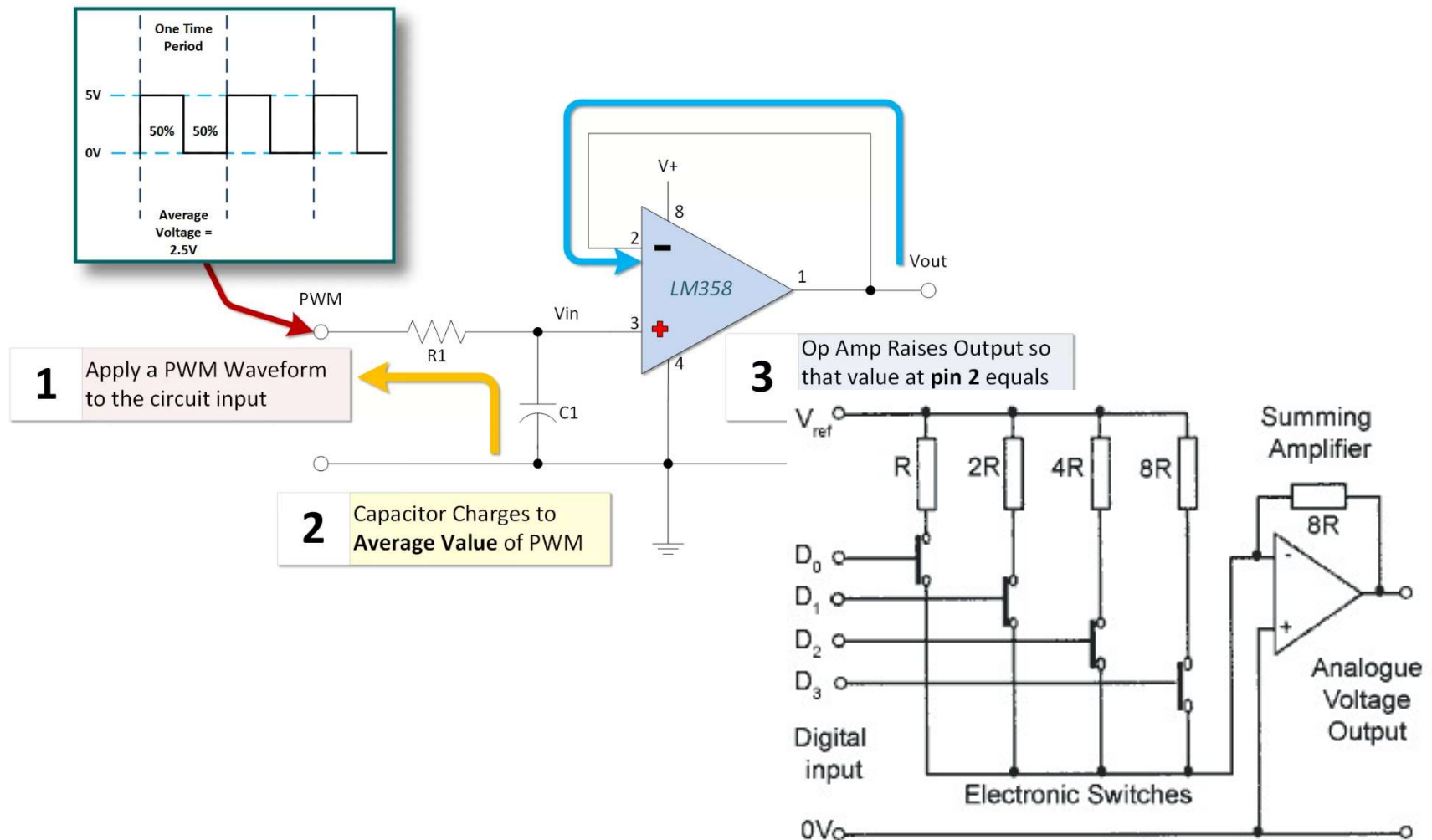
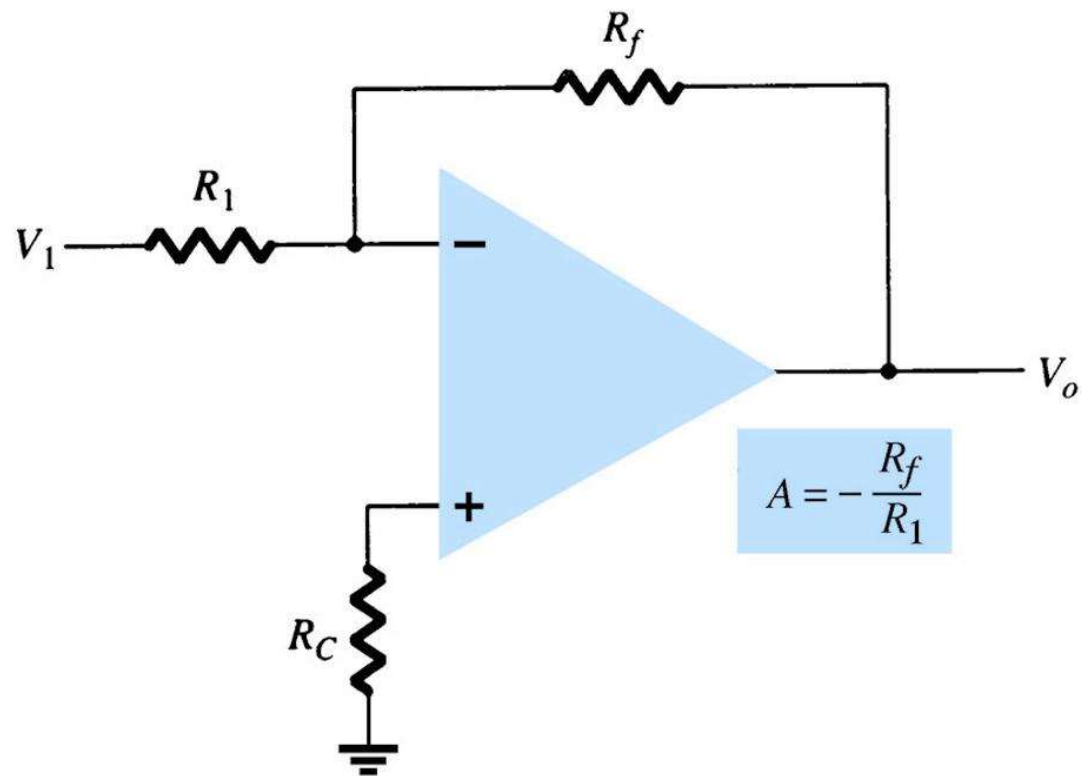


# Circuitos com AMP OP

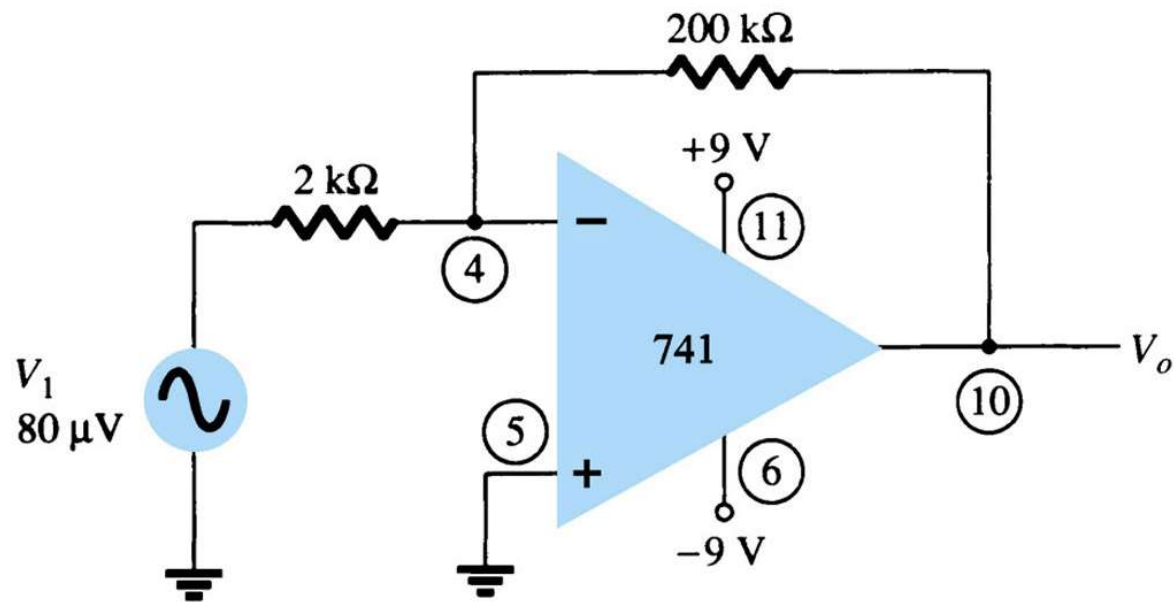


# Configuração Inversora



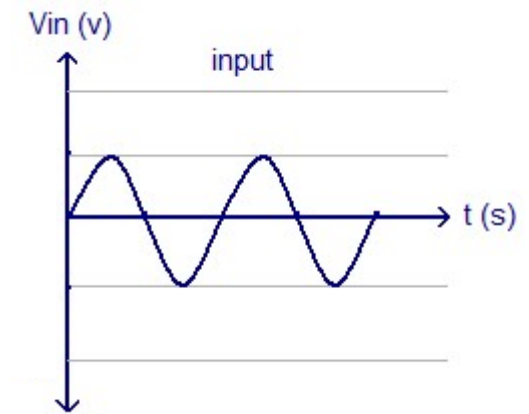
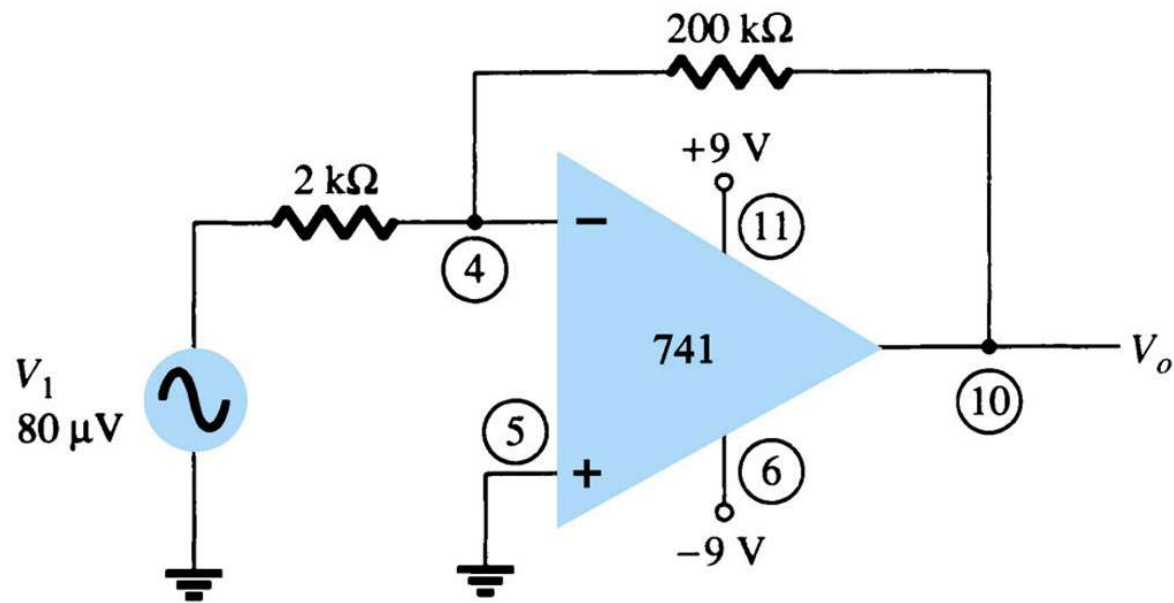
# Configuração Inversora

## Exemplo



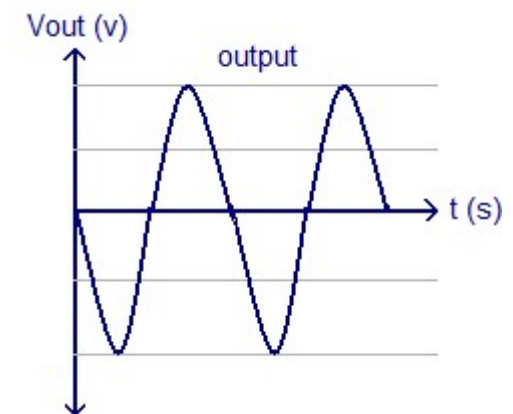
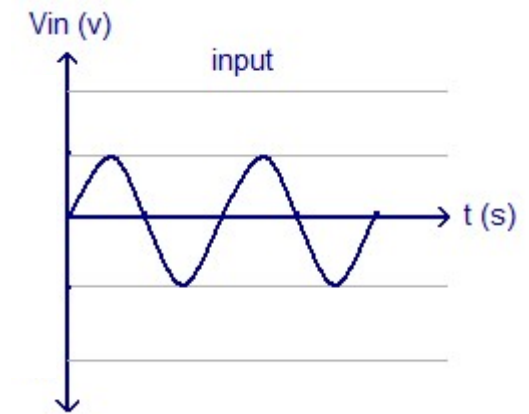
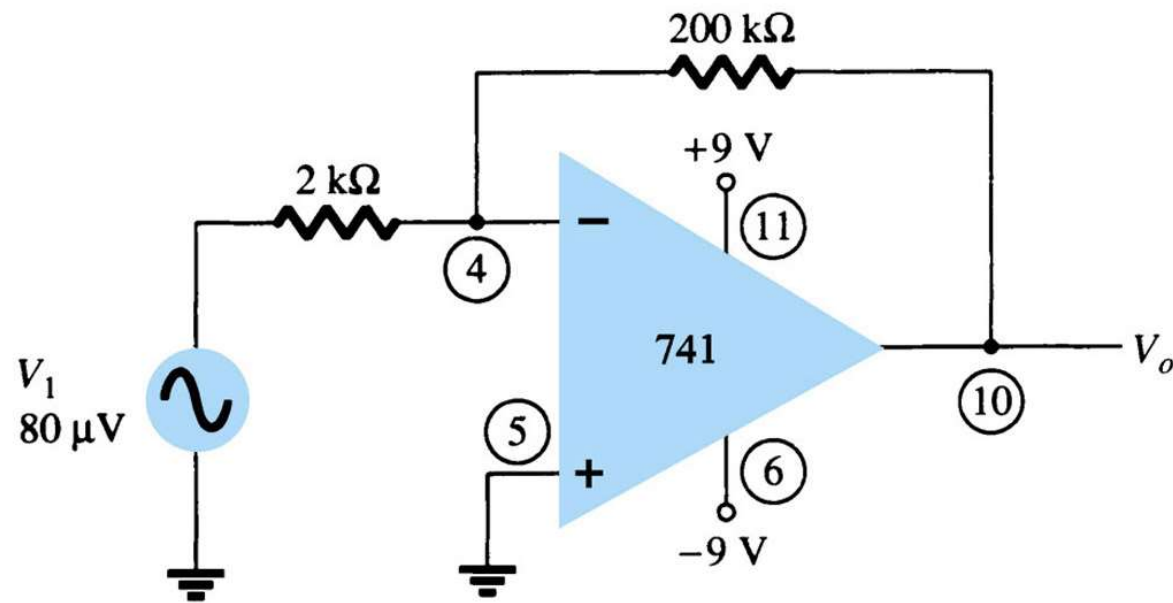
# Configuração Inversora

