

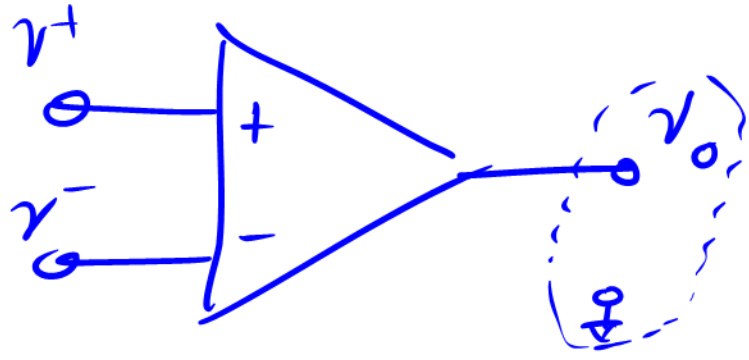
# MIDTERM 2 REVIEW

OH: TODAY @ 3PM - 4:30PM

TOPICS: {  
- AMPS (OP-AMPS)  
- CAP  
- RC CIRCUITS (DC, SS, AC, STEP)  
- AC CIRCUITS PULSE

HW DUE TOMORROW

# AMPLIFIERS



$$v_o = A \cdot (v^+ - v^-)$$

VOLTAGE AMPLIFIER

CURRENT AMPLIFIER

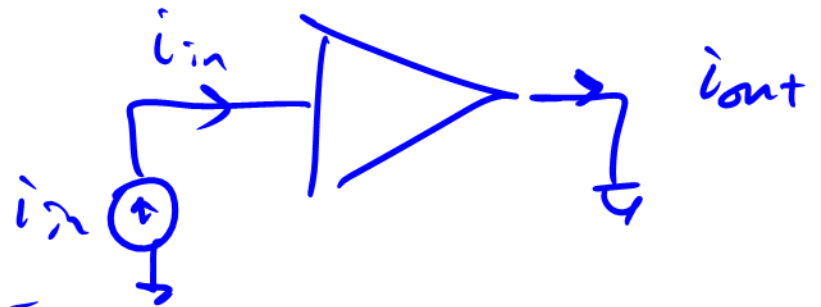
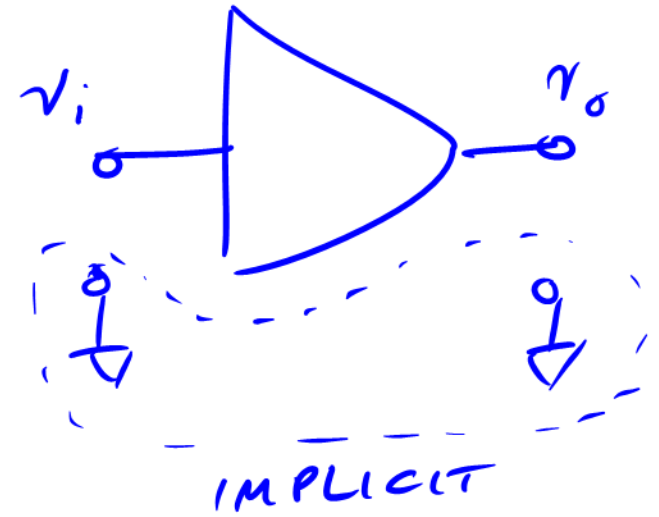
$$i_o = A \cdot i_{in}$$

