Sheet 4
Non-linear Applications of Op-Amp

1) For the circuit shown in fig. (p1), if V_{EE} = 15V, R = 30Ω, $I_S = 10^{-13}$A, Q in active mode with β_F = 30. Then find:
   a. I_c and the output voltage of the op-amp .
   b. What is the min. V_{cc} needed for Q to operate in active region?
   c. What must be the power dissipation rating of the resistor R?

2) For the circuit shown in fig. (p2), if the max. Op-amp output current is 5 mA and β_F = 50, what is the min. value of R?

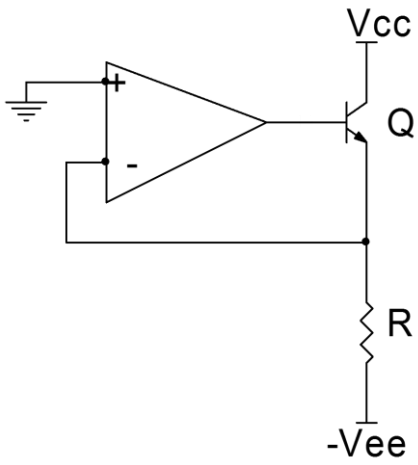

Fig (p1)

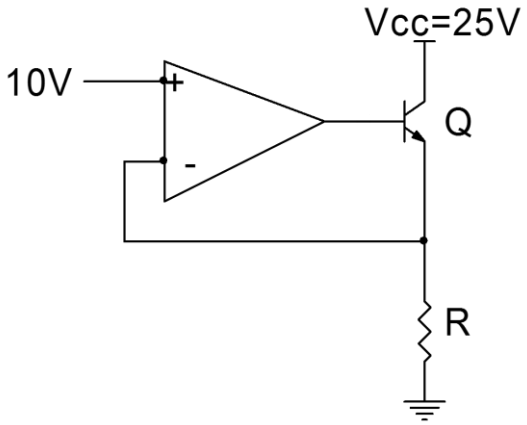

Fig (p2)

3) For both circuits in fig (p3-a) and fig (p3-b)
   a. Sketch the dc transfer characteristic of the circuit.
   b. Sketch the output waveform when a sinusoidal input of 1v amplitude and 1 KHz frequency is applied.

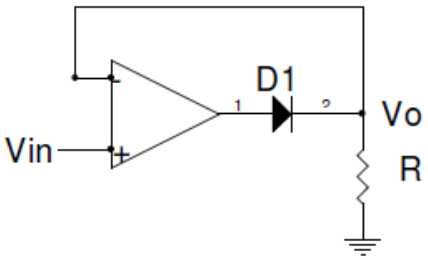

Fig (p3-a)

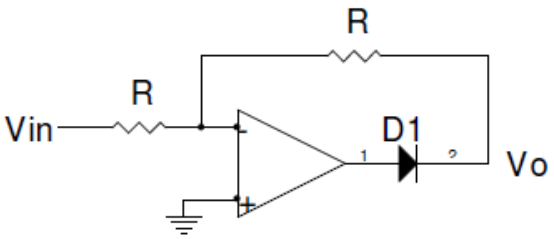

Fig (p3-b)

4) Describe the operation of the peak detector circuit shown in fig (p4).

5) Find the dc transfer characteristic of the circuit shown in fig (p5).
Given that ($V_{Z1} = V_{Z2} = 5V$).

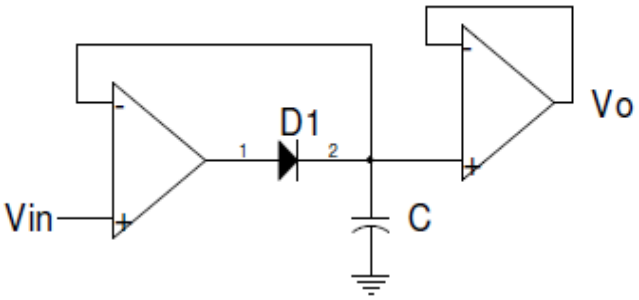

Fig (p4)

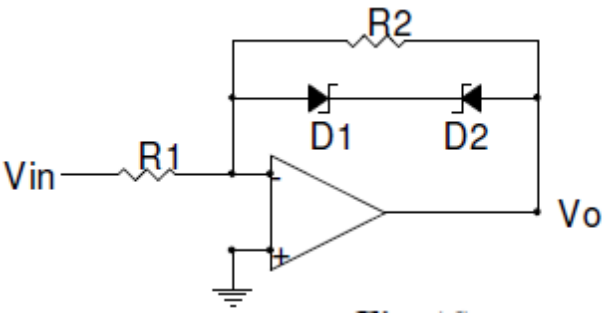

Fig (p5)

6) Find the dc transfer characteristic of the circuit shown in fig (p6).
Given that (VZ1 = 3V and VZ2 = 6V).