## Exemplo

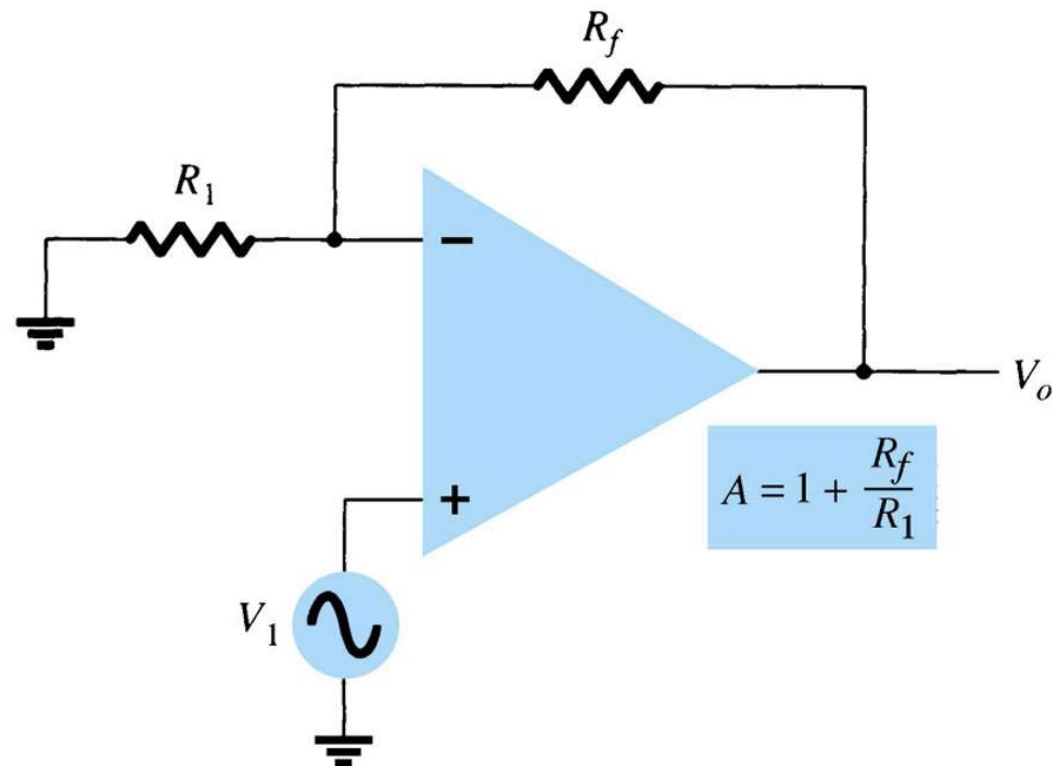


# Configuração Inversora

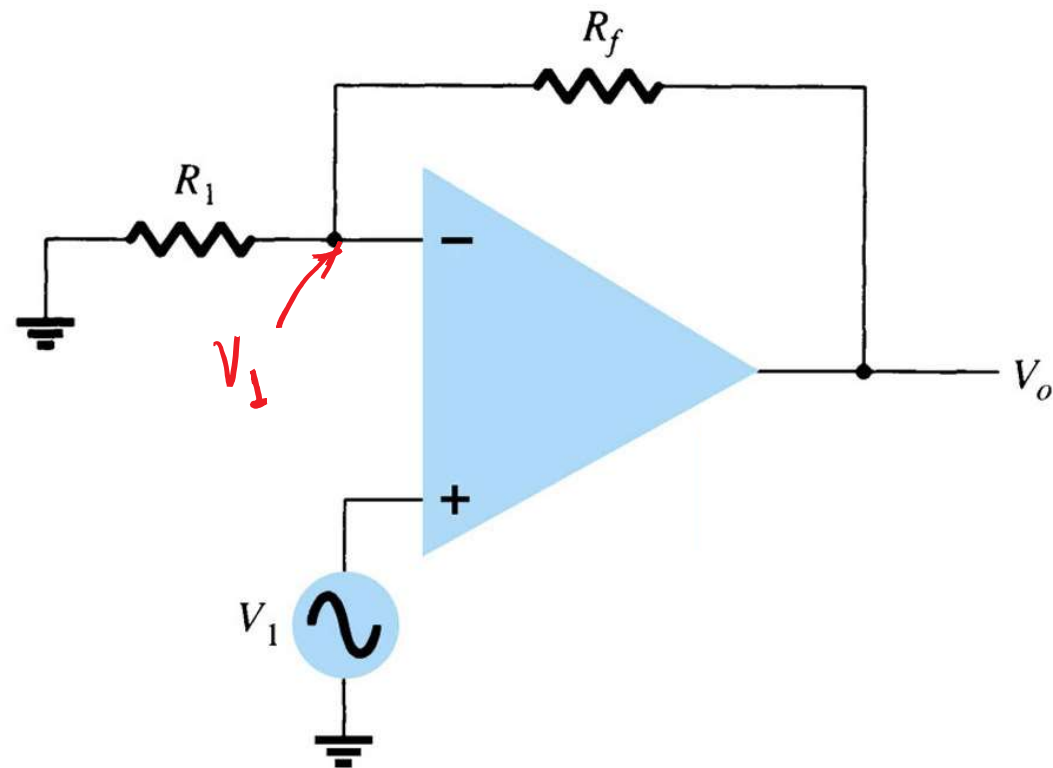
## Exemplo



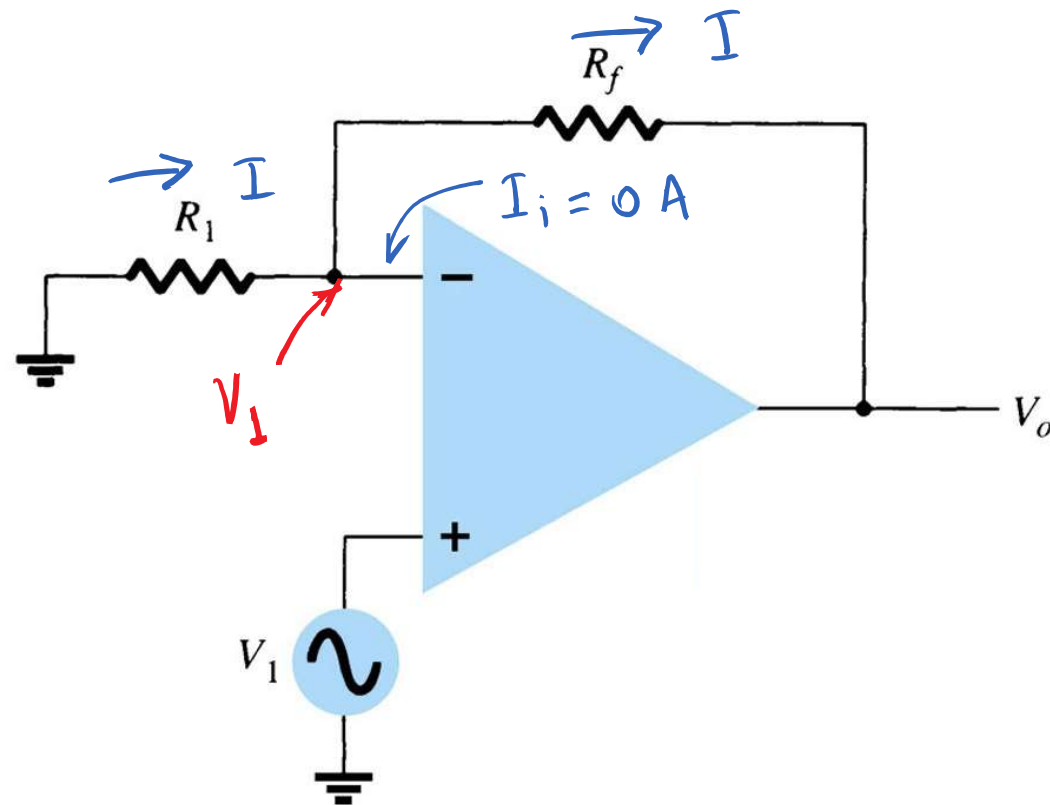
# Configuração Não-Inversora



# Configuração Não-Inversora

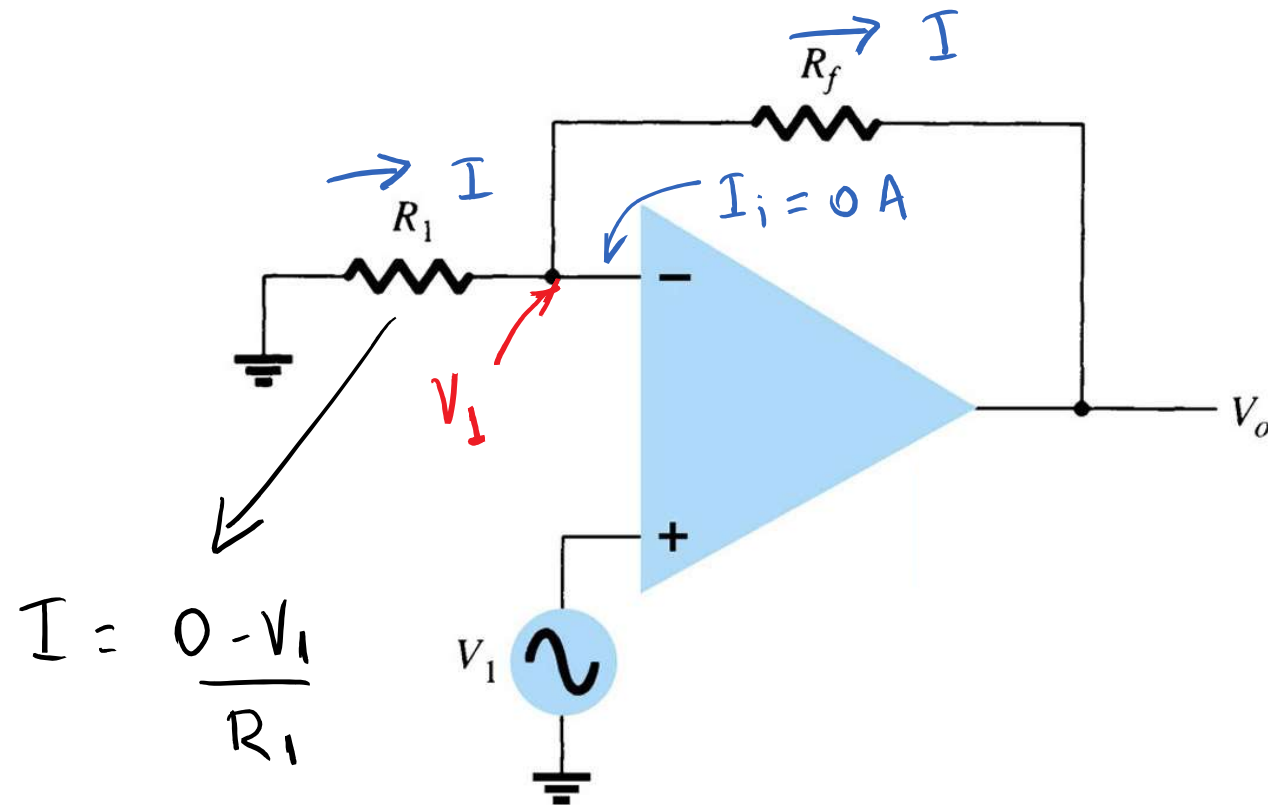


# Configuração Não-Inversora

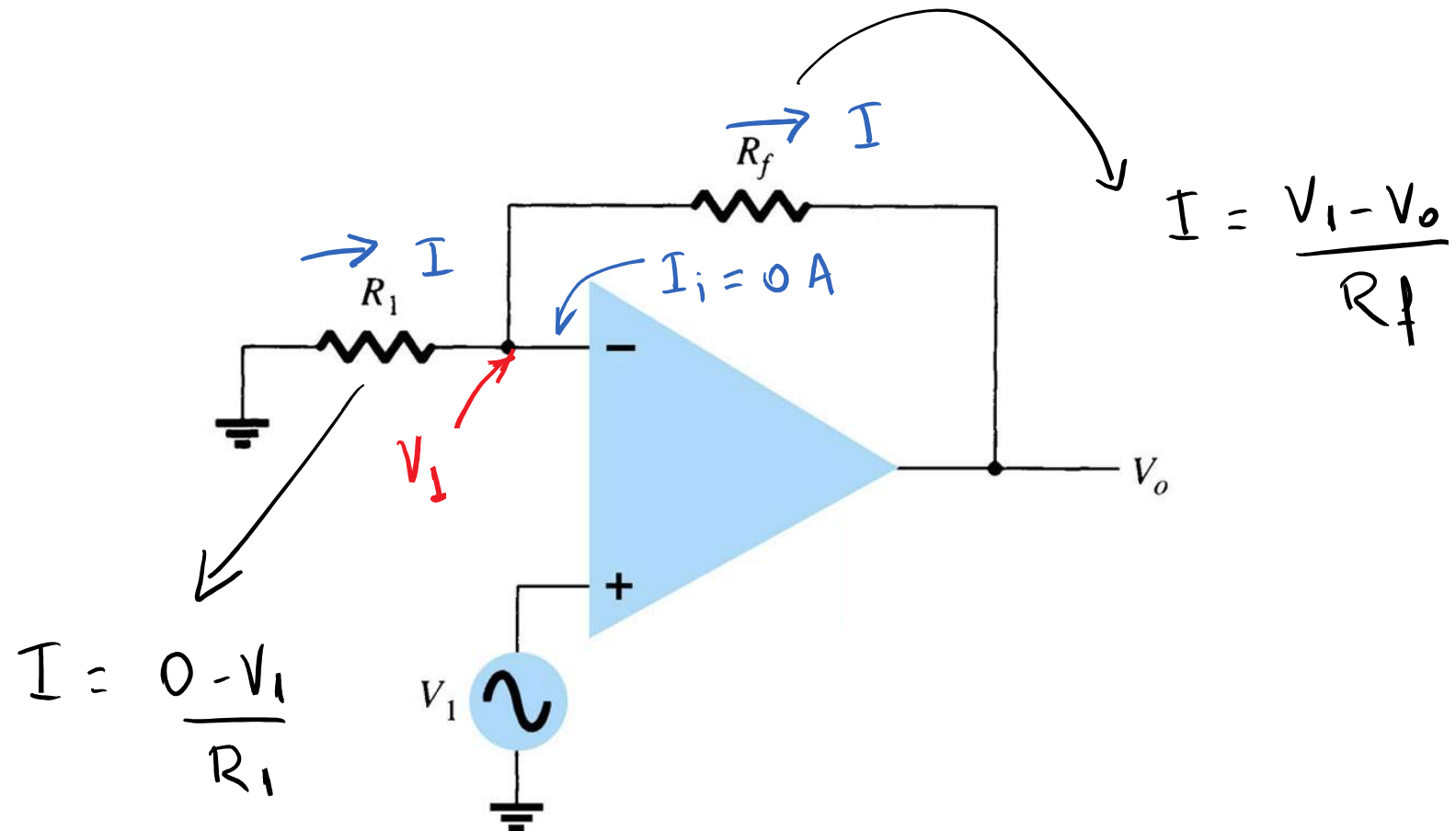




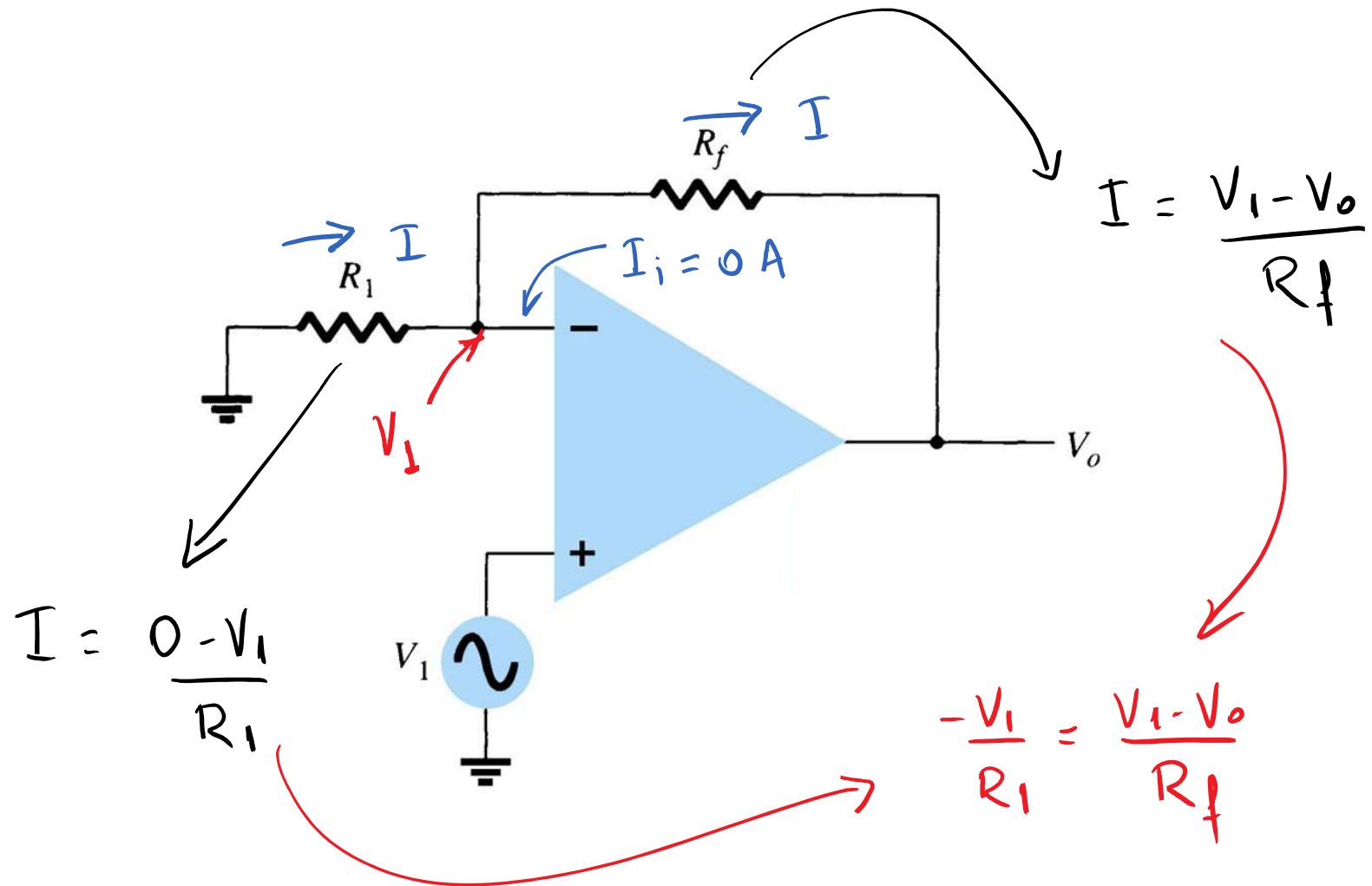
# Configuração Não-Inversora



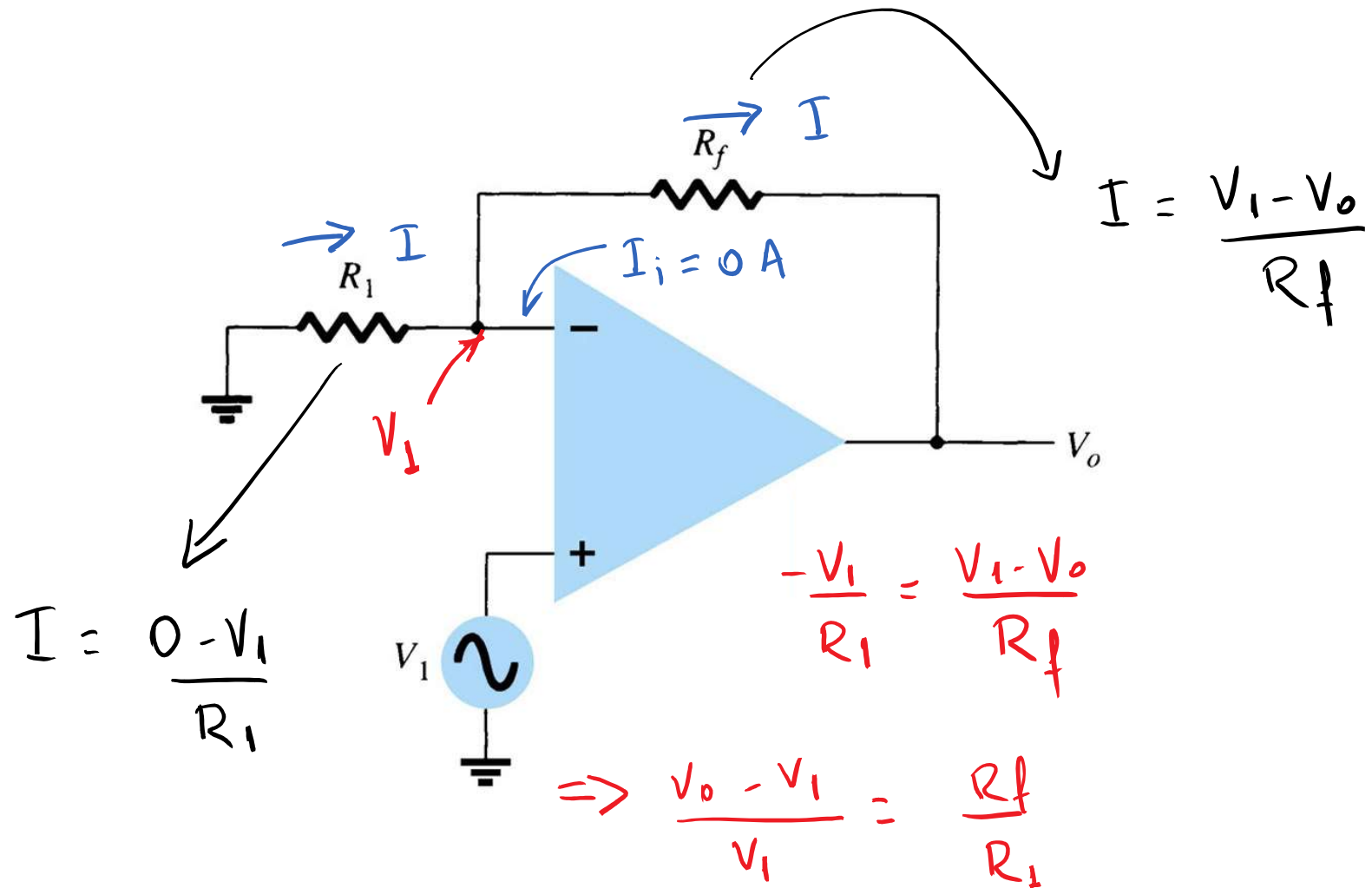
## Configuração Não-Inversora



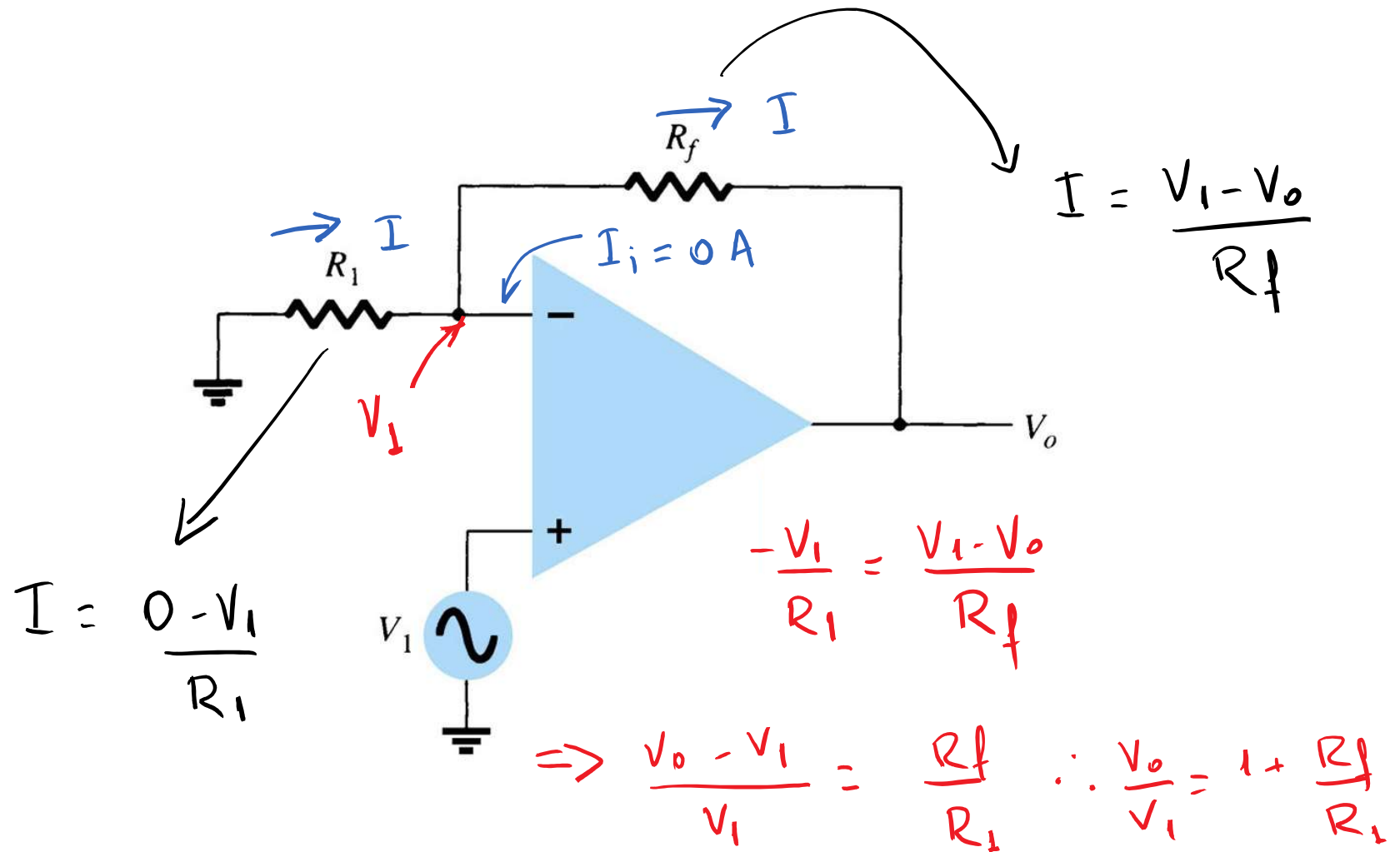
## Configuração Não-Inversora



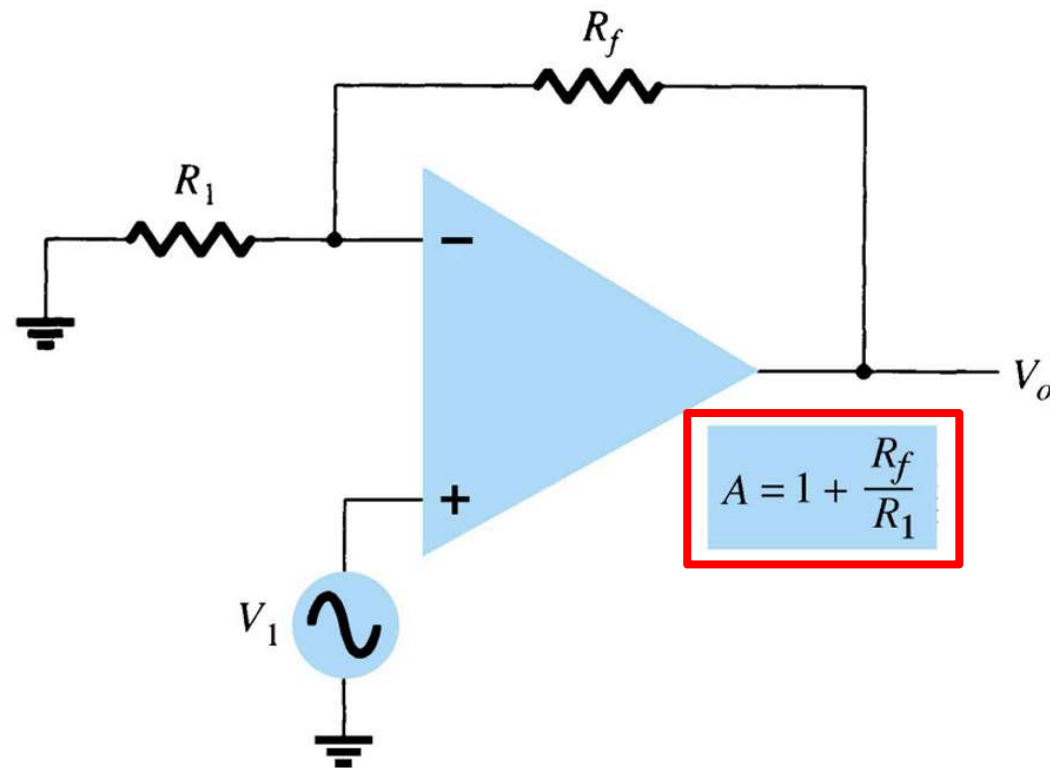
## Configuração Não-Inversora



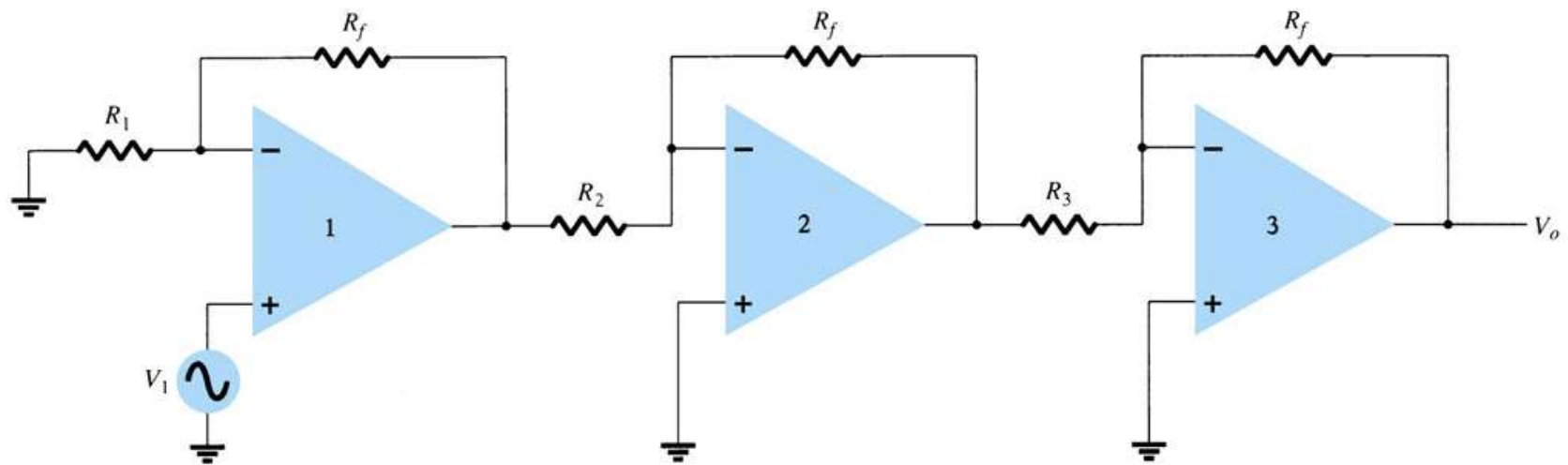
