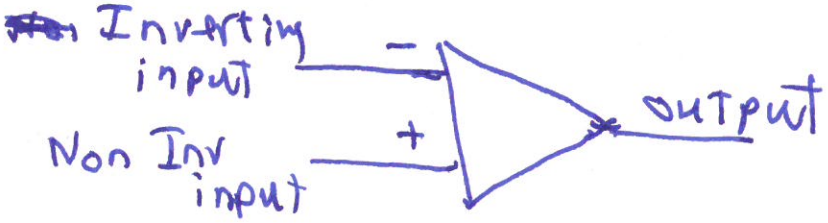
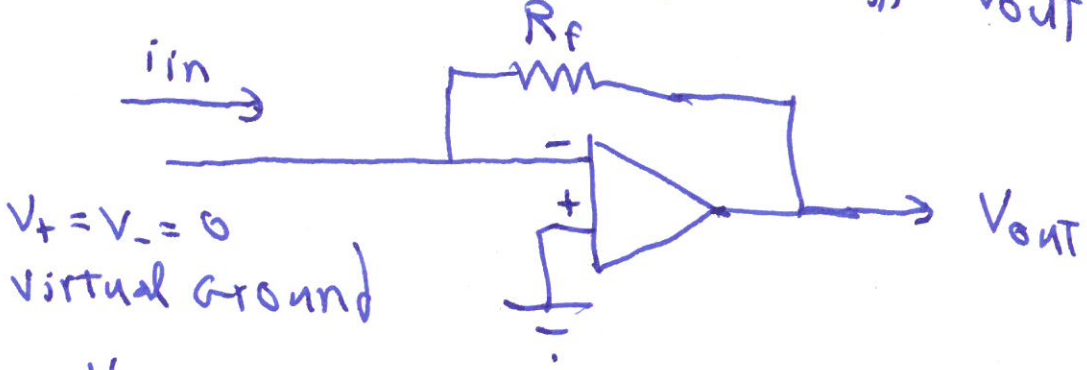


Gain is ∞

$i_+ = i_- = 0$

Transimpedance Amp i_{in} V_{out}



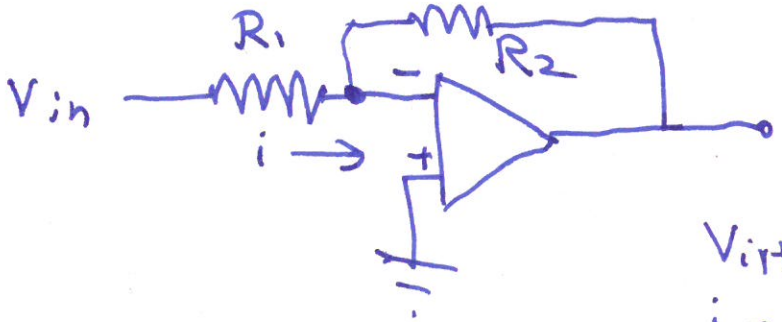
$V_+ = V_- = 0$
Virtual Ground

$V_{out} = - i_{in} R_f$ $\quad V_- = V_+ = 0$

$V_{in} = 0$ for any current; $R_{in} = 0$

$R_{out} = 0$

Voltage Amplifier



Virtual Ground

$i = \frac{V_{in}}{R_1} = - \frac{V_{out}}{R_2}$

$V_{out} = -V_{in} \frac{R_2}{R_1}$

$A_V = - R_2 / R_1$

$$A_V = -\frac{R_2}{R_1}$$

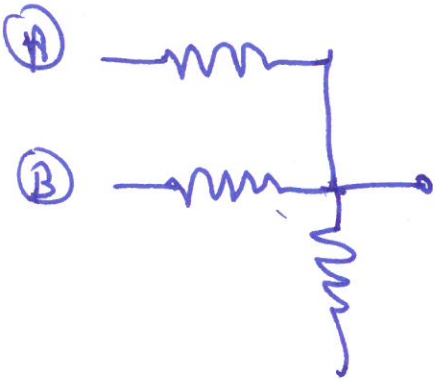
Most Common Amplifier

$R_{in} = R_1$

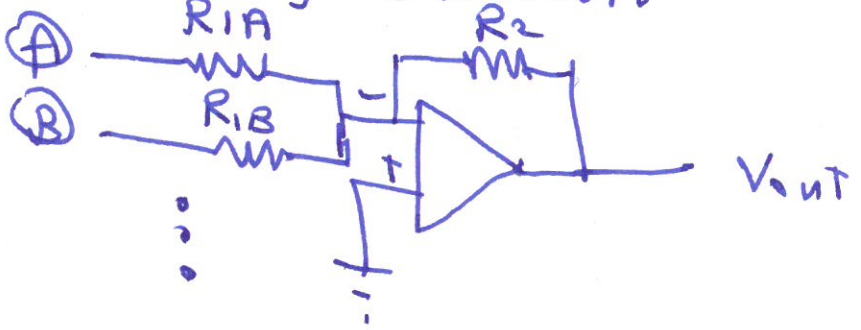
~ Not so good

$R_{out} \approx 0$

Good for Voltage out



Summing Junction



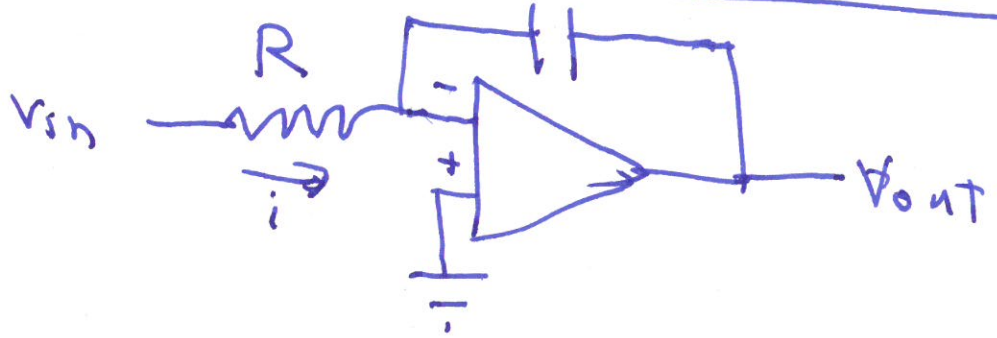
$$V_{out} = -\frac{R_2}{R_{1A}} V_A - \frac{R_2}{R_{1B}} V_B \quad \cdots$$

