EE 330
Homework 6
Fall 2020
Due Friday September 25

Problem 1

Suppose you have a diode whose junction cross sectional area is $100\mu m^2$ and has the following additional properties:

J_{SX}	m	V_{G0}	n	A
$0.5\ A/\mu m^2$	2.3	$1.17V$	1	$100\mu m^2$

What is the current flow through the device if biased with a forward voltage of $0.6V$ at a temperature of $125°C$? What about at $0°C$? At $27°C$? Are diodes temperature-dependent devices?

Problem 2

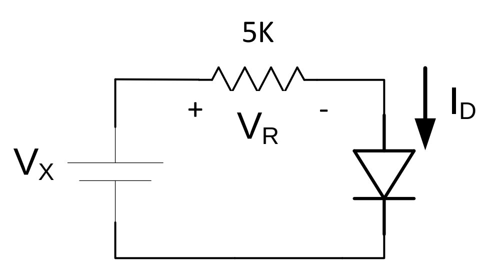
Using your favorite plotting tool (we recommend MATLAB or Excel), plot the I-V characteristic of a diode when applied a forward voltage ranging between $0.5V$ and $0.8V$. You should have at least 10 increments between the starting and stopping voltages. You may use the following parameters for the diode:

$\boldsymbol{J_{SX}}$	$\boldsymbol{m}$	$\boldsymbol{V_{G0}}$	$\boldsymbol{n}$	$\boldsymbol{A}$
$0.5\ A/\mu m^2$	2.3	$1.17V$	1	$100\mu m^2$

Repeat this process for five unique (non-duplicate) temperatures of your choice which are between $0°C$ and $125°C$. Comment on how diode current changes with forward voltage and temperature. Further, comment on *why* the diode current may change with temperature (not in terms of equations, but in terms of what's physically happening in the pn-junction); if you need to refer to external learning resources, cite them.

Problem 3

Determine the current I_D (within ±5%) if V_x=12V for the following circuit. Assume the area of the diode is $200\mu^2$ and $J_s(300K) = 10^{-15}A/u^2$.



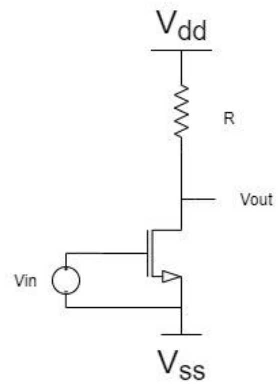
Problem 4

Repeat the previous question if V_X = 500mV.

Problem 5

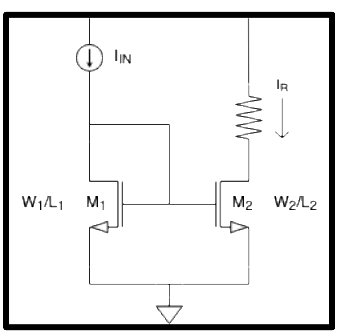
Assume the following configuration with $\mu Cox = \frac{300\mu A}{V^2}, V_T = 0.5V, V_{ss} = 0V, and\ V_{dd} = 10V$. Find Vout for:

(a) R=100Ω, $\frac{W}{L} = 2$, and Vin =1V
(b) R=1kΩ, $\frac{W}{L} = 1$, and Vin =3V
(c) R=2.5kΩ, $\frac{W}{L} = \frac{1}{2}$, and Vin =5V



Problem 6

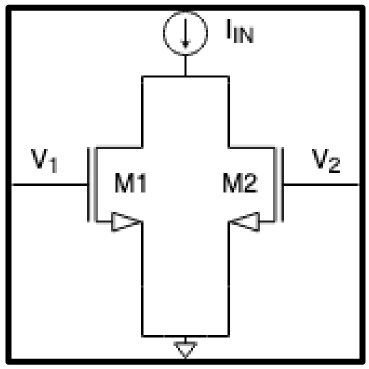
In the circuit below, assume that M_1 and M_2 are both in the saturation mode of operation. Knowing that the width-length ratio of M_1 is W_1/L_1 and the width-length ratio of M_2 is W_2/L_2, and also that the current flowing through M_1 is I_{IN}, what is the current flowing through M_2? Note that your final answer should be in terms of W_1/L_1, W_2/L_2, and I_{IN}. What might this circuit be useful for?