## Configuração Não-Inversora



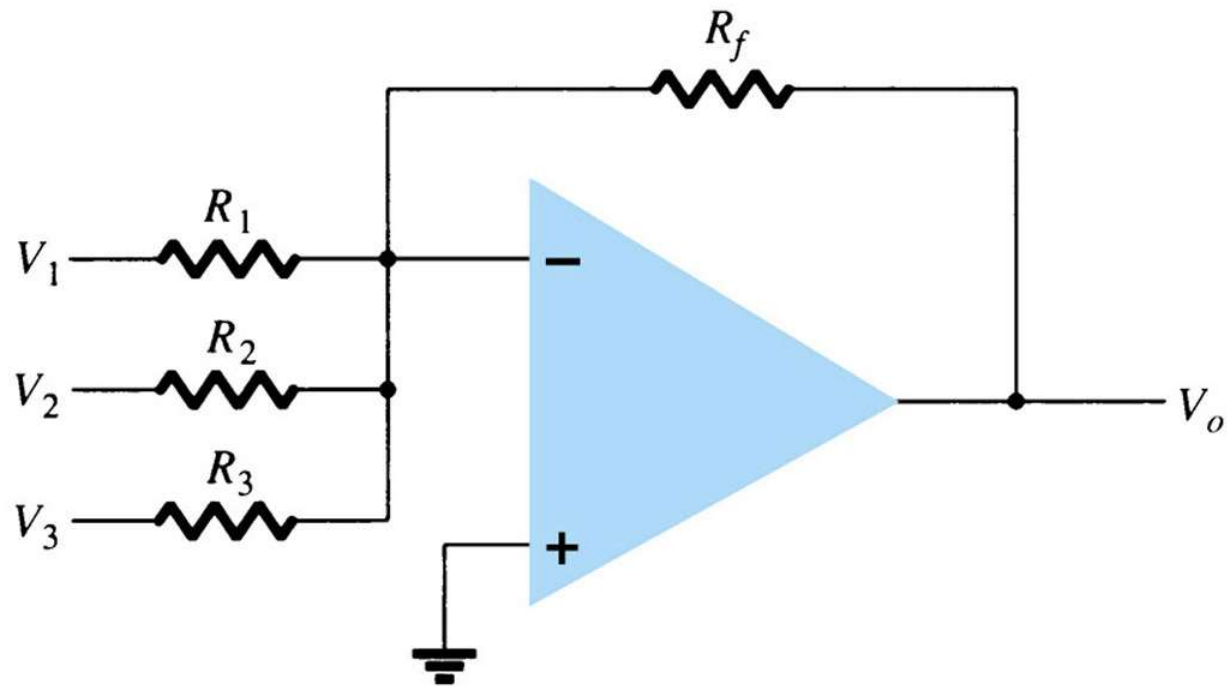
# Configuração Não-Inversora



# Configuração em Cascata

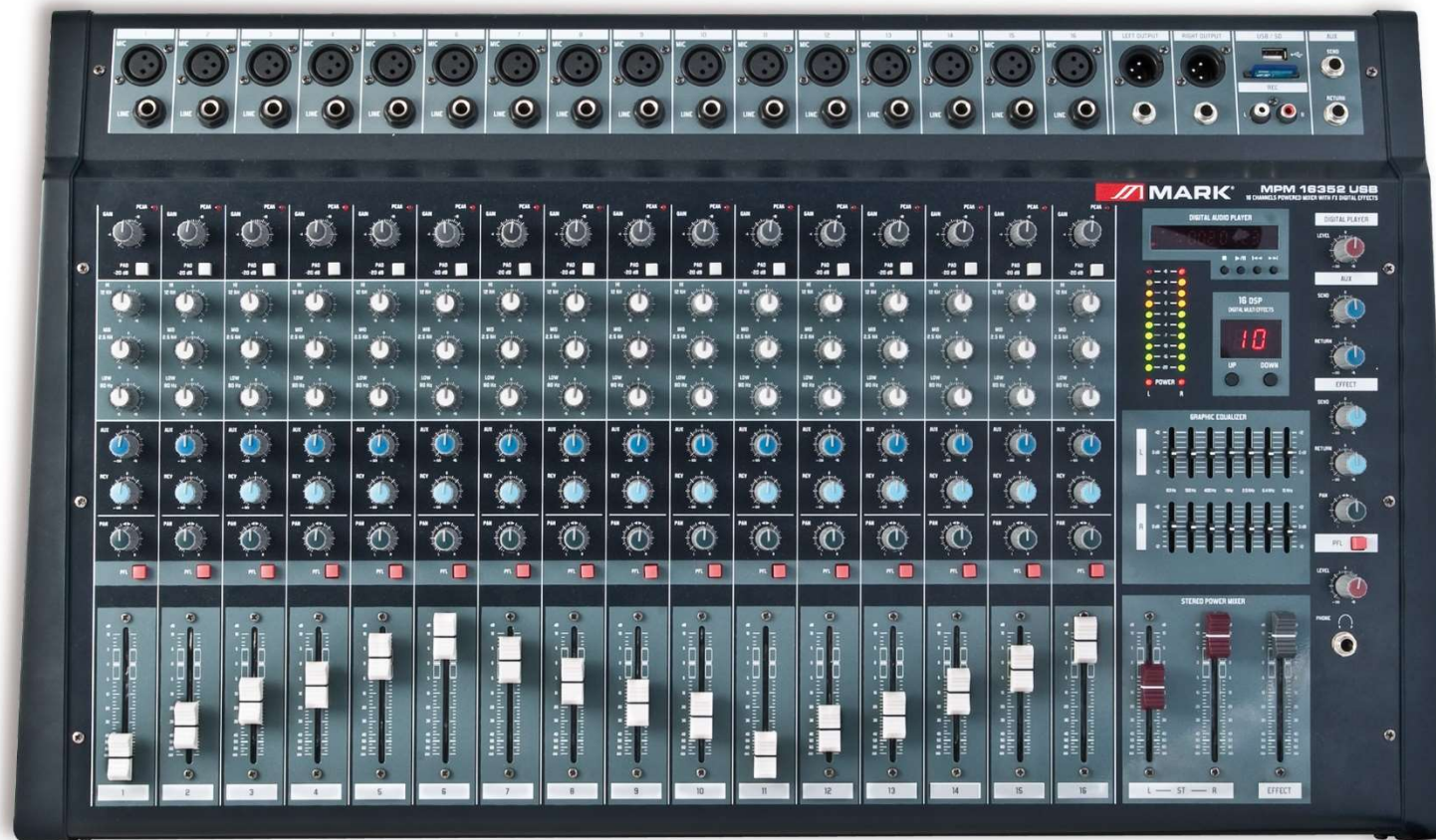


# Amplificador Somador

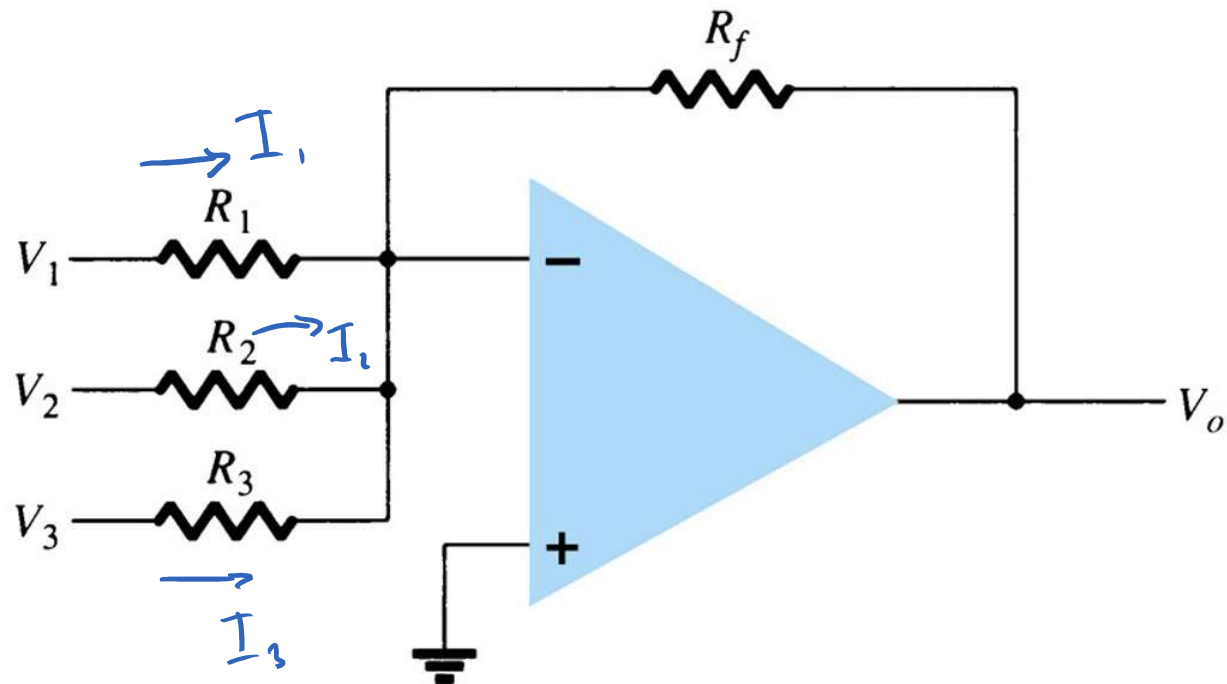




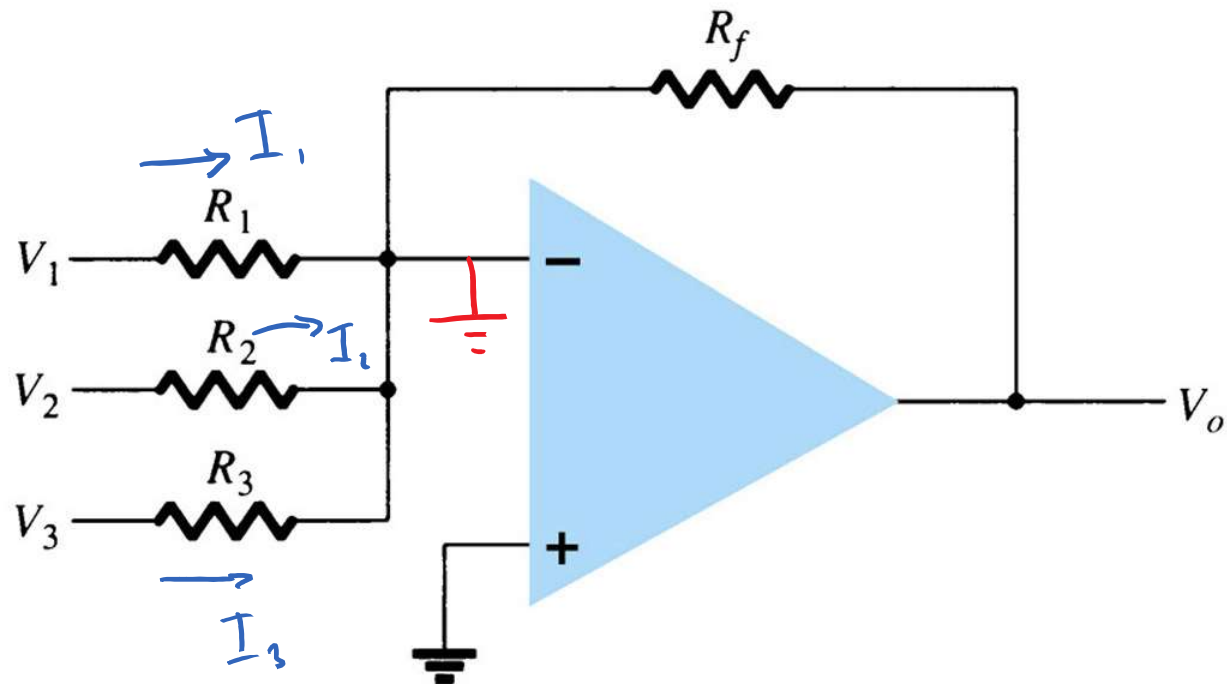
# Amplificador Somador - Aplicação



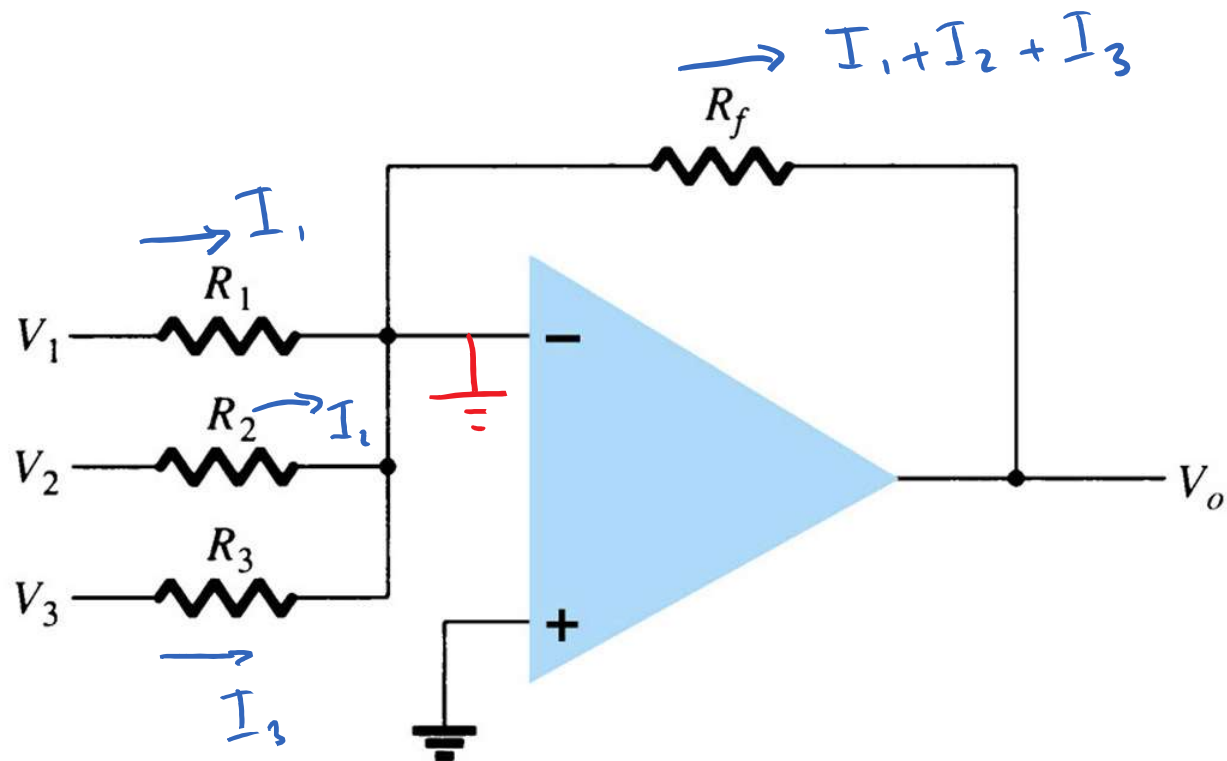
# Amplificador Somador



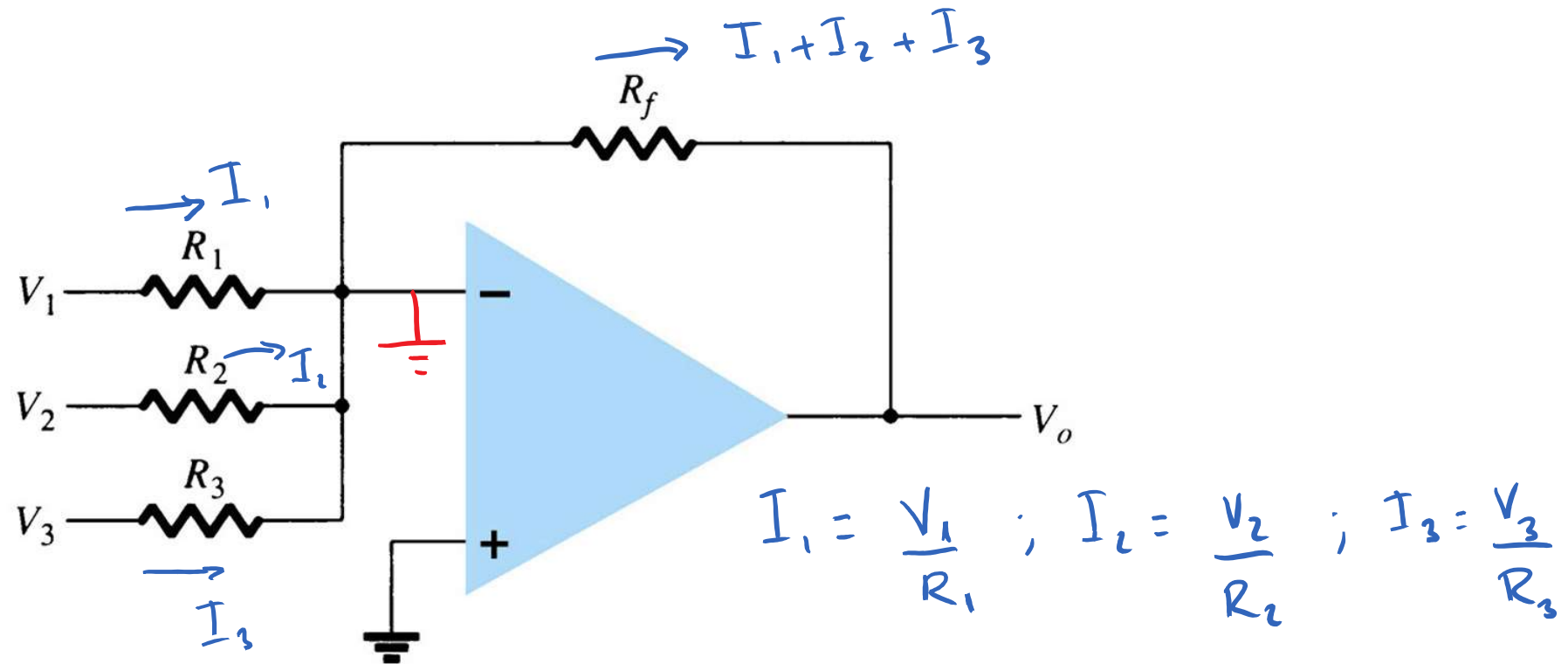
# Amplificador Somador



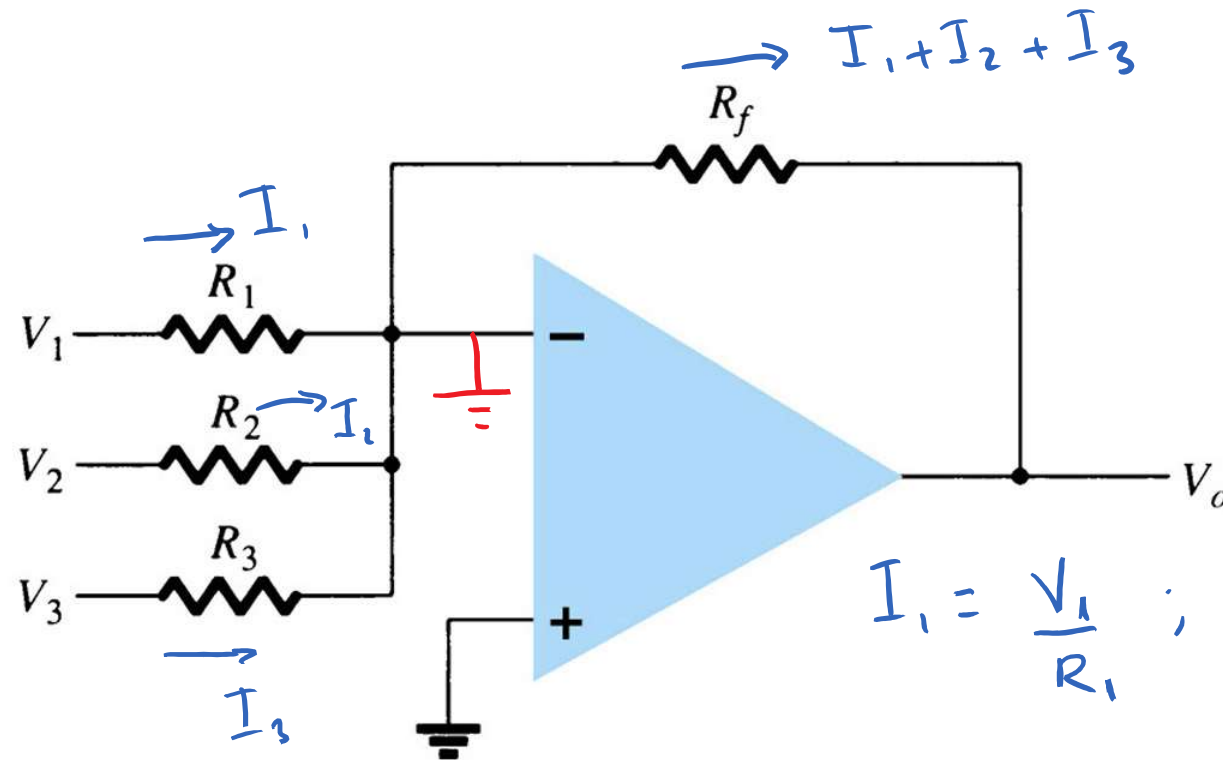
# Amplificador Somador



# Amplificador Somador



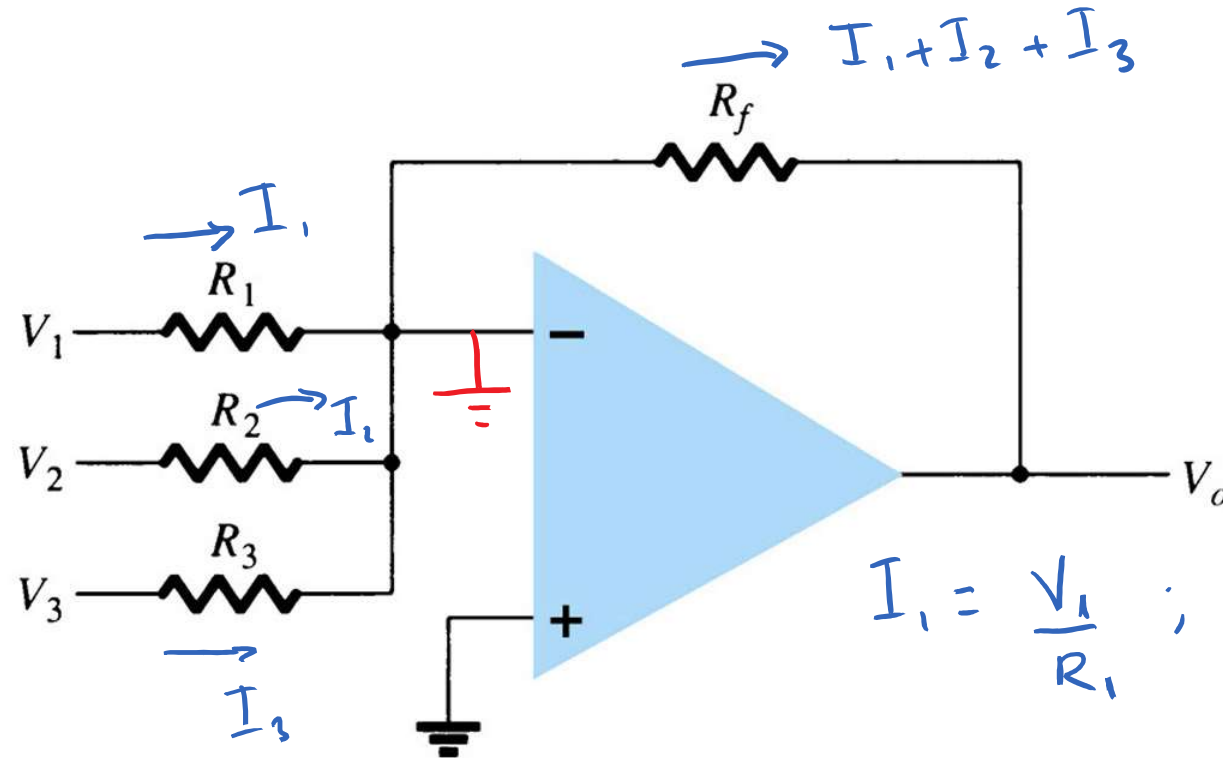
# Amplificador Somador



$$I_1 = \frac{V_1}{R_1} ; I_2 = \frac{V_2}{R_2} ; I_3 = \frac{V_3}{R_3}$$

