1. For the three-stage NMOS enhancement-load amplifier shown in Fig. P1, let $V_{th} = V_{a}$
$= 2V$, $K_i = 0.5mA/V^2 = 4K_2$, and $C_1, C_2$ large. ($V_{th}$: threshold voltage of $Q_{2a}, Q_{1b}$,
and $Q_{1c}$, $V_a$: threshold voltage of $Q_{2a}, Q_{1b}$, and $Q_{1c}$, $K_i$: conductivity parameter of
$Q_{2a}, Q_{1b}$, and $Q_{1c}$, $K_2$: conductivity parameter of $Q_{2a}, Q_{1b}$, and $Q_{1c}$)
(a) Calculate the dc voltage at the output $v_o$ (5%)
(b) Find the small-signal voltage gain $A_v$ for $r_s = \infty$. (5%)
(c) What is the input resistance $R_{in}$? (5%)
(d) For $C_2 = 0$, what does the input resistance become? (5%)

![Fig. P1](image)

2. The circuit shown in Fig. P2 is intended to supply current to floating loads (those for
which both terminals are ungrounded) while making greatest possible use of the
available power supply.
(a) Assuming ideal op amps, find the voltage gain $v_o / v_i$. (10%)
(b) Assuming that the op amps operate from $\pm 15V$ power supplies and that their
output saturates at $\pm 14V$, what is the largest sine wave output ($V_{rms}$) that can
be accommodated? (5%)
3. For the common-emitter amplifier shown in Fig. P3, let $V_{cc} = 9V$, $R_L = 27k\Omega$, $R_F = 15k\Omega$, $R_E = 12k\Omega$, and $R_C = 2.2k\Omega$. The transistor has $\beta = 100$, $V_{BE} = 0.7V$, $V_A = 100V$, and the thermal voltage $V_T = 25mV$.

(a) Calculate the dc bias current $I_B$. (5%) 

(b) If the amplifier operates between a source for which $R_S = 10k\Omega$, and a load of $2k\Omega$, replace the transistor with its hybrid-$\pi$ small-signal model, and find the values of $g_m$, $r_o$, $r_i$, and $A_v$. (10%)
4. Assuming each transistor in Fig. P4 has $\beta=100$ and $r_e=100\Omega$.
   
   Find (a) the voltage gain of the amplifier (5%)  
   (b) the input resistance of the amplifier. (5%)

4. Fig. P5 shows how shunt-series feedback can be employed to design a current amplifier utilizing an op amp. The circuit is a closed-loop circuit. The feedback analysis method, therefore, should be used here. For the case: the open-loop voltage gain of the op amp = 10000, $R_m=100\ K\Omega$, the output resistance of the op amp = 1 KΩ, $R_s = 10\ K\Omega$, $r=100\ \Omega$, and $R_f = 1\ K\Omega$.

   Find (a) the closed loop gain $\frac{I_o}{I_s}$ (5%)  
   (b) the input resistance of the closed-loop circuit (5%)  
   (c) the output resistance of the closed-loop circuit (5%)  
   (d) If the loop gain is very large, show the current gain is given approximately by $\frac{I_o}{I_s} \approx 1 + \frac{R}{r}$. (5%)

5. Fig. P5 shows how shunt-series feedback can be employed to design a current amplifier utilizing an op amp. The circuit is a closed-loop circuit. The feedback analysis method, therefore, should be used here. For the case: the open-loop voltage gain of the op amp = 10000, $R_m=100\ K\Omega$, the output resistance of the op amp = 1 KΩ, $R_s = 10\ K\Omega$, $r=100\ \Omega$, and $R_f = 1\ K\Omega$.

   Find (a) the closed loop gain $\frac{I_o}{I_s}$ (5%)  
   (b) the input resistance of the closed-loop circuit (5%)  
   (c) the output resistance of the closed-loop circuit (5%)  
   (d) If the loop gain is very large, show the current gain is given approximately by $\frac{I_o}{I_s} \approx 1 + \frac{R}{r}$. (5%)

Fig. P4

Fig. P5
6. A circuit is shown in Fig. P6.
   Find (a) the feedback gain $\beta(s)$ (5%)
   (b) the loop gain $L(s) = A(s) \beta(s)$ (5%)
   (c) the frequency for zero loop-phase (5%)
   (d) the $\frac{R_1}{R_2}$ for oscillation. (5 %)

![Circuit Diagram]

Fig. P6