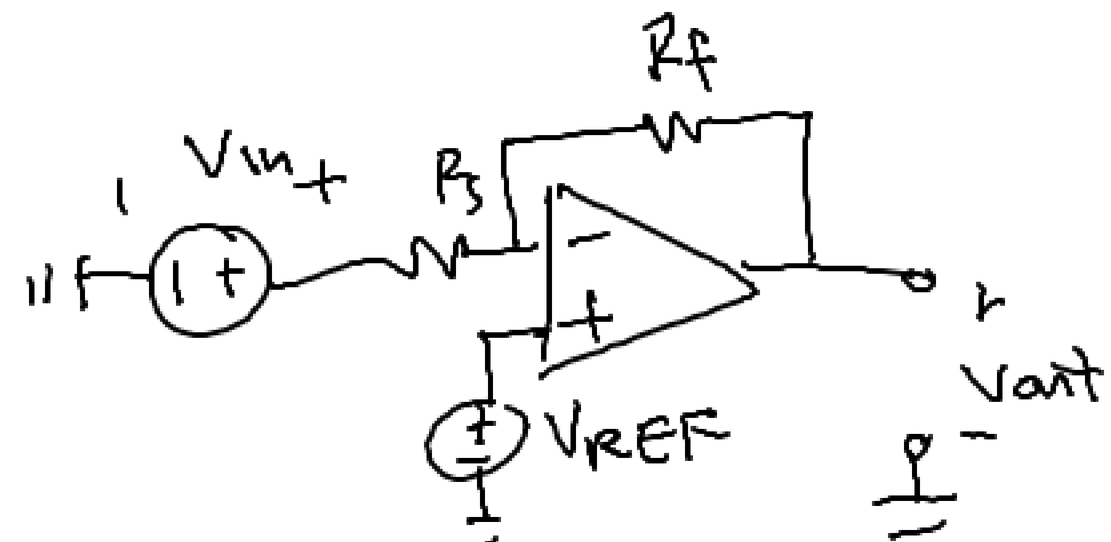
EECS16A DIS 5A

Topics for today

① Some reference designs/topologies
② How to combine circuits and deal with loading

Term: (circuit) topology: refers to a specific circuit
Ex: "(inverting op amp) topology"



$$V_{out} = v_{in}\left(-\frac{R_f}{R_s}\right) + V_{REF}\left(\frac{R_f}{R_s}+1\right)$$