$$V \rightarrow I$$

$$I \rightarrow V$$

TRANS CONDUCTANCE

TRANS RESISTANCE



$$G = \frac{S_{out}}{S_{in}}$$

$$G_V = \frac{V_{out}}{V_{in}} \left( \frac{V}{V} \right) = \text{UNITLESS}$$

$$G_I = \frac{i_{out}}{i_{in}} \left( \frac{I}{I} \right) = \text{UNITLESS}$$

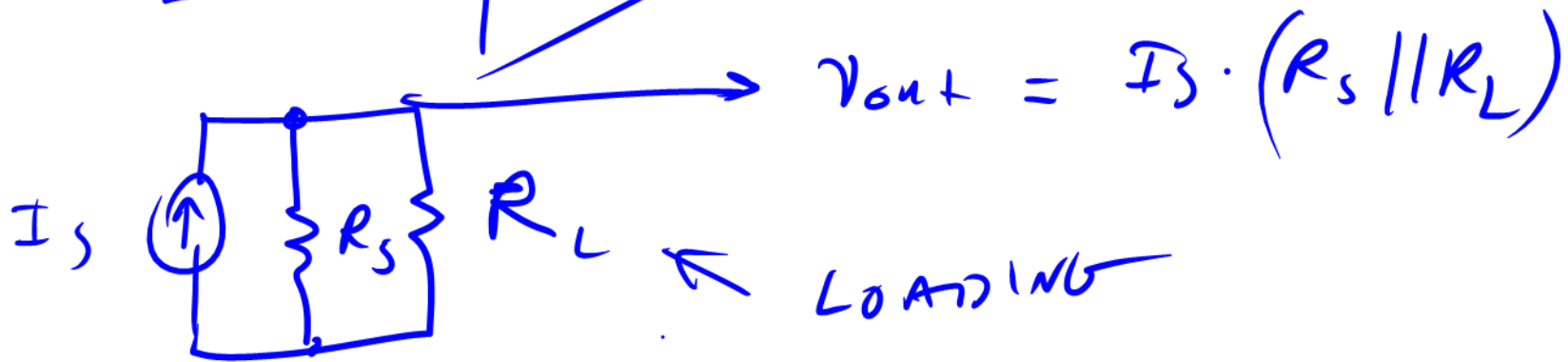
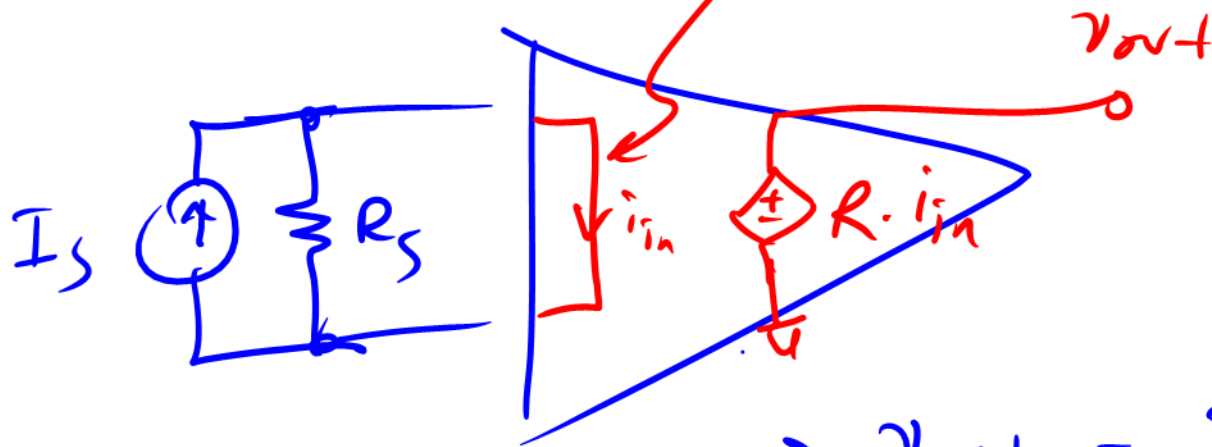
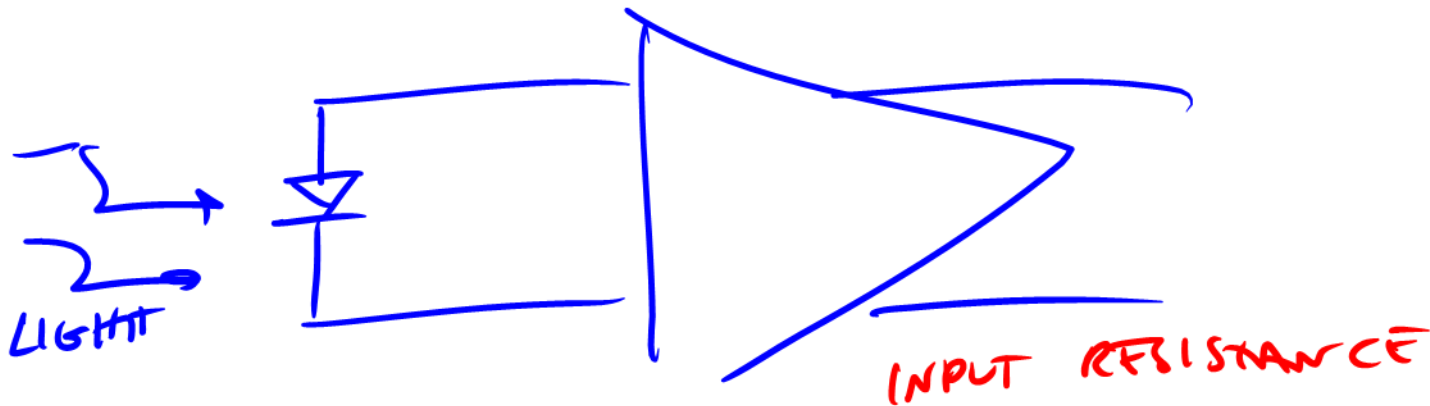
$$R = G_R = \frac{V_{out}}{i_{in}} \left( \frac{V}{I} \right) = \text{RESISTANCE (IMPEDANCE)}$$

TRANS-RESISTANCE

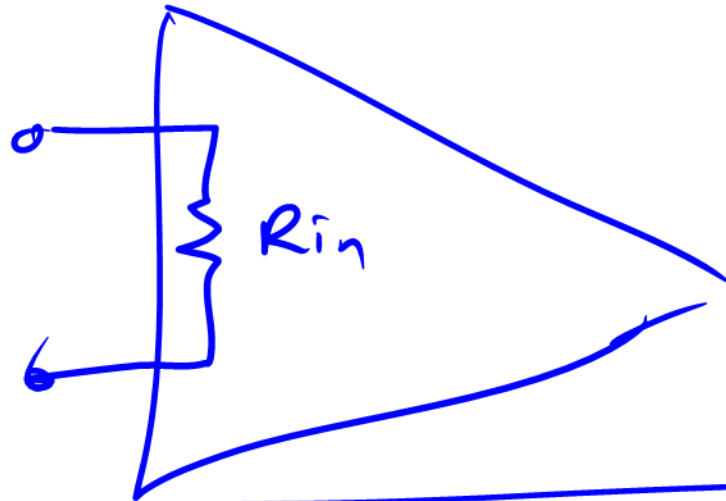
$$G_M = \frac{i_{out}}{V_{in}} \left( \frac{I}{V} \right) = \text{CONDUCTANCE (ADMITTANCE)}$$

