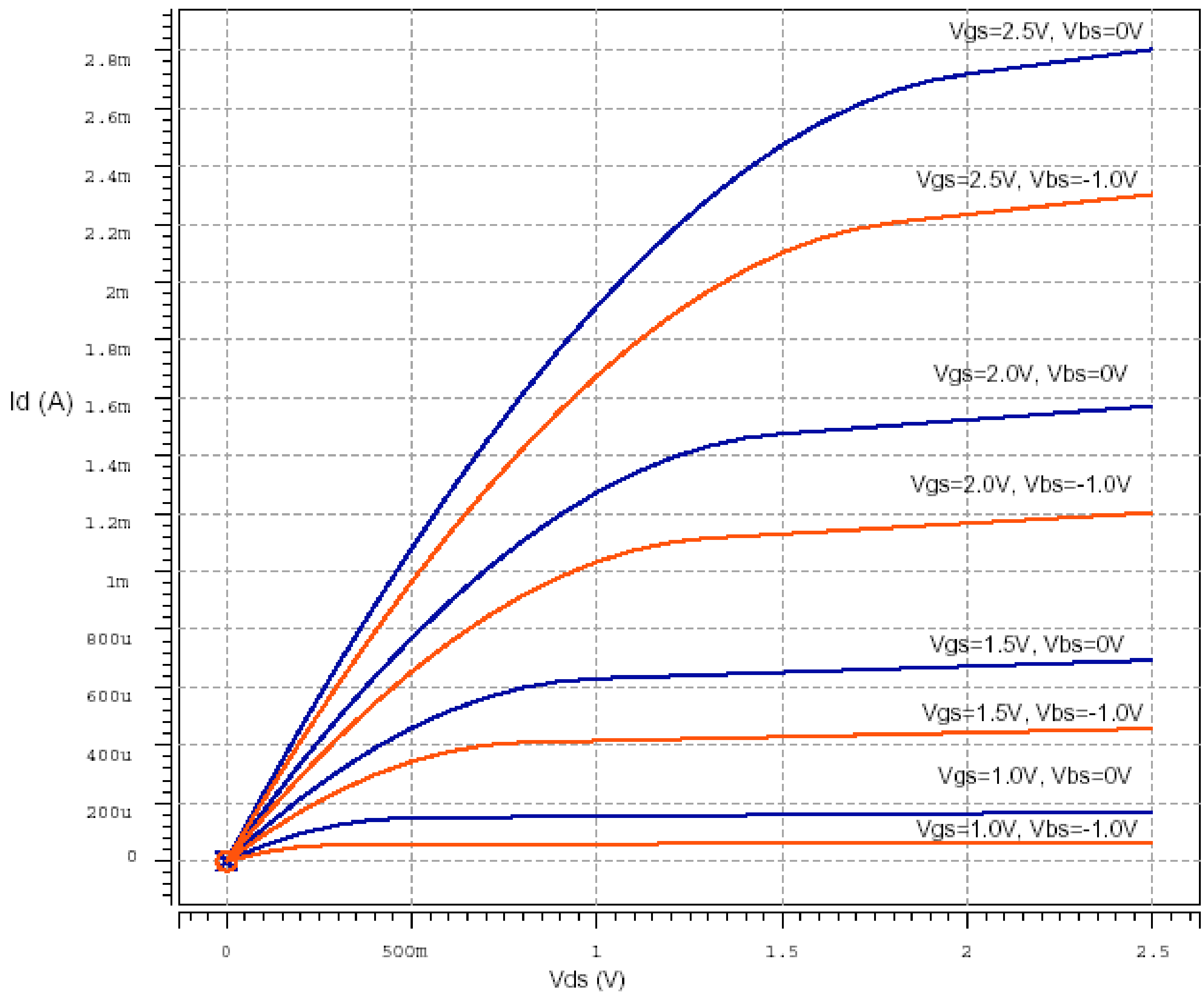
UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences
Last modified on September 3, 2003 by Nuntachai Poobuapheun (nuntachp@eecs.berkeley.edu)

Borivoje Nikolic *Homework #2* *EECS 141*

Problem 1 – Extracting Unified Model Parameters

Shown below are the I-V curves for an NMOS transistor.



In this problem, the objective is to use a transfer curve like the one above to obtain information about the transistors. The transistor has (W/L)=(10/1). You may also assume that velocity saturation does not play a role in this example. Also assume $-2\Phi_F = 0.6V$

From the figure above, determine the following parameters: V_{T0}, γ, λ.

Problem 2 - Generating I-V Curves for a PMOS Transistor

This problem requires you to generate I-V curves for a PMOS transistor. In order to do so, you must have SPICE properly configured in your EECS instructional account.