$$I_1 + I_2 + I_3 = - \frac{V_o}{R_f}$$

# Amplificador Somador

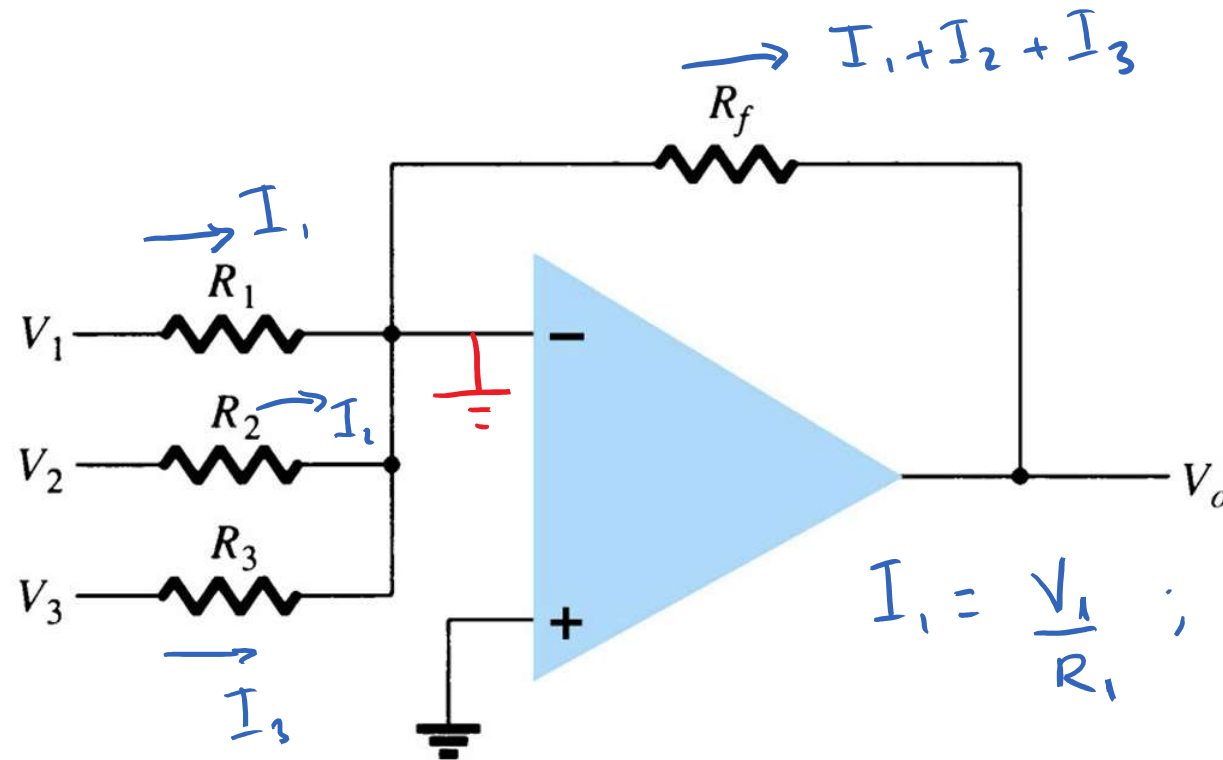


$$I_1 = \frac{V_1}{R_1} ; I_2 = \frac{V_2}{R_2} ; I_3 = \frac{V_3}{R_3}$$

$$I_1 + I_2 + I_3 = - \frac{V_o}{R_f}$$

$$\Rightarrow - \frac{V_o}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

# Amplificador Somador



$$I_1 = \frac{V_1}{R_1} ; I_2 = \frac{V_2}{R_2} ; I_3 = \frac{V_3}{R_3}$$

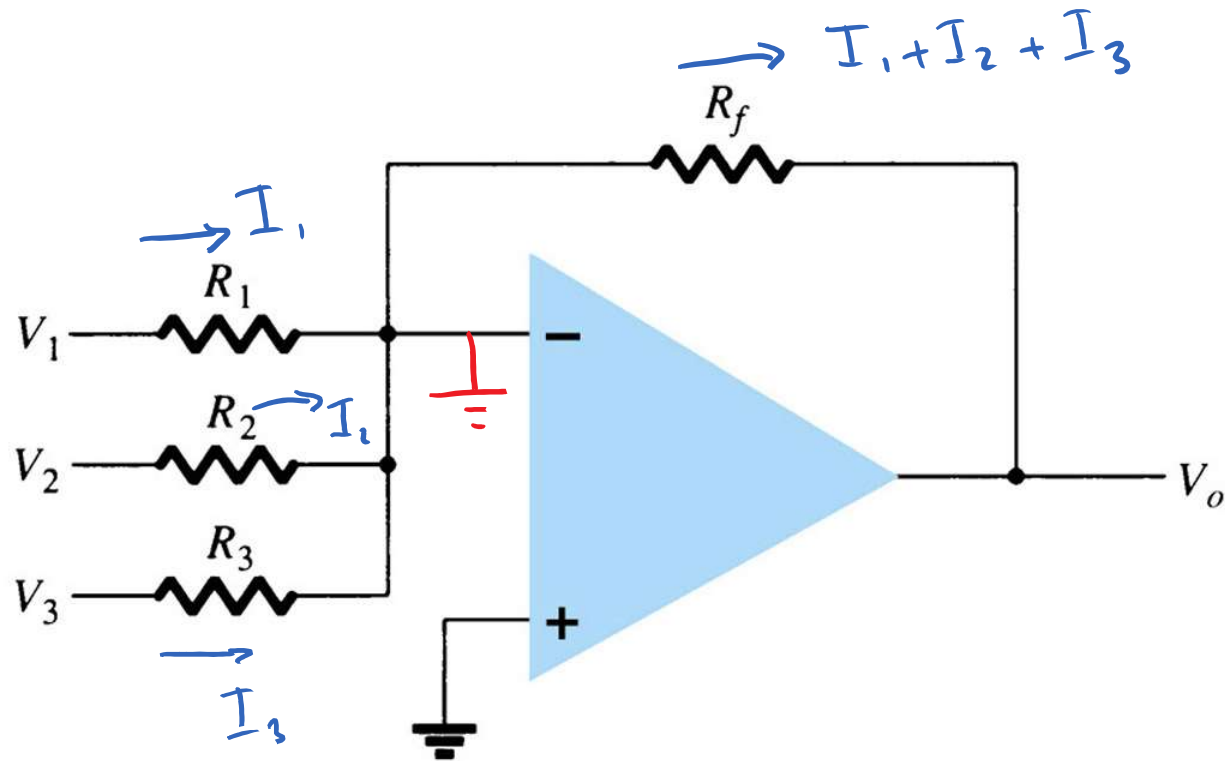
$$I_1 + I_2 + I_3 = -\frac{V_o}{R_f}$$

$$\Rightarrow -\frac{V_o}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

$$\Rightarrow V_o = -R_f \left[ \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right]$$