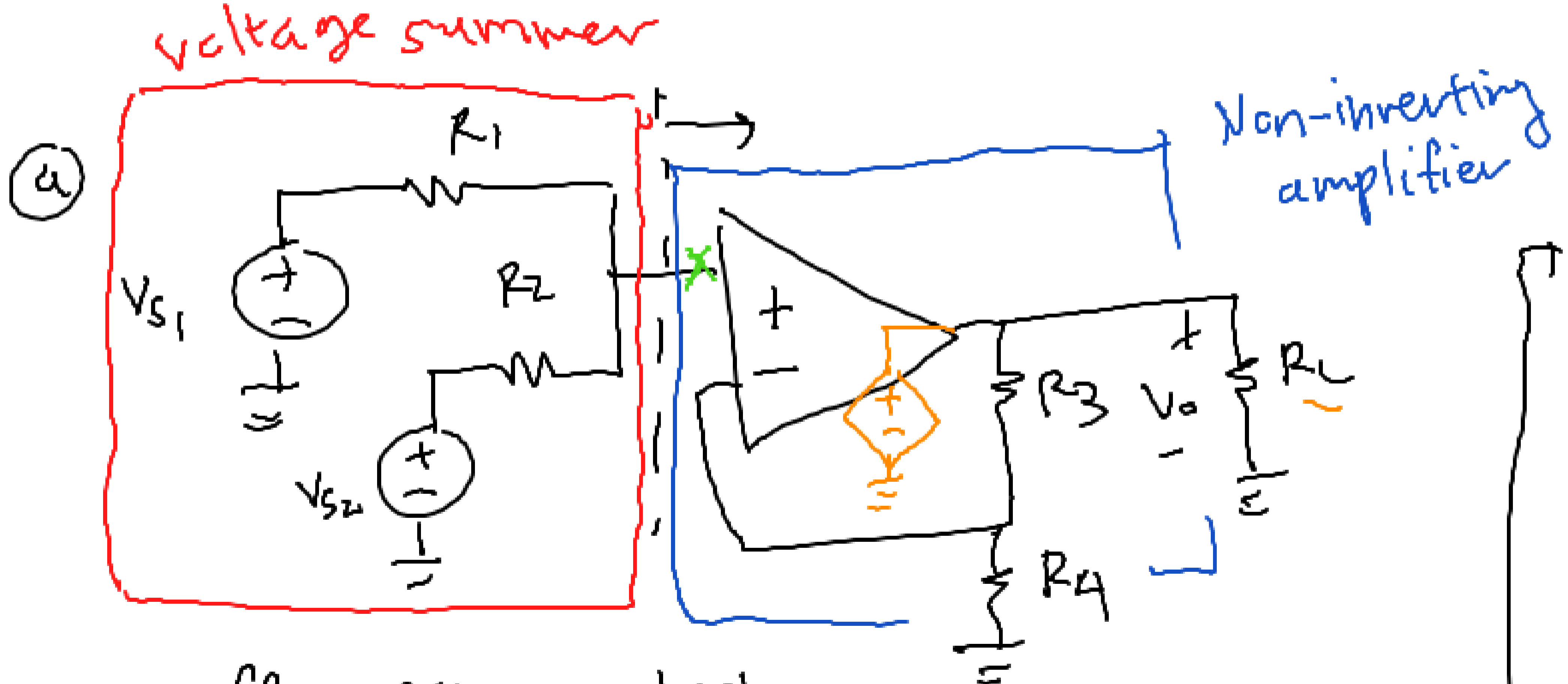
Choose $\frac{R_f}{R_s}$. Do we get to choose the coefficients separately? No, we can't

Can't do $-10\,V_{in} + 2V_{ref}$
Not possible

$\frac{R_f}{R_s} = 3$

$5V_{ref}$?

(a)



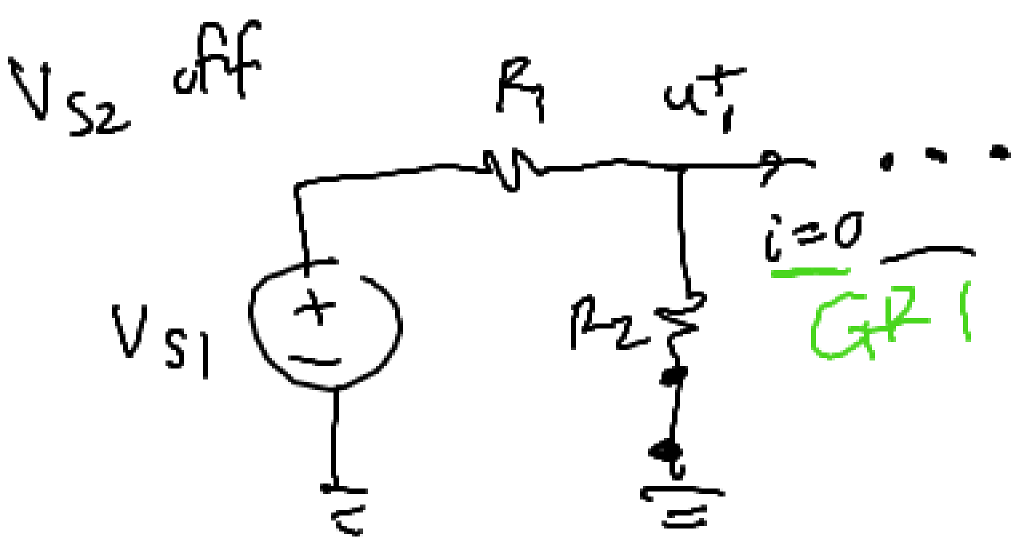
$$U^+ = \frac{R_2}{R_1+R_2} V_{S_1} + \frac{R_1}{R_1+R_2} V_{S_2}$$

