※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Consider the instrumentation amplifier of Fig. 1 with a common-mode input voltage of +5V (dc) and a differential input signal of 5-mV-peak sine wave. Let R_1=1 kΩ, R_2=200 kΩ, and R_3=1 kΩ, R_4=10 kΩ.

   (a) Find the voltage v_{o1} with common-mode and differential-mode voltages (4%)

   (b) Find the voltage v_{o2} with common-mode and differential-mode voltages (4%)

   (c) Find the voltage v_o with common-mode and differential-mode voltages (4%)
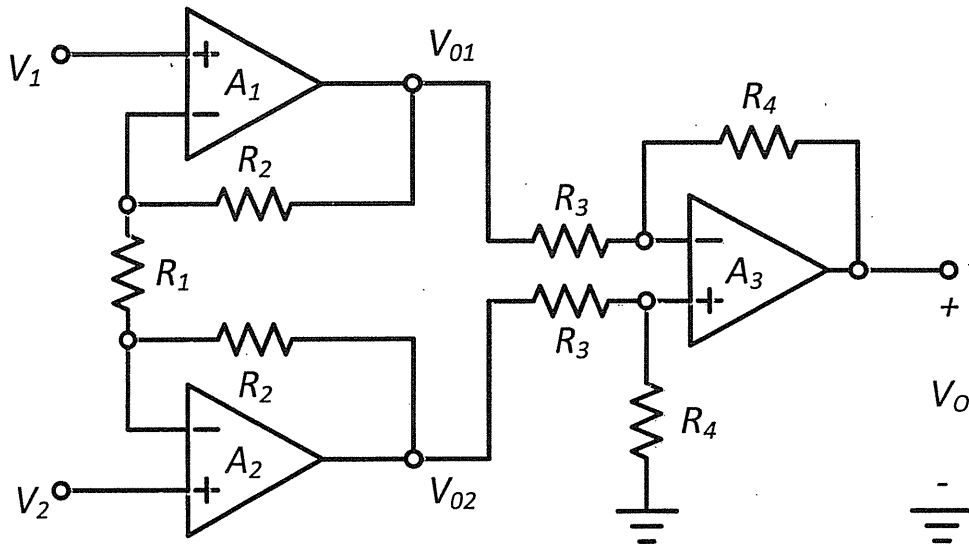

Fig. 1

2. Consider the limiter circuit as shown in Fig. 2. Assume the diodes to be ideal (voltage drop of V_D=0), find the output voltage (V_O) according to the different input voltages (V_I) with

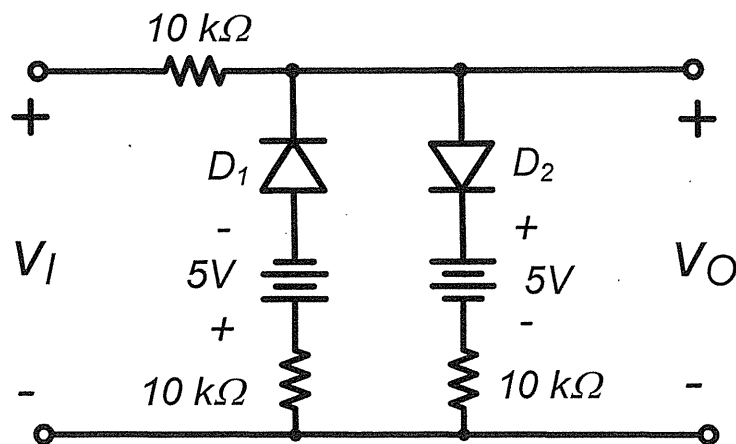   (a) V_I = +1V (4%)

   (b) V_I = +6V (4%)

   (c) V_I = -6V (4%)

Fig. 2

3. A CMOS differential amplifier operated at a bias current of 1.6 mA employs transistors with W/L=100 and $\mu_n C_{ox}$=0.4 mA/V^2, using R_D=10 kΩ and R_{SS}=25 kΩ.

