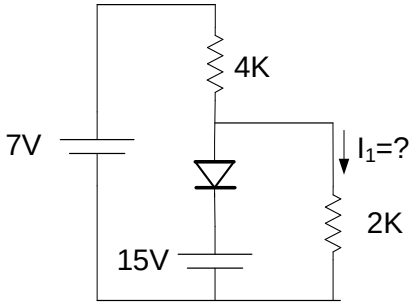
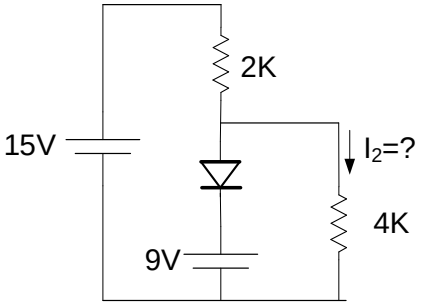
EE 330
Homework 7
Spring 2019 Due Friday March 1

Unless specified to the contrary, assume all n-channel MOS transistors have model parameters $\mu_n C_{OX} = 300\mu A/V^2$ and $V_{Tn0} = 0.5V$, all p-channel transistors have model parameters $\mu_p C_{OX} = 75\mu A/V^2$ and $V_{Tp0} = -0.5V$. Correspondingly, assume that at T=300K, all npn BJT transistors have model parameters $J_S = 10^{-14} A/\mu^2$ and $\beta=100$ and all pnp BJT transistors have model parameters $J_S = 10^{-14} A/\mu^2$ and $\beta = 25$. If the emitter area of a transistor is not given, assume it is $100\mu^2$. If parameters are needed for process characterization beyond what is given, use the measured parameters from the TSMC 0.18μ process(given in HW6).

Problem 1

Determine the currents indicated with a ? in the following circuits. Assume the diodes are ideal.

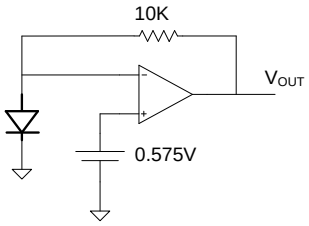




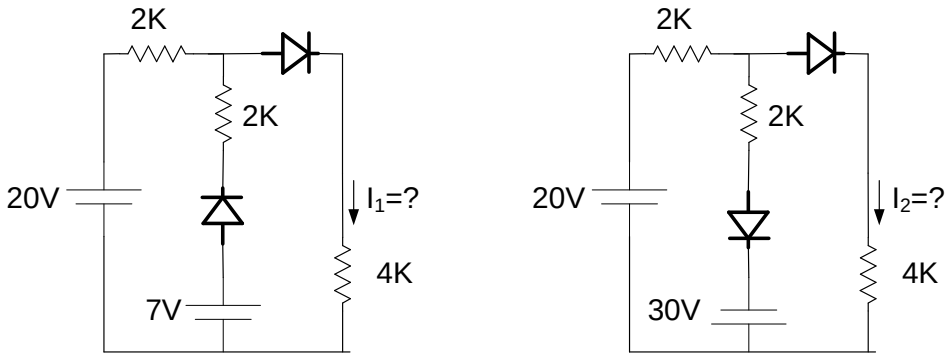
Problem 2

Assume the op amp is ideal and biased with V_{DD}=20Vand V_{SS}=-20V and the diode is characterized by model parameters: $J_{SX}=0.5A/\mu^2$, $V_{G0}=1.17V$, m=2.3. Assume the area of the junction is $200u^2$.

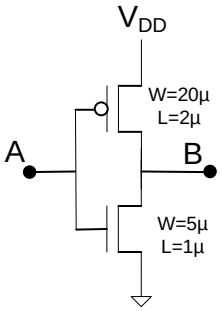
a) Determine V_{OUT} if T= -20°C
b) Repeat part a) if T= 40°C.
c) Repeat part a) if T=120°C



Problem 3 Determine the currents indicated with a ? in the following circuits. Assume the diodes are ideal.



