1. For the three-stage NMOS enhancement-load amplifier shown in Fig. P1, let $V_{t1} = V_{t2} = 2\text{V}$, $K_1 = 0.5\text{mA/V}^2 = 4K_2$, and C_1, C_2 large. (V_{t1} : threshold voltage of Q_{1A}, Q_{1B}, and Q_{1C}, V_{t2} : threshold voltage of Q_{2A}, Q_{2B}, and Q_{2C}, K_1 : conductivity parameter of Q_{1A}, Q_{1B}, and Q_{1C}, K_2 : conductivity parameter of Q_{2A}, Q_{2B}, and Q_{2C})

(a) Calculate the dc voltage at the output v_o. (5%)

(b) Find the small-signal voltage gain A_v for $r_o = \infty$. (5%)

(c) What is the input resistance R_{in}? (5%)

(d) For $C_2 = 0$, what does the input resistance become? (5%)

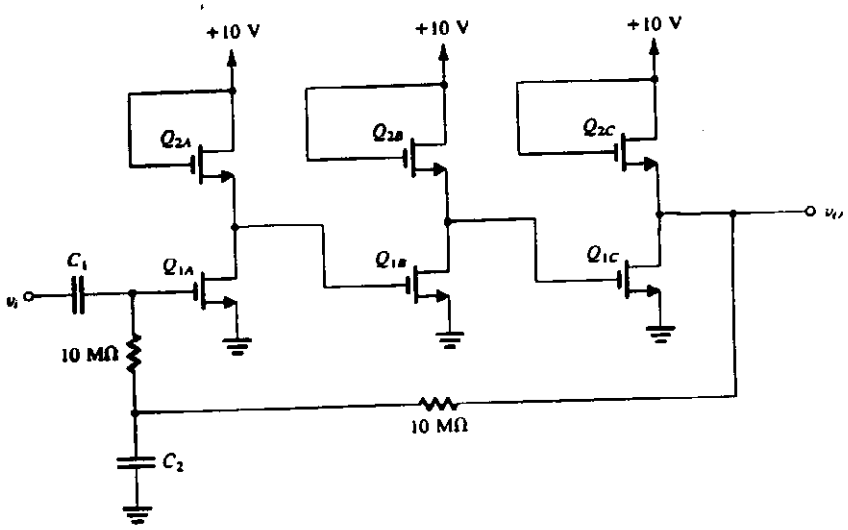

Fig. P1

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 ±15V power supplies and that their output saturates at ±14V, what is the largest sine wave output (Vrms) that can be accommodated? (5%)

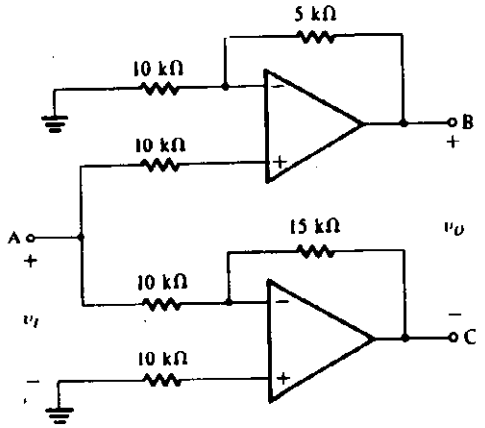

Fig. P2

3. For the common-emitter amplifier shown in Fig. P3, let $V_{CC}=9$V, $R_1=27$kΩ, $R_2=15$kΩ, $R_E=1.2$kΩ, and $R_C=2.2$kΩ. The transistor has $\beta=100$, $V_{BE}=0.7$V, $V_A=100$V, and the thermal voltage $V_T=25$mV.

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

(b) If the amplifier operates between a source for which $R_S=10$kΩ, and a load of 2kΩ, replace the transistor with its hybrid-π small-signal model, and find the values of g_m, r_π, r_o, and A_v. (10%)

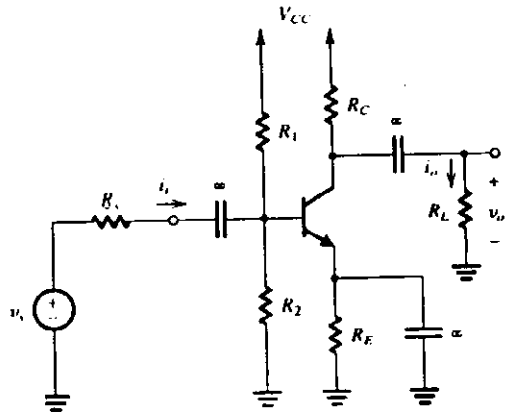

Fig. P3

4. Assuming each transistor in Fig. P4 has β=100 and $r_e = 100\Omega$.

Find (a) the voltage gain of the amplifier (5%)

(b) the input resistance of the amplifier. (5%)

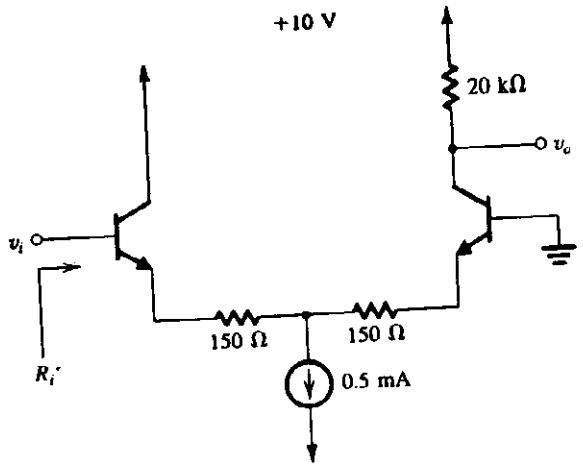

Fig. P4

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_{id} =100 KΩ, the output resistance of the op amp = 1 KΩ, R_s = 10 KΩ, R_L = 10 KΩ, r =100 Ω, and R_f = 1 KΩ,

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 $\frac{I_o}{I_s} \cong 1 + \frac{R_f}{r}$. (5%)

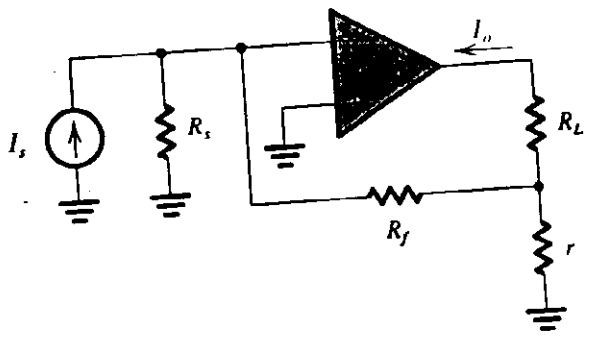

Fig. P5

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 $\frac{R_2}{R_1}$ for oscillation. (5 %)

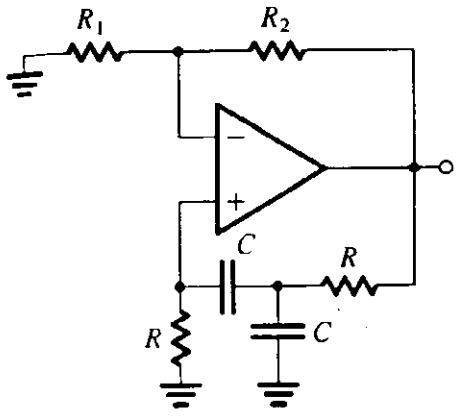

Fig. P6