(6%) 1. (a) A p-n junction diode has doping density of $N_A = 1 \times 10^{17} cm^{-3}$ and $N_D = 1 \times 10^{15} cm^{-3}$. Please calculate the contact potential V_O of this diode. (if $n_i = 1 \times 10^{10} cm^{-3}$) (3%)
(b) If a resistor R=10KΩ is connected with this diode from p-type to n-type terminal. Please calculate the conduction current of this circuit. (3%)

(6%) 2. For a npn bipolar junction transistor, the reverse saturation currents of the emitter-base and base-collector junction are $I_{ES} = 1 \times 10^{-15} A$ and $I_{CS} = 2 \times 10^{-15} A$, respectively. If the common-emitter forward short-circuit current gain is $\beta_F = 100$. Please estimate the values of α_F, α_R, and β_R. (6%)

(6%) 3. For a certain JFET has $I_{DSS} = 10mA$ and $V_P = -8V$.
(a) Is this a p-channel or n-channel FET? (3%)
(b) Calculate I_D at $V_{GS} = -3V$. (3%)

(15%) 4. An inverter circuit is shown in Fig. 1. The output characteristics of Q_1 and Q_2 are shown in Fig. 2 and Fig. 3, respectively. Assume that $C_{tot} = 0.4pF$, $V_{OH} = 5.8V$, $V_{OL} = 0.5V$ and that the input signal has $V(0) = 0.3V$ and $V(1) = 6V$. Please estimate the propagation delay t_{PHL} and t_{PLH} of this circuit.

(25%) 5. For the active-load differential amplifier of Fig. 4 when biased with a current $I = 0.2mA$, and if the BJTs have $\beta = 200$, $V_T = 25mV$, and $V_A = 100V$,
(a) Find the values of R_i, G_m, and r_o.(6%)
(b) Find the open-circuit voltage gain.(4%)
(c) Find the output resistance of the cascode amplifier.(5%)
(d) What is the voltage gain from the base to the collector of Q_1(3%)
(e) What is the minimum value of V_{BIAS} that results in the upper limit of the input common-mode range being at least +10V?(3%)
(f) Compare to the C-E configuration, what is the advantages of the cascode amplifier to the frequency response?(4%)

(5%) 6. The transistor shown in Fig. 5 has $\beta = 100$, $r_\pi = 1K\Omega$ and $r_o \to \infty$.
(a) Determine the value of the lower -3dB frequency, f_L.(3%)
(b) Given $i(t)$ as 100Hz square wave, determine the percentage tilt in the output. What is the lowest frequency square wave that exhibits no more than 2 percent tilt?(2%)

(10%) 7. The compensated return ratio of a wide-band single-loop amplifier is

$$T(s) = \frac{10^4}{[1 + (s/w_1)][1 + (s/10^7)][1 + (s/10^8)]}$$

(a)Determine its dominant pole w_1 so that its phase margin is approximately 90^0.(5%)
(b)Draw its Bode diagram.(5%)

(17%) 8. An instrumentation amplifier circuit is shown in Fig. 6 where $R_1 = R_2$, $R_3 = R_4$, and all transistors are identical. (a) Identify the function of each component.(12%) (b) Derive $\frac{v_o}{v_{in}}$ =?(5%)

(10%) 9. Explain by means of an asymptotic Bode diagram why a practical integrator deviates from an ideal one at both high and low frequencies.

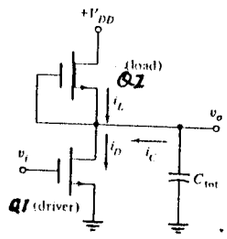

Fig. 1

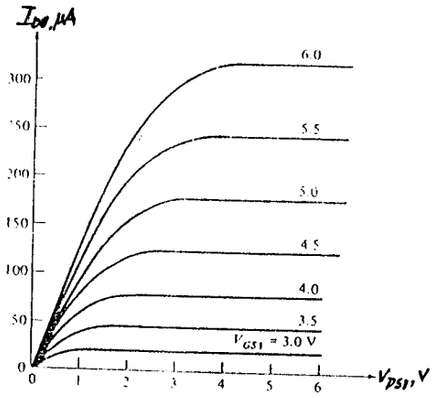

Fig. 2

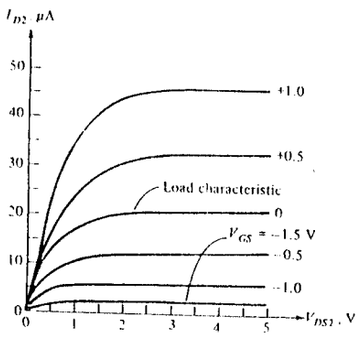

Fig. 3

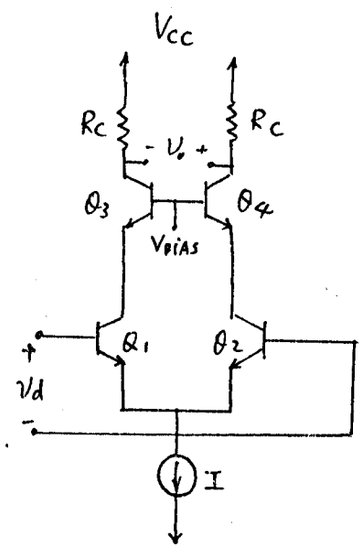

Fig. 4

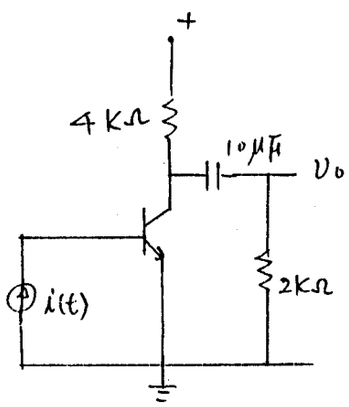

Fig. 5

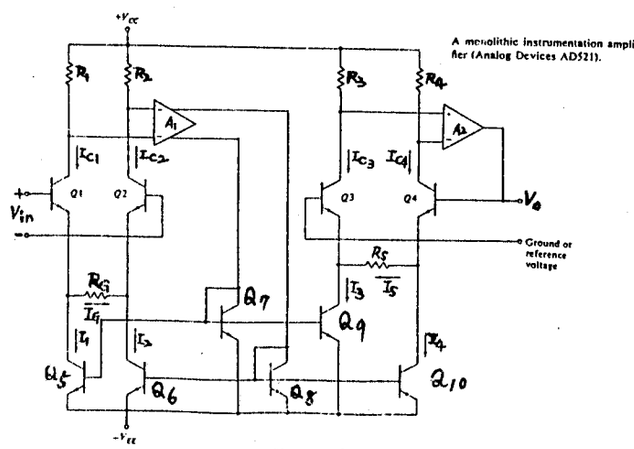

Fig. 6