1. Please explain the following terms:
   (a) Electrons (電子) & holes (電洞) (5 points)
   (b) Depletion region (空乏區) of a diode. (5 points)
   (c) Junction capacitance (接面電容) of a diode (5 points)
   (d) Body effect in MOSFET. (5 points)
   (e) CMOS technology. (5 points)

2. For the configurations shown in Fig. 1, determine the small-signal resistances R_X and R_Y. Assume $\lambda \neq 0$ (i.e. output resistance r_o is not negligible). (10 points)

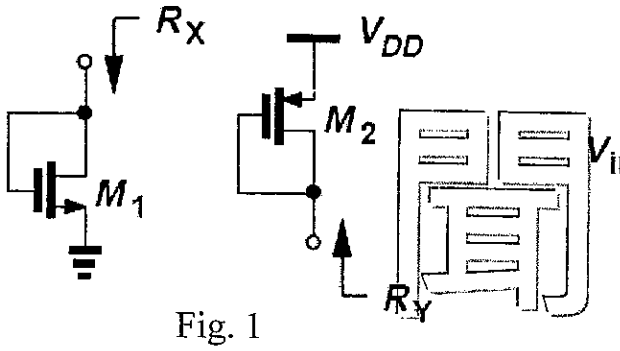

Fig. 1

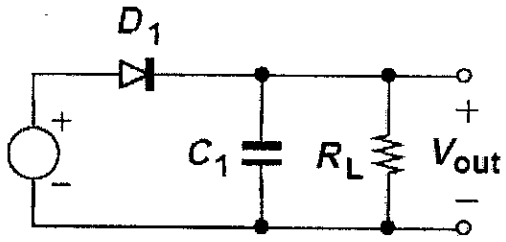

Fig. 2

3. (a) For the half-wave rectifier shown in Fig. 2, plot the output waveform for different values of smoothing capacitor C_1. (10 points)
   (b) Describe the advantages of a full-wave rectifier when compared with a half-wave rectifier. (5 points)

4. In Fig. 3, calculate the values of I_2, I_3 and V_R. Assume that the voltage drop across the diodes (D_1, D_2) and V_{BE} of Q_1 is 0.7V. Neglect the base current of Q_1. (10 points)

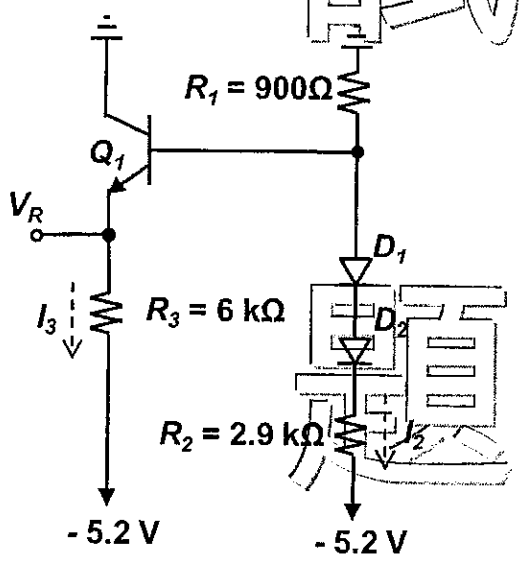

Fig. 3

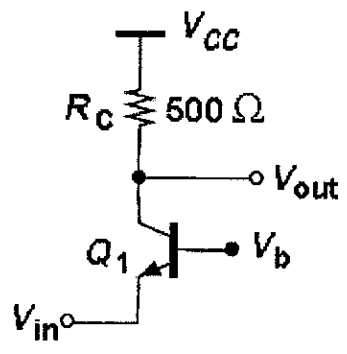

Fig. 4

5. In Fig. 4, Q_1 has $\beta = 80$, $V_A = 15$ V, and is biased at $I_C = 2.5$ mA. Assume $V_T = 25$ mV. Calculate its voltage gain (A_v), input resistance (R_{in}), and output resistance (R_{out}). (10 points)

6. In Fig. 5, assume M_1 is at saturation and has $(W/L)_1 = 50$, $\mu_n C_{ox} = 50\mu A/V^2$, $V_{TH} = 0.5V$, $\lambda = \gamma = 0$. $V_{DD} = 3V$, $I_{out} = 200\mu A$.
(a) Determine R_1/R_2. (5 points)
(b) Calculate the sensitivity of I_{out} to V_{DD}, defined as $\partial I_{out}/\partial V_{DD}$ and normalized to I_{out}. (5 points)

