# EECS 105 – Microelectronic Devices and Circuits

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## Homework Assignment # 6, Due March 2, 2001

Unless stated otherwise, use the following parameters in the problems
n-channel MOSFET:

$\mu_n C_{ox}$=50$\mu$A/V$^2$, $V_{TOn}$=1.0V, $\gamma_n$=0.6V$^{1/2}$, $\lambda_n$=(0.1/L)V$^{-1}$ *(L in mm)*, $\phi_p$=-0.42V

p-channel MOSFET:

$\mu_p C_{ox}$=25$\mu$A/V$^2$, $V_{TOp}$=-1.0V, $\gamma_p$=0.6V$^{1/2}$, $\lambda_p$=(0.1/L)V$^{-1}$ *(L in mm)*, $\phi_n$=0.42V

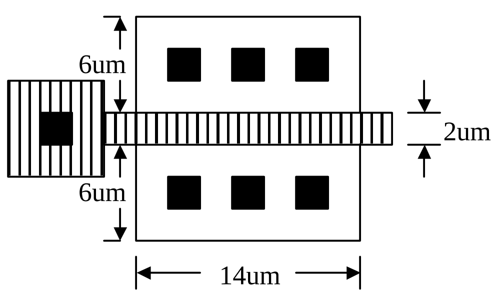
### 6.1 MOSFET Capacitances

The n-channel MOSFET shown in the layout is biased at the operating point: $V_G$=4V, $V_D$=5V, $V_S$=1V, and $V_B$=0V. For this problem, include $L_D$=0.1um in finding the channel length L from the layout.

(a) Find the small signal parameters $g_m$ and $r_o$ at this operating point.

(b) Find the capacitances $C_{gs}$, $C_{gd}$, $C_{db}$, and $C_{sb}$. In calculating the overlap capacitances, only consider the under diffusion of the drain and source diffusion by $L_D$. Also you can neglect the sidewall capacitance and use a substrate doping $N_a$=10$^{17}$cm$^{-3}$

(c) Draw the small-signal model for the n-channel MOSFET as is shown in Fig. 4.24. You can neglect $C_{gb}$




### 6.2 SPICE Models for the MOSFET

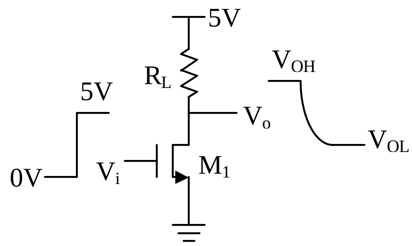
Use the n-channel MOSFET from problem 6.1 in a inverter with a resistive load $R_L$=10k$\Omega$

a) Write a SPICE .MODEL card for the n-channcel MOSFET (See an example in p.244), you can neglect TOX, CJSW, MJ and PB in your .MODEL card

b) Write a SPICE device card for $M_1$ (See an example in p.245)

c) Simulate the circuit in SPICE with the cards obtained in (a), (b), find out $V_{OH}$($V_i$=0V) and $V_{OL}$($V_i$=5V)

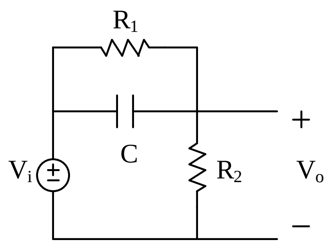
d) What's the fall time $t_F$ in your SPICE simulation when $V_i$ switches from 0V to 5V?




**6.3 Bode Plot**

a) Find the voltage transfer function $H(j\omega)=V_o(j\omega)/V_i(j\omega)$

b) Draw the Bode plot with R1=100kΩ, R2=10kΩ and C=1pF (use radians/sec for the horizontal axis, not Hz)




**6.4 Bode Plot**

Assume an ideal op-amp is used in this problem

a) Find the voltage transfer function $H(j\omega)=V_o(j\omega)/V_i(j\omega)$

b) Draw the Bode plot with $R_1$=10kΩ, $R_2$=100kΩ and $C_1$=$C_2$=1pF (use radians/sec for the horizontal axis, not Hz)