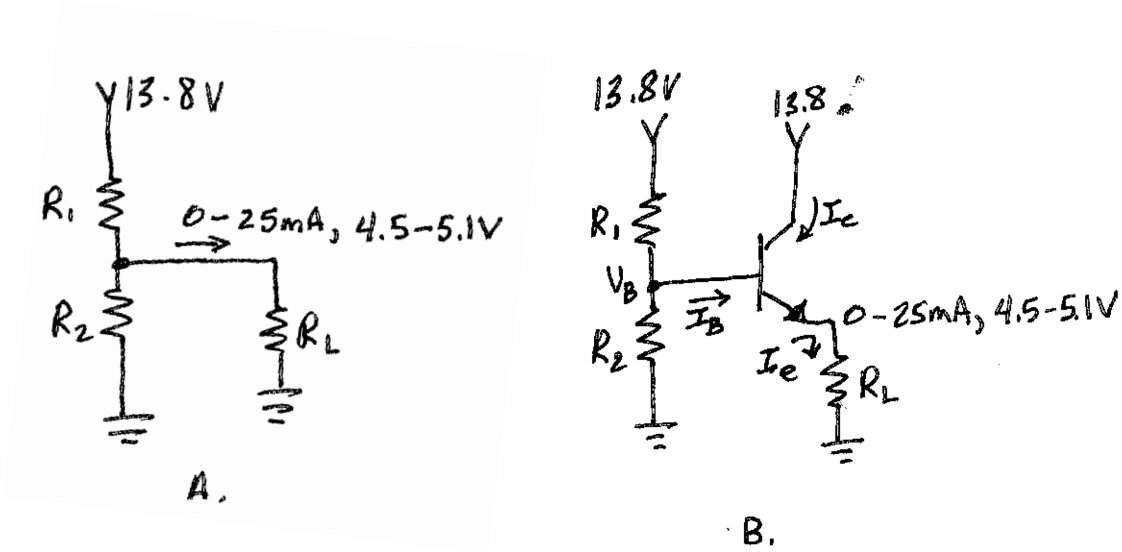
Let's explore two DC power supply designs. Suppose you have a 12V car battery (so its voltage is typically 13.8VDC) and you want to power some digital logic circuits that require 4.5-5.1VDC at 0-25mA. How do you do that? Exceeding 5.1V will blow up the logic circuits and below 4.5V they stop working reliably. Let's compare two designs: a passive voltage divider (A) and a 1-transistor power supply (B).



1) Show that the digital circuits are equivalent (*from* the point of view of the power supply) to a load impedance > 180 Ohms.
2) Design a voltage divider circuit with 2 resistors as your power supply (drawing A). Show that their values are around 38 and 65 ohms. (Hint: you'll need 3 equations relating the 3 unknowns. One equation is R_L = 180Ω or ∞. You get multiple equations for R1 and R2 by analyzing the circuit under different extremes, like no load and maximum load).
3) Show that this power supply draws ~1.8W of power with no load and 2W under full load. Show that its *efficiency* (power to load / total power used) is ~5%.
4) Now build an equivalent power supply with an emitter follower (drawing B). Assume V_{BE} = 0.6V, h_{fe} = 100. Label all voltages and currents (more variables, more equations) under the two extreme values of R_L = 180Ω and ∞. Show the effective impedance the voltage divider sees "looking at" the base at full load is ~20kOhm.
5) Show the voltage divider resistors should be 4kΩ and 5.8kΩ.
6) Show this power supply uses ~19mW without load
7) Under full load, show the transistor dissipates ~230mW (from the collector to emitter), and the efficiency of the fully loaded power supply is ~30%, five times better than the passive one. Remember, from the point of view of R_L, these two power supplies behave the same. But the transistor supply runs vastly cooler, delivering the same power to the load with much less waste.
8) What key lessons did you learn from this exercise?