EE 2274
MOSFET BASICS

Pre Lab: Include your CRN with prelab.

1. Simulate in LTspice a family of output characteristic curves (curve tracer) for the 2N7000 NMOS You will need to add the 2N7000 model to LTspice if you have done it previously. Must include LTspice schematic, and label all plots.
   a. Use a DC Sweep of Vdd from 0 to 10 volts in 100mv increments to change the drain-source voltage (V_{DS}) X axis of the MOSFET curve. Y axis = I_D in mA.
   b. Use the step sweep from 1 to 3 volts to change the gate to source voltage (V_{GS}) of each curve in 200mv increments.
   c. Run the simulation and then click on All and OK to display all the curves.
   d. In the plot window right click then “select steps” select the Vgs = 3V step. Use this curve to calculate Vtn or just set the V_{GS} = 3.0V and not do the step command.
   e. V_{TN} can be found by subtracting V_{DS} of any curve from V_{GS} of the curve at the point where the current I_D begins to flatten out

$$V_{TN} = V_{GS} - V_{DS\ flat}$$

V_{GS} step used = _______________ V_{DS} used to calculate = ____________________

V_{TN} ____________________

I_D = ______________ at V_{TN}

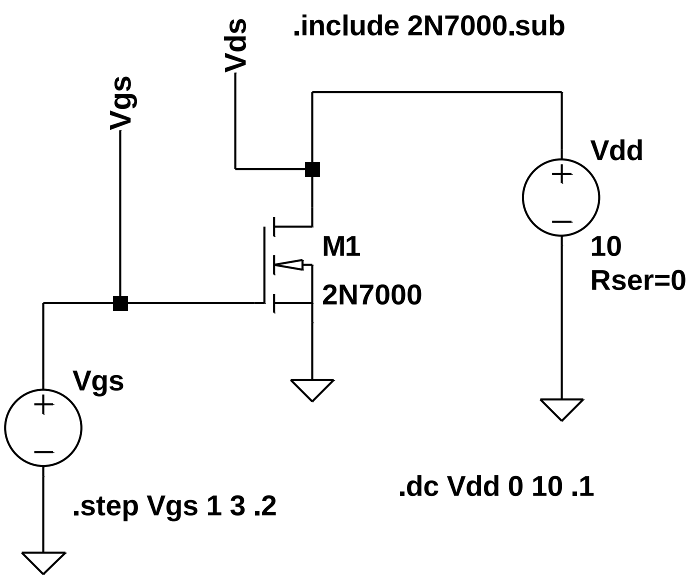

Figure 1

2. Build a four resistor bias circuit (figure 2) for a NMOS. Design the circuit such that Vdd = 10Vdc,Vg=5V, Vds=5V, Id=10ma, IRg2=1ma, assume Vgs=2.4V.

Set the value of I_D by setting the value of **R_S**. Because **Vs = Vg – Vgs** assume Vgs is almost constant so Vs is almost constant, so changing **Rs** will not change Vs but it will change **Is** and assume **Id = Is**.
Set the Value of V_{DS} by setting the value of R_D where $V_{RD} = I_D(R_D)$ and $V_{DS} = V_{DD} – V_S – V_{RD}$. Include the design values and the standard 10% resistor values. Simulate in LTspice with (DC op pnt)".op" and include schematic with currents and voltages (right click schematic - view – Place .op Data Label), **two simulations** design value and standard values of resistors.
Show your work. Must include LTspice schematic, and label all plots.

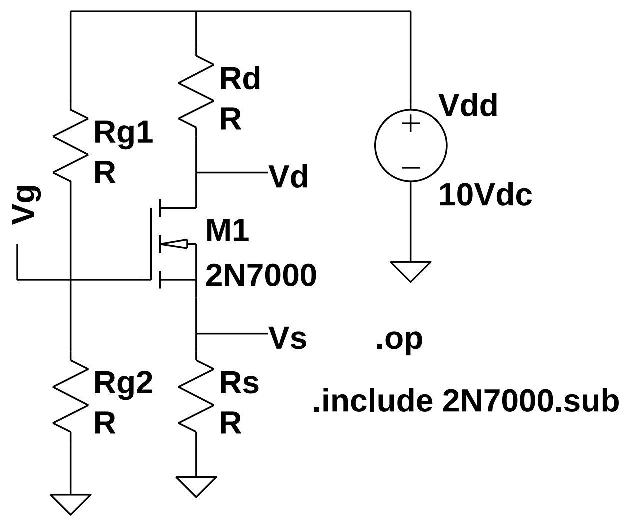

Figure 2

	Design value	Standard 10% value		Design value	Standard 10% value
Rg1			Rd		
Rg2			Rs		

