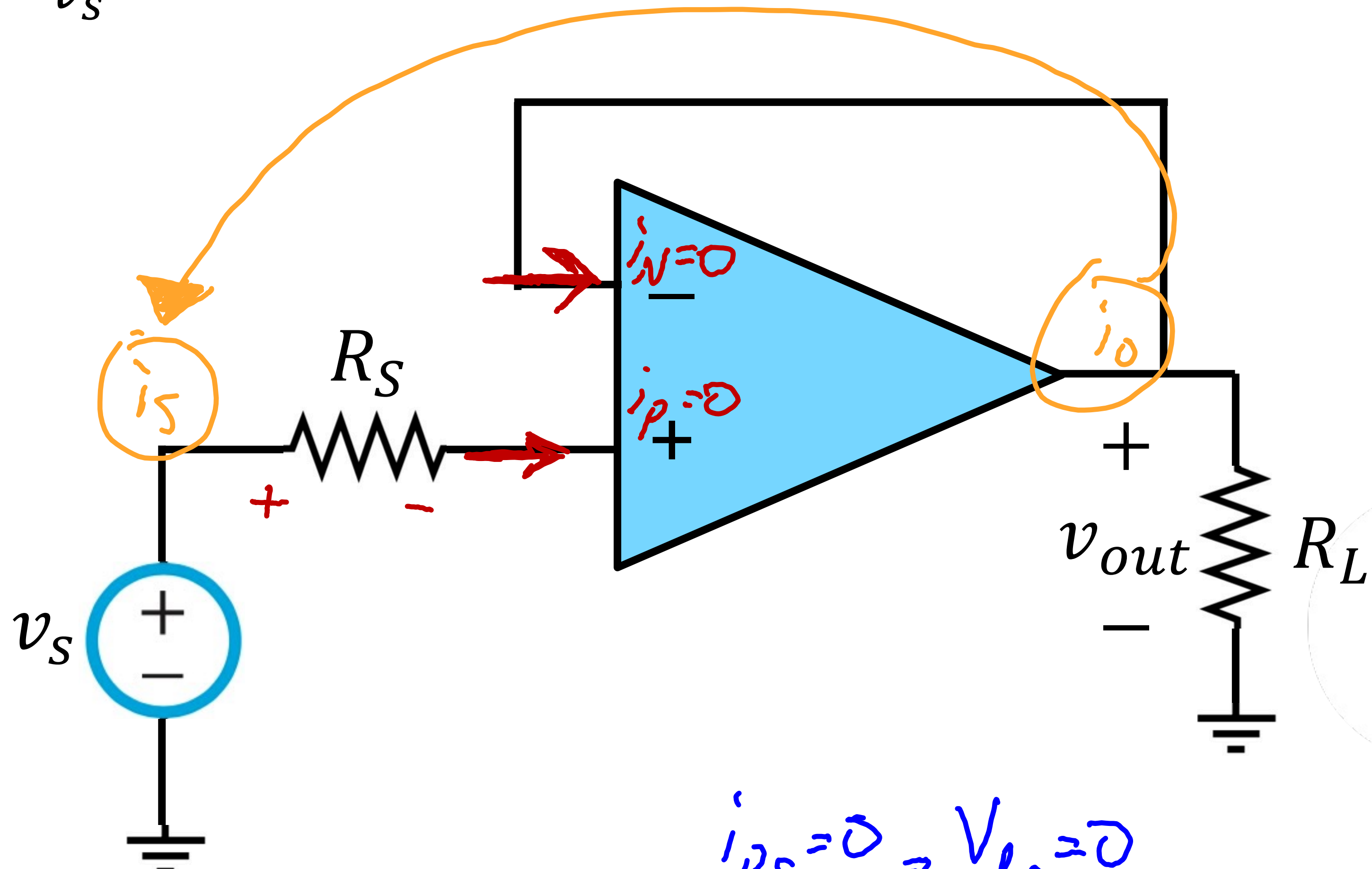