TRANS-CONDUCTANCE

# PHOTO DIODE

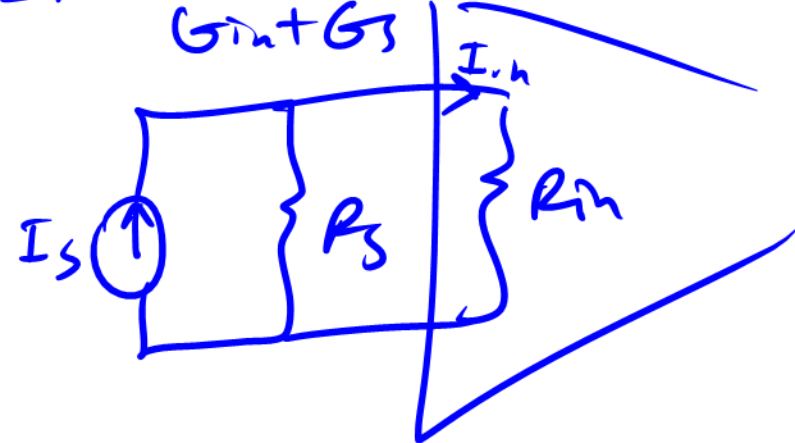


# LOADING : INPUT

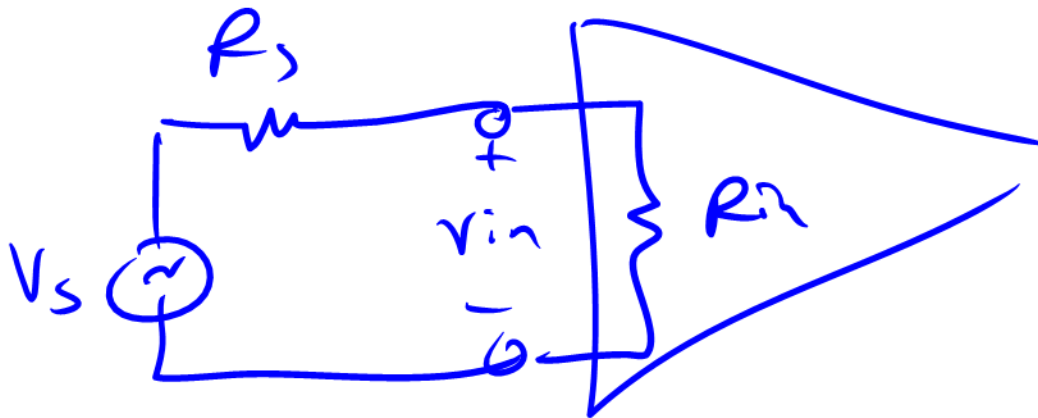


$$R_{in} \rightarrow 0 \Omega$$

$$I_{in} = \frac{G_{in}}{G_{in} + G_S} I_S$$



CURRENT DIV



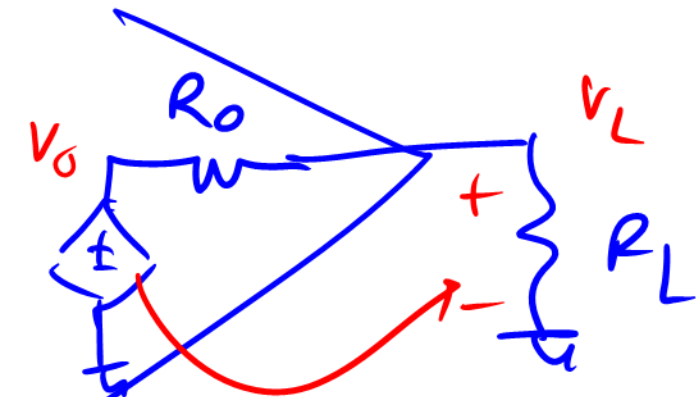
VOLTAGE DIV

$$R_{in} \rightarrow \infty \Omega$$

$$v_{in} = \frac{R_{in}}{R_{in} + R_S} \cdot V_S$$

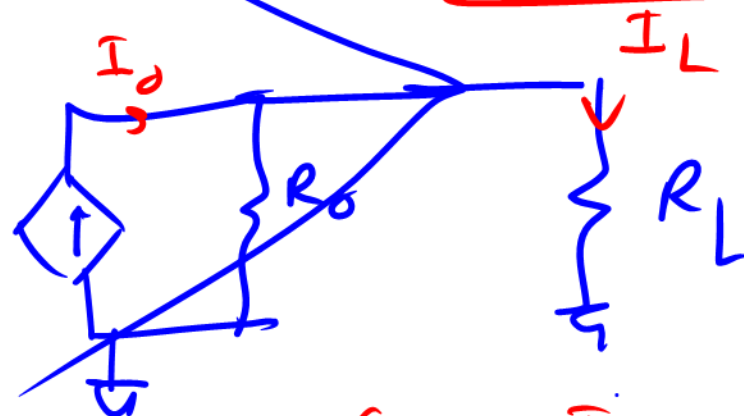
*(Note: In the original image,  $R_{in}$  in the numerator is circled in red, and a red arrow points to a tilde symbol below it.)*

# LOADING : output



$$V_L = \frac{R_L}{R_L + R_o} V_o$$

$R_o \ll R_L$   
LARGE LOAD



$$I_L = \frac{G_L}{G_L + G_o} I_o$$

$G_L \gg G_o$

$R_L \ll R_o$   
SMALL LOAD

# AMPLIFIER GAIN

$$A_{\text{eff}} = \left\{ \begin{array}{l} \text{EFFECTIVE GAIN} \\ \text{WHICH INCLUDES} \\ \text{LOADING} \end{array} \right.$$

