1. (30%) Consider a rectifier circuit shown in Fig. 1, where the diode is assumed to be ideal.
   (a) (10%) Please plot the waveform of the output voltage $V_0(t)$.
   (b) (15%) Consider now a capacitor is added to the circuit, as shown in Fig. 2. Two cases of capacitor are considered:
   (i) $C = 1\mu F$; (ii) $C = 0.01\,F$
   Which capacitor can make the output voltage closer to DC output (i.e., the output waveform more flat)? State the reasons. No score will be given without reasons.
   (c) (5%) Suppose now that the diode is not ideal. Please discuss the effects of actual diode.

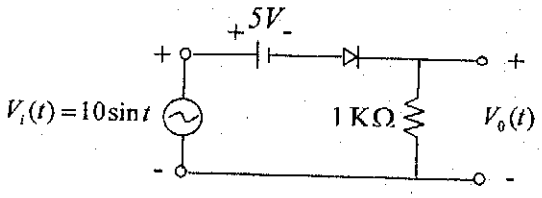

Fig. 1

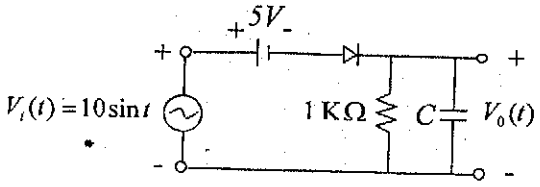

Fig. 2

2. (10%) The instrumentation amplifier has widespread applications. Please determine the voltage gain $A_v = \frac{v_o}{v_1 - v_2}$ of the instrumentation amplifier circuit shown in Fig. 3. *(Assume ideal op-amps)*

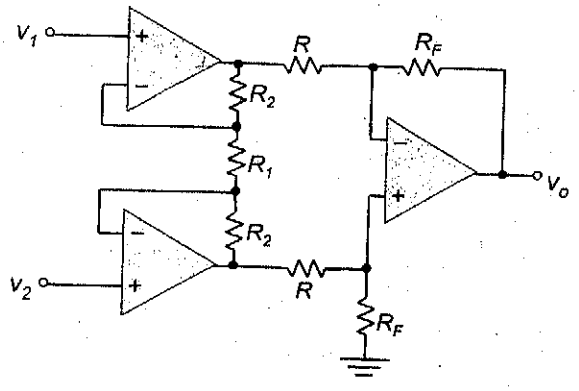

Fig. 3

3. (20%) In many op-amp applications, one is to use as a voltage-to-current converter. Fig. 4 shows a voltage-to-current converter circuit. Please answer the following questions *(the ideal op-amp is assumed)*

(a) (10%) Please derive the relation $a \cdot i_L = b \cdot v_I$, where a is the function of R_1, R_2, R_3, R_F, Z_L; b is the function of R_1, R_3, R_F; v_I is the input voltage; i_L is the current flowing through Z_L *(see Fig. 2)*.

(b) (5%) According to the result derived in question *2(a)*, at what kind of condition, we can design the circuit such that i_L is independent of Z_L? (*Hint: think about how to adjust the coefficient of* Z_L)

(c) (5%) Let $Z_L = 100\Omega$, $R_1 = 10k\Omega$, $R_2 = 1k\Omega$, $R_3 = 1k\Omega$, and $R_F = 10k\Omega$. If $v_I = -5V$, determine the output voltage v_o.

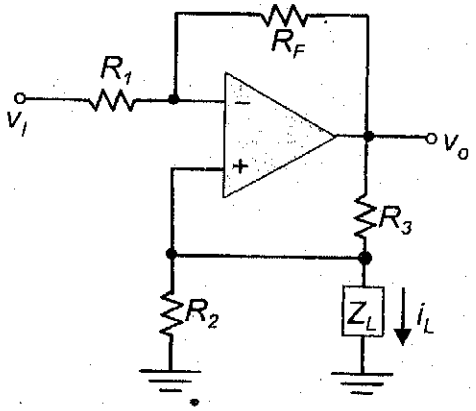

Fig. 4

4. (10%) The BJT circuit is shown in Fig. 5. Let the V_{BE}=0.6V and the current amplification factor β=100. Please find the V_{CE} and determine the operating mode of the BJT.

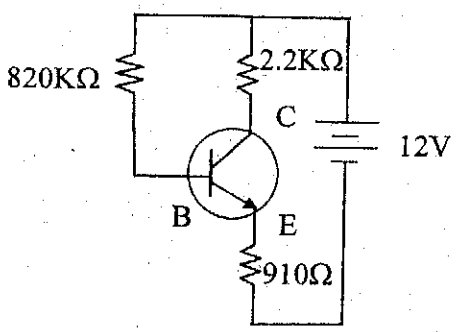

Fig. 5

(5) (30%) Determine the operating Q point in the n-channel enhancement mode MOSFET circuit given as Fig. 6 below. The circuit parameters are given as V_{DD}=36V; R_D=10Ω, R_1=R_2=2$M\Omega$, V_T=4V; K =0.1mA/V^2. Here K is the conductance parameter. The operating condition is to assume that V_{DSQ}=V_{DD}/2=18V.

(a) (10%) Determine V_{GG}, R_s, and i_{DQ}.

(b) (10%) What is the operating region of the MOSFET?

(c) (10%) Draw the circuit of the common-source amplifier using the *N-MOS*. Draw the small-signal equivalent circuit of the amplifier. Explain the parameter in the equivalent circuit.

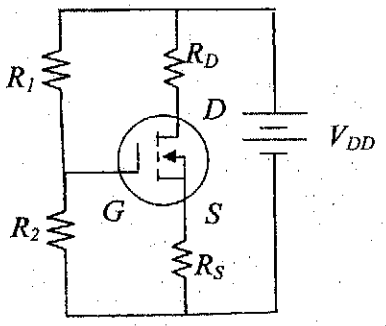

Fig. 6