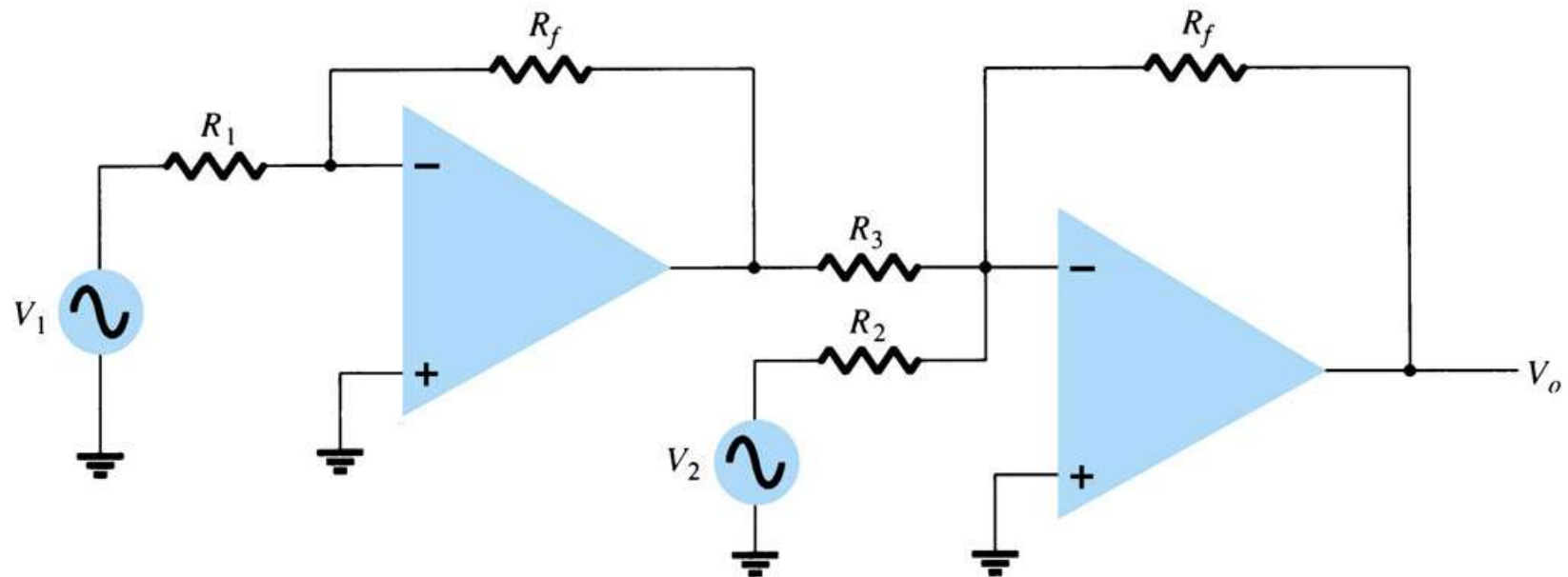


# Amplificador Somador

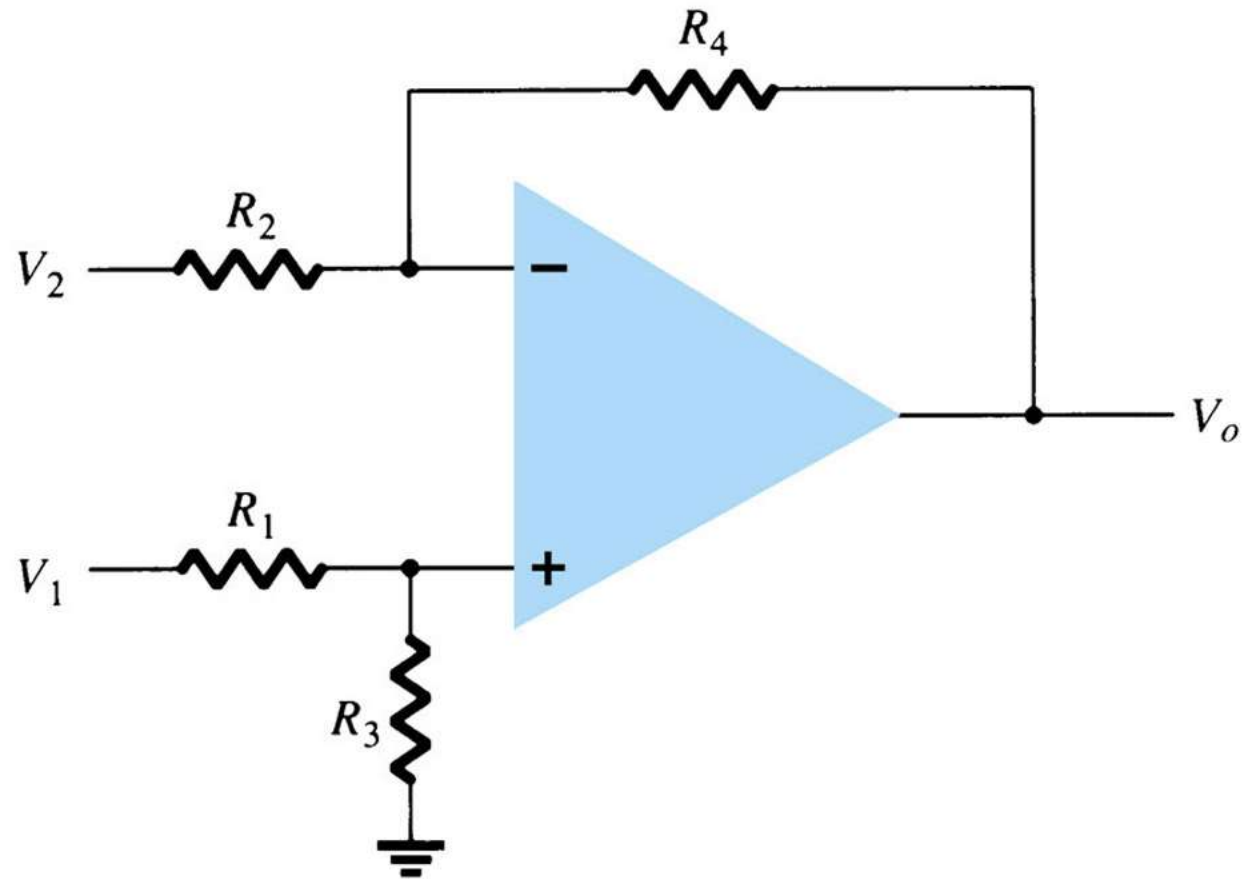


$$\text{Se } R_1 = R_2 = R_3 = R_f$$
$$\Rightarrow V_o = -[V_1 + V_2 + V_3]$$

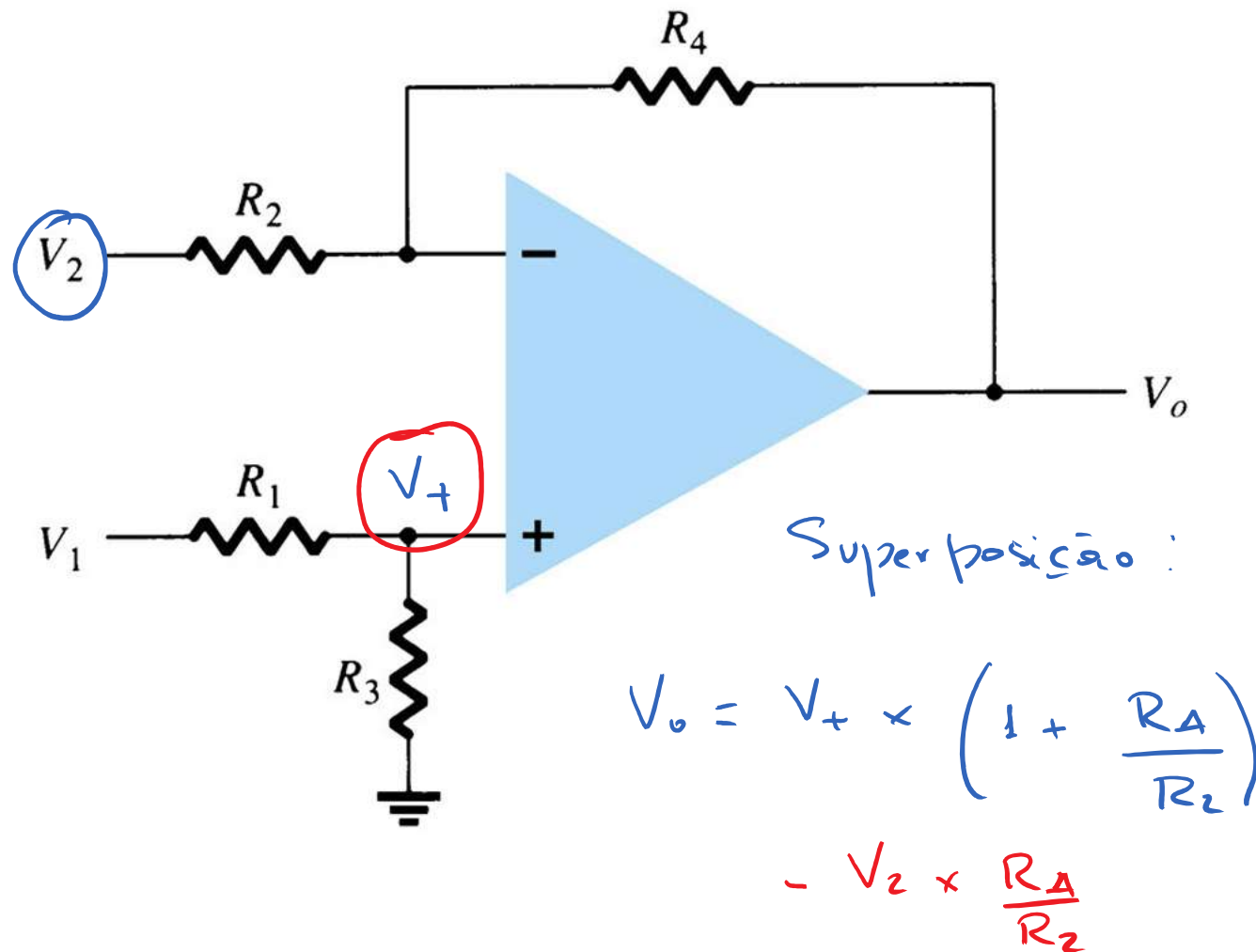
## Circuito Subtrator 1 – dois estágios



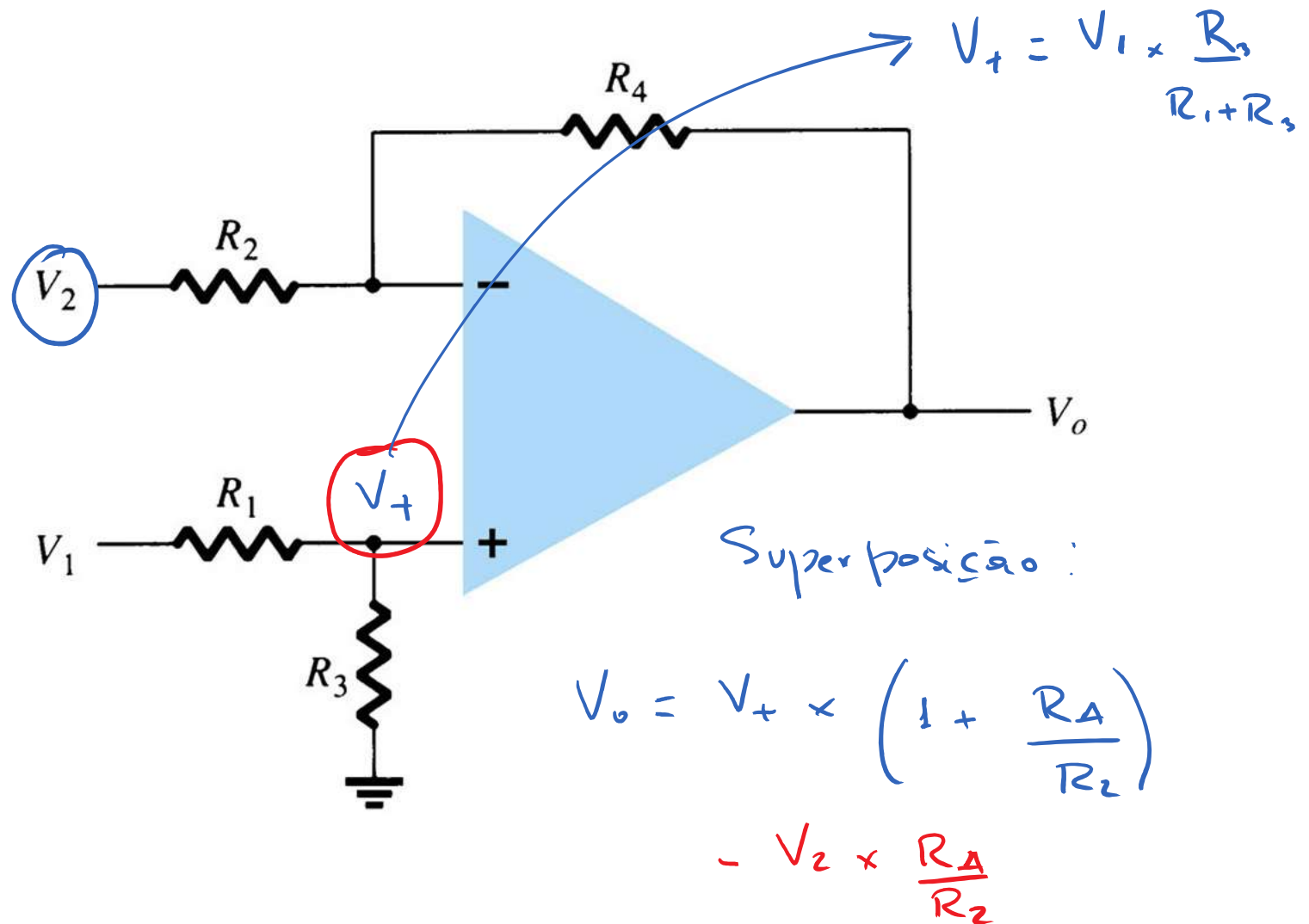
## Circuito Subtrator 2 - simples



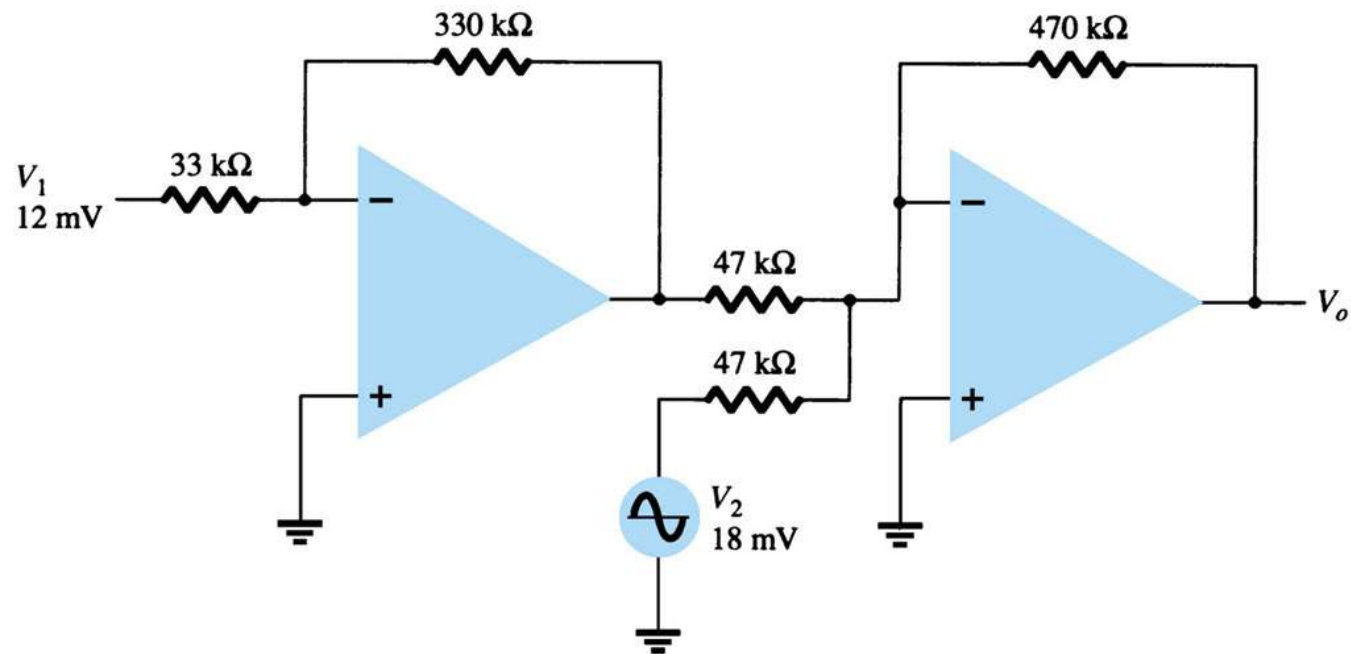
## Circuito Subtrator 2 - simples



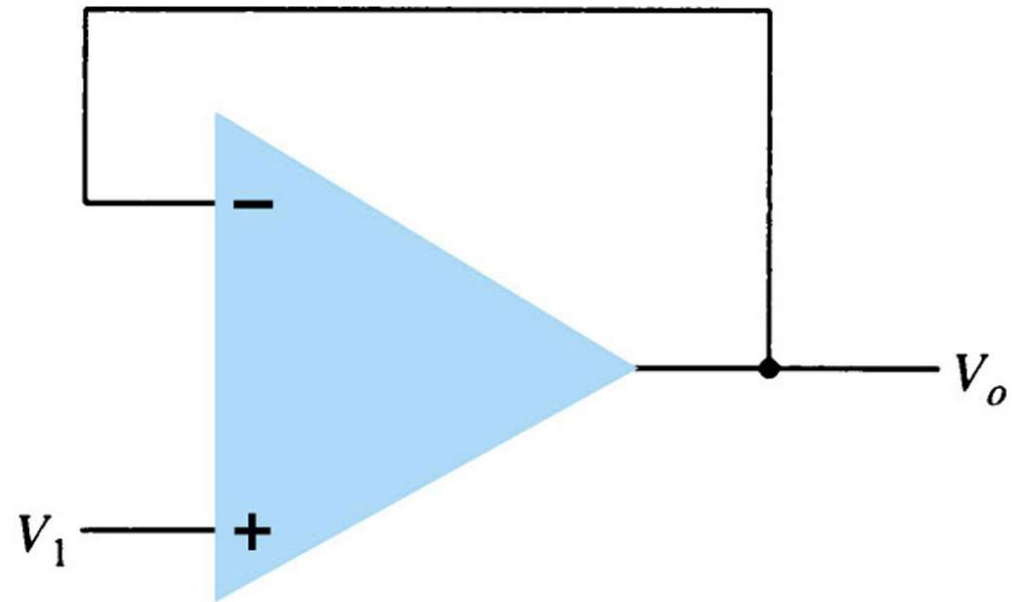
## Circuito Subtrator 2 - simples



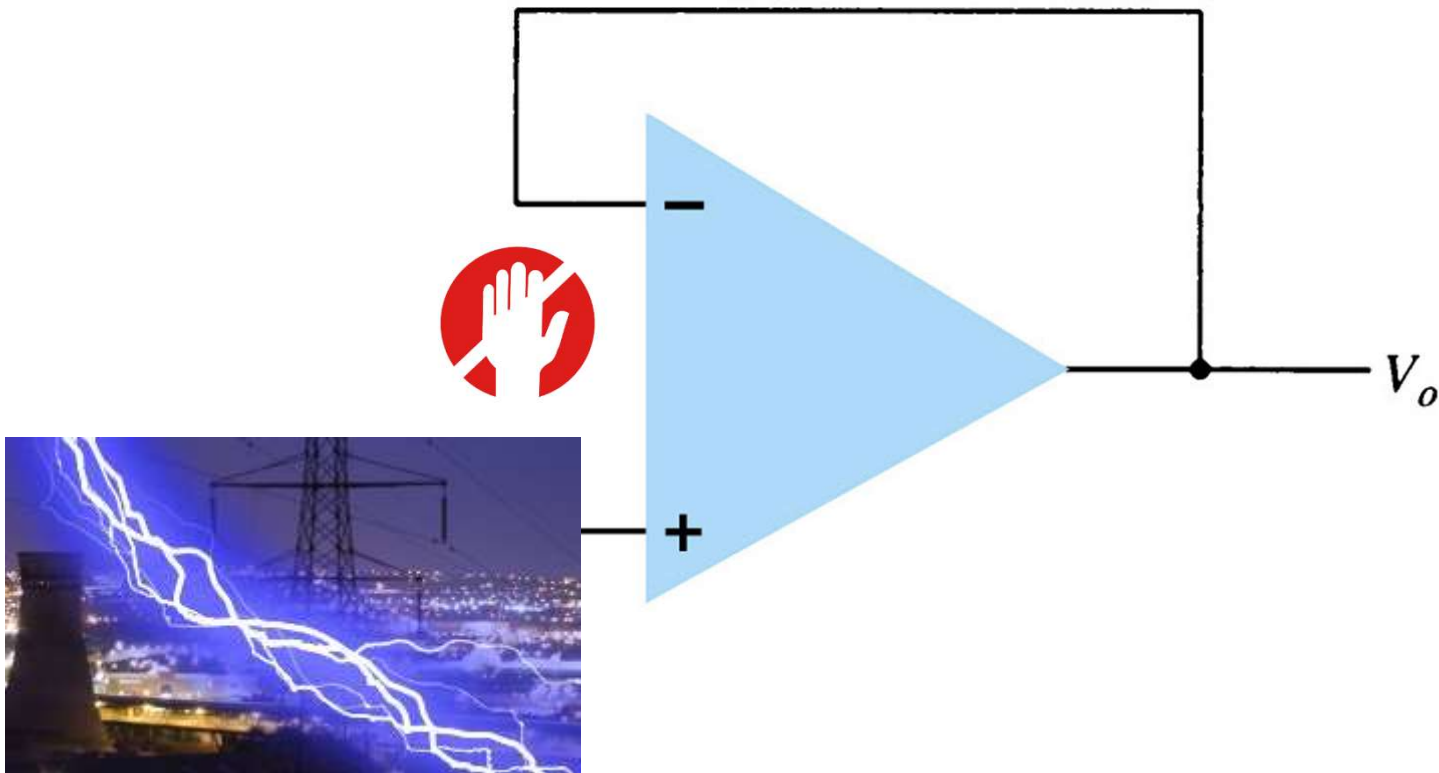
**Exemplo: Calcule  $v_o$**



## Seguidor de tensão (*Buffer*)

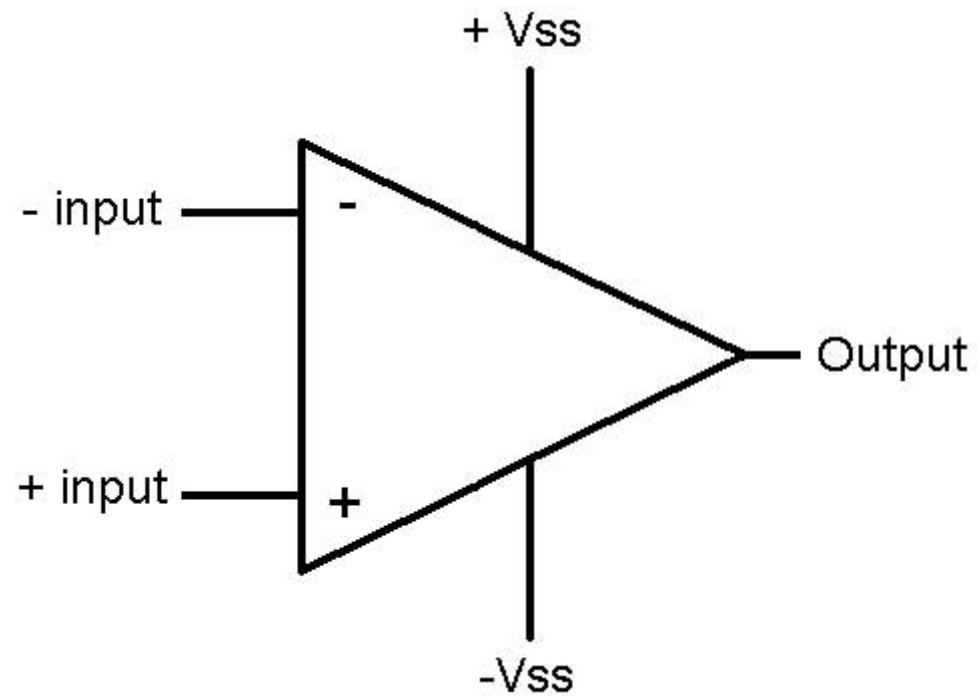


## Seguidor de tensão (*Buffer*)

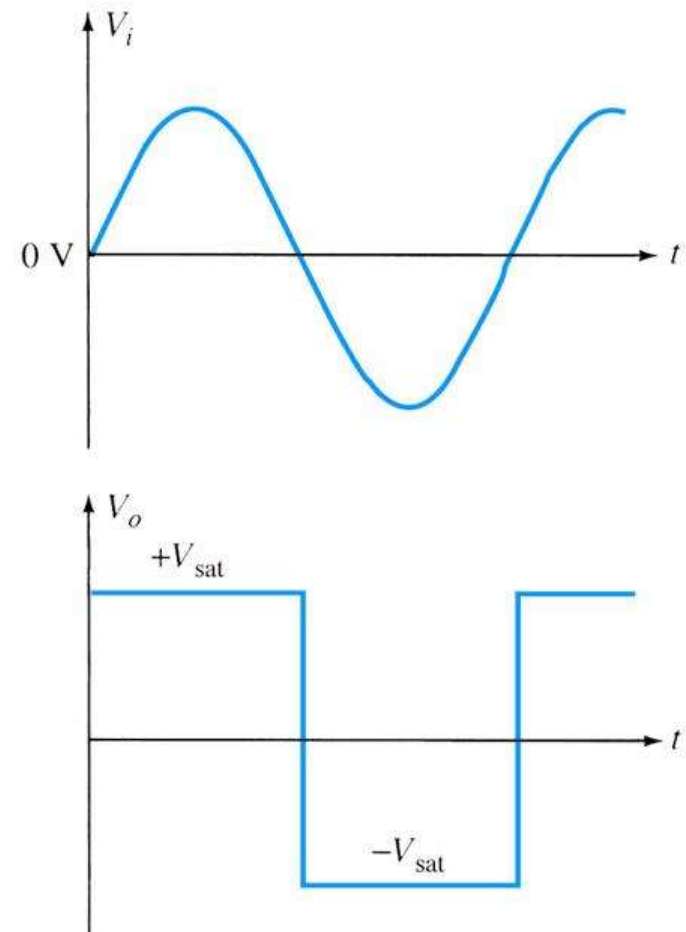
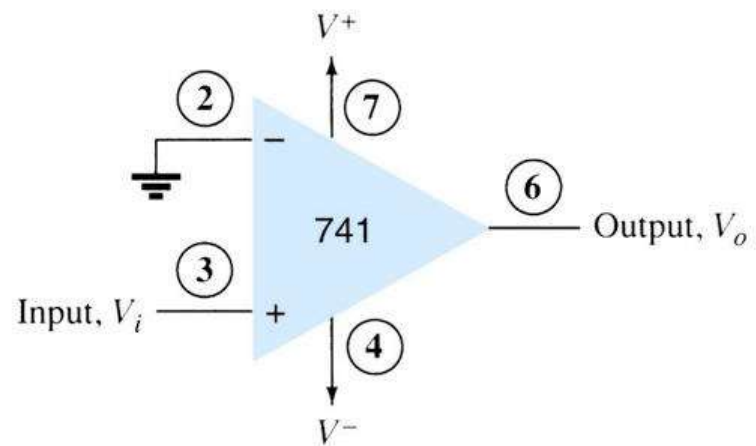