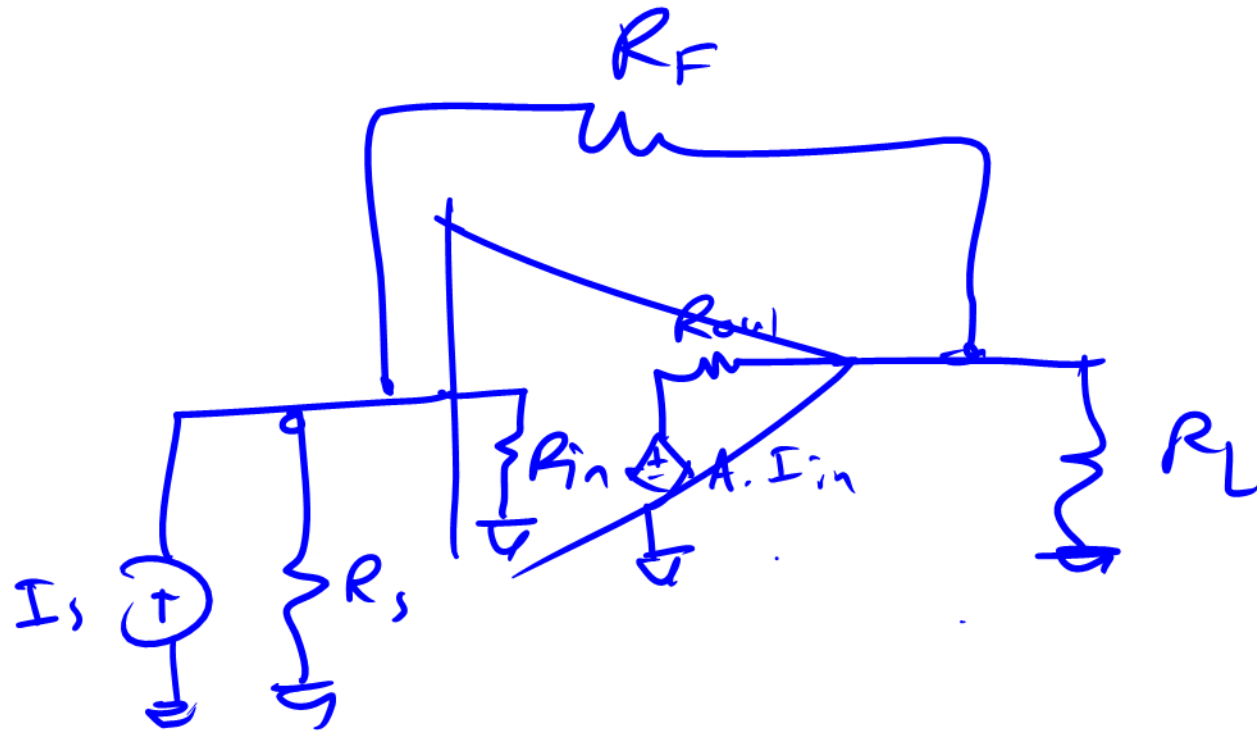
$$A_{\text{eff}} = Z_{\text{IN}} \cdot A_{\text{int}} \cdot Z_{\text{OUT}}$$

INPUT LOADING  $\frac{X_{\text{in}}}{X_{\text{in}} + X_s}$

INTERNAL GAIN

OUTPUT LOADING  $\frac{X_L}{X_L + X_o}$

AMPLIFIER w/ FEEDBACK (NOT ON EXAM)



GOLDEN RULES DO NOT APPLY

FOR GENERAL AMPLIFIERS  $\rightarrow$   
USE FULL NODE ANALYSIS



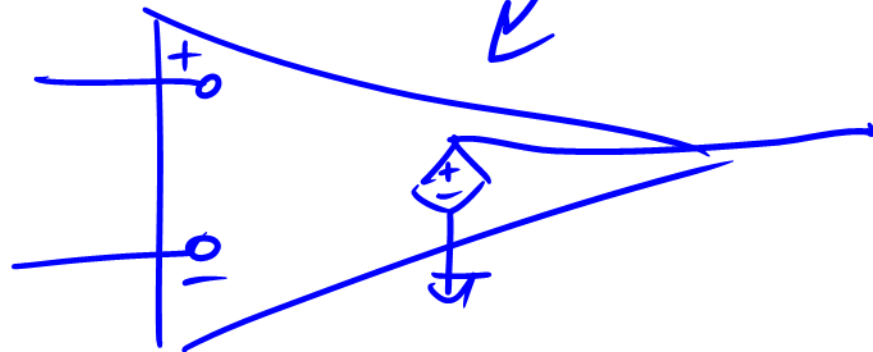
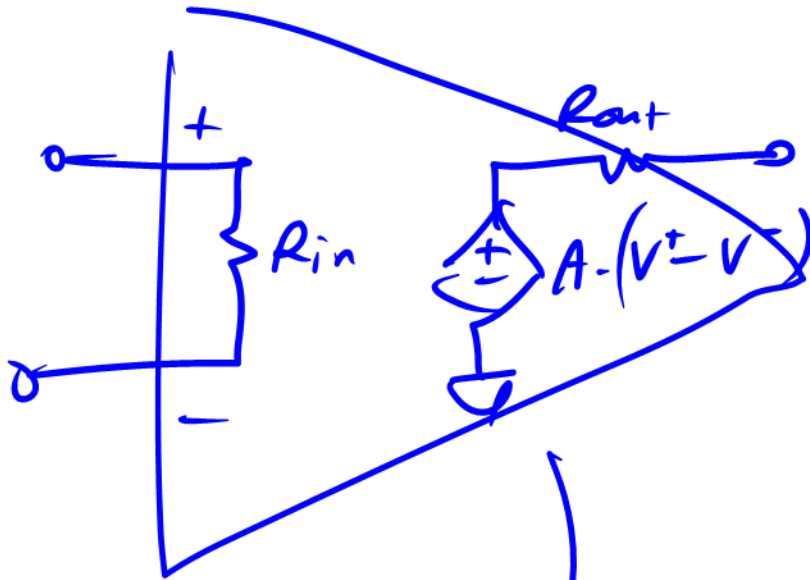
# OP-AMPS : IDEAL

