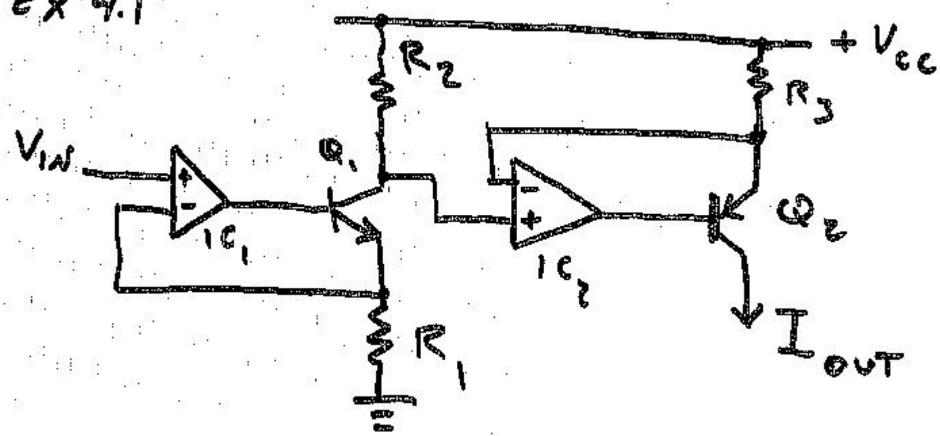
Ex 4.1



NOTE: BOTH OP-AMPS HAVE NEG. FEEDBA

$$I_{OUT} = \frac{V_{cc} - V_{E,Q_2}}{R_3}$$

NOW, $V_{E,Q_2} = V^+_{IC2} = V_{C,Q1}$ (NEG. FEEDBA

$$V_{C,Q1} = V_{cc} - I_{C,Q1} \cdot R_2$$

BUT, $I_{C,Q1} \simeq I_{E,Q1} = \frac{V_{IN}}{R_1}$

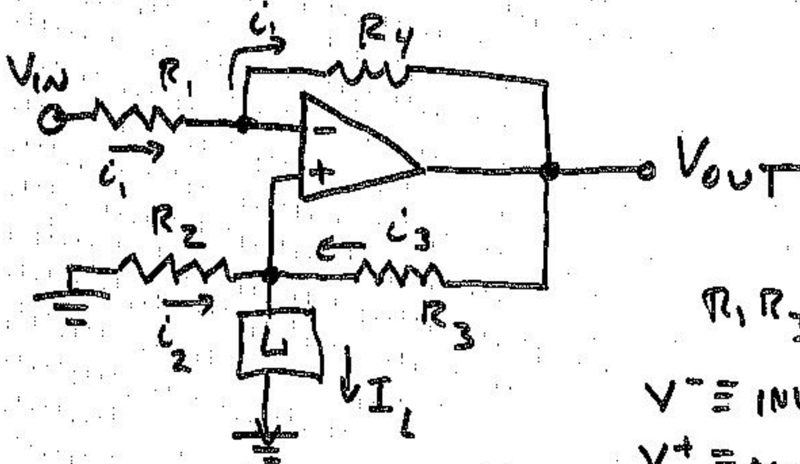
$\Rightarrow V_{C,Q1} = V_{cc} - V_{IN}\frac{R_2}{R_1}$

SO,

$$I = \frac{V_{cc} - \left(V_{cc} - V_{IN}\frac{R_2}{R_1}\right)}{R_3} = +\frac{V_{IN} R_2}{R_1 R_3}$$

Ex. 4.2

THE STRATEGY IS TO EXAMINE CURRENT FLOW. IDEALLY, OP-AMPS DRAW NO INPUT CURRENT.



$R_1 R_3 = R_2 R_4$

$V^- \equiv$ INVERTING VOLT.

