1. Fill the blanks with either **0** or ∞. (a) An ideal current amplifier has its input resistance, R_{in} = __①__, and output resistance, R_{out} = __②__. (b) An ideal operational amplifier would have __③__ voltage gain, __④__ input impedance, __⑤__ output impedance, and __⑥__ bandwidth. **[12 pts**, each blank 2 pts]

2. For a saturation n-type MOSFET, (a) how does its transconductance, g_m, relate to its threshold voltage (V_T), applied gate-source volatge (V_{GS}), aspect ratio (W/L), and drain current (I_D)? [**7 pts**] (b) How does g_m change for the following conditions? Fill the blanks with ***increase***, ***decrease*** or ***not change***. [**8 pts**, each blank 2 pts]
   (a) W/L is doubled but I_D remains constant. g_m will __①__.
   (b) $V_{GS} - V_{TH}$ is doubled but I_D remains constant. g_m will __②__.
   (c) I_D is doubled but W/L remains constant. g_m will __③__.
   (d) I_D is doubled but $V_{GS} - V_{TH}$ remains constant. g_m will __④__.

3. For a MOSFET, M_1, four bias cases are as shown in Fig. 1. Assume the threshold voltage, V_T, of M_1 is 0.5V. What is its operation mode for each bias case? Answer each with ***cutoff***, ***linear***, or ***saturation***. [**8 pts**, each answer 2 pts]

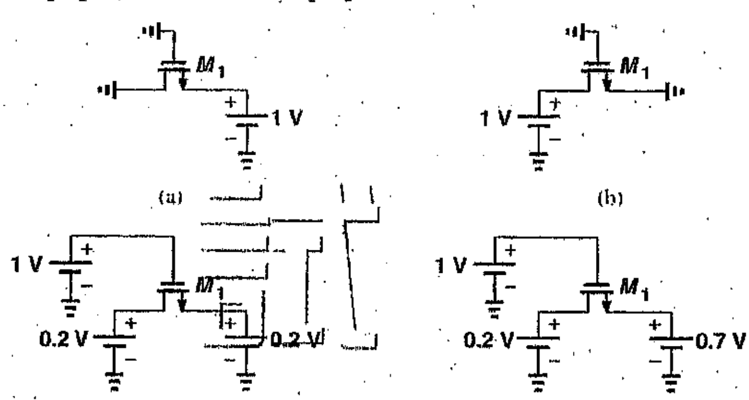

Fig. 1

4. In Fig. 2, $R_1 = R_2$. Assume D_1 behaves as an ideal switch with a turn on voltage of 0.5V. Derive or plot its input/output characteristic. [**5 pts**]

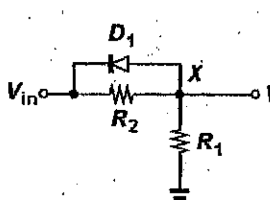

Fig. 2

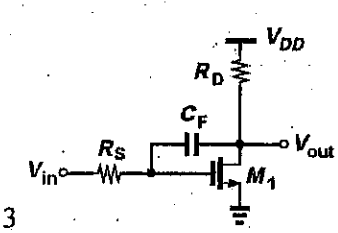

Fig. 3

5. Estimate the poles of the circuit shown in Fig. 3 using Miller's theorem. Assume M_1 has a transconductance of g_m and $\lambda = 0$. [**10 pts**]

6. Assume the op amps in Fig. 4 are ideal. (a) Determine Z_{in}. **[5 pts]** (b)What type of component the circuit simulated? **[5 pts]**

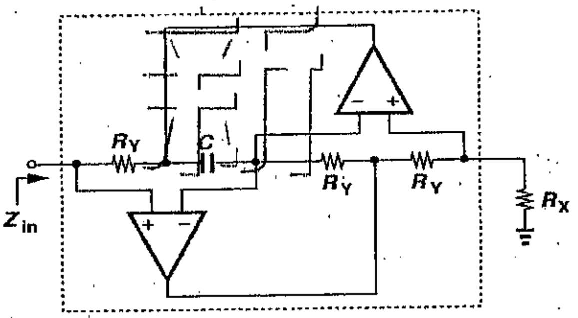

Fig. 4

7. Assume the op amp in Fig. 5 is ideal. (a) Derive the transfer function, $V_{out}/V_{in}(s)$. **[5 pts]** (b) What type of filter the circuit realized? **[5 pts]**

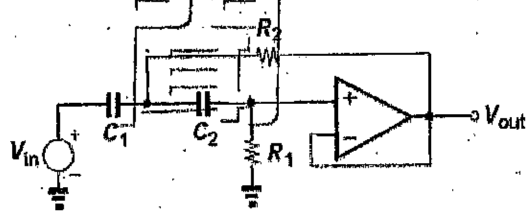

Fig. 5

8. For the circuit shown in Fig. 6, (a) what is its feedback topology? **[5 pts]** (b) Determine the voltage gain, V_{out}/V_{in}, if $A_1 = \infty$. **[5 pts]** (c) Repeat problem (b) if $A_1 \neq \infty$. **[5 pts]**

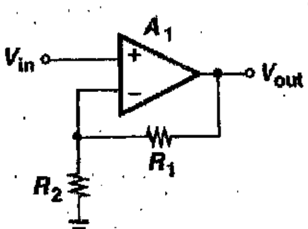

Fig. 6

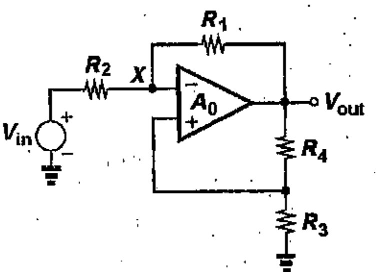

Fig. 7

9. Determine the voltage gain, V_{out}/V_{in}, of the circuit shown in Fig. 7 if $R_1 = R_4 = 10$ KΩ, $R_2 = R_3 = 1$ KΩ, and $A_0 = \infty$. **[10 pts]**

10. Determine the current values of I_1 and I_2 of the circuit shown in Fig. 8. **[5 pts]**

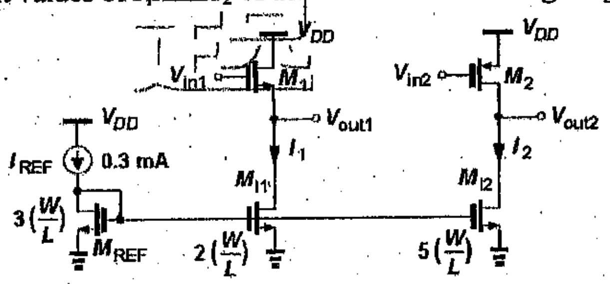

Fig. 8