Looks like voltage summer equation

Turn off a source, check for how it influences a quantity

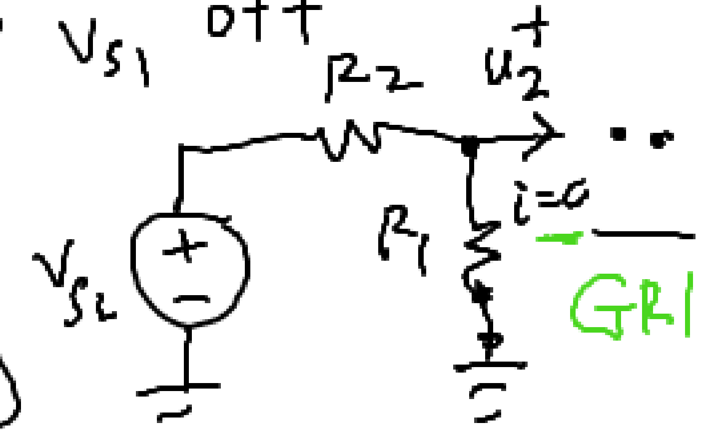
Look at u_+

V_{S2} off



$$U_1^+ = \frac{R_2}{R_1+R_2} V_{S1}$$

V_{S1} off



$$U_2^+ = \frac{R_1}{R_1+R_2} V_{S2}$$

$$V_{out} = V_{in}\left(1 + \frac{R_{top}}{R_{bot}}\right)$$

? ?

$V_{in} = u^+$

$V_{out} = V_o$

$R_{top} = R_3$

$R_{bot} = R_4$

$$V_o = \left(\frac{R_2}{R_1+R_2} V_{S_1} + \frac{R_1}{R_1+R_2} V_{S_2}\right)\left(1 + \frac{R_3}{R_4}\right)$$

Does R_L influence things? No

Does R_1, R_2 matter for the input? No (no loading)

(b) Say that V_{S_1} and V_{S_2} capture data/information (numbers)

$$V_o = \left(\frac{R_2}{R_1+R_2}V_{S_1} + \frac{R_1}{R_1+R_2}V_{S_2}\right)\underbrace{\left(1+\frac{R_3}{R_4}\right)}$$

← non inverting amp can only have multipliers ≥ 1

$$= V_{S_1} + V_{S_2} \; ?$$

Voltage summer

$$\alpha V_{S_1} + (1-\alpha)V_{S_2}$$

$$\frac{1}{2}V_{S_1} + \frac{1}{2}V_{S_2}$$

$$2 \cdot \frac{1}{2}(V_{S_1}+V_{S_2})$$

Can we choose α to get $\alpha = 1$, $1-\alpha = 1$?