$V^+ \equiv$ NON-INVERTING V.

$$i_1 = \frac{V_{IN} - V^-}{R_1} = \frac{V^- - V_{OUT}}{R_4} \qquad (1)$$

$$I_L = i_2 + i_3$$

$$= \frac{0 - V^+}{R_2} + \frac{V_{OUT} - V^+}{R_3} \qquad (2)$$

SINCE $V^- = V^+$, (1) BECOMES:

$$\frac{V_{IN} - V^+}{R_1} = \frac{V^+ - V_{OUT}}{R_4} \qquad (3)$$

EX 4.2 CONT.

Eq (3) $\Rightarrow$ $V_{OUT} - V^{+} = -\frac{R_4}{R_1}(V_{IN} - V^{+})$

FROM (2)

$$\frac{-V^{+}}{R_2} - \frac{R_4}{R_1 R_3}(V_{IN} - V^{+}) = I_L$$

BUT $R_1 R_3 = R_2 R_4$, SO

$$I_L = \frac{-V^{+}}{R_2} - \frac{1}{R_2}(V_{IN} - V^{+})$$

$$\therefore \boxed{I_L = -\frac{V_{IN}}{R_2}}$$

Ex. 4.3

(a)

$R_F = R_{IN} = 10\,k\Omega$

OBVIOUSLY, $G = -1$

SWITCH ON INVERT

SWITCH ON FOLLOWER:

$$V^+ = V^- = V_{IN}$$

$$i = \frac{V_{IN} - V^-}{R_1} = 0$$

BUT

$$i = \frac{V_- - V_{OUT}}{R_F} = 0$$

$$\Rightarrow \underline{V_{OUT}} = V_- = \underline{V_{IN}}$$

$$\therefore \boxed{G = +1}$$ AS ADVERTIZED.

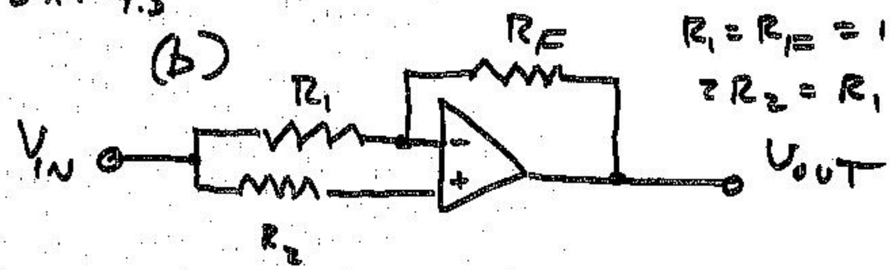
T. CUAN

Ex. 4.3

(b)

$R_1 = R_F = 10\,k\Omega$

$2R_2 = R_1$



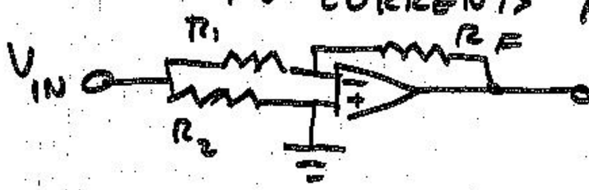
$V^+ = V_{IN}$ (+ INPUT DRAWS NO CURRENT)

NEG. FEEDBACK $\Rightarrow$ $V^+ = V^-$

BY REASONING IN 4.3 (a) THEN.

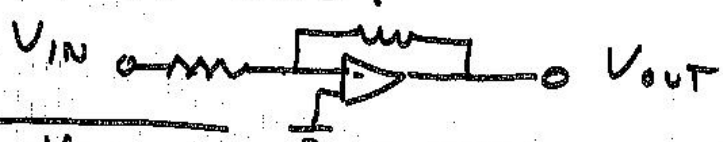
$G = +1$

NOTE: NO CURRENTS FLOWING IN CIRCUIT !



$V^- = V^+ = 0$ (R2 IRRELEVANT)

CIRCUIT LOOKS LIKE:



$$G = \frac{V_{OUT}}{V_{IN}} = -R_F/R_1 = -1$$