INFINITE VOLTAGE GAIN

$$A \rightarrow \infty$$

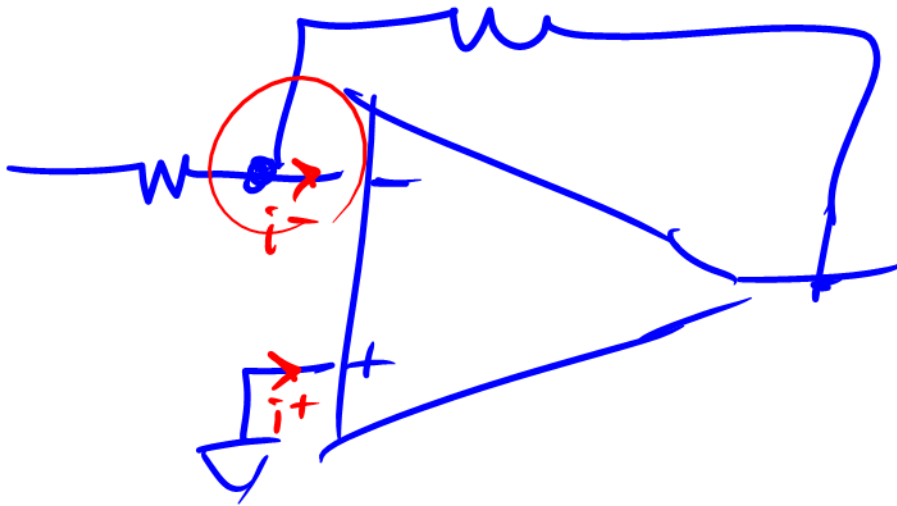
$$R_{in} \rightarrow \infty \Omega$$

$$R_{out} \rightarrow 0 \Omega$$



NO LOADING

OP-AMPS (IDEAL) + NEGATIVE FFB  
(EXAM) ↗

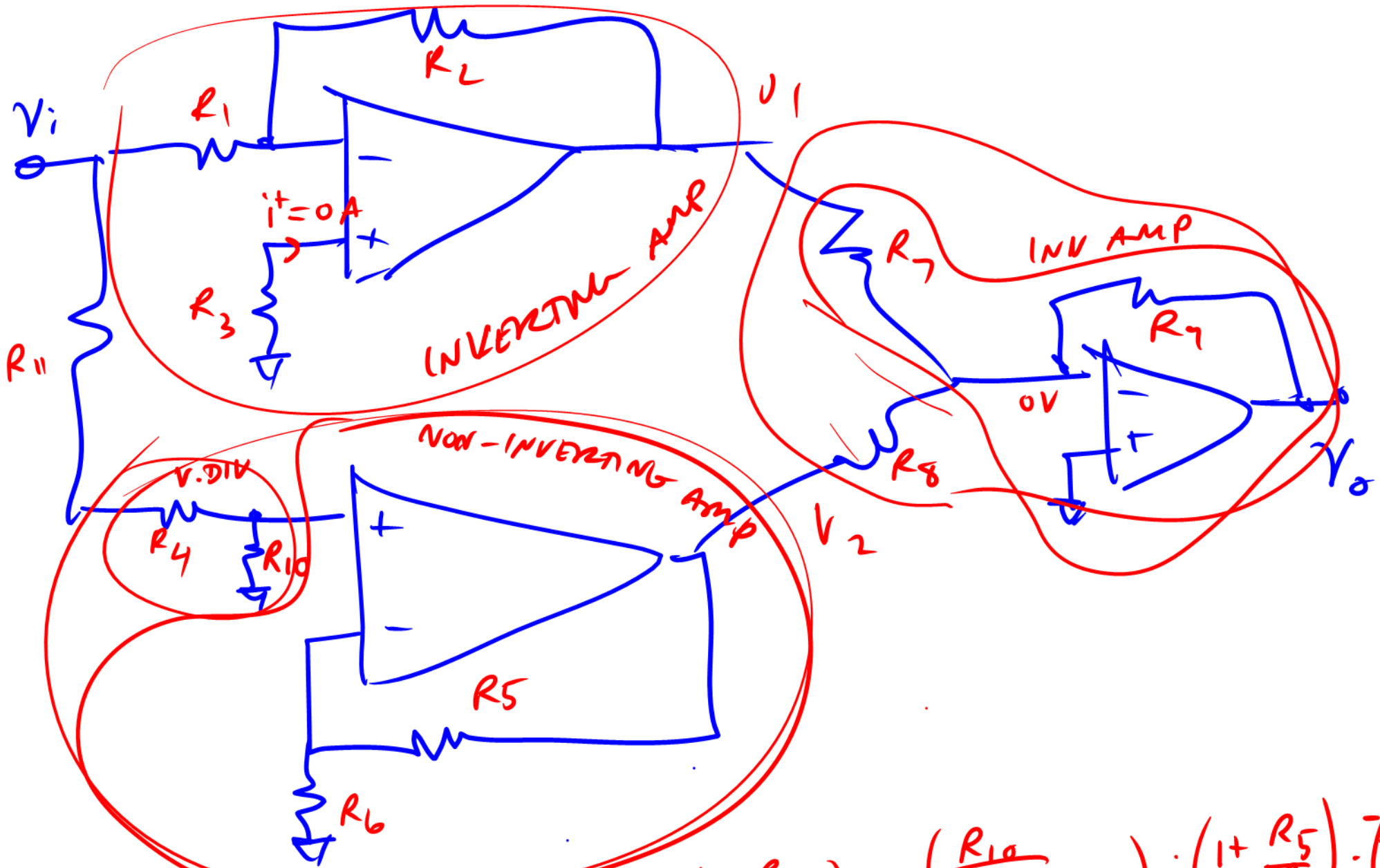


GOLDEN RULES

$$v^+ = v^-$$

$$i^+ = i^- = 0$$

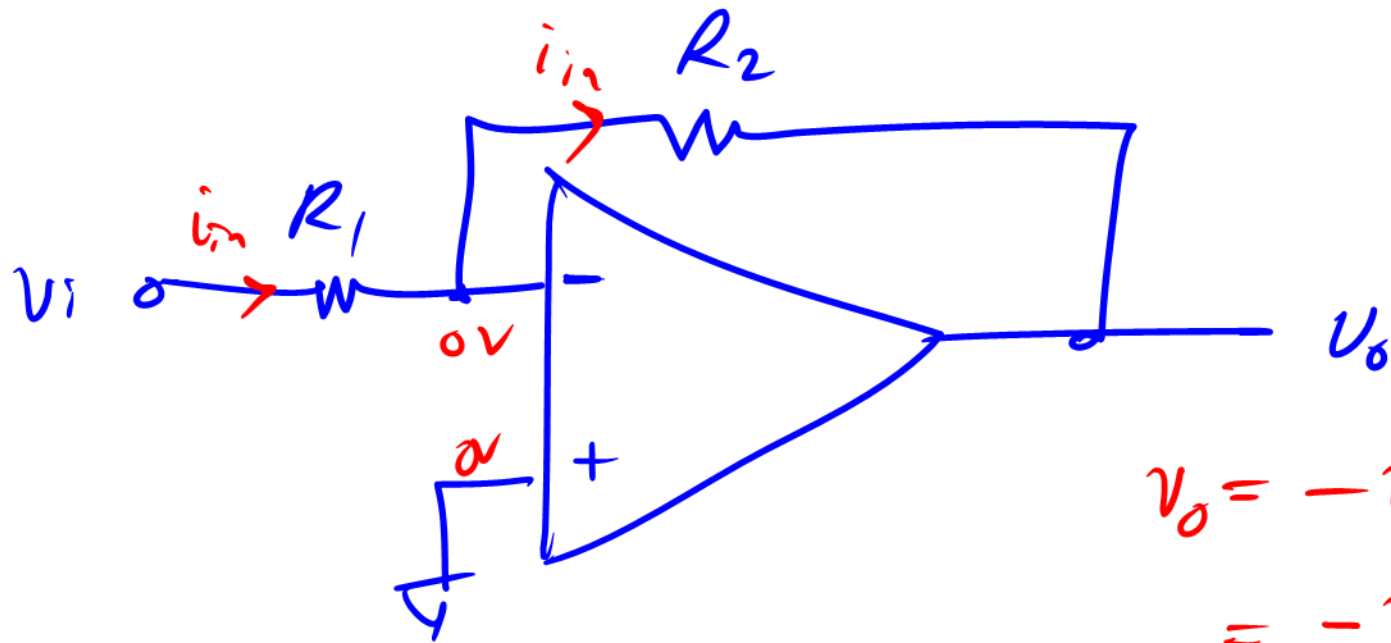
EX