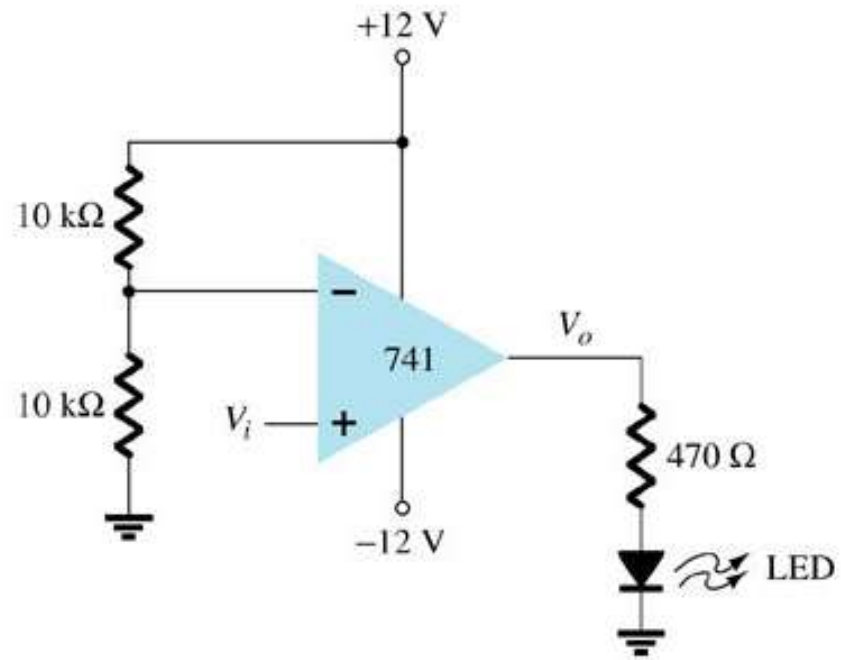
# Aplicações DIGITAIS



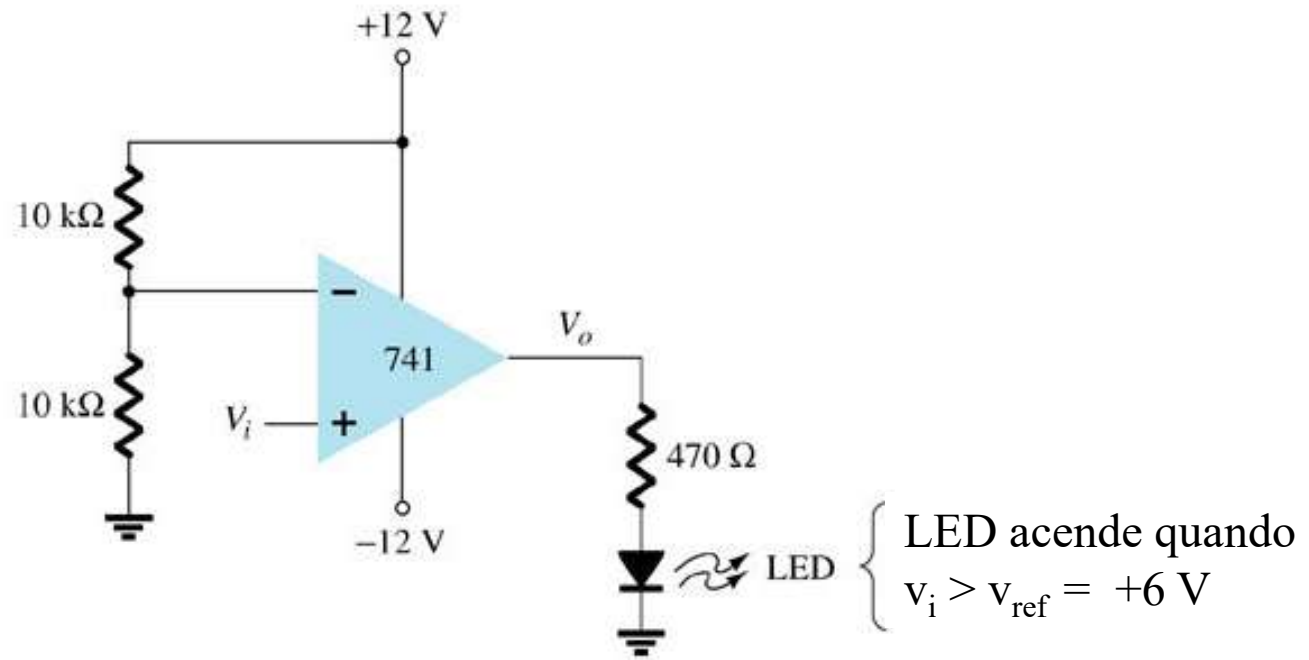
# Comparador



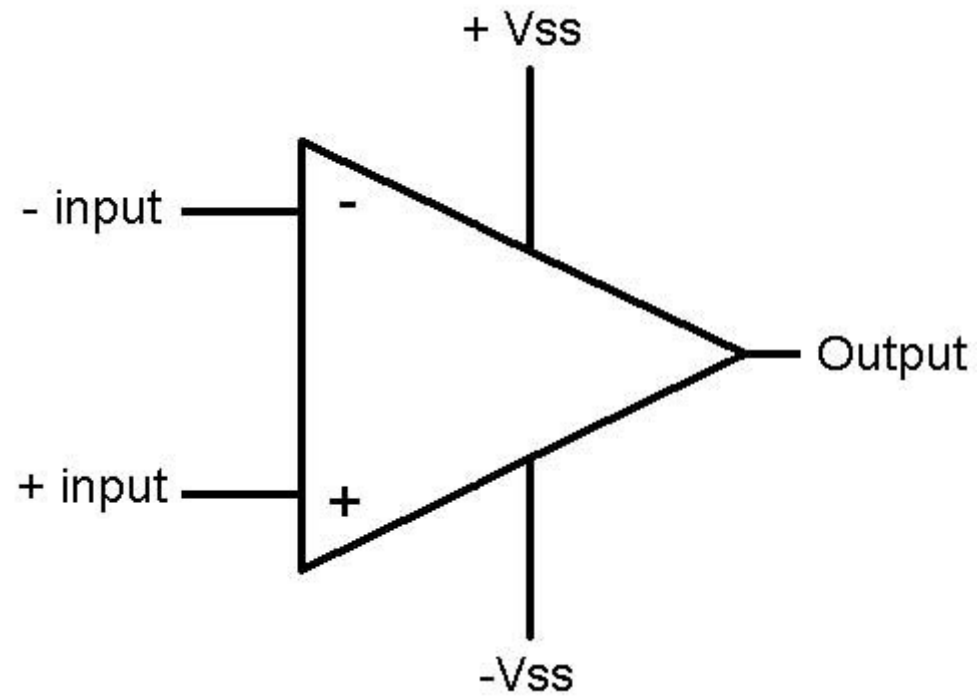
# Comparador



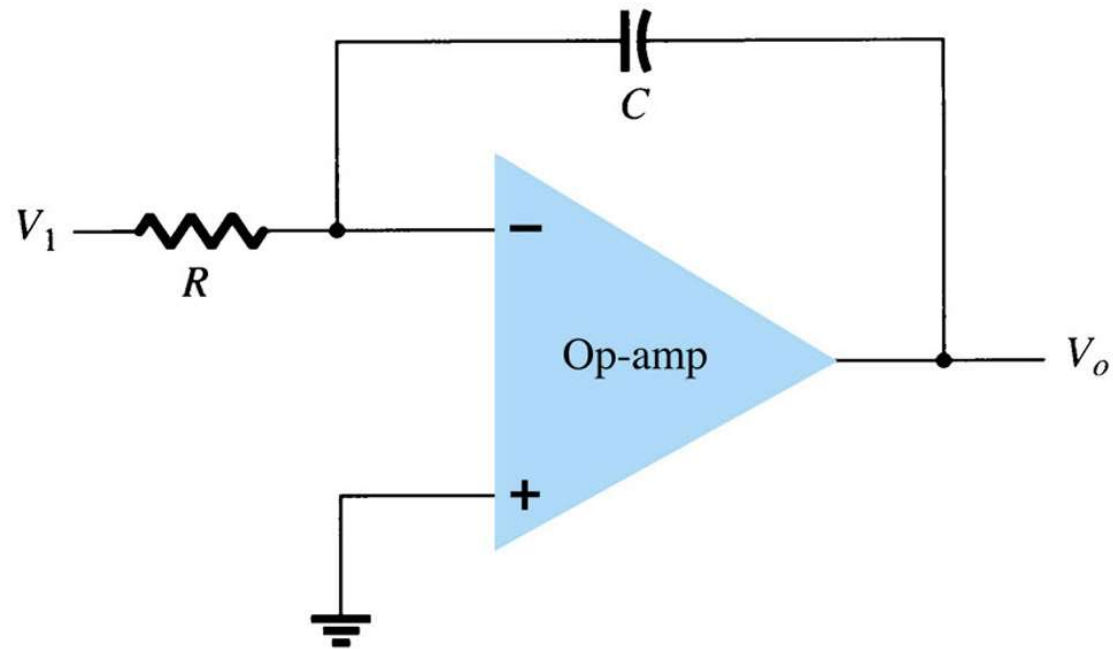
# Comparador



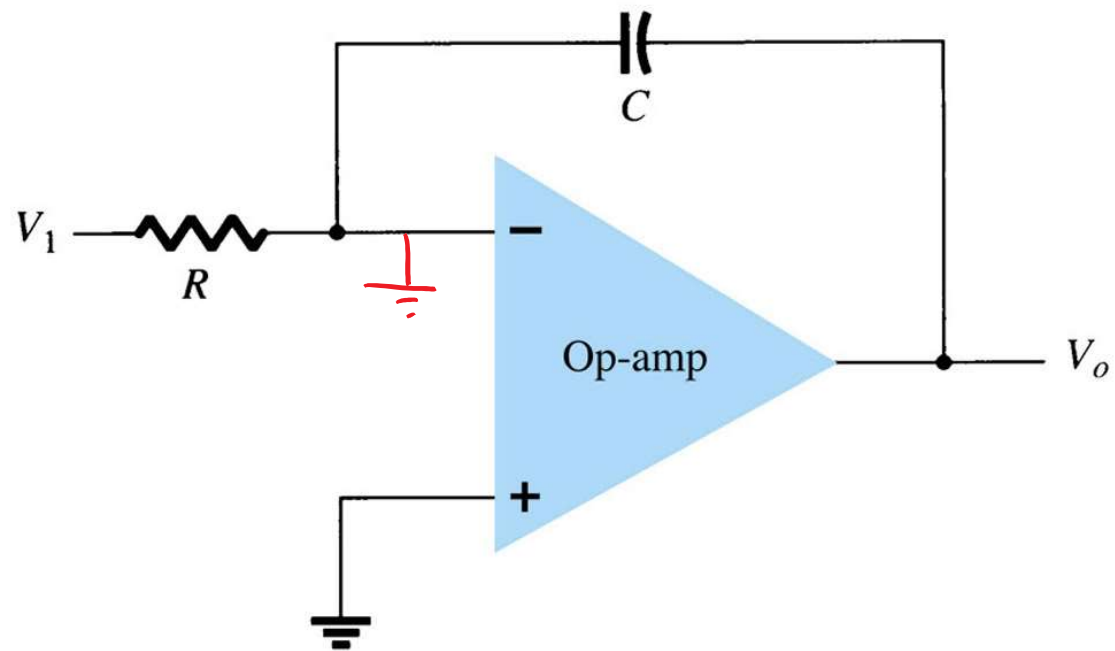
## Mais operações matemáticas com AMP OP