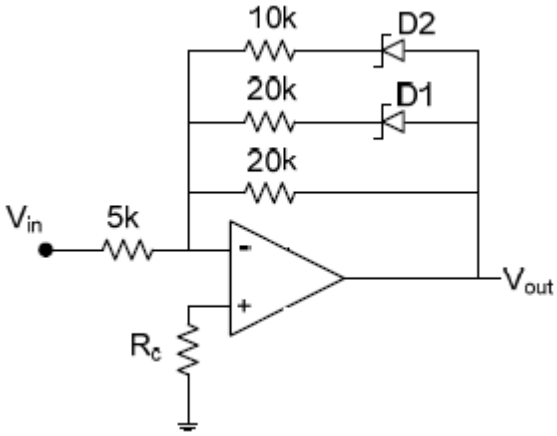

Fig (p6)

7) For the circuit shown in fig (p7), if all transistors are matched, Find:
   a. The input-output relationship.
   b. V_{in} range for proper operation of the circuit.

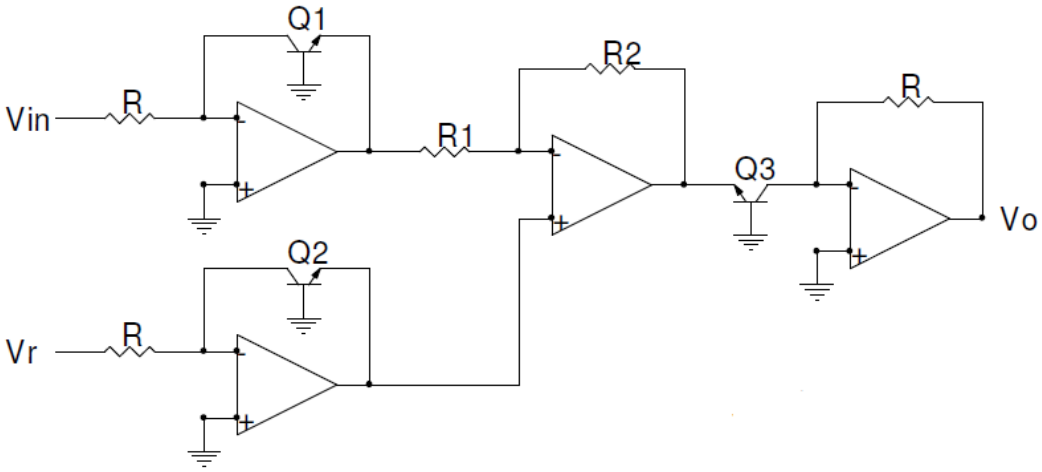

Fig (p7)

8) Implement the following mathematical function using Log-Antilog circuits utilizing minimum number of op-amps.

$$F = K.\frac{X^2\sqrt{Y}}{Z^3}$$

9)
   a. For the circuit shown in fig (p9-a), show that $I_1I_2 = I_3I_4$, if all transistors are matched. Then find the conditions on I_1, I_2, I_3 and I_4 for proper operation of the circuit.
   b. The circuit shown in fig (p9-b) is implemented in a commercial ICRC4200. It has a variety of applications. One of these applications is a four quadrant analog multiplier as shown in fig (p9-b). Find the output voltage V_o and the conditions on V_x and V_y for proper operation.
   c. The RC4200 can be used to implement a one-quadrant analog divider as shown in fig (p9-c). Find the output voltage V_o and the conditions on V_x and V_z for proper operation.

d. Show how to use the circuit shown in fig (p9-c) to implement a square rooting circuit.