   (a) Find the differential gain (4%)

   (b) Find the common-mode gain when the drain resistance has a 1% mismatch (4%)

   (c) Find the CMRR (4%)
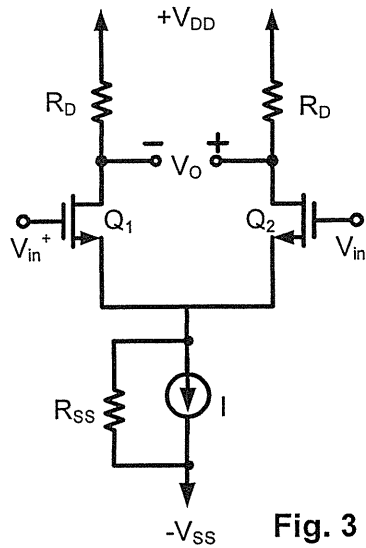

Fig. 3

4. Consider a CS amplifier as shown Fig. 4 with g_m=2mA/V, r_o=20 kΩ, R_L=20 kΩ, R_{sig}=20 kΩ, C_{gs}=20 fF, C_{gd}=5 fF, and C_L=5 fF.

   (a) Find the voltage gain A_M (V_O/V_{sig}) and the 3-dB frequency f_H (using the method of open-circuit time constants) (10%)
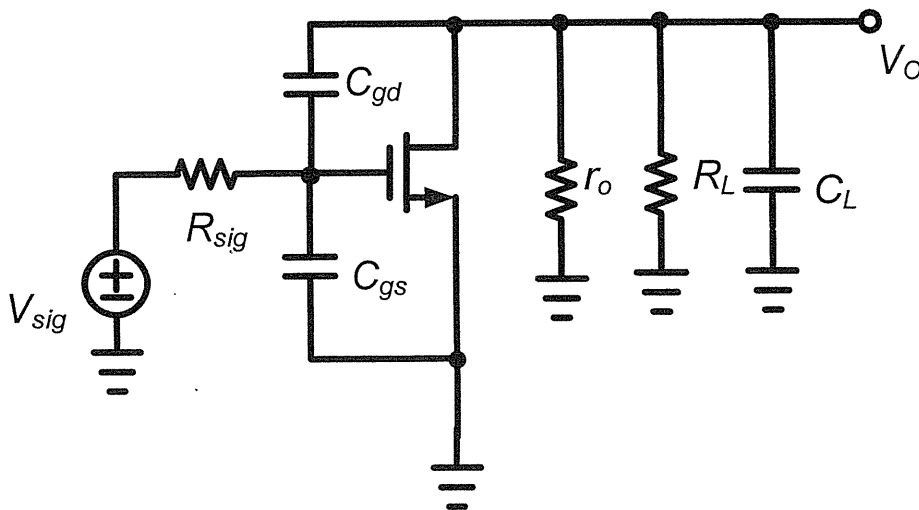
   (b) Find the gain-bandwidth product (4%)

Fig. 4

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

5. Explanatory questions:

　(a)　Explain why a two-pole system cannot oscillate. (5%)

　(b)　Can the circuit shown in Fig. 5 oscillate? Explain. (5%)
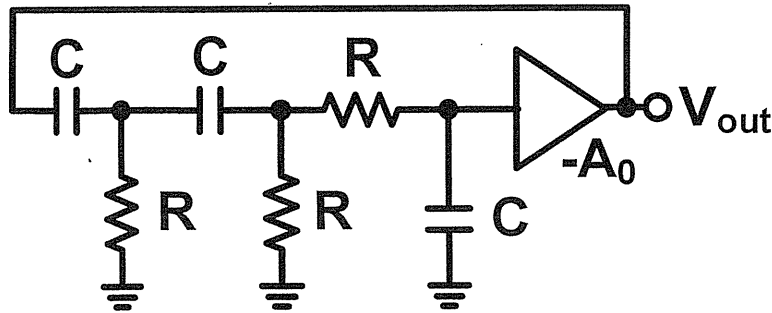

