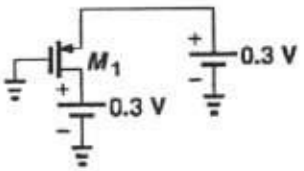
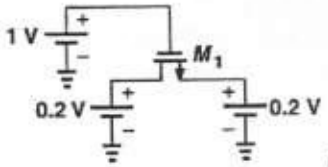
●不可使用電子計算機

1. (25%) Explain the following effects or terminologies. Your answers can be in either English or Chinese.
   (a) Illustrate the p-substrate MOS structure and explain the three operational modes under different bias voltages.
   (b) Briefly explain how the *depletion region* is formed in PN junction.
   (c) Explain the *body effect* in MOSFET
   (d) Explain the *channel length modulation* in MOSFET.
   (e) Explain the *Early effect* in BJT

2. (10%) For the circuits (2a) and (2b), determine the operational region of each M1. Suppose $V_{THN} = |V_{THP}| = 0.5V$



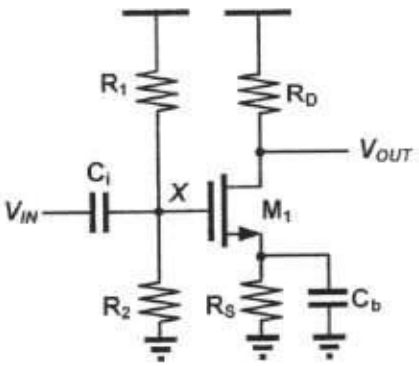
(2a)



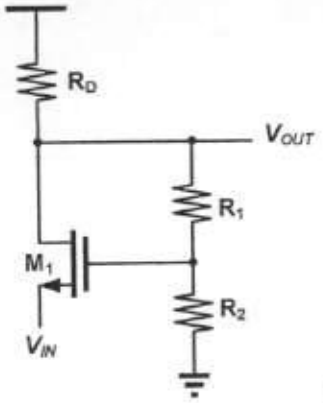
(2b)

3. The drain current (i_D) of an NMOS transistor is 1mA when (V_{GS}-V_{TH})=0.6V. When (V_{GS}-V_{TH})=0.8V, the drain current (i_D) of this NMOS transistor becomes 1.6mA. For this transistor, $\mu_n C_{ox}$=200uA/V^2. If this NMOS are operated at triode region for the above cases and voltage between drain and source (V_{DS}) are constant, please find
   (a) voltage between drain and source (V_{DS}) (5%)
   (b) aspect ratio of this transistor (W/L) (5%)

4. For the following circuit, assume λ=0 and transconductances of transistors M_1 is g_{m1}, capacitors, C_i and C_b are very large.
   (a) What's the purpose of resistors, R_1 and R_2? (5%)
   (b) Please derive the gain of this circuit from node X to V_{out} at midband frequency? (5%)
   (c) Please using Miller effect to derive the locations of poles in this circuit? (10%)

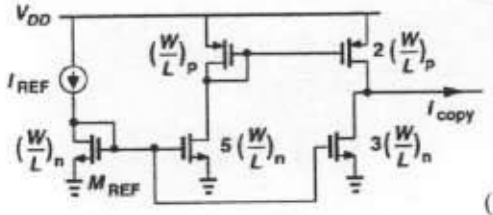


5. For the following circuit, assume $\lambda=0$ and transconductance of transistors M_1 is g_{m1}. Meanwhile, the transistor is operated at saturation region and $R_1+R_2 >> R_D$.
   (a) Please derive the open-loop gain of this circuit (5%)
   (b) Please derive the gain of the feedback network in this circuit (5%)
   (c) Please calculate the open-loop input impedance (5%)
   (d) Please derive the closed-loop gain of this circuit (5%)



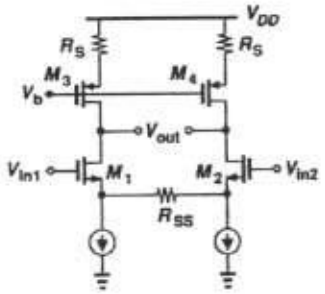
(5)

6. (5%) Assuming $\lambda=0$. Calculate I_{copy} in the circuit (6a).

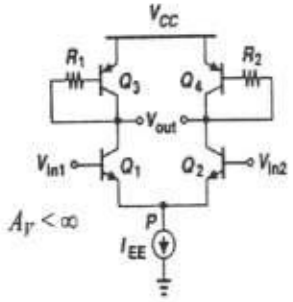


(6a)

7. (10 %) Assume perfect symmetry. Find the differential voltage gain of the given amplifiers (7a) and (7b).
   Assume in the circuits (7a) and (7b), $\lambda \neq 0$ and $V_A < \infty$, respectively.



(7a)



(7b)