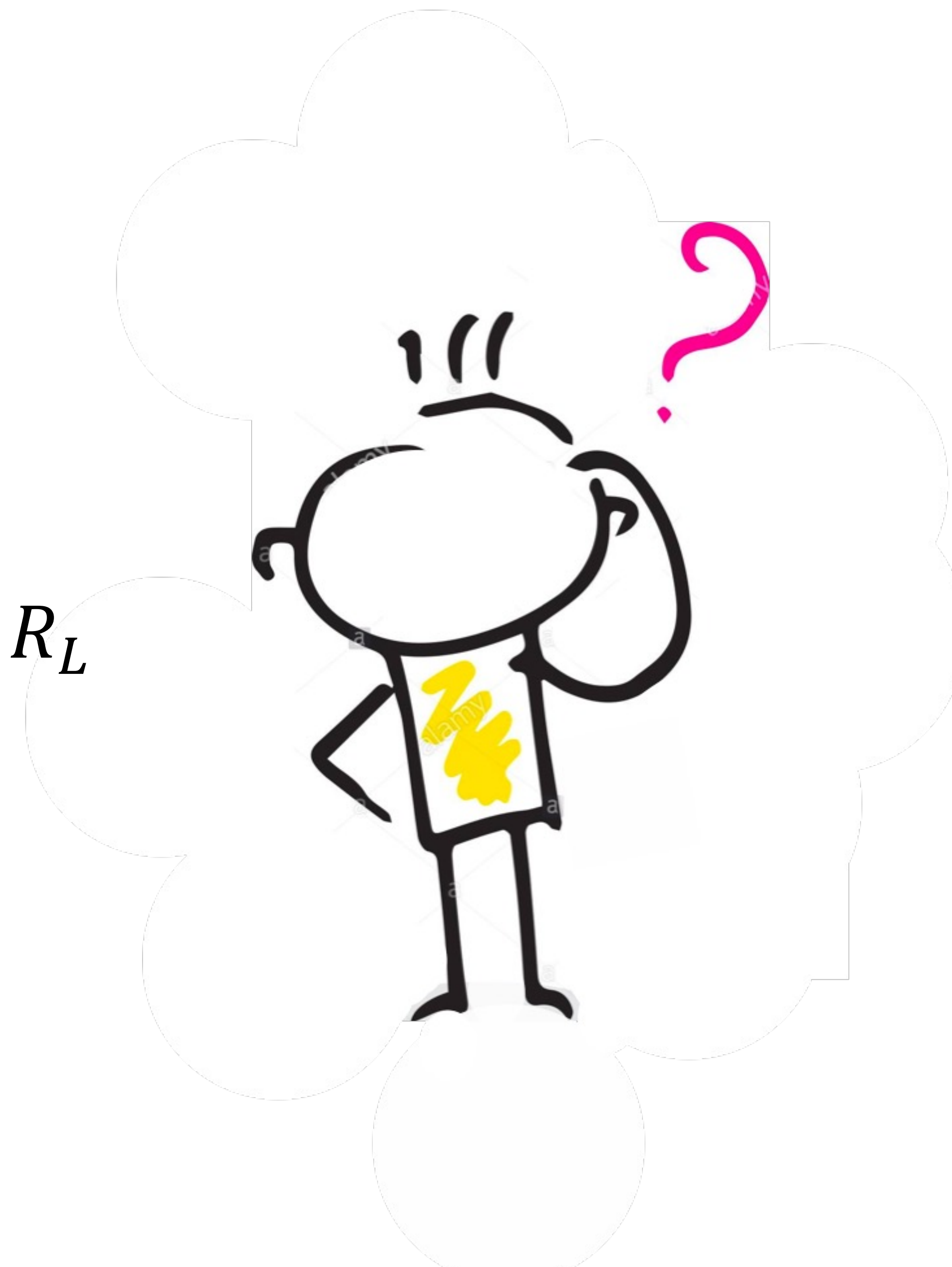
Last Class…

