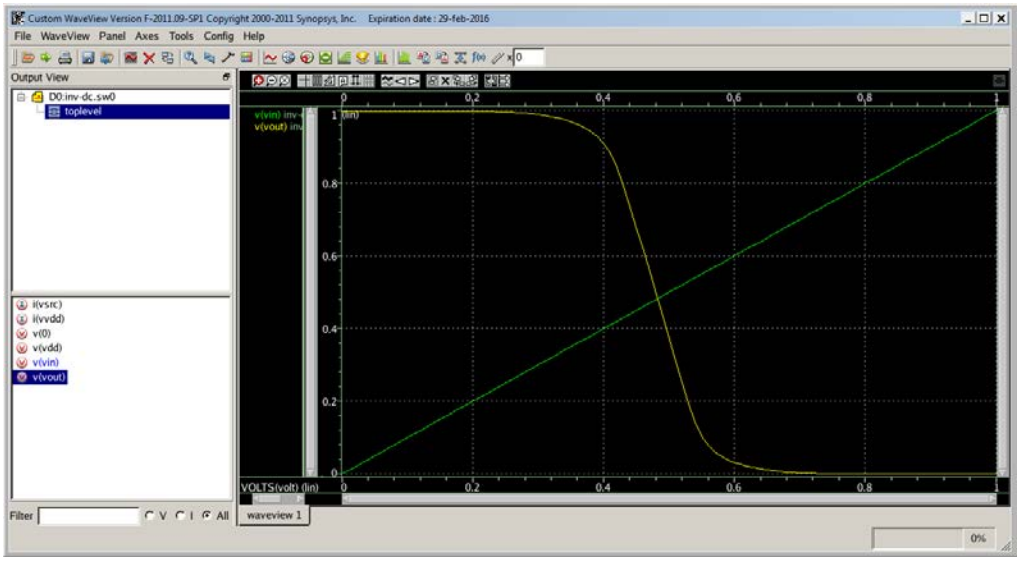
Homework Assignment 6
(Due Mar. 20th at the beginning of the class)

***** Submission policy: Please zip your source code and waveform screenshots into a single file and send it to daehyun@eecs.wsu.edu. The file name should be *firstname_lastname*.zip (or .tar.gz or .tar …)

(1) **[DC Characteristics, 30 points]** Download http://eecs.wsu.edu/~ee434/Homework/hw06.zip and unzip it. Open "inv-dc.sp" in a text editor and see the contents of the file. We use ".DC" for DC simulation.

- Run HSPICE for the DC simulation.
  - > hspice inv-dc.sp
- Open the DC simulation result.
  - wv inv-dc.sw0
- Double-click v(vin) and v(vout) to visualize the DC characteristics of the inverter.
- Drag and drop one of the graphs into the other one as follows:



- Measure V_{IL}, V_{IH}, V_{OL}, V_{OH} (use "Difference" in the measurement tool).
- In my window, $V_{IL} = 375mV, V_{IH} = 580mV, V_{OL} = 45mV, and\ V_{OH} = 950mV$.
- $NM_L = 375mV - 45mV = 330mV, NM_H = 950mV - 580mV = 370mV$.
- Now, make a three-input NAND gate netlist (pFETs: W=140nm, nFETs: W=270nm).

- **The three input signals are named (A, B, C). A is the one whose drain is connected to the output node and C is the one whose source is connected to the ground. B is the one in between A and C.**
- [**Submit**] Run DC sweep analysis for (ABC = 011→111). Compute and submit NM_L and NM_H.
  - $V_{IL} = 333mV, V_{OH} = 947mV, V_{IH} = 547mV, V_{OL} = 52mV$
  - $NM_H = 947mV - 547mV = 400mV$
  - $NM_L = 333mV - 52mV = 281mV$
- [**Submit**] Run DC sweep analysis for (ABC = 101→111). Compute and submit NM_L and NM_H.
  - $V_{IL} = 361mV, V_{OH} = 960mV, V_{IH} = 540mV, V_{OL} = 55mV$
  - $NM_H = 960mV - 540mV = 420mV$
  - $NM_L = 361mV - 55mV = 306mV$
- [**Submit**] Run DC sweep analysis for (ABC = 110→111). Compute and submit NM_L and NM_H.
  - $V_{IL} = 360mV, V_{OH} = 960mV, V_{IH} = 530mV, V_{OL} = 61mV$
  - $NM_H = 960mV - 530mV = 430mV$
  - $NM_L = 360mV - 61mV = 299mV$
- **Note: I don't need screenshots. I just need numbers.**
- [How to run DC simulations for multi-input circuits] If you simulate ABC = 011→111, use the following statements:
  - VA nA 0 PWL 0p 0 200p 0 210p Vsup 1n Vsup 1.01n 0 2n 0
  - VB nB 0 Vsup
  - VC nC 0 Vsup
  - .tr 1p 2.2n
  - .DC VA 0 Vsup 0.01