Make sure you add the following line to your deck:

```
.lib '/home/ff/ee141/MODELS/g25.mod' TT
```

Using SPICE, generate a family of curves for a PMOS transistor with the following parameters:

Supply Voltage = 2.5V
W/L = 5.0u/0.25u
Sweep V_{DS} from –2.5V to 0V in 0.1V increments
V_{GS} = -0.2V, –0.7V, –1.2V, –1.7V, –2.2V
V_{BS} = 0V, 0.6V, 1.2V

Problem 3 – Device Analysis

Below is a table showing a set of measurements performed on a newly fabricated MOS transistor by an EE143 student. He presented these data as a challenge for you to figure out his experiment setup using your EE141 knowledge. You are convinced that these measurements and few assumptions will get you the information that you need.

Measurement Number	V_{GS}	V_{DS}	V_{SB}	Id	Operation Region
1	-2.5V	-2.5V	0	-621.6uA	
2	1.0V	-1V	0	0	
3	-0.7V	-0.9V	0	-22.4uA	
4	-2.0V	-2.5V	0	-421.1uA	
5	-2.5V	-2.5V	-1V	-482.4uA	
6	-2.5V	-1.5V	0	-581.0uA	
7	-2.5V	-0.8V	0	-470.6uA	

You may assume that V_{DSAT} = -1V and $|-2\Phi_F| = 0.6V$

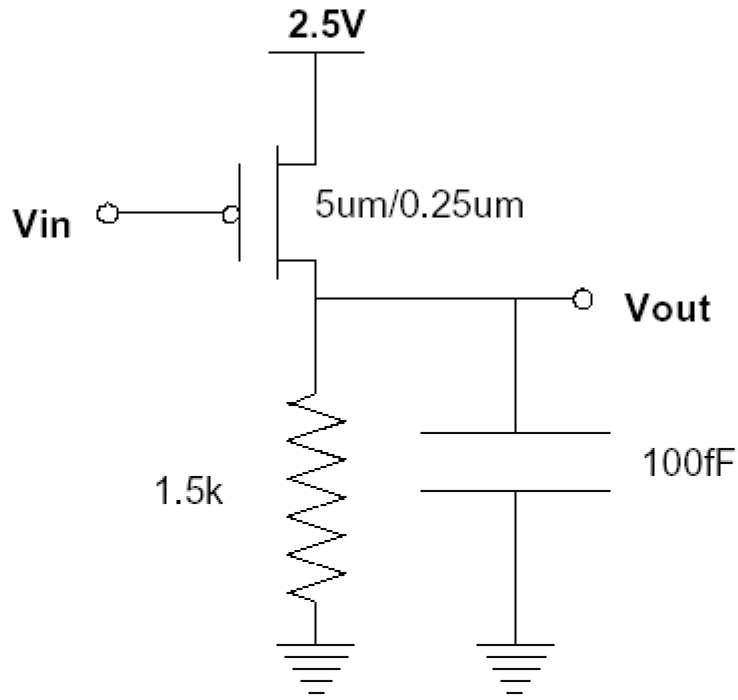
3A Is the measured transistor a PMOS or an NMOS device? Explain your answer

3B From the measurements above, determine the following parameters: V_{T0}, γ, λ.

3C Now, to really impress your friend, complete the missing column in the table above using the values you obtained in 3B. Possible operation regions are: "LINEAR", "CUTOFF", "SATURATION", or "VELOCITY SATURATION". Briefly explain your judgment.

Problem 4 - First Order Delay Analysis

The figure below is a very atypical RTL circuit where the active device is a PMOS transistor. Way back in the old day, when RTL design was popular, such circuits normally used an NMOS transistor with a resistive load.



Because we haven't yet covered timing analysis using the full transistor model, you may make the following assumptions:

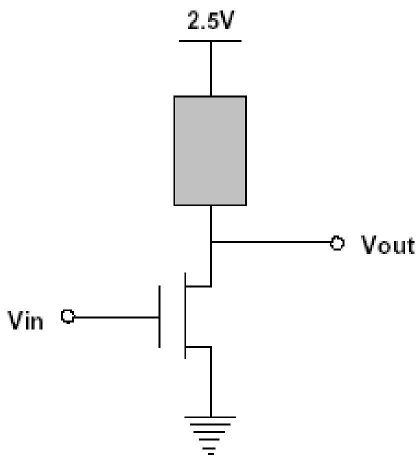
Assume switch model behavior of the transistor.
When Vin>1.25V, the resistance of the transistor is infinite.
When Vin<1.25V, the transistor can be modeled as having a resistance of 20Ω

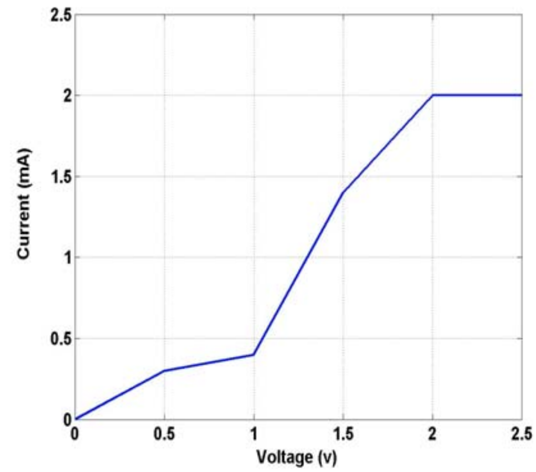
4A Determine V_{OH} and V_{OL}. Explain your answer.