$$G = \left(-\frac{R_2}{R_1}\right) \cdot \left(-\frac{R_4}{R_7}\right) + \left(\frac{R_{10}}{R_{10} + R_4 + R_{11}}\right) \cdot \left(1 + \frac{R_5}{R_6}\right) \cdot \left(-\frac{R_7}{R_8}\right)$$

# BUILDING BLOCKS

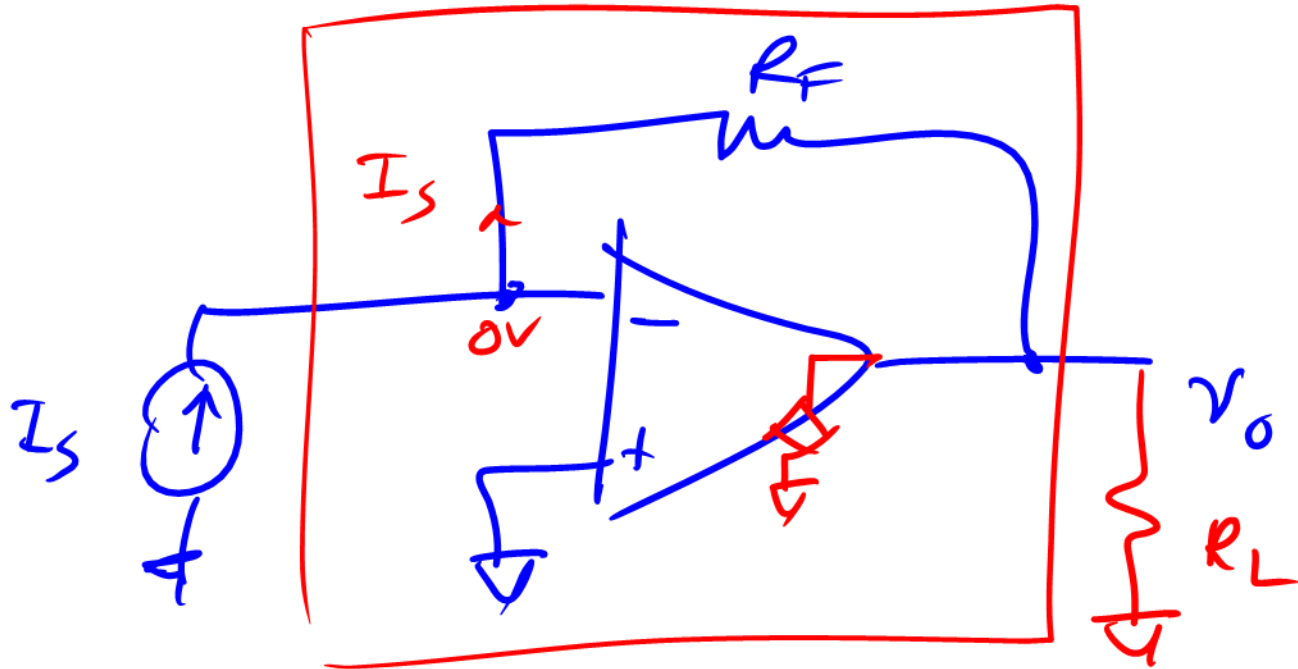
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$$V_o = -i_{in} \cdot R_2$$
$$= -\frac{V_i}{R_1} \cdot R_2$$