Exercise

Design A D-A converter

input 0 or +5 volts on each channel

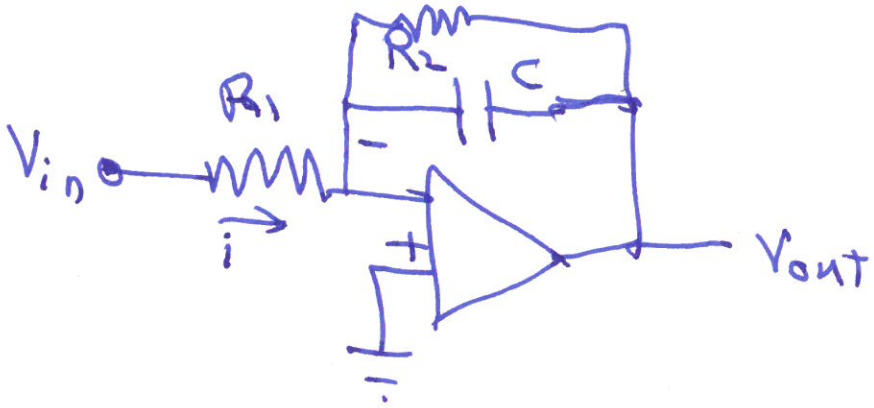
B	A	
0	0	1 → V_{out} = 1 volt
0	1	0 → 2
0	1	1 → 3
⋮		⋮



$$i = \frac{V_{in}}{R} = -C\frac{dV_{out}}{dt}$$

$$V_{out}(t) = V_{out}(0) + \frac{\int_0^t V_{in}(t')\,dt'}{RC}$$

Low Pass filter



Frequency Domain

$$i = \frac{V_{in}}{R_1} = \frac{-V_{out}}{R_2 \,||\, \frac{1}{jwC}}$$

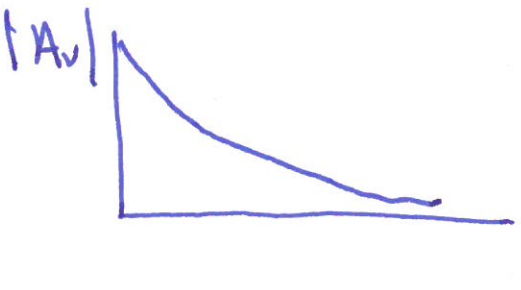
$$V_{out} = -V_{in}\,\frac{R_2 \,||\, \frac{1}{jwC}}{R_1} = \frac{-V_{in}\,R_2/jwC}{R_1(R_2 + \frac{1}{jwC})}$$

$$A_v = \frac{V_{out}}{V_{in}} = \frac{-R_2}{R_1 R_2 jwC + R_1}$$

Special Cases

$C \to 0$ $\qquad A_v = -\frac{R_2}{R_1}$

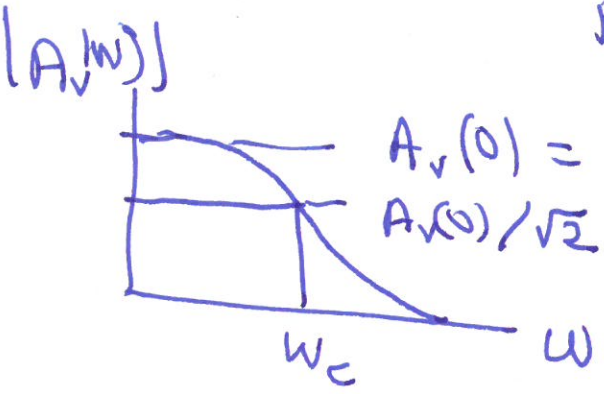
$R_2 \to \infty$ $\qquad \frac{V_{out}}{V_{in}} = -\frac{1}{R_1 jwC}$



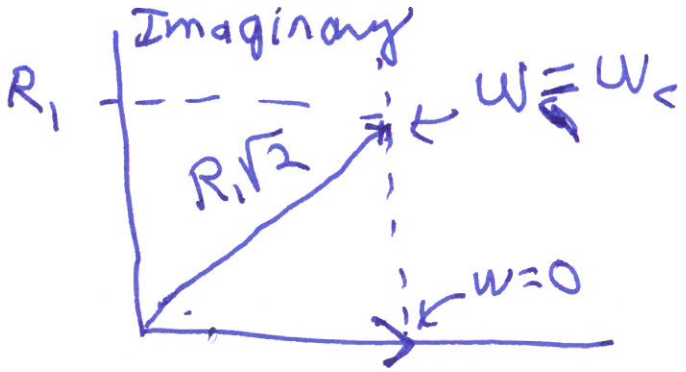
$$\int \cos \omega t = \frac{1}{\omega} \sin \omega t$$

General case

$$A_v(\omega) = -\frac{R_2}{R_1 R_2 j\omega C + R_1}$$



Denominator



$$R_1 R_2 \omega C = R_1$$

$$\omega_c = \frac{1}{R_2 C}$$

$$f_c = \frac{1}{2\pi R_2 C}$$