1. Show that for the Hartley oscillator of Fig. 1,

(a) the frequency of oscillation is given by $\omega_o = 1/\sqrt{(L_1 + L_2)C}$, and (8 points)

(b) the condition for oscillations to start is $g_m R > (L_1 / L_2)$ (7 points)

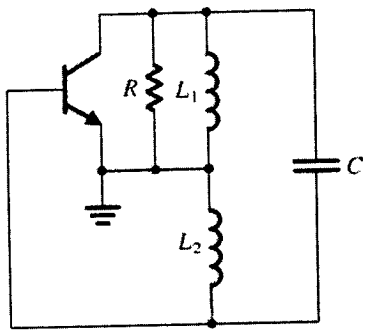

Fig. 1

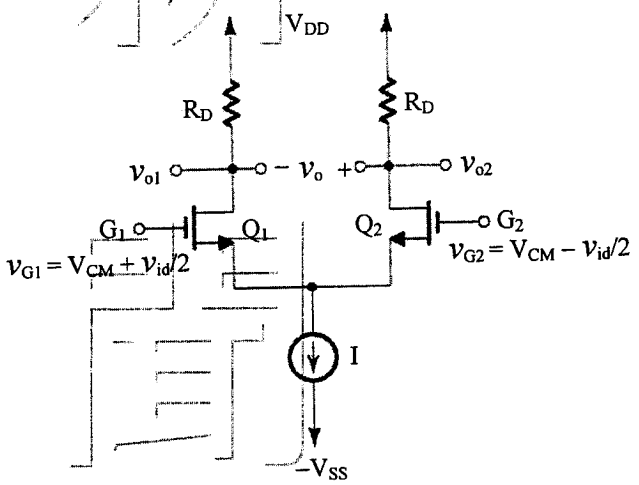

Fig. 2

2. A MOS differential pair (see Fig. 2) is operated at a total bias current of 0.8 mA, using transistors (i.e. Q_1 and Q_2 in Fig. 2) with a W/L ratio of 100, $\mu_n C_{ox} = 0.2$ mA/V^2, $V_A =$ 20 V, and $R_D = 5$ kΩ. Find

(a) Overdrive voltage V_{OV} of the transistors. (4 points)

(b) Transconductance g_m of the transistors. (4 points)

(c) Output resistance r_o of the transistors. (4 points)

(d) Differential gain A_d of the differential pair. (3 points)

3. An op amp having a single-pole roll-off at 100 Hz and a low-frequency gain of 10^5 is operated in a feedback loop with $\beta = 0.01$. What is the factor by which feedback shifts the pole? To what frequency? If β is changed to a value that results in a closed-loop gain of 1, to what frequency does the pole shift? (10 points)

4. Plot the complete circuit of an emitter follower. Calculate its voltage gain at very low frequencies. (10 points)

5. (a) For the circuit in Fig. 5a find the values of i_O and the voltage gain v_O/v_I. (4 points)
(b) For the circuit in Fig. 5b, derive the transfer function and find the dc gain and the 3-dB frequency. (6 points)

