科目：電子學 適用：電機系

編號：351

考生注意：
1.依次序作答，只要標明題號，不必抄題。
2.答案必須寫在答案卷上，否則不予計分。
3.限用藍、黑色筆作答；試題須隨卷繳回。

1. In Fig. 1, a silicon ***pn*** junction has doping of $N_A = 5\text{x}10^{15}$ cm^{-3} and $N_D = 2\text{x}10^{16}$ cm^{-3}. Assume the number of electrons per unit volume for pure silicon is $n_i = 10^{10}$ cm^{-3}.

(a) Determine the electron and hole densities in both sides of junction. [5%]

(b) Determine the built-in potential, V_B, at room temperature. [5%]

Use $V_B = 25\times\ln\frac{N_A \cdot N_D}{n_i^2} mV,\quad \ln 10 = 2.3$

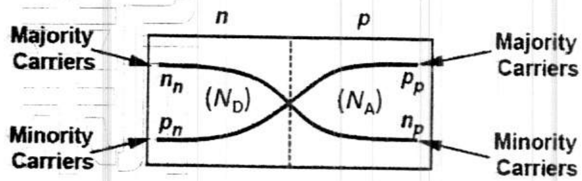

Fig. 1

n_n : Concentration of electrons on n side
p_n : Concentration of holes on n side
p_p : Concentration of holes on p side
n_p : Concentration of electrons on p side

2. In the circuit of Fig. 2, each input can assume a value of either zero or $V_{DD} = 5$ V. Determine the response observed at the output. Assume the diode is ideal. [5%]

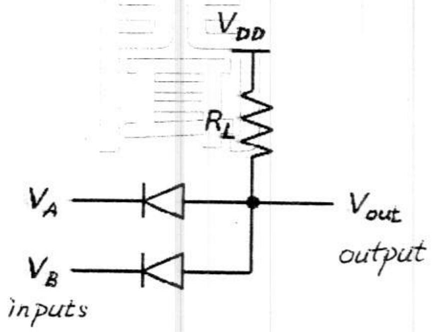

Fig. 2

3. In the circuit of Fig. 3, Q_1 has $I_S = 5\text{x}10^{-16}$A, and $\beta = 100$, $V_A = 10$V.

(a) Determine the terminal currents (I_B, I_C, and I_E) of Q_1 and verify operation in the forward active region. [5%]

(b) Derive its small signal parameters, g_m , r_π ,and r_o. [5%]

$I_C = I_S \cdot e^{\frac{V_{BE}}{V_T}}$, $V_T = 25$ mV, and $e^{30} \approx 10^{13}$. $\quad g_m = \frac{dI_C}{dV_{BE}},\quad r_\pi = \frac{dV_{BE}}{dI_B}\quad r_o = \frac{dV_{CE}}{dI_C}$

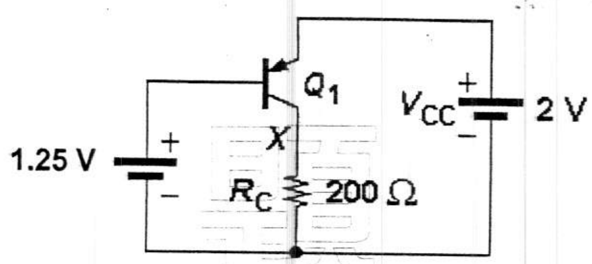

Fig. 3

4. In Fig. 4, M_1 has $\mu_n C_{ox}$ = 100 μA/V², V_{TH} = 0.5 V, λ = 0.1 V⁻¹, and $(W/L)_1$ = 20, and V_{DD} = 2.5 V, R_D = 800 Ω, R_G = 20 kΩ, R_S = 200 Ω.