4B Calculate t_{pLH} and t_{pHL} to obtain the average propagation delay, t_p

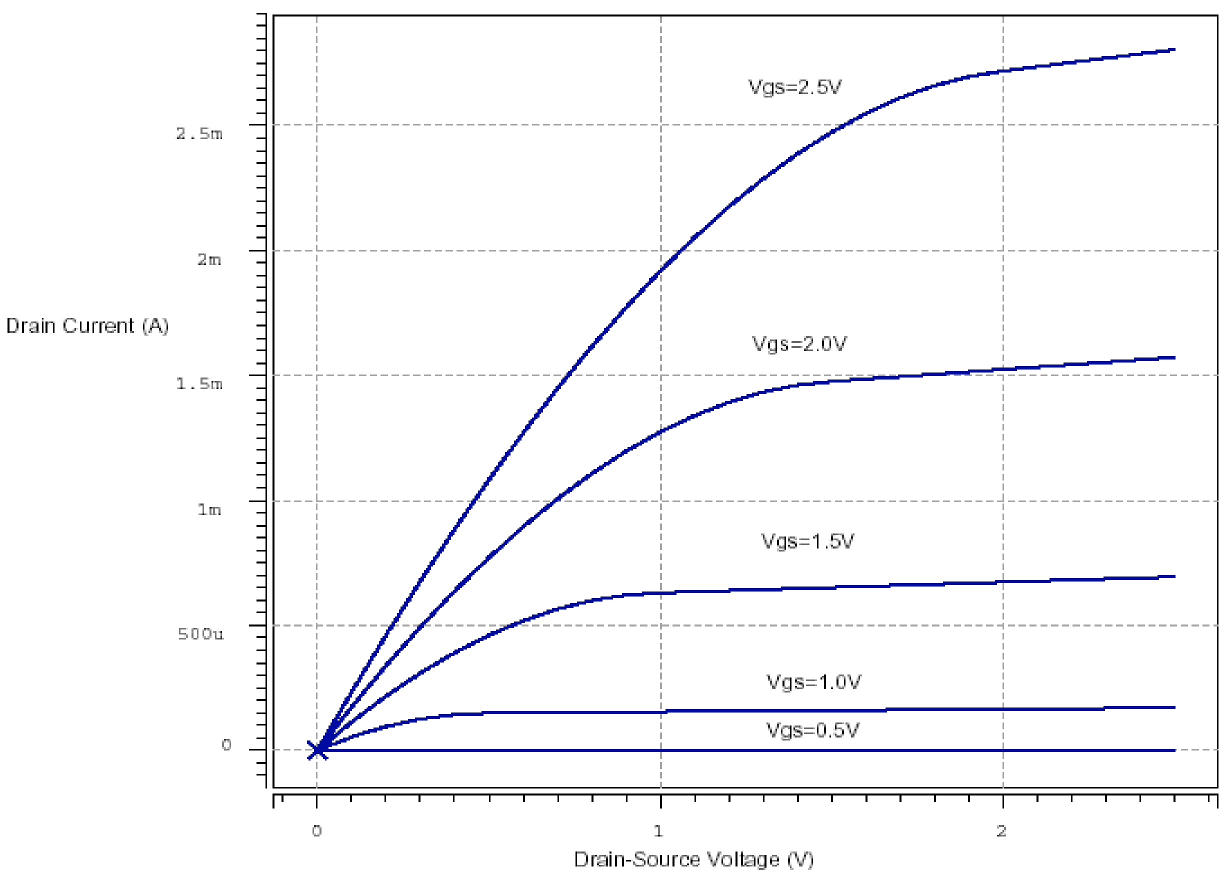
Problem 5 – Generating a Voltage Transfer Characteristic

The circuit below features an NMOS transistor that is coupled with a non-linear load device represented by the shaded box. Accompanying the figure is the I-V characteristic of this non-linear load device.





Of course, we also have the family of I-V curves of our NMOS transistor given below:



5A Draw the VTC for this circuit. Determine (or estimate, if necessary, from your VTC) the following parameters: V_{OH}, V_{OL}, V_M

5B This circuit can be used as an alternative to a traditional CMOS inverter (where the non-linear device is a PMOS transistor). From the concepts discussed thus far in the lecture and from the results of your VTC, what are the **disadvantages** of this method.