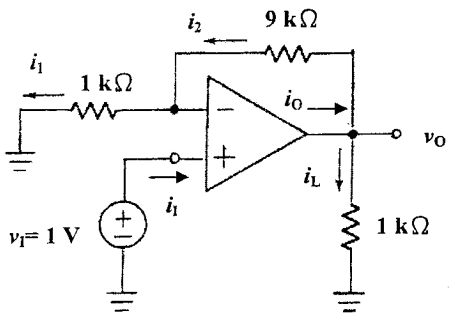

Fig. 5a

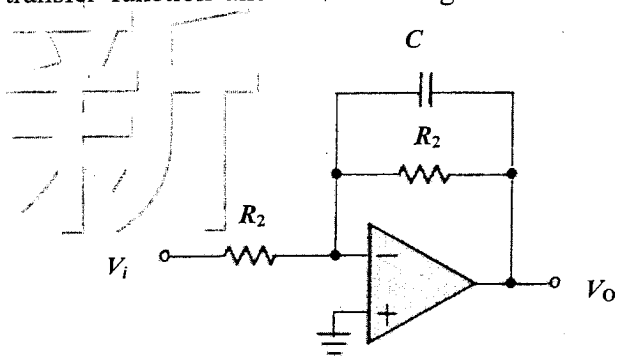

Fig. 5b

6. (a) Assuming the diodes to be ideal, sketch the transfer characteristic v_O versus v_I for the circuits shown in Fig. 6a. (4 points)
(b) For the circuits in Fig. 6b-6c, sketch the output for the input shown in Fig. 6d. Label the most positive and most negative output levels. Assume the diodes are ideal and CR >>T. (6 points)

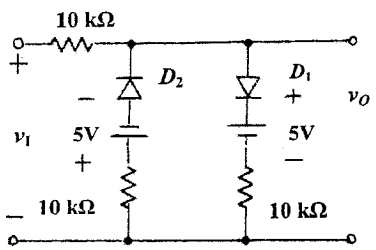

Fig. 6a

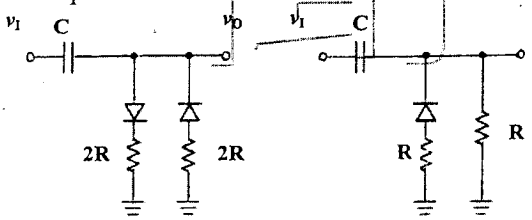

Fig. 6b

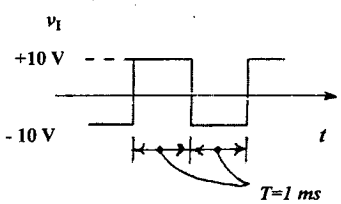

Fig. 6c

Fig. 6d

7. For the common-source amplifier in Fig. 7, the transistor has v_t= 1V, and k'$_n$W/L=2mA/V^2.
(a) Find the drain current I_D and drain voltage V_D that the bias circuit establishes. (4 points)
(b) Find g_m and r_o if VA=100V. (6 points)
(c) Find R_{in} and v_o/v_{sig}. (6 points)

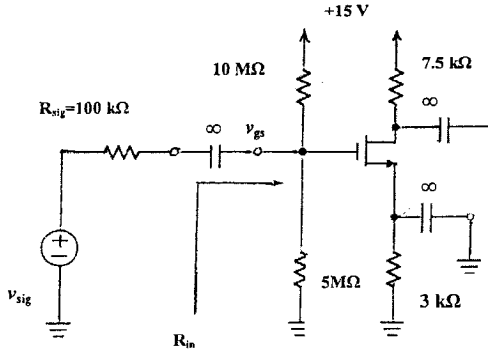

Fig. 7

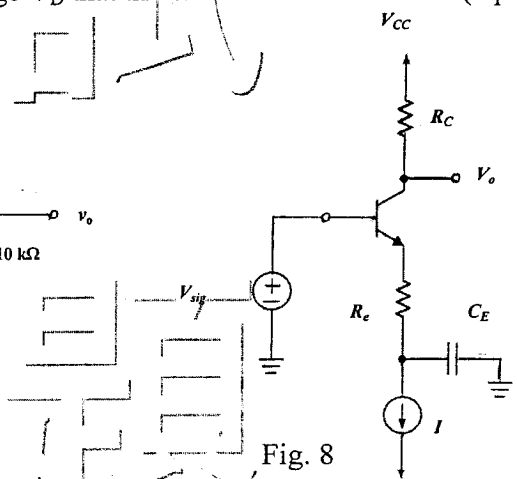

Fig. 8

8. The common-emitter amplifier of Fig. 8 includes an emitter degeneration resistance R_e.
(a) Assuming α~1, neglecting r_x and r_o, and assuming the current source to be ideal, derive an expression for the small-signal voltage gain A(s)=V_o/V_{sig} that applies in the midband and the low frequency band. Also find the midband gain A_M and the lower 3-dB frequency f_L. (12 points)
(b) What is the factor that the magnitude of A_M reduced by including R_e. (2 points)