(a) Calculate the drain current, I_D. [5%]

(b) Find its small signal parameters, g_m and r_o. [5%]

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2 \qquad g_m = \sqrt{2\mu_x C_{ox}\frac{W}{L}I_D}$$

$$r_O = \frac{1}{\lambda I_D}$$

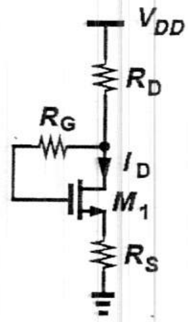

Fig. 4

5. In Fig. 5, find V_1 and V_2. [10%]

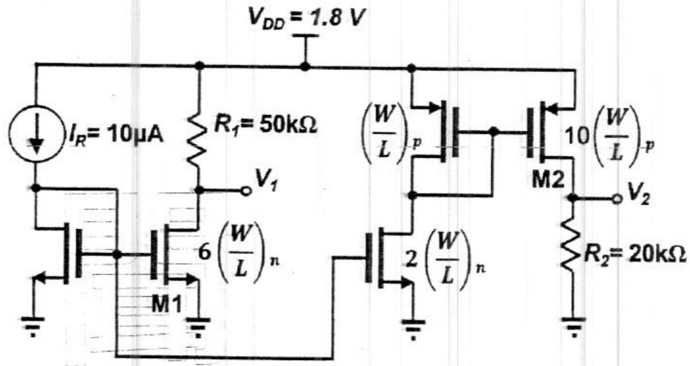

Fig. 5

6. Determine the closed-loop gain of the circuit in Fig. 6,

(a) if $A_0 = \infty$. [5%]

(b) if $A_0 \neq \infty$, and $R_1 = R_4$, $R_2 = R_3$. [5%]

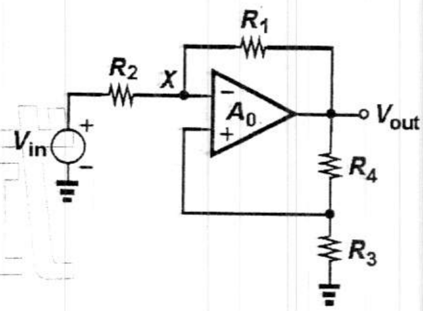

Fig. 6

7. In Fig. 7, derive $H(s) = V_{out}/V_{in}$ if the Op-Amp is ideal. [10%]

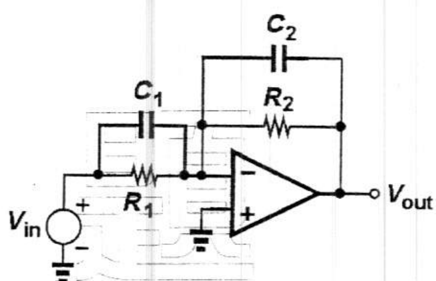

Fig. 7

8. Draw the Bode plot of magnitude and phase for the transfer function below. **[10%]**

$$\mathrm{H(s)} = \frac{10^4 s}{(s^2 + 110s + 1000)}$$

No Fig. 8

9. The circuit shown in Fig. 9 has a voltage gain of **8**, and input impedance (R_{in}) of **24** kΩ. V_{DD} = **2.5** V, R_G = **0**, R_S = **200** Ω, R_D = **400** Ω, a voltage drop of **400** mV across R_S, and both C_1 and C_2 are large enough.

   (a) Find g_m, I_D, and V_{GS} of M_1. **[10%]**

   (b) Find R_1 and R_2. **[10%]**

   (c) Find the DC voltage at V_{out} node, and the total power consumption. **[5%]**

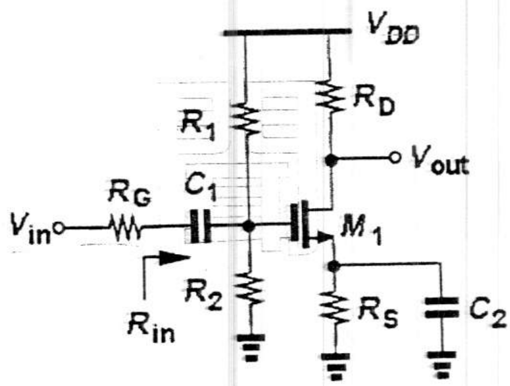

Fig. 9