Problem 7

a) In the circuit below, assume that M_1 and M_2 are both in the saturation mode of operation. Knowing that the width-length ratios of M_1 and M_2 are the same, and $V_1 = V_2$, express the currents through M_1 and M_2 in terms of I_{IN}. Then, using the relationship that you found, assume that I_{IN} is equal to $100\mu A$. What is I_{M1} and I_{M2}?

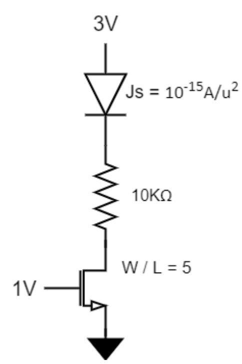
b) Using the I_{M1} and I_{M2} values that you just found, determine what values of V_1 and V_2 are needed to make M_1 conduct I_{M1} and M_2 conduct I_{M2} if $\frac{W}{L} = 2$ for both NMOS devices. Continue to assume saturation. Further, assume V_T for this process is $0.5V$ and that μC_{ox} is $300\mu A/V^2$.



Problem 8

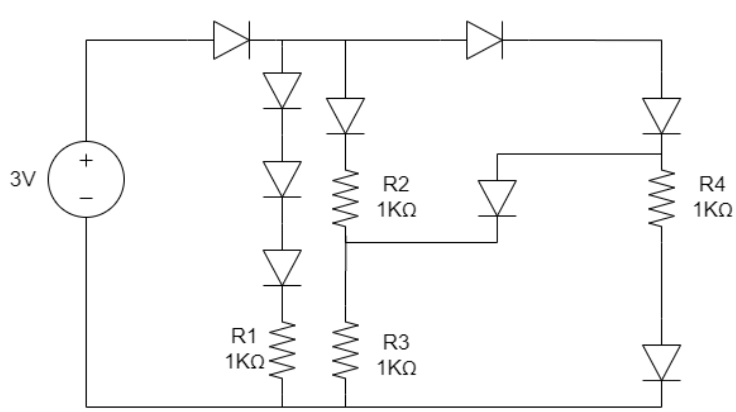
1) Find the current through the NMOS when it is in between triode and saturation (that is to say, when $V_{DS} = V_{GS} - V_T$). Assume that $V_T = 0.5V$ and $\mu C_{ox} = 300\mu A/V^2$.

2) Find the area of the diode that would have the same current as part 1.



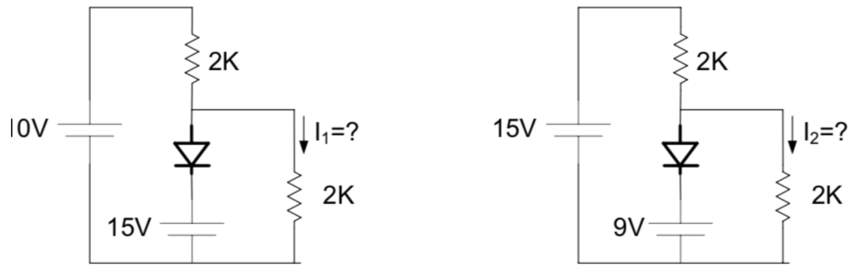
Problem 9

Solve for current through each resistor using the on/off model of the diode, wherein a forward voltage greater than $0.6V$ indicates that the diode is a short-circuit.



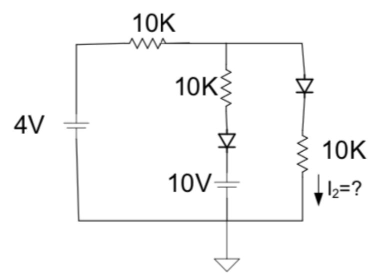
Problem 10

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



Problem 11

Determine the quantities indicated with a ? in the following circuit. Assume the diodes are ideal.



Problem 12

Assume the junction area of diode D_1 is $150\mu m^2$ and that of diode D_2 is 5 times as large. Determine the current I_{D1} if $V_x = 1.5V$ and $T = 300°K$. Assume J_S for the process where the diodes are fabricated is $5fA/\mu m^2$.