INVERTING AMP

$$\frac{V_o}{V_i} = -\frac{R_2}{R_1}$$



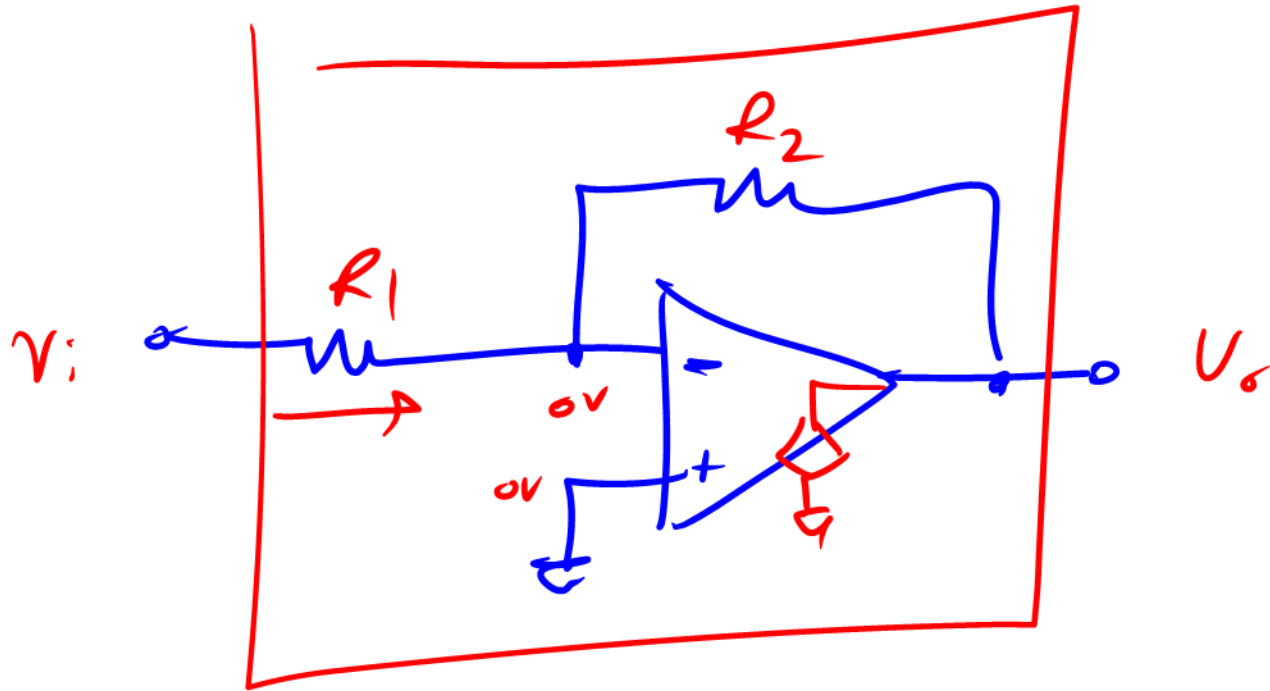
$$v_o = -R_F \cdot I_s$$

TRANS-RESISTANCE AMP

$$R_{in} = 0 \Omega$$

$$R_{out} = 0 \Omega$$

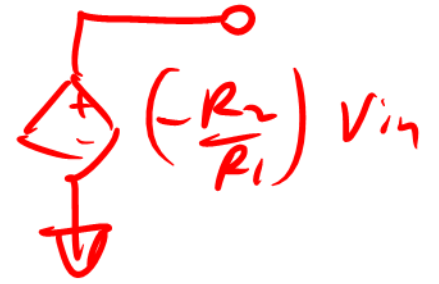
# NON-IDEAL VOLTAGE AMP



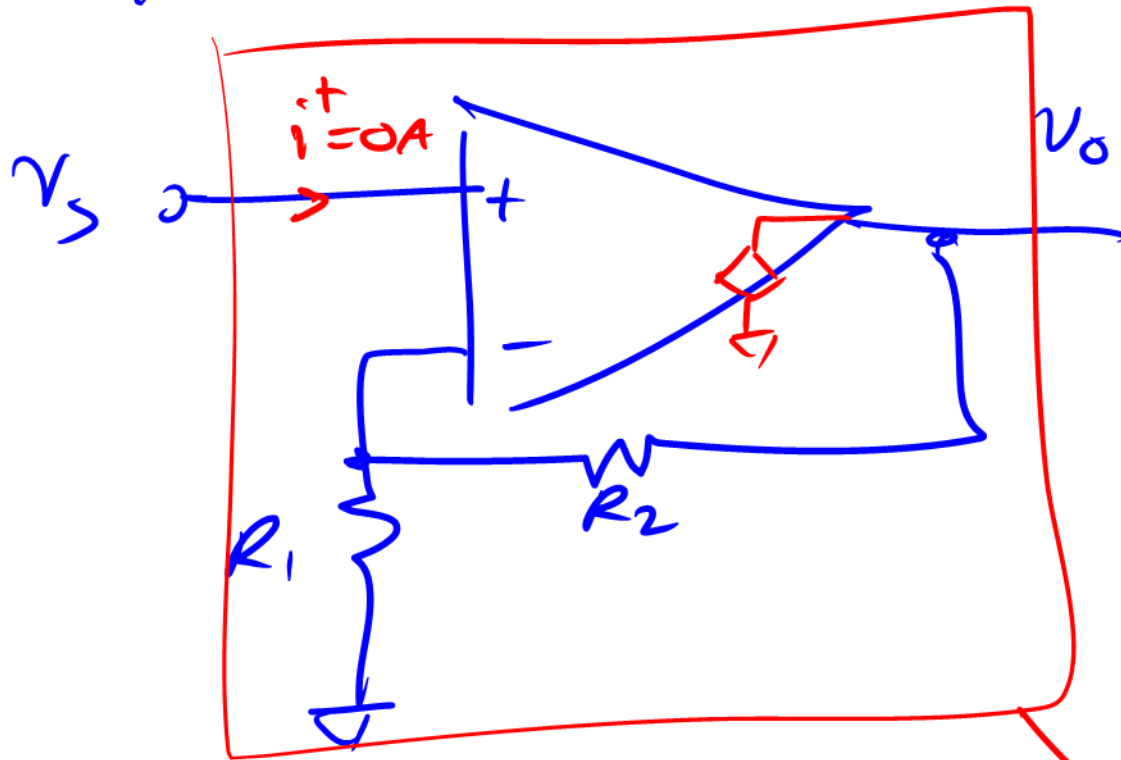