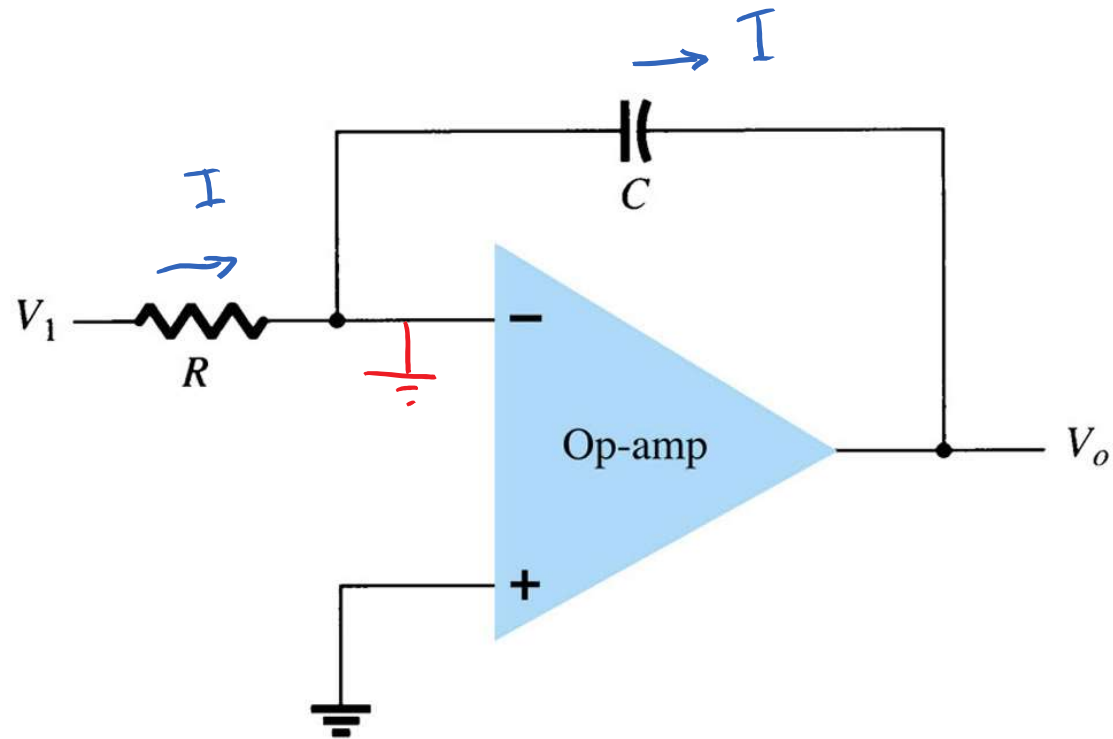
# Integrador



# Integrador

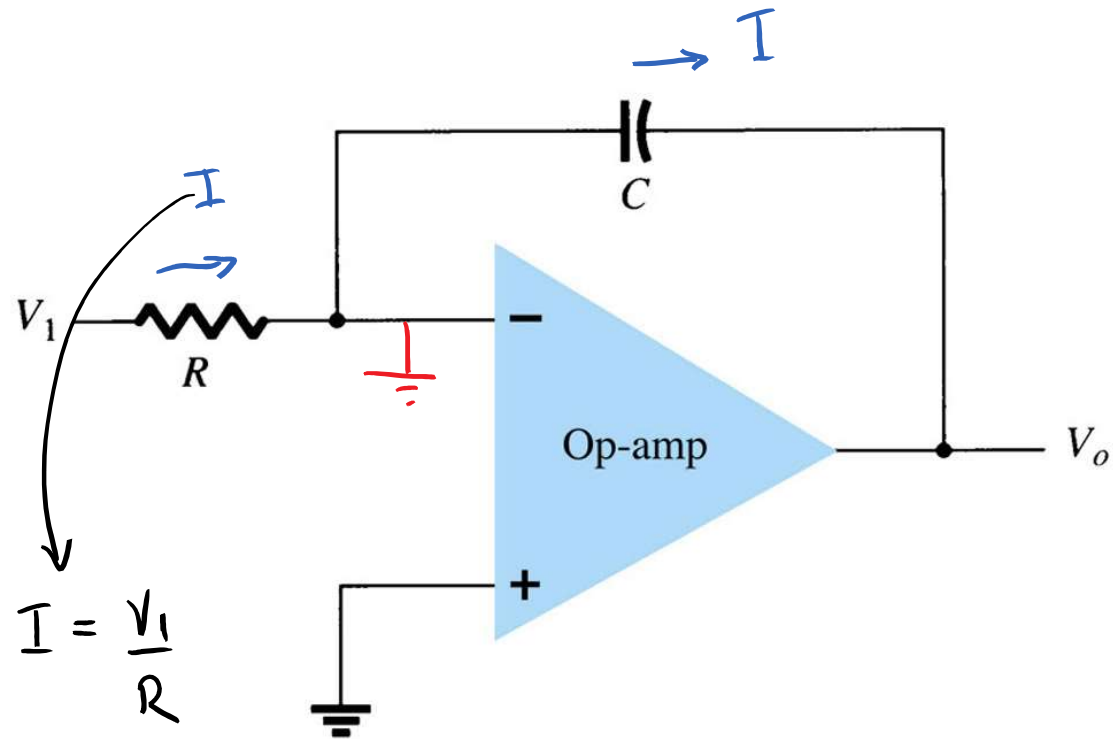


# Integrador

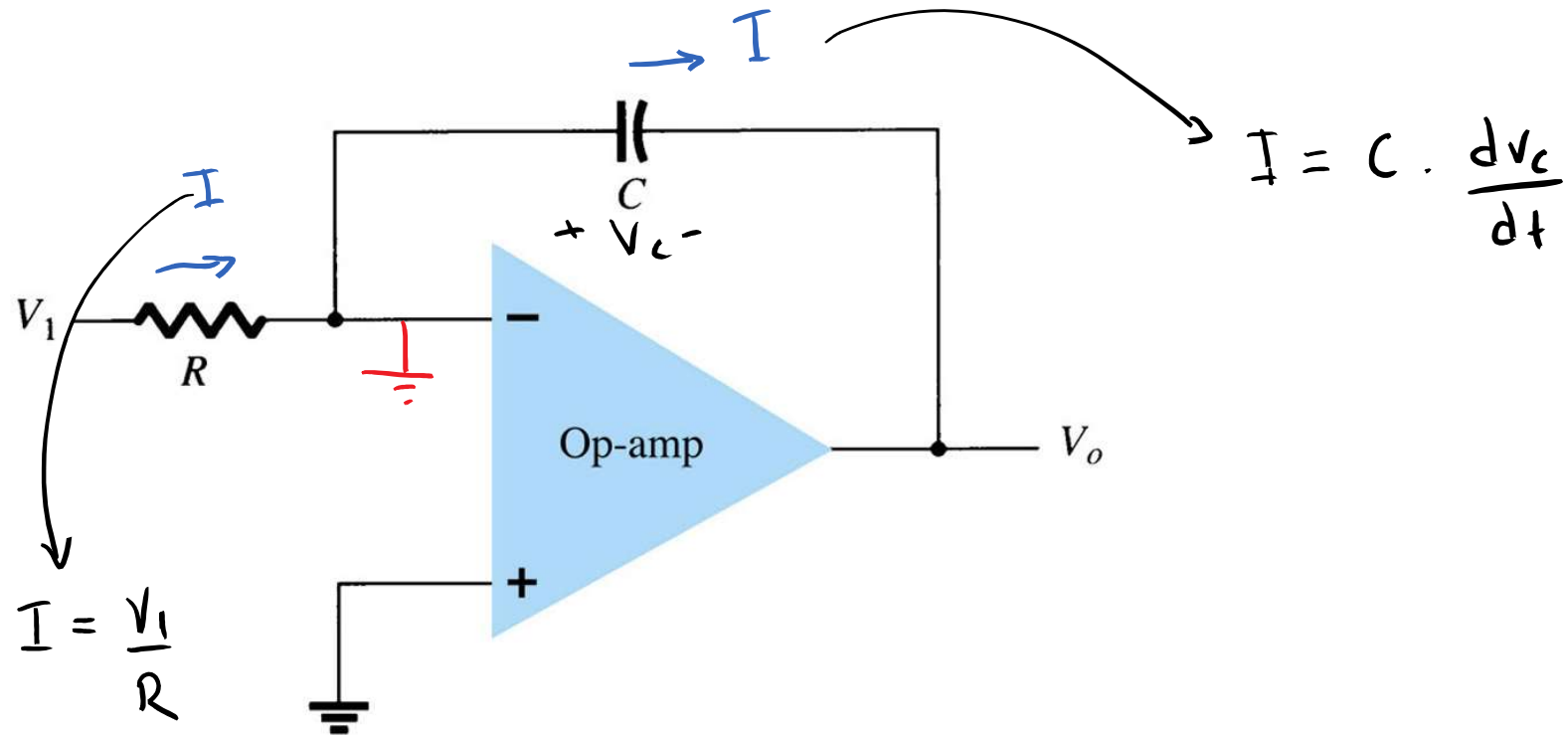




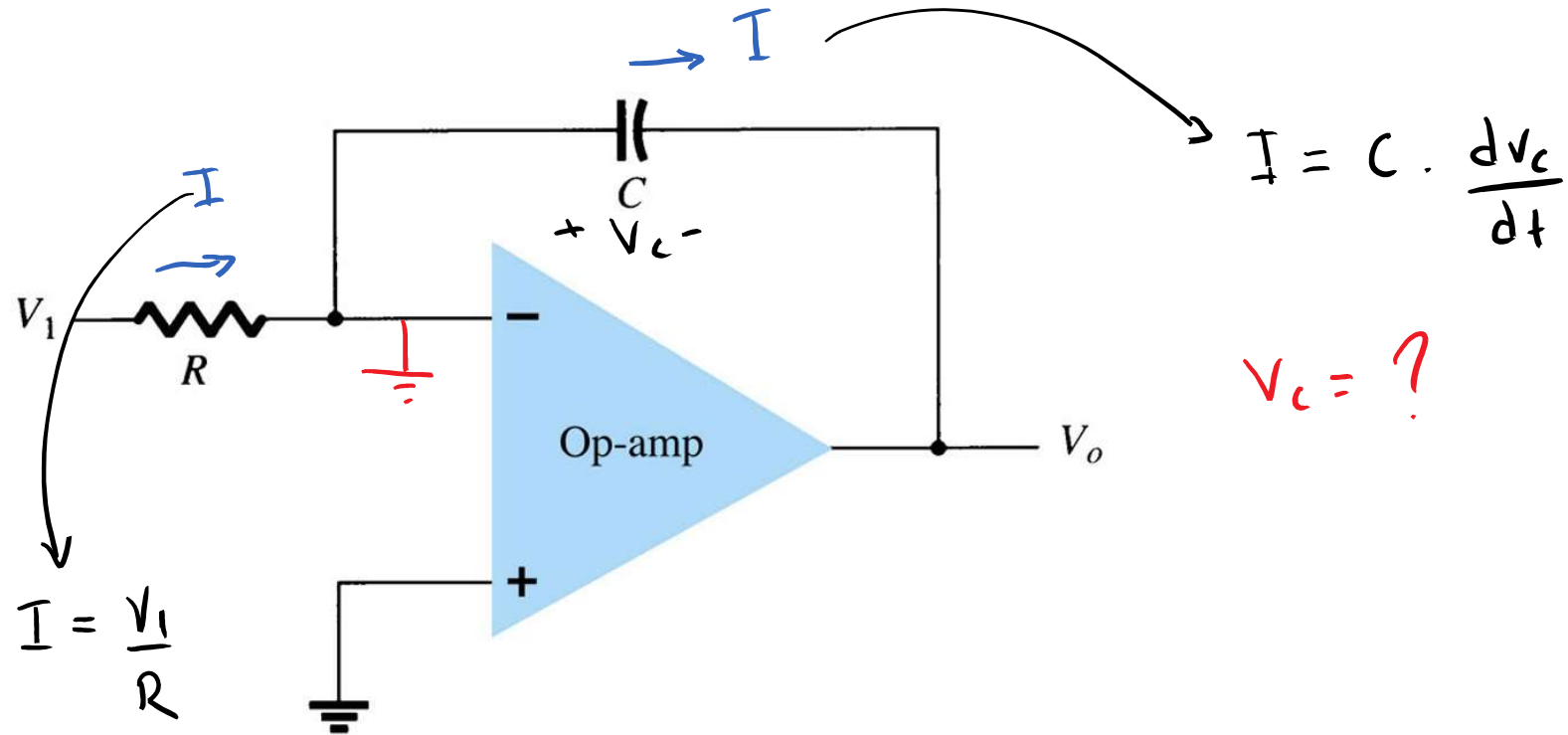
# Integrador



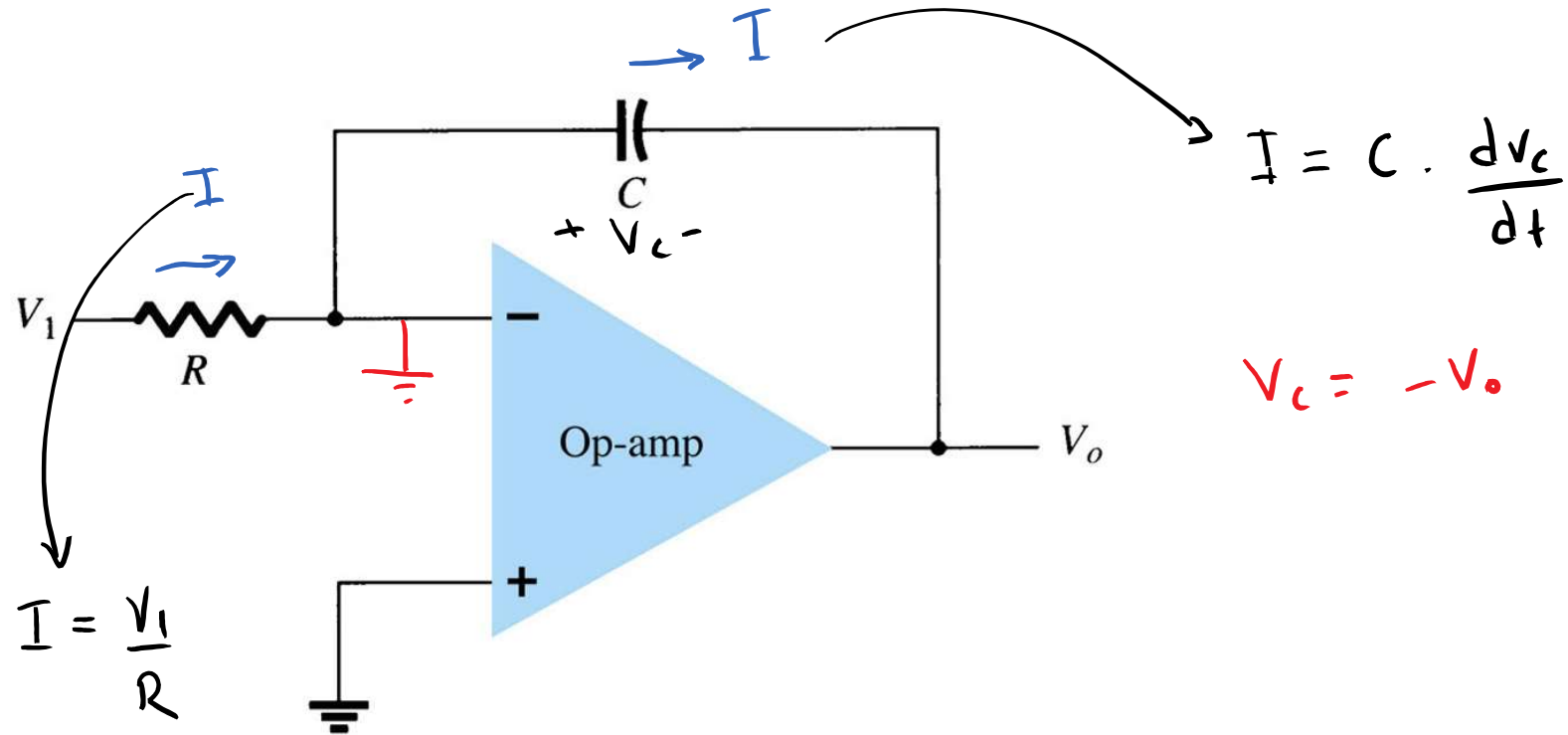
# Integrador



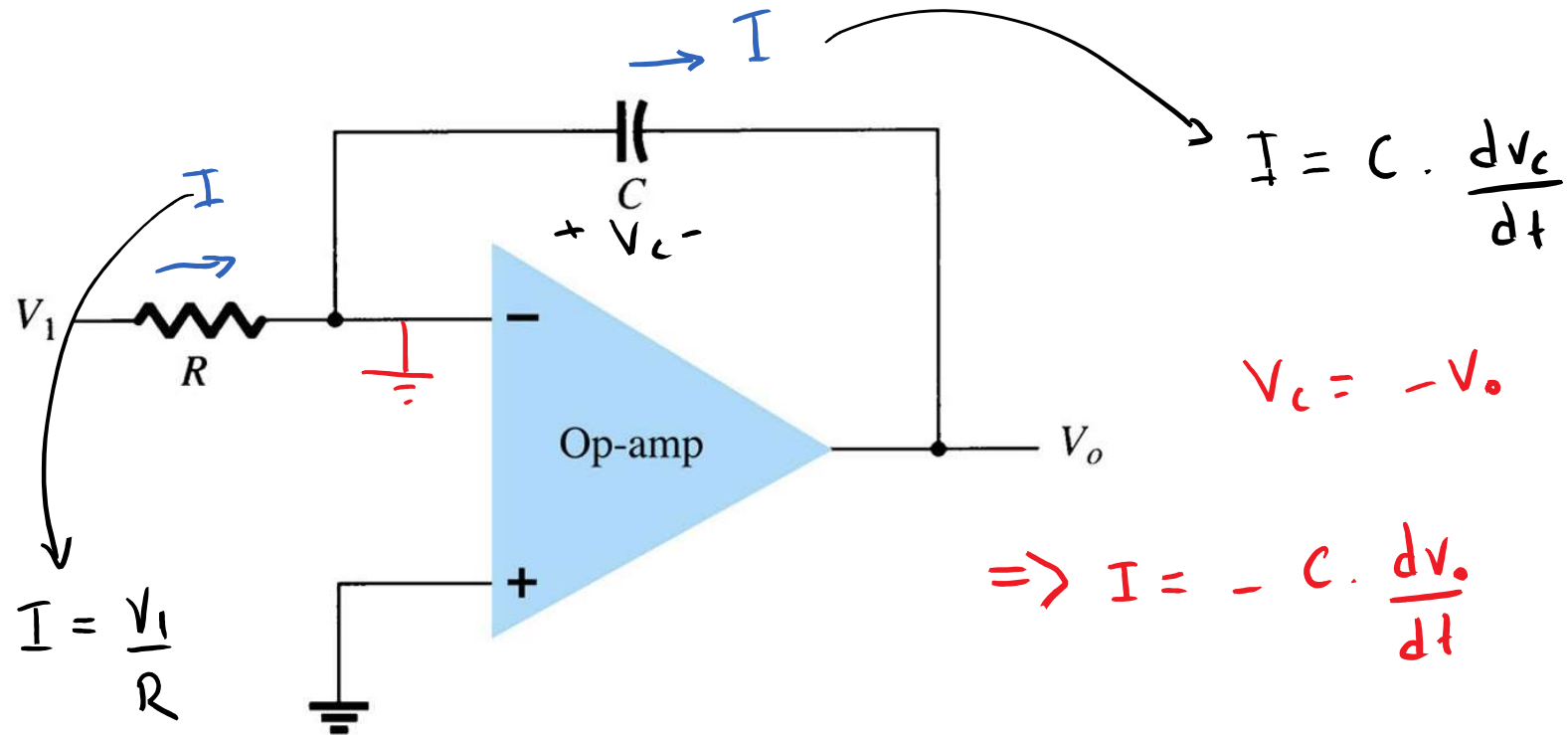
# Integrador



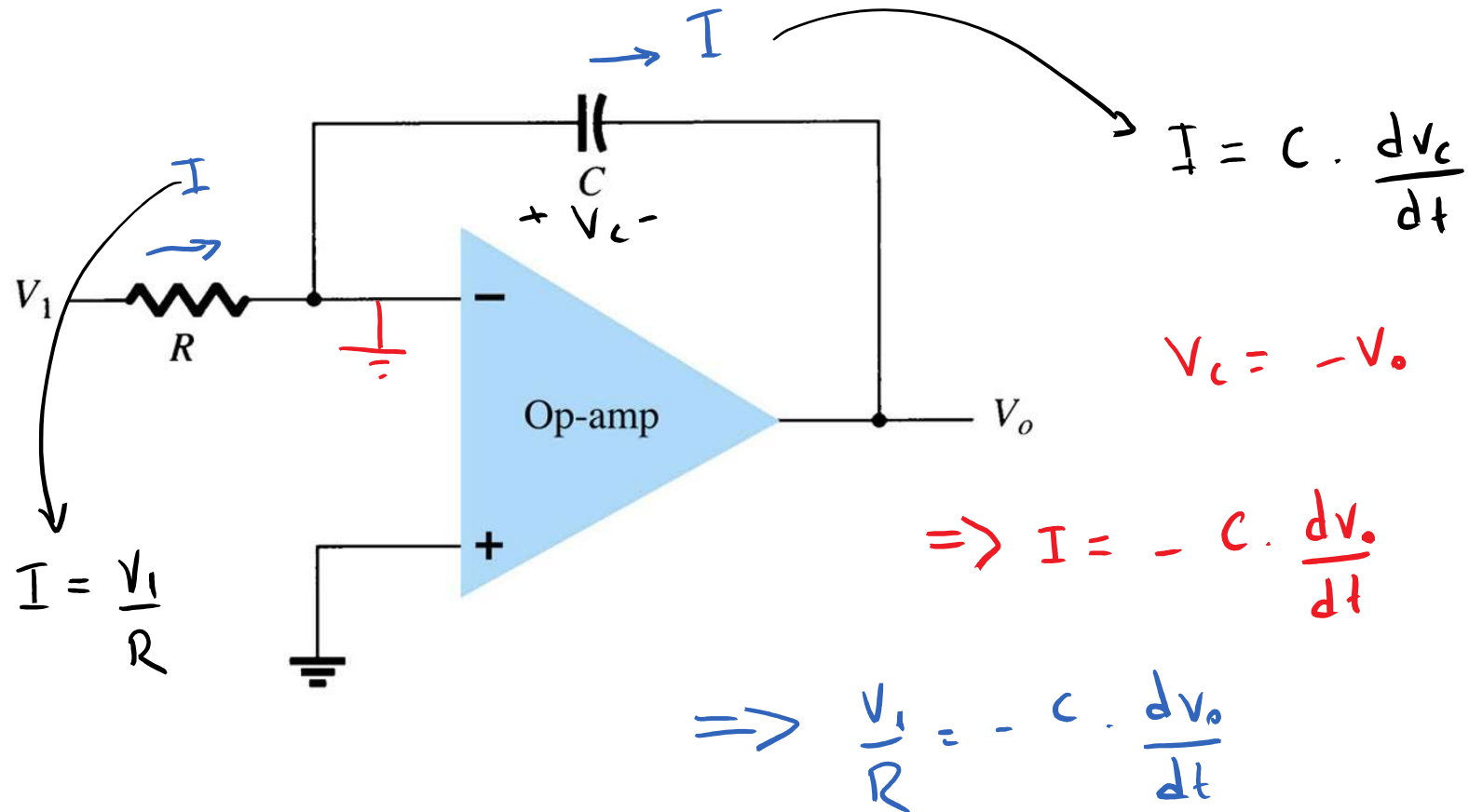
# Integrador



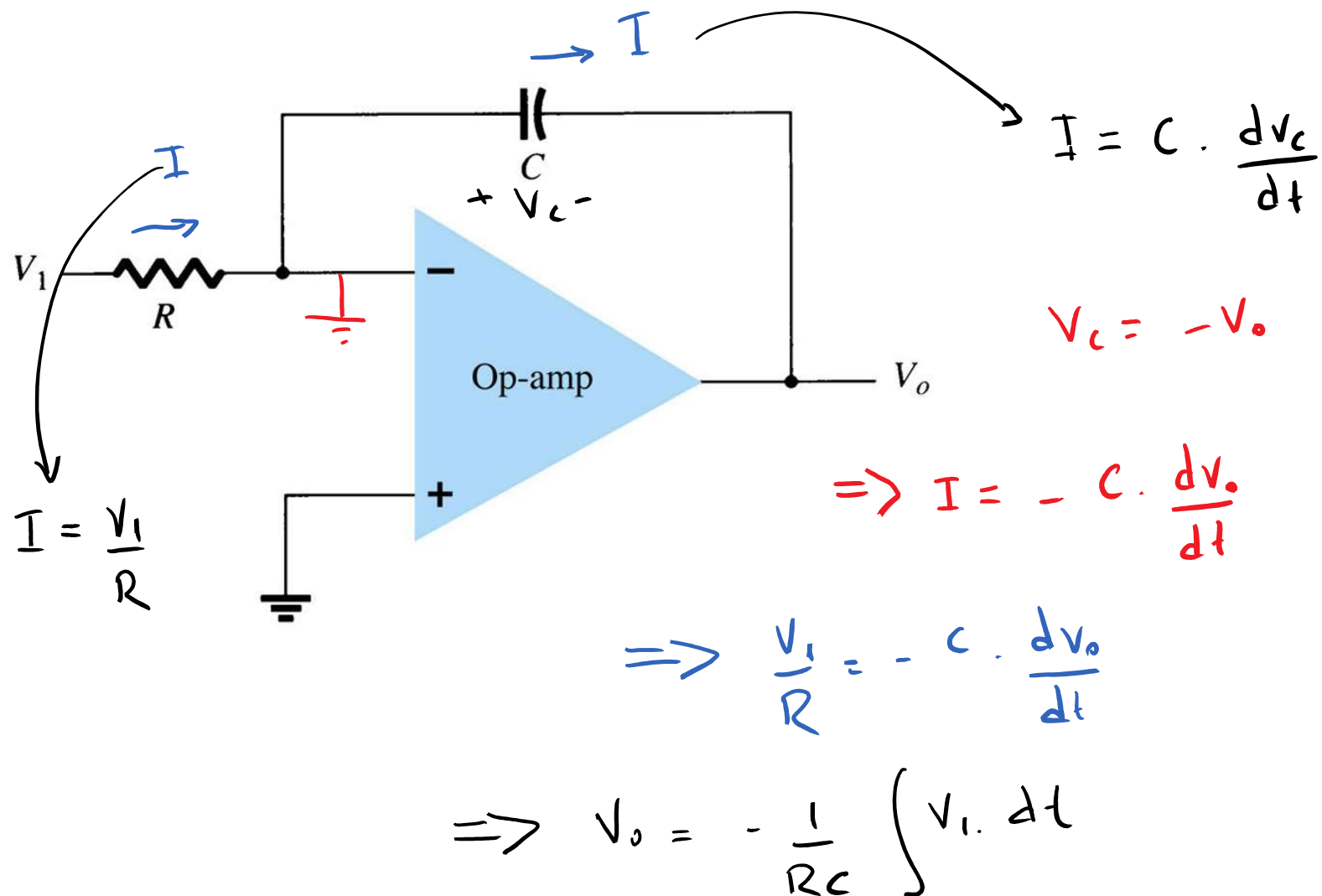
# Integrador



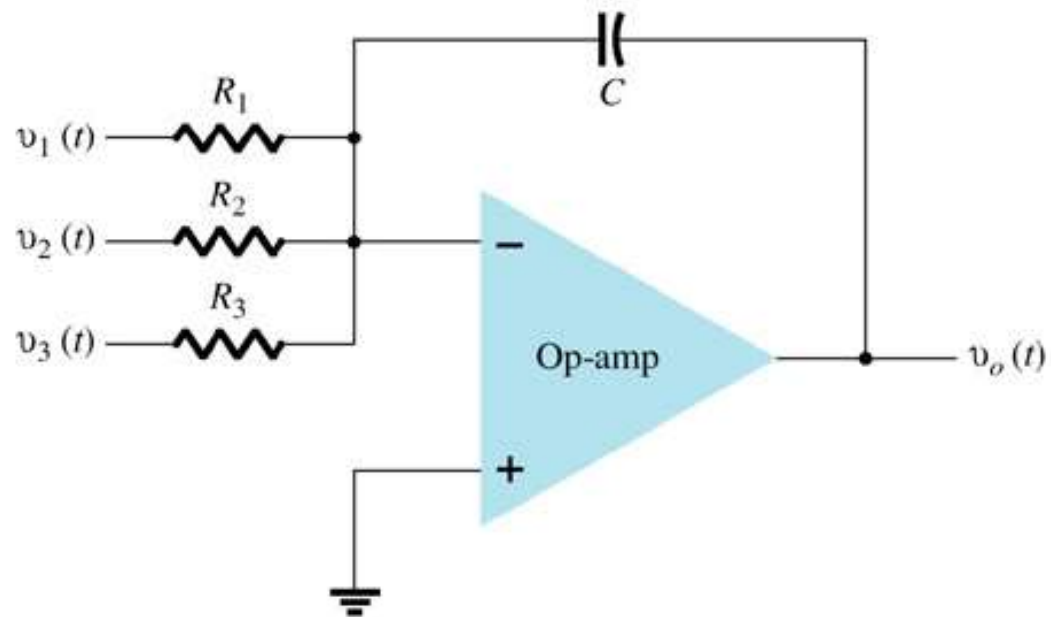
# Integrador



# Integrador

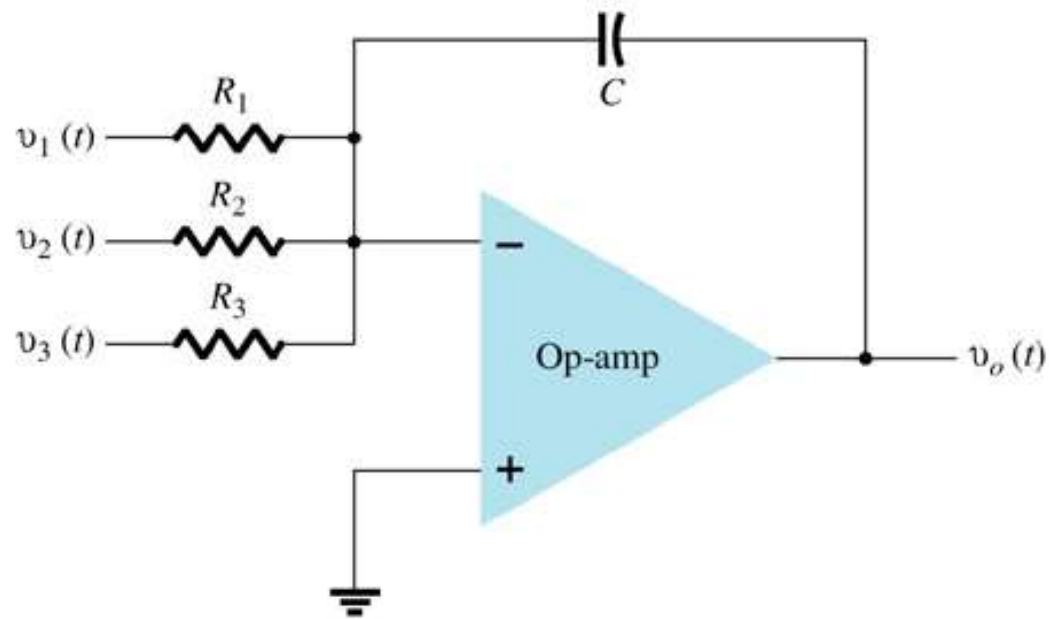


# Integrador Somador



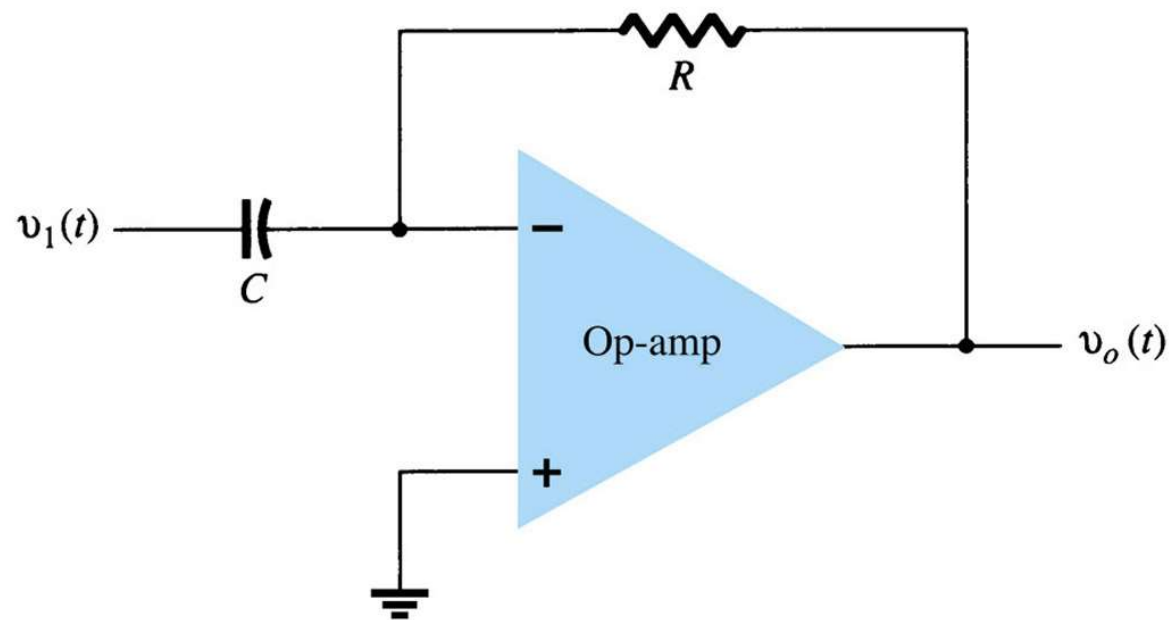


# Integrador Somador

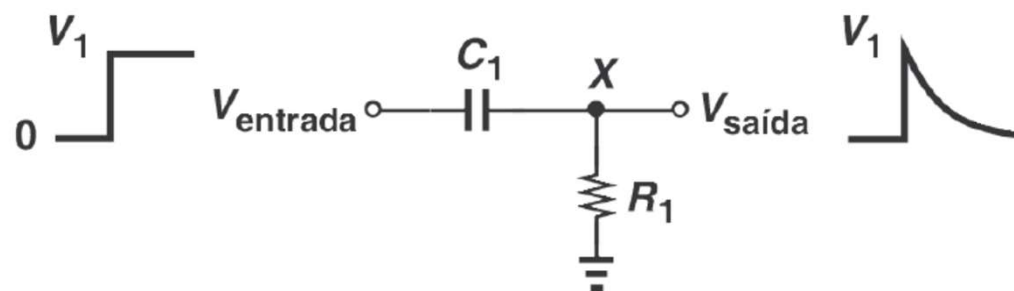
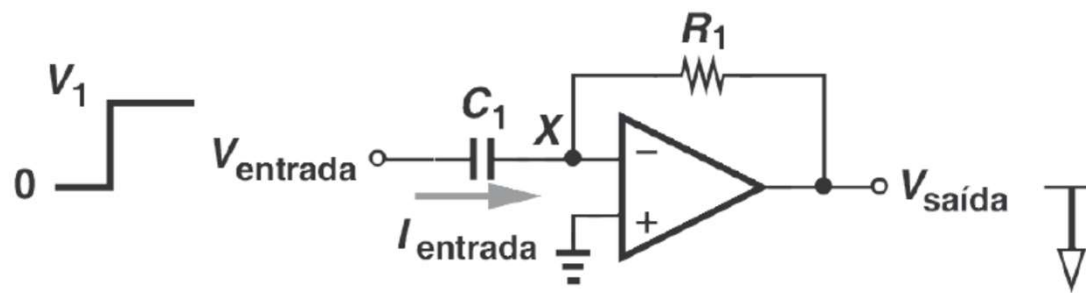


$$v_o(t) = - \left[ \frac{1}{R_1 C} \int v_1 \cdot dt + \frac{1}{R_2 C} \int v_2 \cdot dt + \frac{1}{R_3 C} \int v_3 \cdot dt \right]$$