Find $\frac{v_{out}}{v_s}$ given that:

Bigger than





Volt Follower

ideal model $V_N = V_p$

$i_{R_S} = 0 \Rightarrow V_{R_S} = 0$

$V_s = V_p$

$V_{out} = V_s \Rightarrow \boxed{\frac{V_{out}}{V_s} = 1}$

THE OHIO STATE UNIVERSITY

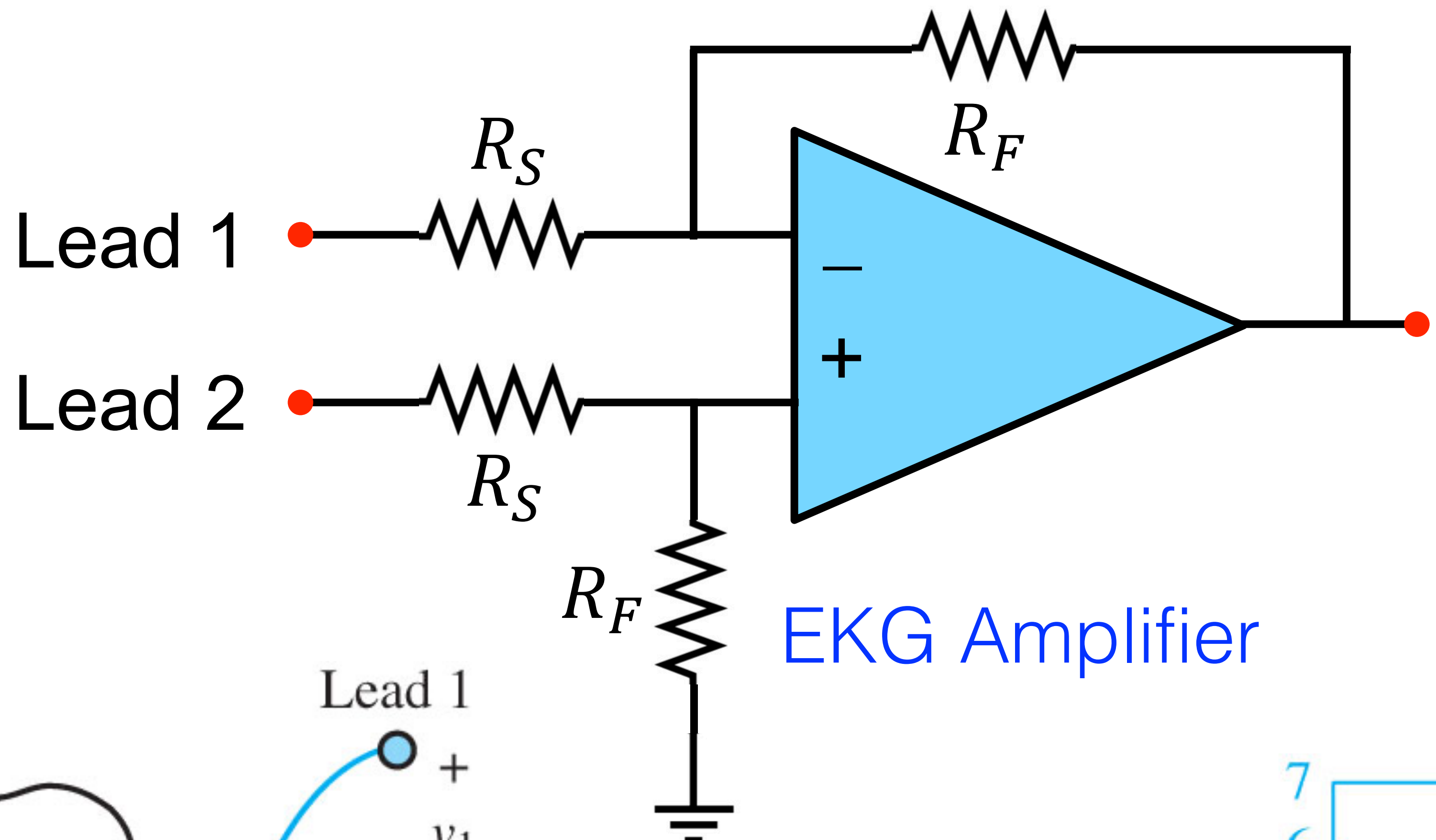
COLLEGE OF ENGINEERING

Op-amp models (Part 2)