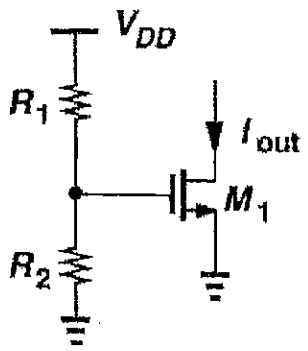

Fig. 5

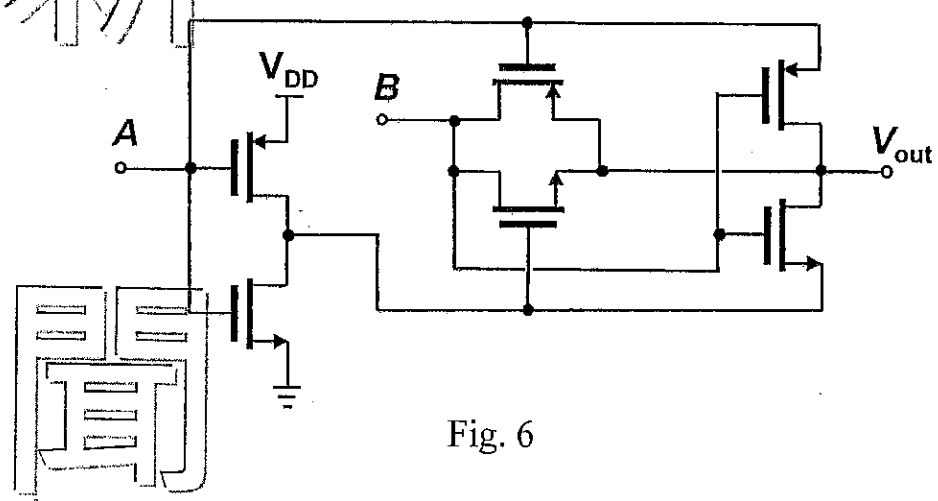

Fig. 6

7. In Fig. 6, A and B are two logic inputs. What is the logic function of V_{out}? (5 points)

8. In Fig. 7, the MOSFETs have their geometry size as labelled, and V_{DD} is 5V. Calculate the voltage values of V_1 and V_2. (5 points)

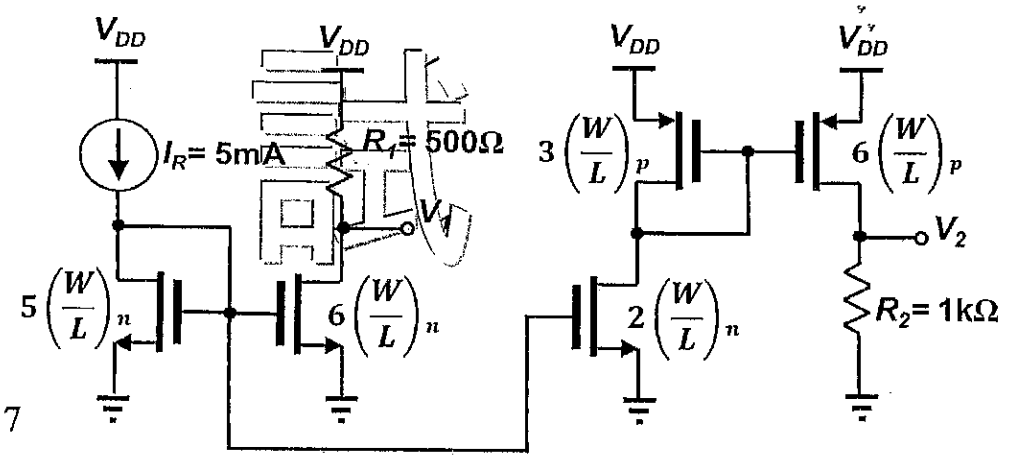

Fig. 7

9. In Fig. 8, assume the operational amplifier is ideal.
(a) Derive the transfer function, $H(s) = V_{out}/V_{in}$. (5 points)
(b) What type of filter it is? (5 points)

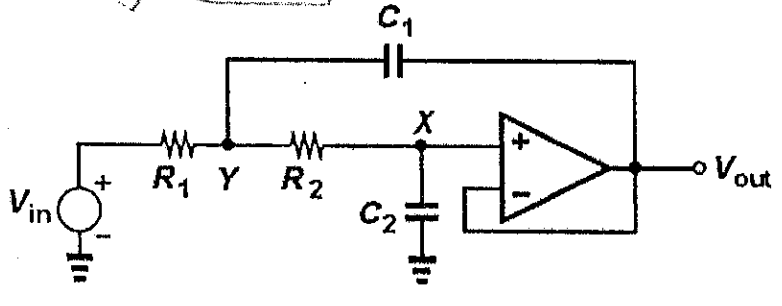

Fig. 8