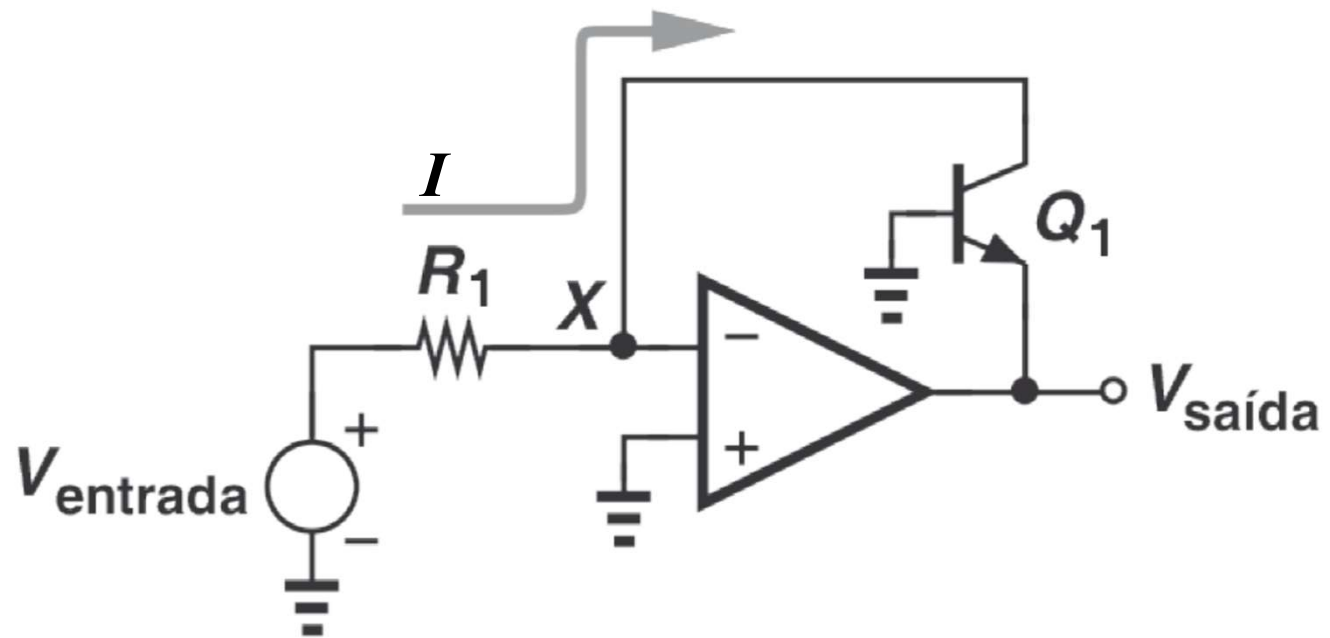
# Derivador



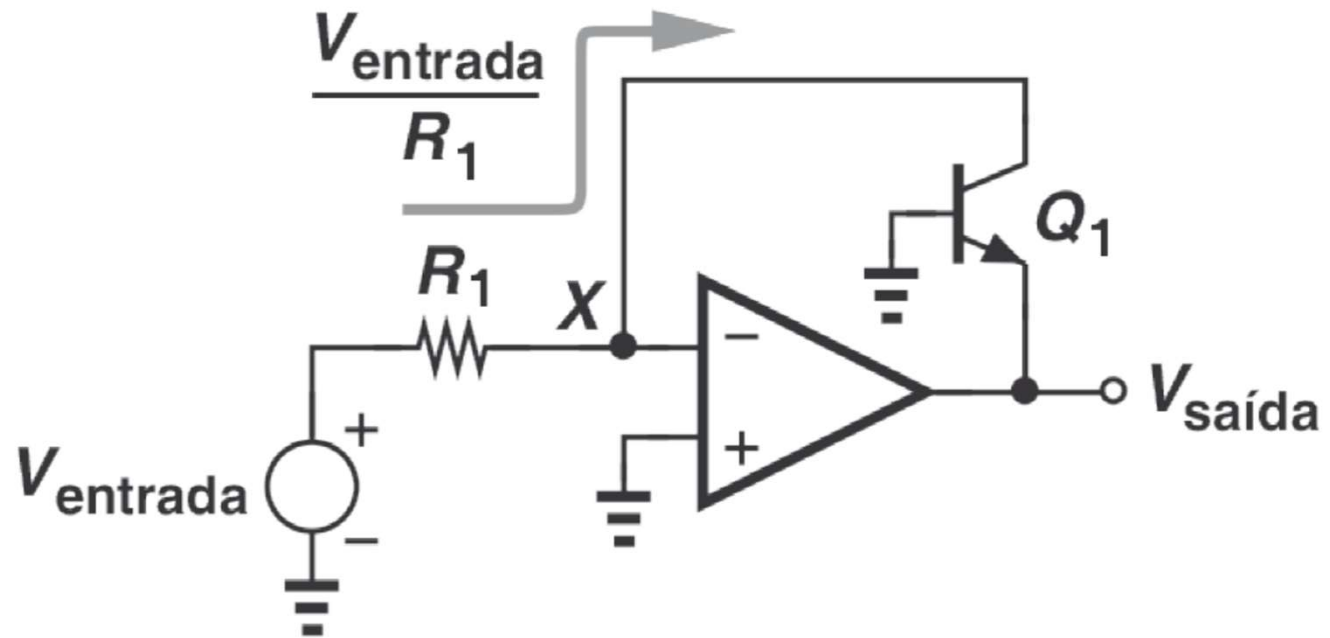
## Derivador *versus* circuito RC



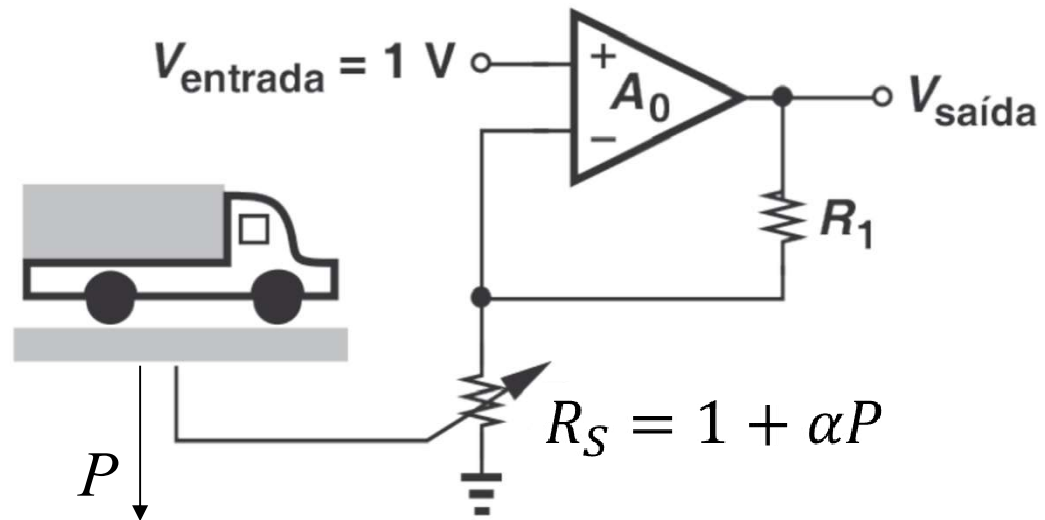
# Logarítmico



# Logarítmico



## Exercício

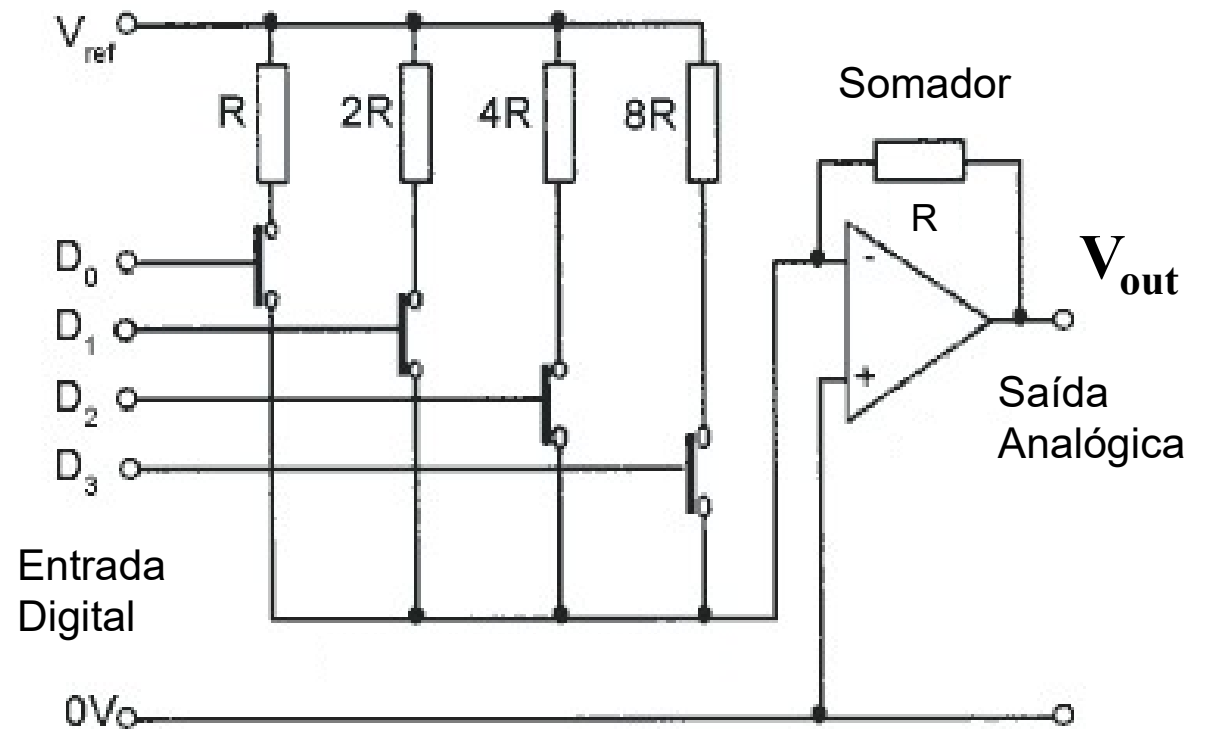


Calcule a variação de  $V_{\text{saída}}$  em função do peso  $P$

# Conversor D/A

$$V_{\text{ref}} = 5 \text{ V}$$

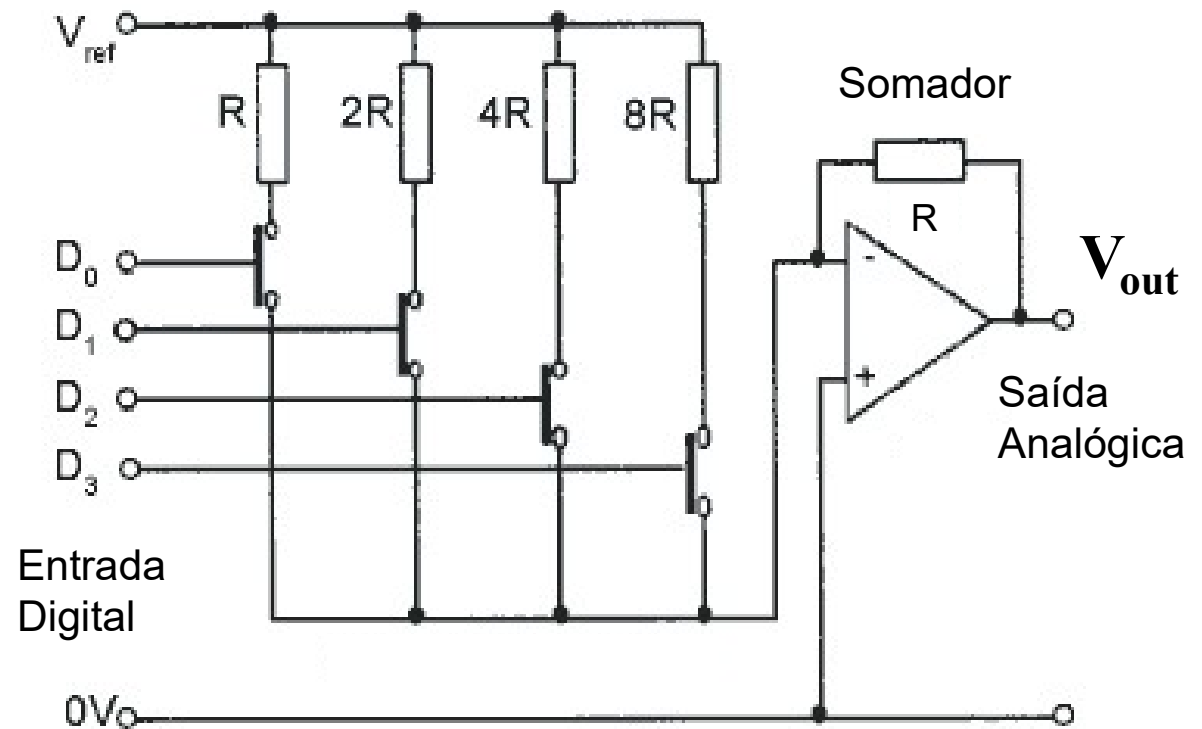
D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	V <sub>out</sub>
0	0	0	0	?
0	0	0	1	?
0	0	1	0	?
0	0	1	1	?
0	1	0	0	?
0	1	0	1	?
0	1	1	0	?
0	1	1	1	?
1	0	0	0	?
1	0	0	1	?
1	0	1	0	?
1	0	1	1	?
1	1	0	0	?
1	1	0	1	?
1	1	1	0	?
1	1	1	1	?



# Exercício: calcule os valores marcados

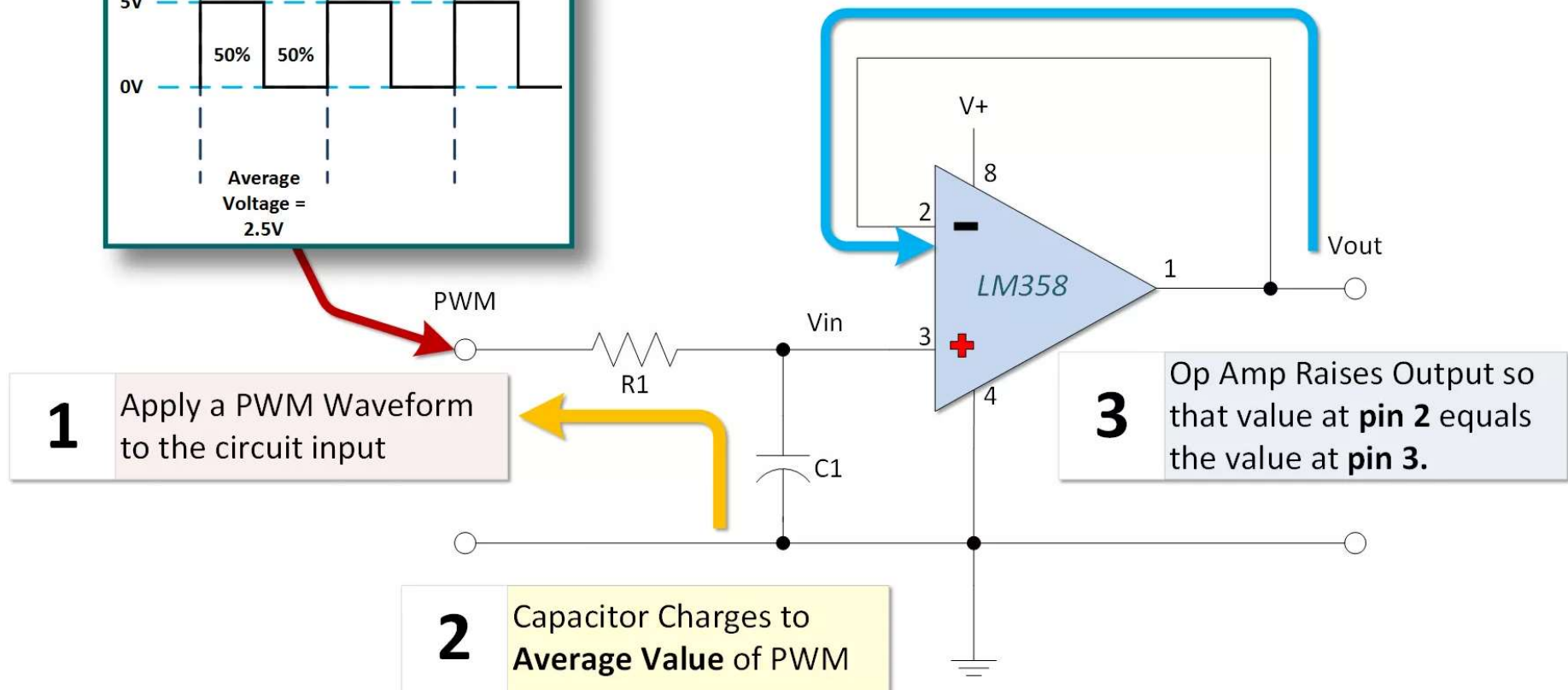
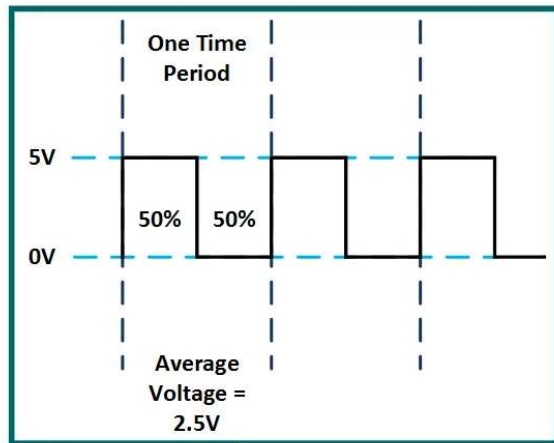
$$V_{\text{ref}} = 5 \text{ V}$$

D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	V <sub>out</sub>
0	0	0	0	?
0	0	0	1	?
0	0	1	0	?
0	0	1	1	?
0	1	0	0	?
0	1	0	1	?
0	1	1	0	?
0	1	1	1	?
1	0	0	0	?
1	0	0	1	?
1	0	1	0	?
1	0	1	1	?
1	1	0	0	?
1	1	0	1	?
1	1	1	0	?
1	1	1	1	?

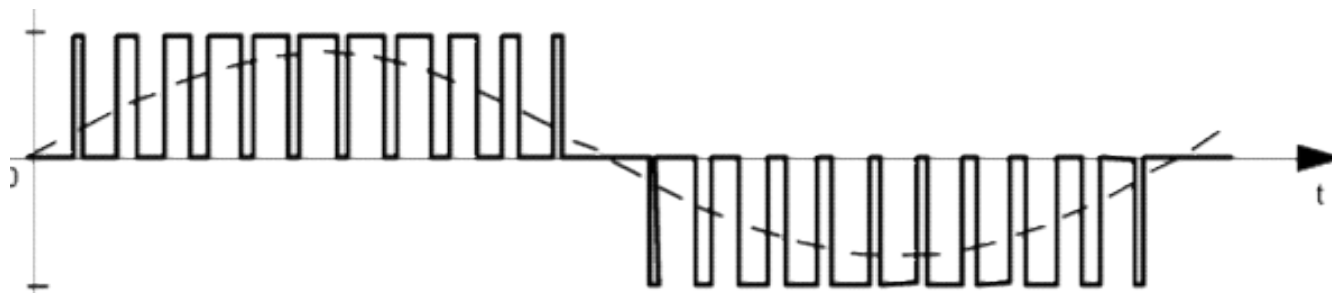




# Conversor PWM para tensão com AMP OP



# Conversor PWM para tensão com AMP OP



# Amplificador de Instrumentação