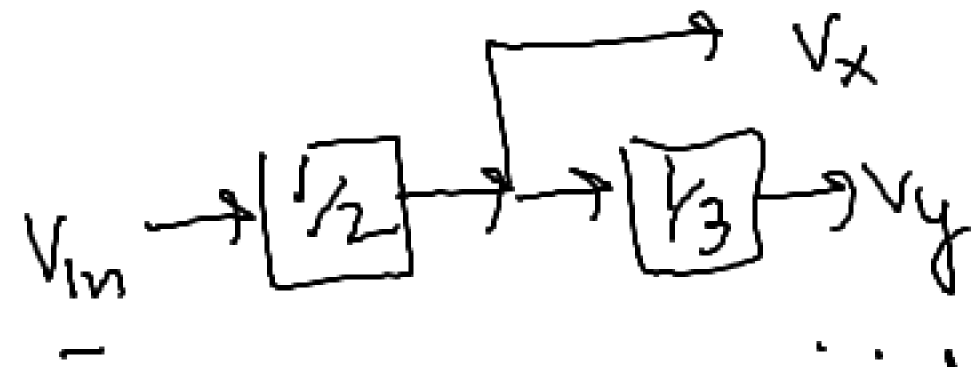
$$\alpha = (1-\alpha)$$

$$\Rightarrow \alpha = \frac{1}{2}$$

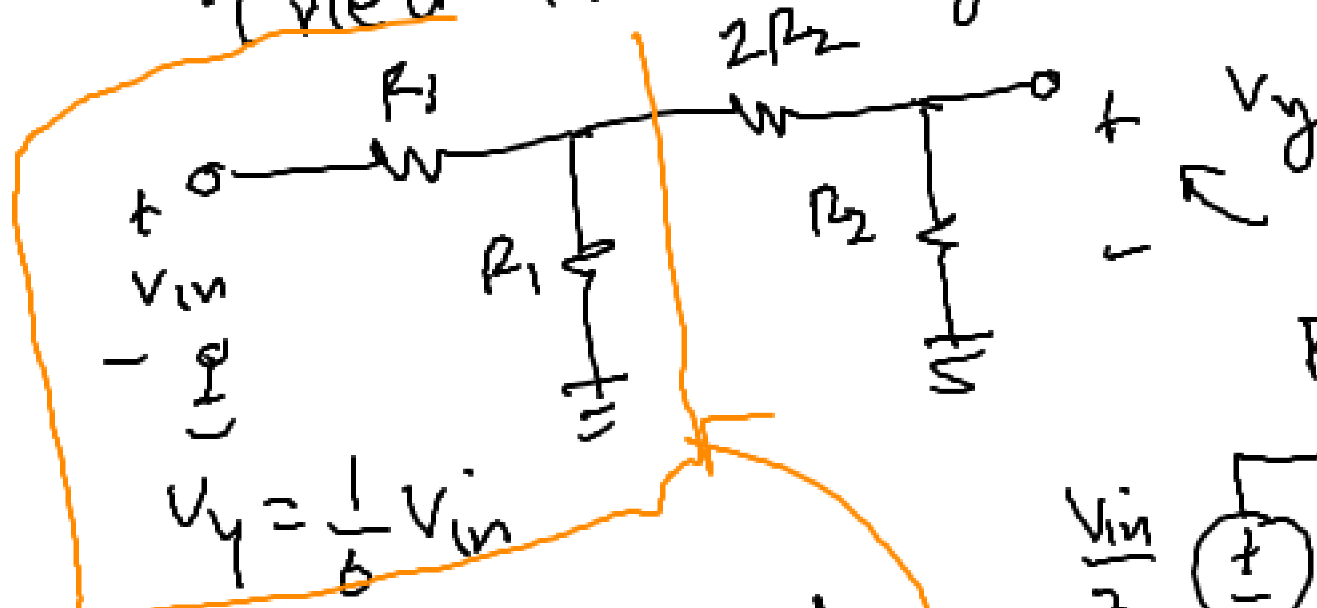
$\Rightarrow$ $\boxed{R_1 = R_2 = R_3 = R_4}$

$$\frac{R_2}{R_1+R_2} = \frac{1}{2} \qquad \frac{R_1}{R_1+R_2} = \frac{1}{2} \qquad \left(1+\frac{R_3}{R_4}\right) = 1+1 = 2$$