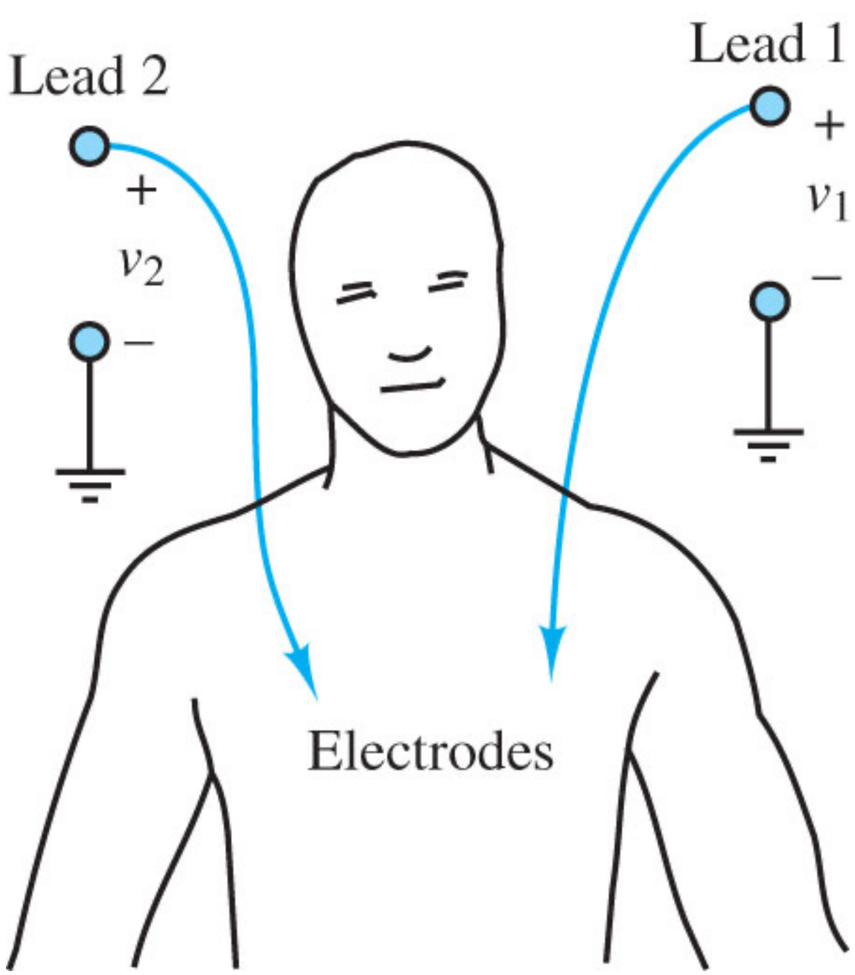
This Lecture…

- Learning Objectives:
  - Analyze a circuit using the behavioral and ideal model of the op-amp.
  - Identify the voltage gain of a non-inverting and an inverting amplifier.