Fig. 5

6. Consider a three-pole feedback amplifier with a loop gain function given by

$$T(f) = \frac{\beta(1000)}{(1 + j\frac{f}{10^3})(1 + j\frac{f}{5 \times 10^4})(1 + j\frac{f}{10^6})} \quad where\ \beta\ is\ the\ feedback\ factor$$

　(a)　Determine the value of β that yields a phase margin of 45 degrees. (5%)

　(b)　Find the low-frequency closed-loop gain of this amplifier based on the result of (a). (5%)

7. Consider a power MOSFET for which the thermal resistance parameters are:

　　$\theta_{junction-case}$ = 1.75°C/W, $\theta_{case-sink}$ = 1 °C/W, $\theta_{sink-ambient}$ = 5 °C/W, $\theta_{case-ambient}$ = 50 °C/W

　　For the ambient temperature $T_{ambient}$=30 °C and the rated maximum junction temperature $T_{j,max}$ = 150 °C.

　(a)　Determine the maximum allowable power dissipation for the power MOSFET when no heat sink is used. (3%)

　(b)　Determine the maximum allowable power dissipation for the power MOSFET when a heat sink is used. (3%)

　(c)　Based on the result of (b), find the temperature of the transistor case and heat sink, respectively. (4%)

8. Consider the class-A source-follower circuit shown in Fig. 6. The transistors are matched with parameters $V_{TN} = 0.5$ V, $K_n = 12$ mA/V^2, and $\lambda = 0$.

   (a) Determine the maximum and minimum values of output voltage. (6%)

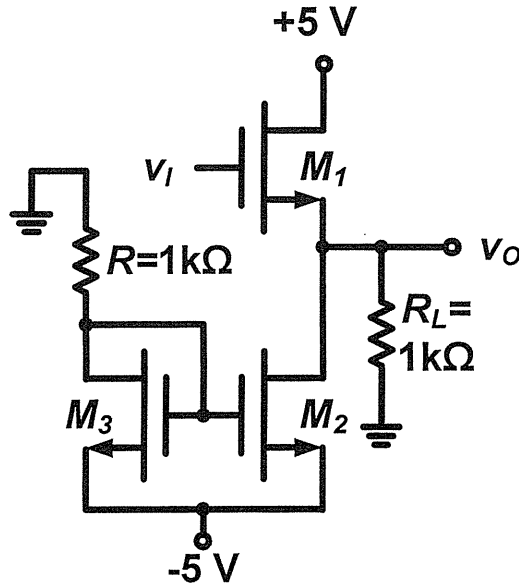   (b) Find the corresponding input voltages for the circuit to operate in the linear region. (6%)

Fig. 6

9. Consider the circuit shown in Fig. 7.

   (a) Determine the required R_2/R_1 value for oscillation to occur. (4%)
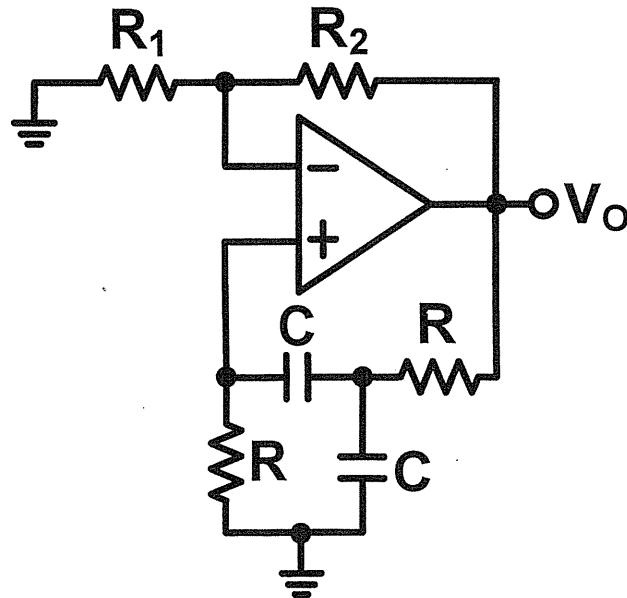
   (b) Find the frequency of oscillation. (4%)

Fig. 7