2

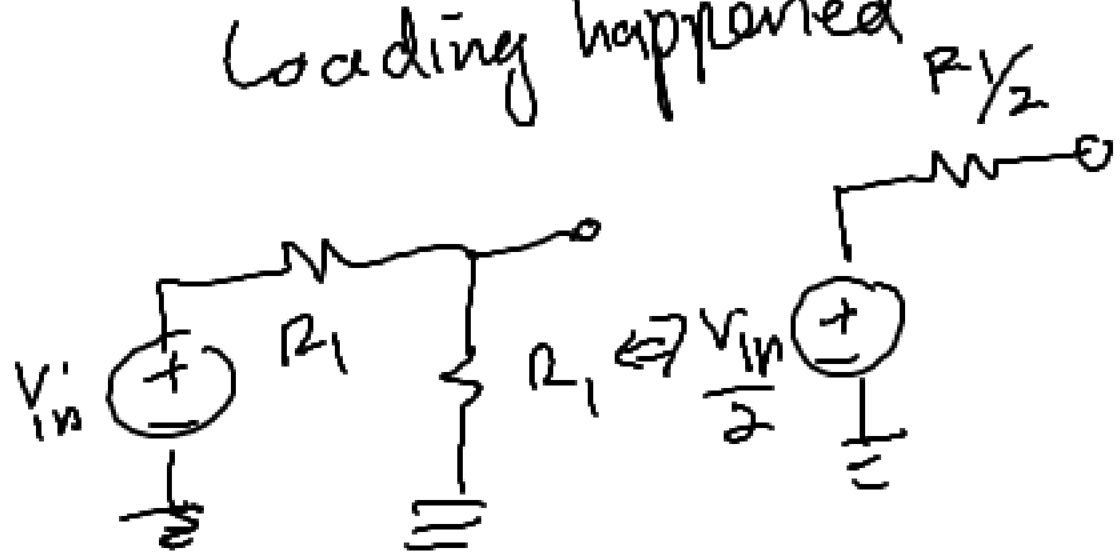


Tried two voltage dividers

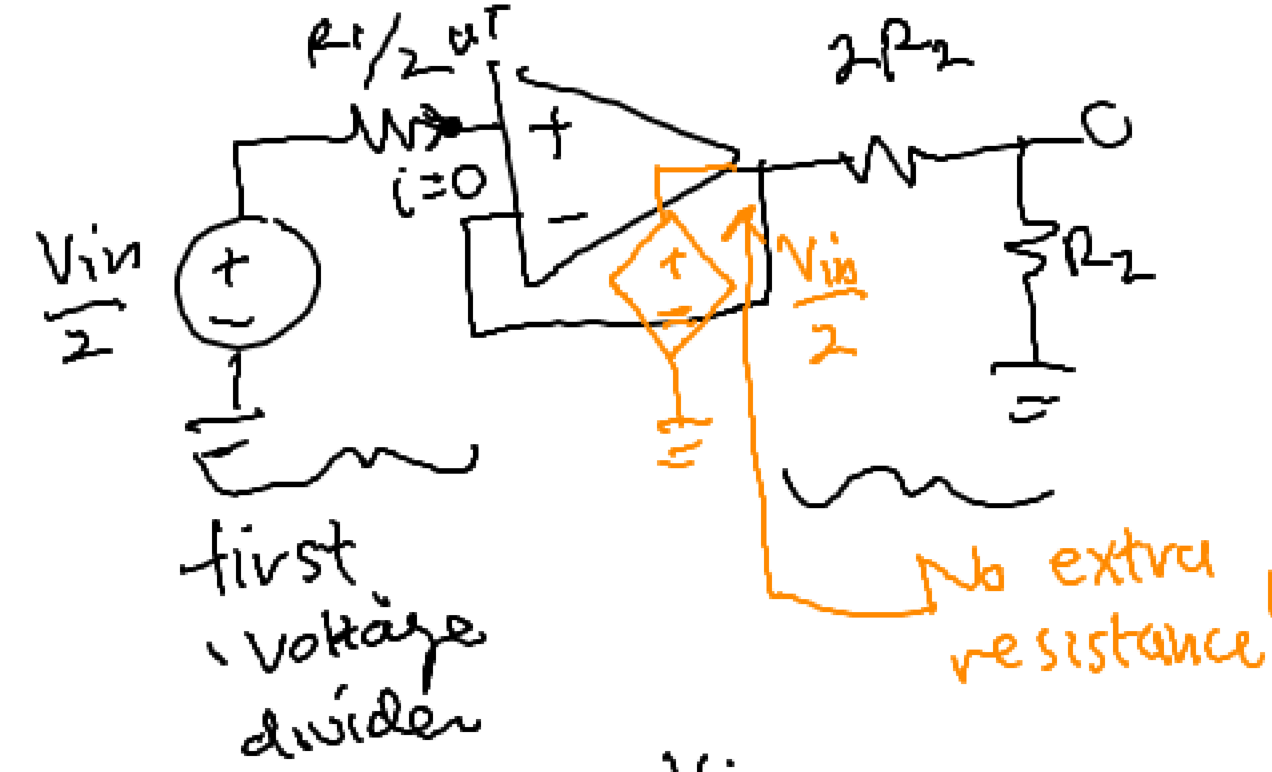


$V_y = \frac{1}{6} V_{in}$

Loading happened



$R_1/2$ is causing the issue



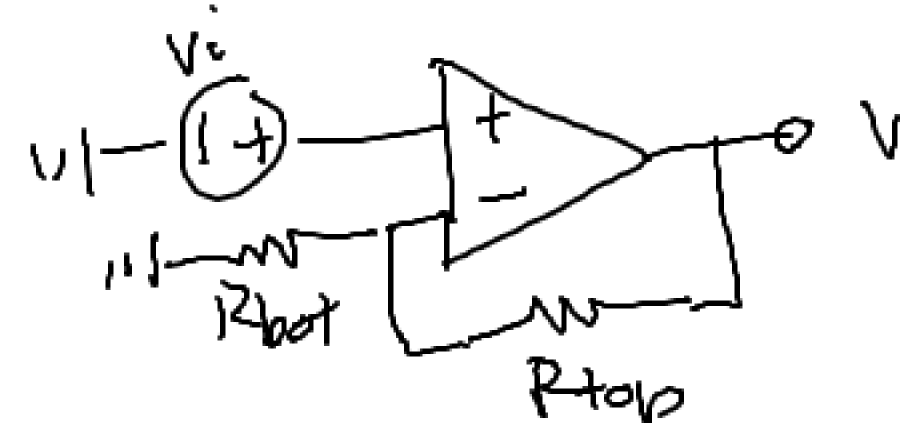
$U^+ = \frac{V_{in}}{2}$

GR 2 $\Rightarrow U^- = U^+ = \frac{V_{in}}{2}$

(i) How to get $V_o = 5V_i$

Non-inverting amp

$R_{top} = \underline{4R}$, $R_{bot} = \underline{R}$ (x2)



$$V_o = \left(1 + \frac{R_{top}}{R_{bot}}\right) V_i = \left(1 + \frac{4R}{R}\right) V_i = 5V_i \checkmark$$

