI/dV using the approximate $I(V)$ expression you derived in part 2c. What factor improvement does this offer compared to the simple resistor?

For reference, the two-Zener circuit presented in class offers comparable improvement over the simple resistor, but at much greater cost (an extra zener and an op amp, as opposed to just two transistors).