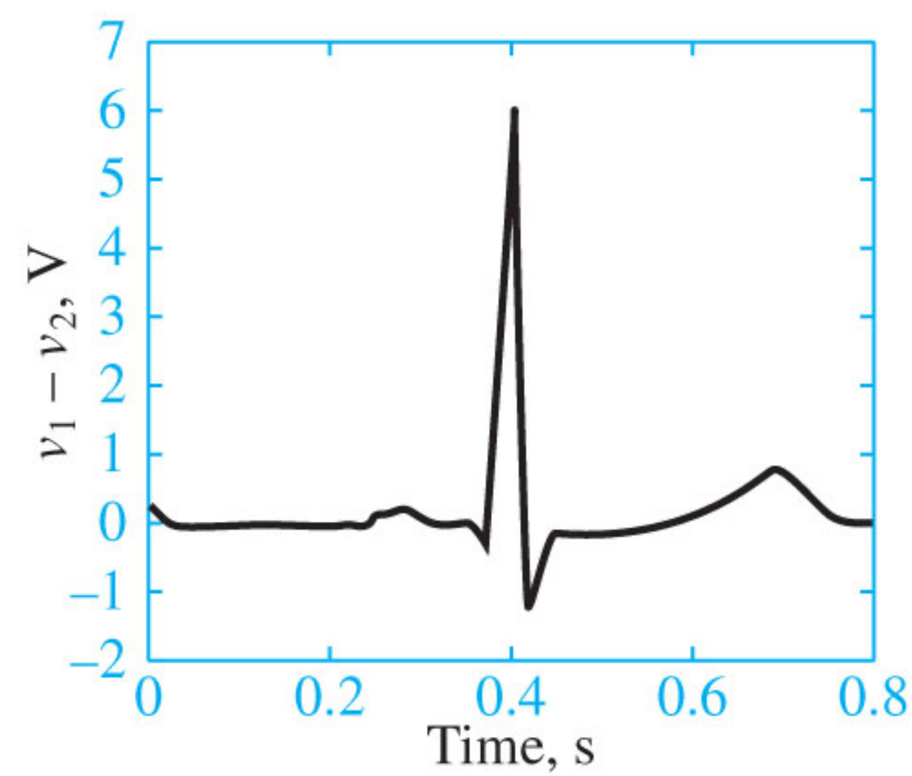
Differential Amplifier



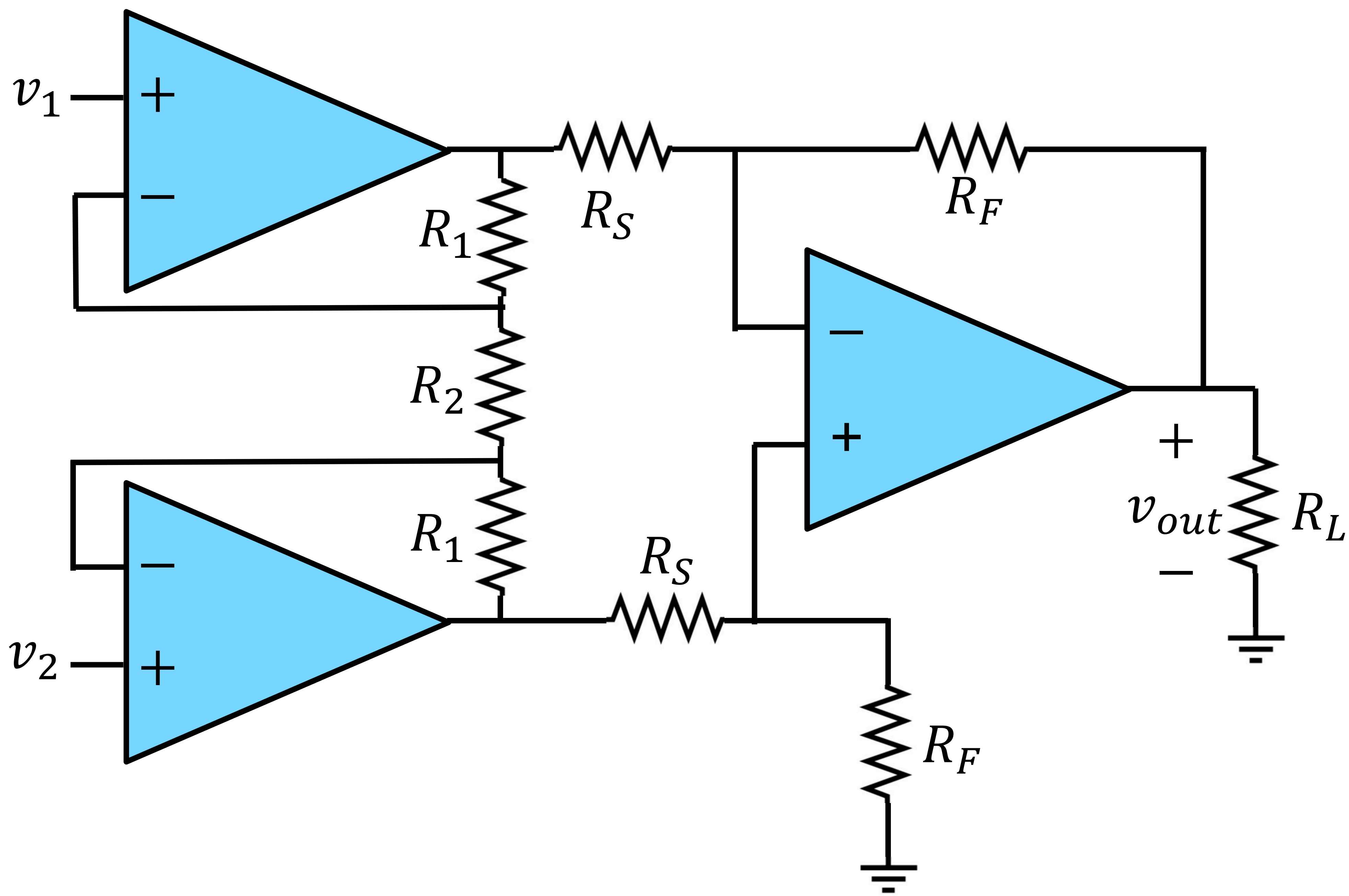
EKG Amplifier



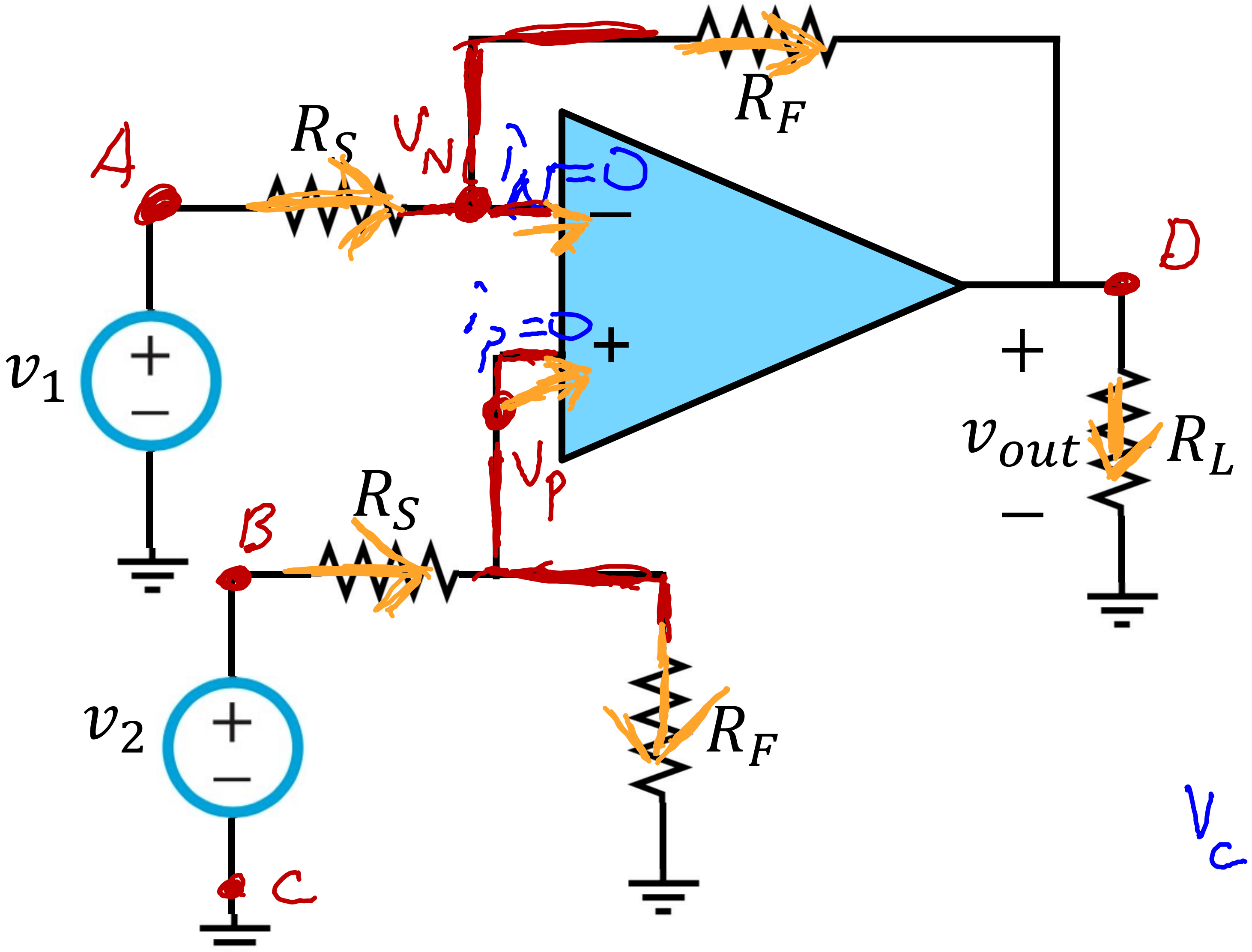
Better version:
Instrumentation
Amplifier



Instrumentation Amplifier



Differential Amplifier



ideal model

$i_p = i_N = 0$

$V_p = V_N$

Do not do KCL @ output (D)

Node Voltage Analysis

$V_C = 0V \quad V_A = V_1 \quad V_B = V_2$

KCL @ N

$i_{RS} = i_{RF} + 0$

$$\frac{V_1 - V_N}{R_S} = \frac{V_N - V_D}{R_F}$$

KCL @ P

$i_{RS1} = i_{RF1} + 0$

$$\frac{V_B - V_P}{R_S} = \frac{V_P}{R_F}$$

$$R_F V_1 - R_F V_N = R_S V_N - R_S V_D$$

$$R_F V_1 - (R_F + R_S) V_N = -R_S V_D \quad 1$$

$$V_P = V_N \qquad 2 \text{ in } 1$$

$$R_F V_1 - \cancel{(R_F + R_S)} \left(\frac{R_F V_B}{\cancel{R_S + R_F}} \right) = -R_S V_D$$