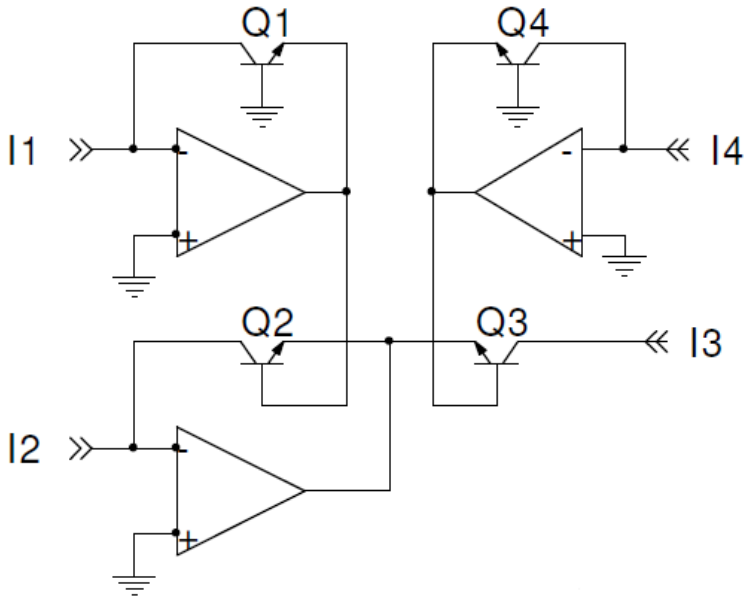

Fig (p9-a)

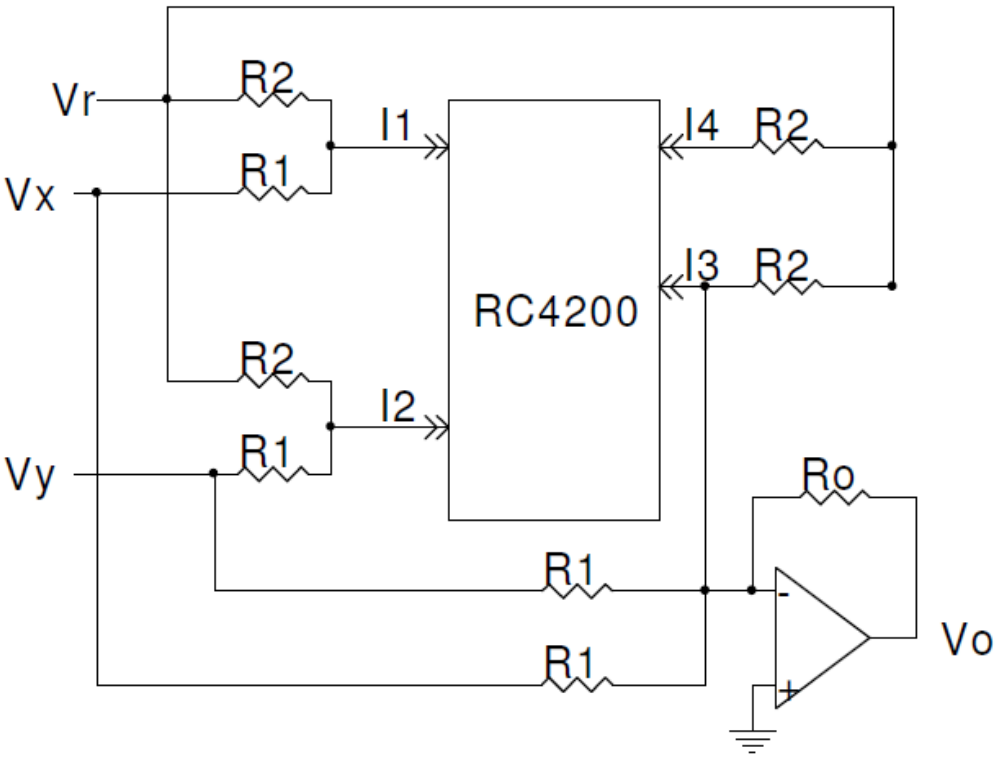

Fig (p9-b)

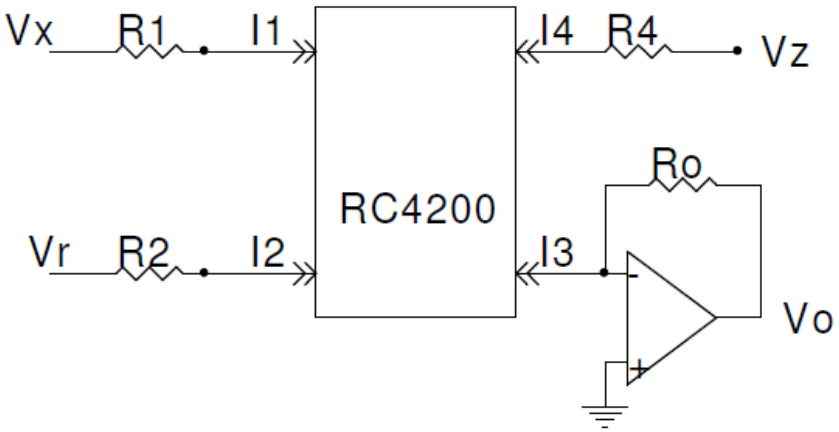

Fig (p9-c)