	Design values	Calculated with standard values
Vdd supply voltage		
V_{Rg1} voltage across Rg1		
V_{Rg2} voltage across Rg2		
V_{Rs} voltage across Rs		
V_{Rd} voltage across Rd		
V_{gs} gate to source voltage		
V_{ds} drain to source voltage		
Is Source current		
I_{Rg1} Current in Rg1		
I_d drain current		

3. Simulate in LTspice the NMOS Inverter shown below (figure 3). Instead of varying the drain-source voltage, vary the gate-source voltage. Use the DC sweep to vary the gate voltage V_{GS} from 0 to 5V step = 100mv and plot this versus I_D, and V_{DS} with supply voltage Vdd=5 volt . Turn your graph in. What is the V_{TN} voltage (just starts to conduct) for the 2N7000? How does this compare with 1e?

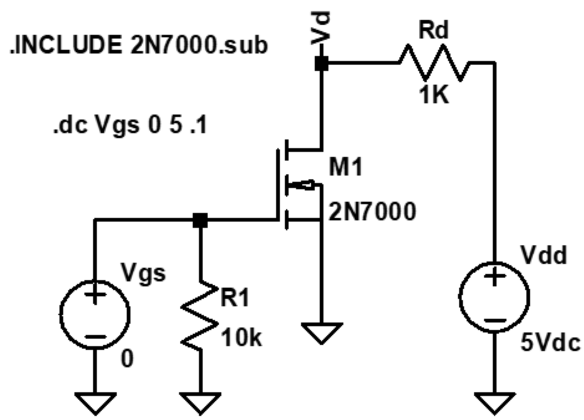

Figure 3 Inverter

V_{TN} = _____________

I_D = ____________ at V_{TN}

Required graphs: Must include LTspice schematic, and label all plots.
1. I-V Characteristic curve of 2N7000 from LTspice.
2. (2 schematics) LTspice .OP simulation of 4 resister bias circuit with **voltage** and **current** displayed on schematic
3. DC sweep of NMOS Inverter – Current
4. DC Sweep of NMOS Inverter – Voltage

LAB Procedure
MOSFET BASICS

Part I. Characteristic Curve

Build the circuit from figure 1 on LTspice. Set Vgs = 5V and run the DC Sweep of Vdd from 0 to 10V in 100mV increments. Recalculate Vtn from this plot from Vgs and Vds. Determine the current Id at Vtn and answer the questions on the datasheet. Include your plot with the lab datasheet.

Part II.

Build the circuit from figure 2 on LTspice using the resistor values you designed in the prelab. Use the standard 10% resistor values. Run a DC Sweep of Vdd from 0 to 12V in 1V increment. Plot the voltage Vg and the current Id of the MOSFET. Answer the questions on the datasheet and include your plot.

Part III. Inverter Circuit

Build the MOSFET Inverter circuit, **figure 3, on LTspice** that you used in the pre-lab.
Change the input Vgs to a pulse with Vinitial = 0V, Von = 5V, Trise = Tfall = 10u, Ton = 0.5m and Tperiod = 1m. This will give you a 0V – 5V volt square wave as your input. Run a transient simulation and plot the voltage Vd and the current Id to display 2-5 cycles. Answer the questions on the lab datasheet and include your plot.

DATA SHEET EXPERIMENT MOSFET BASIC

Name: ____________________________ Date: ____________________________________

Part I.

Turn in the graph.

V_{gs} = _____________
V_{ds} (used to calculate V_{tn}) = _______________
V_{tn} = ______________________
I_D at V_{tn} = ______________

Compare this Vtn with the Vtn you calculated from the prelab. Should there be any difference? Why or why not?

Part II.

Turn in the DC Sweep with plots of Vg and Id.

1. What is the maximum value of the current Id from your plot?

2. What is the value of Vg when the current Id just starts to increase?

3. What is the value of the threshold voltage, Vtn, based on your answer from above?

Part III.

Turn in the transient simulation with plots of Vd and Id.
Must include units.

Turn-on (V_{GS} =5.0V)			Turn-off (V_{GS} = 0.0V)	
III a	I_d (on)		I_d (off)	
III b	V_{ds} (on)		V_{ds} (off)	
III c	T_f (fall Time) time taken for output to fall to 10% of the maximum value		T_r (rise time) time taken for output to rise to 90% of the maximum value	

How can you increase the maximum current Id in the circuit?

Required plots: Must label all plots.
1. I-V Characteristic of MOSFET with Vgs = 5V from Part I.
2. Plot of Vg and Id from Part II
3. Transient simulation plot of Vd and Id from Part III