.model nmos
  +  nmos level=1 tox=2.6n vt0=0.3 gamma=0.2 phi=0.6 u0=250 ld=0.025u
  +  capop=0 acm=3 ldif=0 hdif=0.2u cj=8e-4 cjsw=8e-12 cjgate=8e-11
  +  lambda=0.2
.model pmos
  +  pmos level=1 tox=2.6n vt0=-0.3 gamma=0.2 phi=0.6 u0=100 ld=0.025u
  +  capop=0 acm=3 ldif=0 hdif=0.2u cj=8e-4 cjsw=8e-12 cjgate=8e-11
  +  lambda=0.15

When using the above models, remember to use \(W/Leff\) in your calculations, where \(Leff=L-2*Ld\) and \(Ld=0.025\mu m\). You can calculate \(k'\) directly from the SPICE model parameters \(u0\) and \(tox\).

1. For the circuit (Fig.1) shown on the next page, assume \(VDD=1.2v\), 
\[(W/L)_{1}=(W/L)_{2}=(W/L)_{3}=(W/L)_{4}=(W/L)_{5}=(W/L)_{7}=4u/0.13u,\]
\[(W/L)_{6}=16u/0.13u, (W/L)_{8}=(W/L)_{9} = 8u/0.13u, (W/L)_{1s}= 5u/0.13u, (W/L)_{2s}=0.13u/1u. R_s=380\Omega, R_ref = 1K\Omega, R_D=10K\Omega. V_{ic}=0.9v and V_{id}=0v.\] Ignore the body effect. Ignore the channel length modulation in hand calculation.
   a) What is the purpose of the transistor M1s, M2s and Rs in this circuit? What is the approximate current flow through M2s?
   b) Calculate \(g_{m5}\).
   c) Calculate \(A_{dm}\).
   d) Verify part b & c in SPICE.
2. For the circuit (Fig. 2) shown below, calculate the small signal gain $V_o/V_i$ in terms of small signal parameters $g_m$ and $r_o$ of M1-M5. Ignore the body effect and assume $\lambda \neq 0$. Assume the W/L of M1-M3 are same.