$$R_F (V_1 - V_2) = -R_S V_D$$

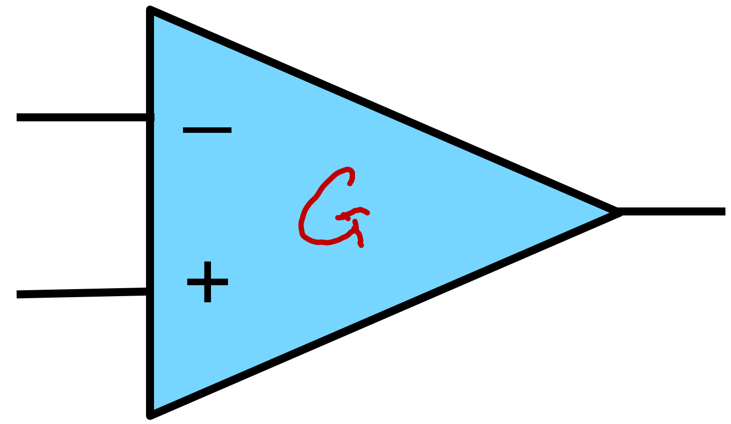
$$\frac{R_F}{R_S} (V_2 - V_1) = V_D$$

$$R_F V_B - R_F V_P = R_S V_P$$

$$R_F V_B = (R_S + R_F) V_P$$

$$2 \quad V_P = \frac{R_F V_B}{(R_S + R_F)}$$

Cascading Amplifiers

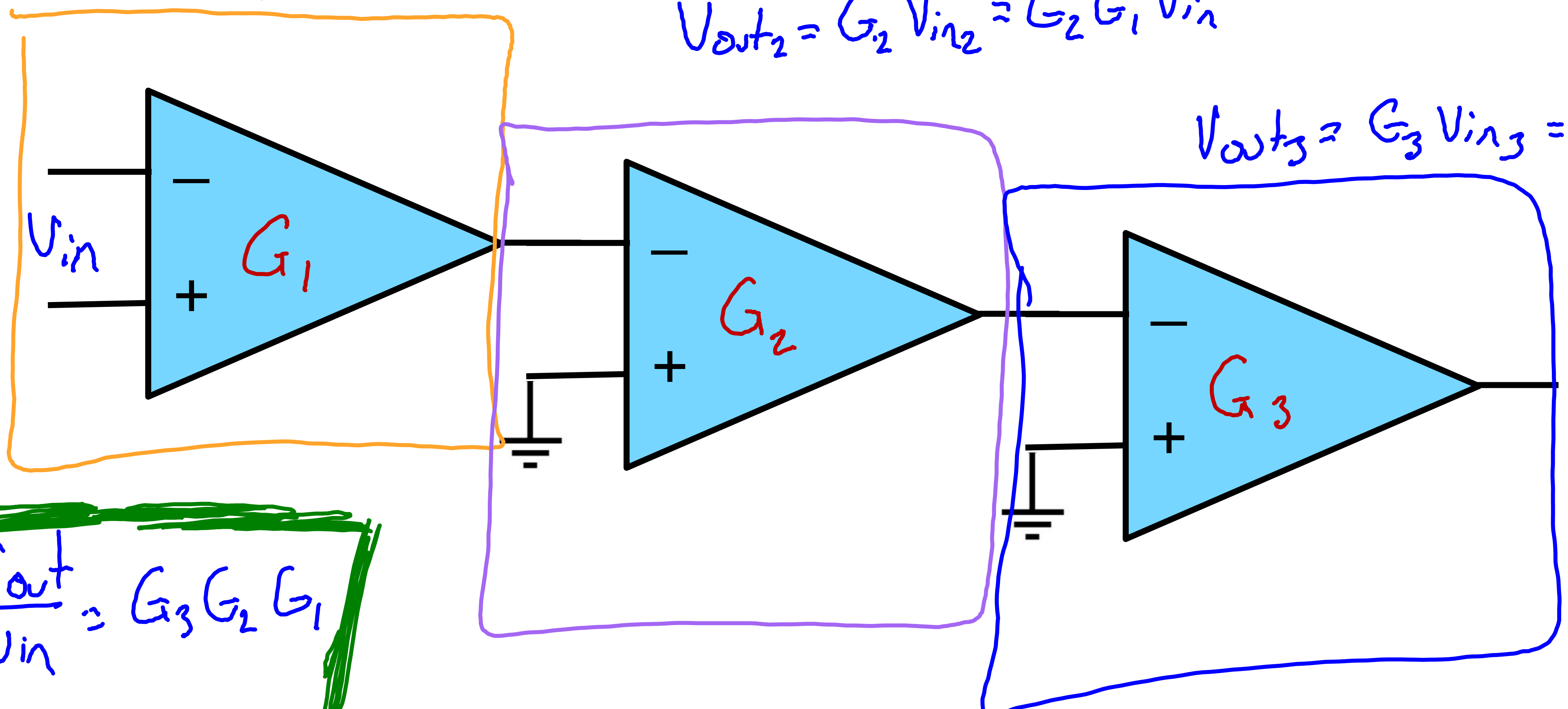


$V_{out} = G * V_{in}$

$V_{out_1} = G_1 V_{in}$

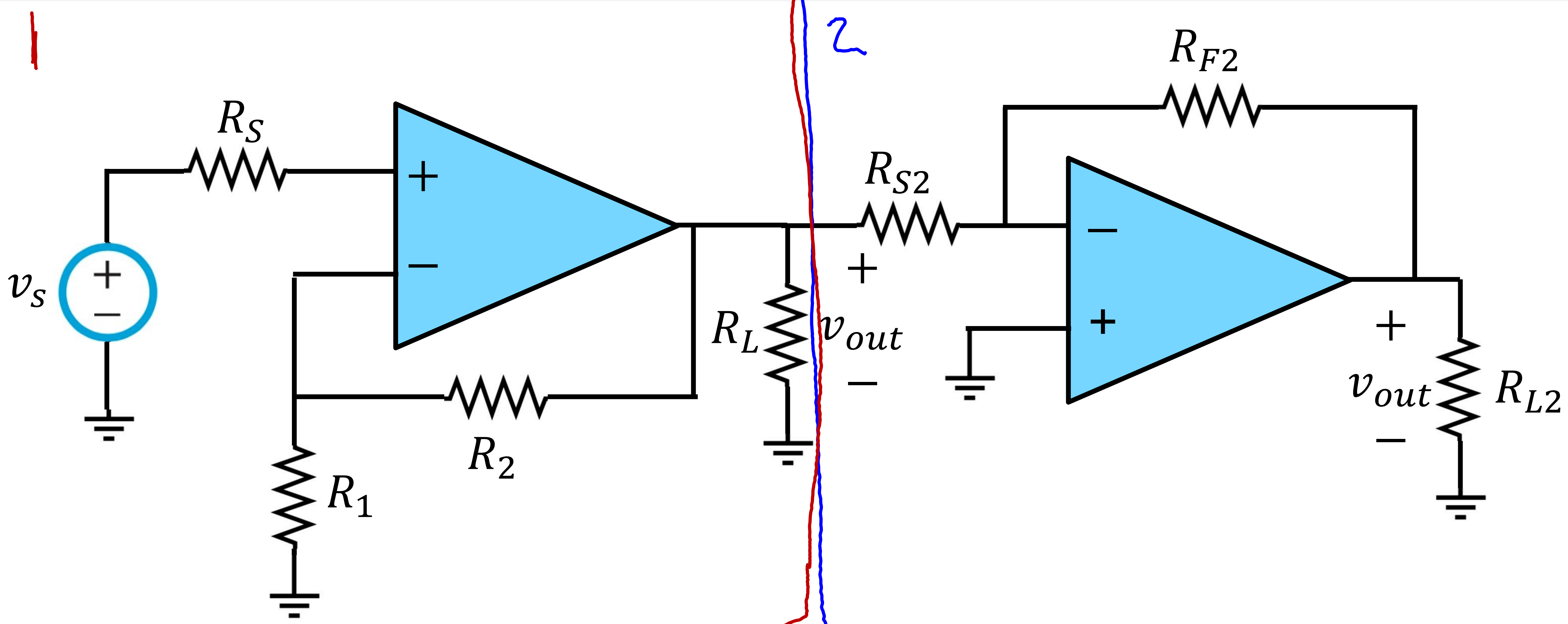
$V_{out_2} = G_2 V_{in_2} = G_2 G_1 V_{in}$

$V_{out_3} = G_3 V_{in_3} = G_3 G_2 G_1 V_{in}$



$$\boxed{\frac{V_{out}}{V_{in}} = G_3 G_2 G_1}$$

Cascading Amplifiers



Non-Inverting

$$G_1 = \frac{R_2 + R_1}{R_1}$$

Inverting Op-Amp

$$G_2 = \frac{-R_{F_2}}{R_{S_2}}$$

$$\frac{V_{out}}{V_S} = G_1 G_2 = -\frac{R_{F_2}(R_2 + R_1)}{R_{S_2} R_1}$$