A. Use SPICE to solve the two midterm problems repeated below and compare the SPICE result to the analytic solution.

B. Repeat A for problem 2 only, while including the body effect with NSUB=1E16 cm\(^{-3}\) and TOX=100nm

1. Consider the circuit below consisting of a diode with a p-type MOSFET load.

\[ V_{DD} = 6V \]

\[ W/L = 10 \]

\[ K_p = \mu_p C_{ox} = 0.1mS/V \]

\[ V_T = -1V \]

\[ V_D \]

a) Calculate the current through the diode \( i_D \) using the constant voltage drop model with \( v_D = 0.7 \) V. \((K_p = 0.1mS, W/L = 10, V_T = -1V)\).

b) For the same circuit draw the load diagram to scale and indicate your solution from part a) on the graph.

c) Calculate the voltage across the diode (no longer 0.7V) using the exponential diode model \( i_D = I_s (\exp(v_D/nV_T) - 1)) \) with \( n = 1.1, V_T = 25mV \) and \( I_s = 10^{12}A \). Iterate if needed to get an accurate value.

2. Consider the MOSFET amplifier with a MOSFET load as shown in the figure.
\[ V_{DD} = 5V \]

\[ K_p = \mu_p C_{ox} = 0.1mS/V \]

\[ V_t = 1V \]

\[ W/L = 2.5 \]

\[ V_{IN} \]

\[ R_{sig} = 10k\Omega \]

\[ 3M\Omega \]

\[ 2M\Omega \]

\[ V_{OUT} \]

\[ W/L = 10 \]

\[ R_L = 10k\Omega \]

\[ a) \] Calculate the DC current through both MOSFETs as well as the DC output voltage \( V_{OUT} \). Also plot the DC output voltage \( V_{OUT} \) as a function of the voltage at the gate (ranging from 0 to 5V) of the lower transistor (with \( W/L = 10 \))

\[ b) \] Calculate the small signal voltage gain \((v_{out}/v_{in})\) of the amplifier. Set the coupling capacitors equal to 1mF. Also plot the small signal voltage gain versus frequency and identify the bandwidth