(ii) $V_o = -2V_i$

Inverting amp (x4)

$R_f = 2R$, $R_s = R$

✓ $R_f = 2R_s$

$R_f = 2k\Omega$, $R_s = 1k\Omega$

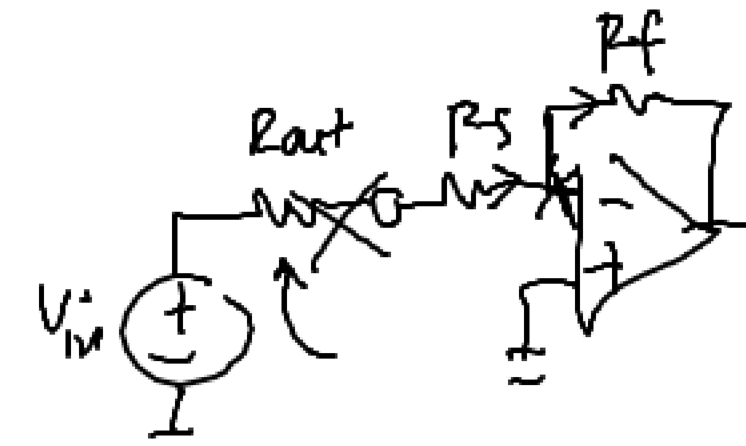
$R_f = 4$ $R_s = 2$

$\frac{R_f}{R_i} = 2$

$$V_o = -\frac{R_f}{R_s} V_i$$

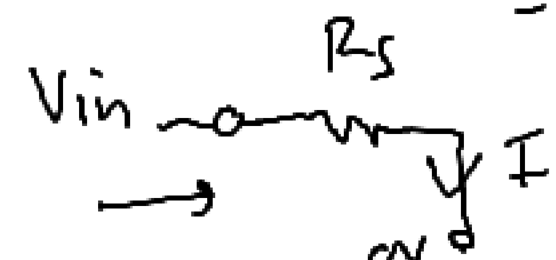
$$-\frac{2R}{R} V_i = -2V_i \checkmark$$

$$-\frac{2k\Omega}{1k\Omega} V_i = -2V_i$$



Inverting amp behaves like it has a resistance on the input → it can load → be careful