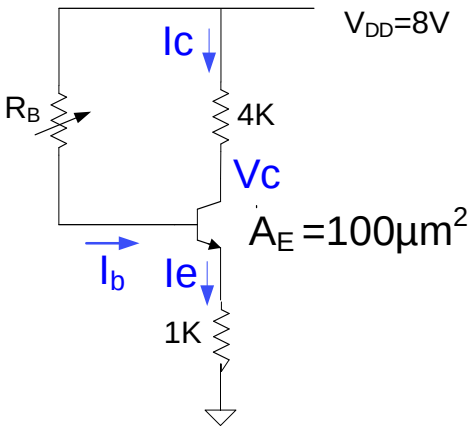
Problem 4 Consider the following inverter. Determine the switch-level model for this inverter that includes the input capacitance and the pull-up and pull-down resistors.



Problem 5 Design a circuit using only MOS transistors (no resistors or other components) that has an output voltage of 0.8Vwhen biased with a single dc power supply of 1.8V.

Problem 6 The following circuit was constructed for measuring the β of the bipolar transistor. To obtain the β, the resistor R_B was adjusted so that the current I_c was precisely 1.000mA. The current I_e was then measured to be 1.0250mA. From these measurements the parameter α of the transistor was obtained and then β was calculated using the well-known relationship between α and β.

a) What is the value of β for the transistor?
b) What would be the worst-case error (in percent) in measuring the β of the transistor using this approach if the current measurements were only accurate to ±0.5%?

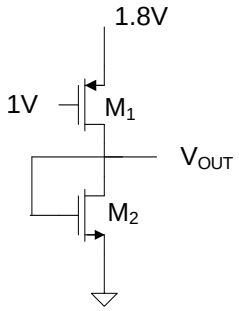


Problem 7

As an alternative to measuring β in the circuit for the previous problem (assuming β is the value determine in part a of the previous problem), the currents I_b and I_c were measured. What would be the worst-case error (in percent) in measuring the β of the transistor using this alternative approach if the current measurements of I_b and I_c were only accurate to ±0.5%?

Problem 8

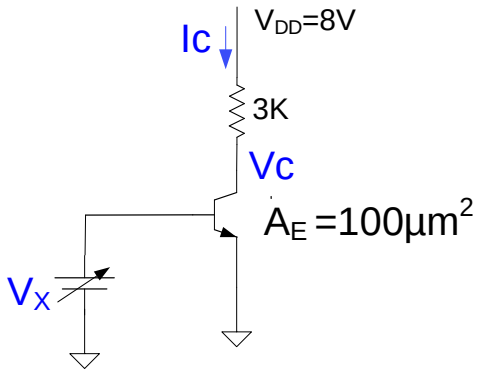
a) Determine V_{OUT} for the following circuit. Assume the devices M_1 and M_2 are identically sized with W=L=5u. The relevant model parameters of the devices are V_{TN}=0.5V, V_{TP}=-0.5V, $\mu_n C_{OX}$=300μAV^{-2} and $\mu_p C_{OX}$=75μAV^{-2}.



Problem 9

Assume the transistor in the following circuit is operating at T=300K and the β of the transistor is 200. Assume the parameter J_{SX} =20x10^{-14}A /μ^2.

a) Precisely determine the value of V_X required to force the collector voltage, V_C, to be 5V.
b) If the value of Vx is decreased by 10uV from the value determined by Vx in part a), how much change will occur in the voltage V_C?
c) If the temperature is increased by 1^{o}C, how much will the voltage obtained in part a) change?
d) Comment on how sensitive this circuit is to change in V_X and to changes in T.



Problem 10 Using ModelSim create a D-flip flop. The D-flip flop should take in a one-bit input and produce a one-bit output. Turn in the D-flip flop code, the test bench code, and the output waveform.