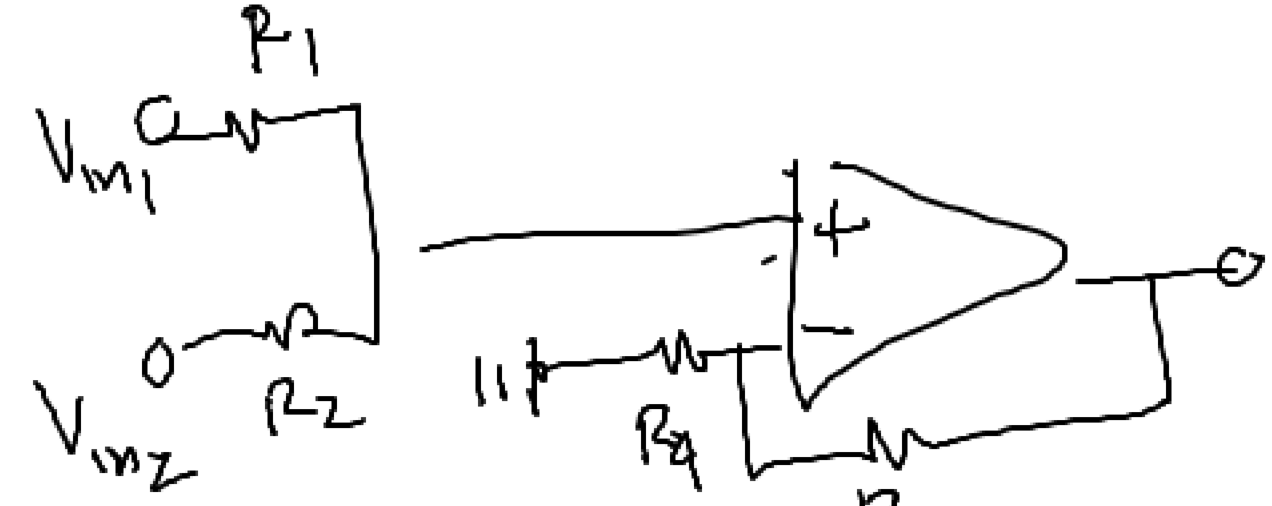
Inverting amp:



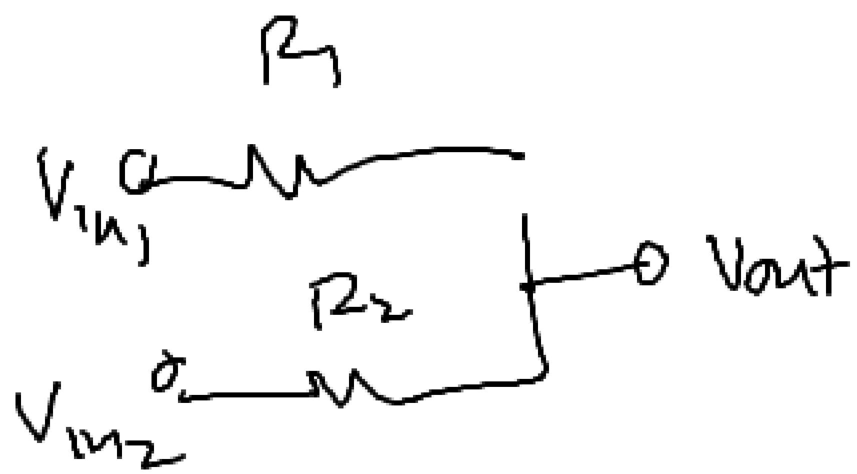
$I = \frac{V_{in} - 0}{R_s} \neq 0$

(iii) Implement $V_o = V_{i1} + V_{i2}$

- → Voltage summer (2x)
- → [Need more?]
- → Op amp?
- → Use [1] (a)/(b)



$R_1 = R_2 = R_3 = R_4$



Need an amplifier to scale things back up

non-inverting amp

$$V_{out} = \underbrace{\left(\frac{R_2}{R_1+R_2}\right)}_{<1} V_{in_1} + \underbrace{\left(\frac{R_1}{R_1+R_2}\right)}_{<1} V_{in_2}$$