$$R_{in} = R_1$$

$$R_{out} = 0 \Omega$$

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



# NON-INVERTING AMP

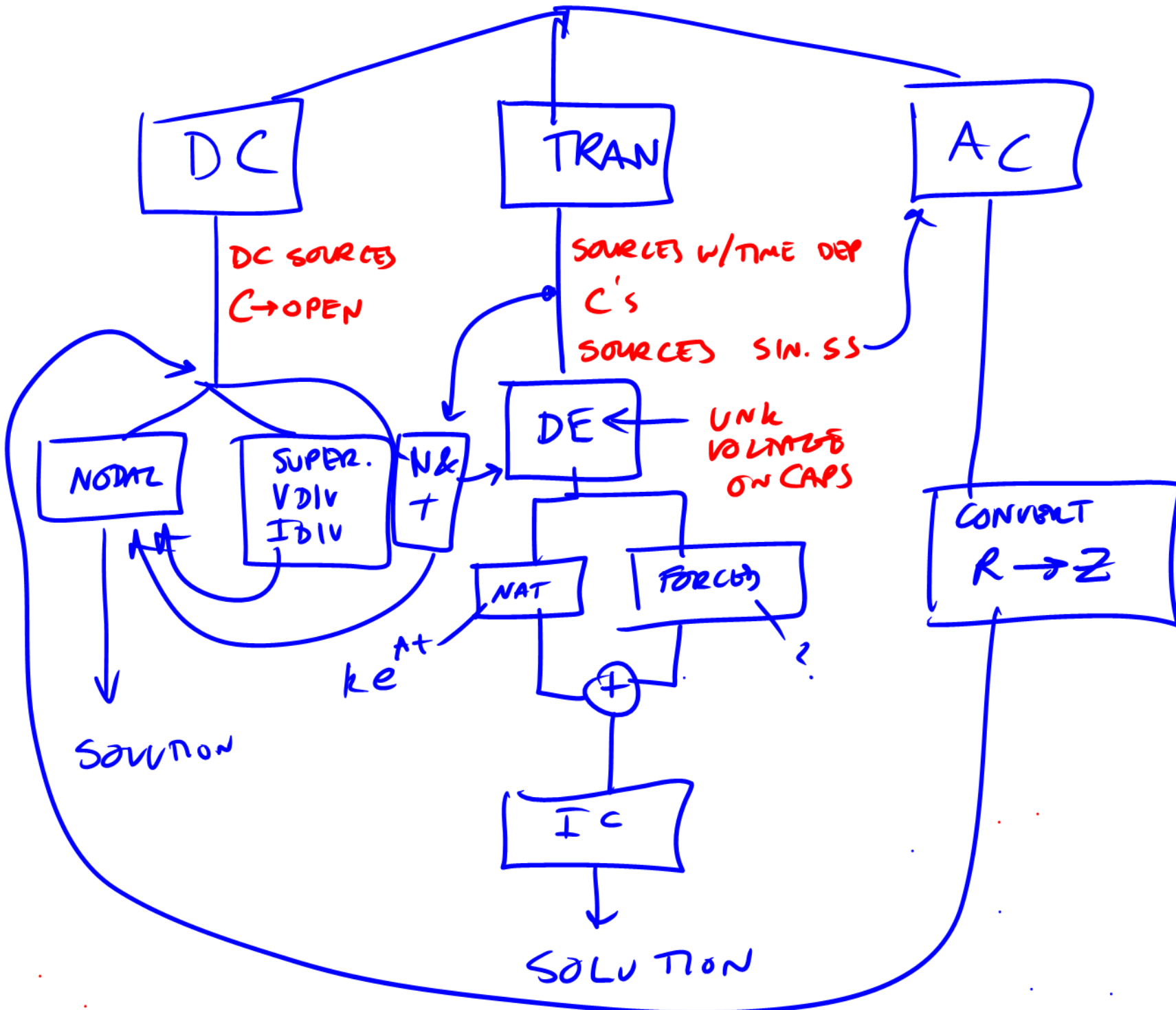


$$\frac{v_o}{v_s} = \left(1 + \frac{R_2}{R_1}\right)$$

$$R_{in} = \infty \Omega$$

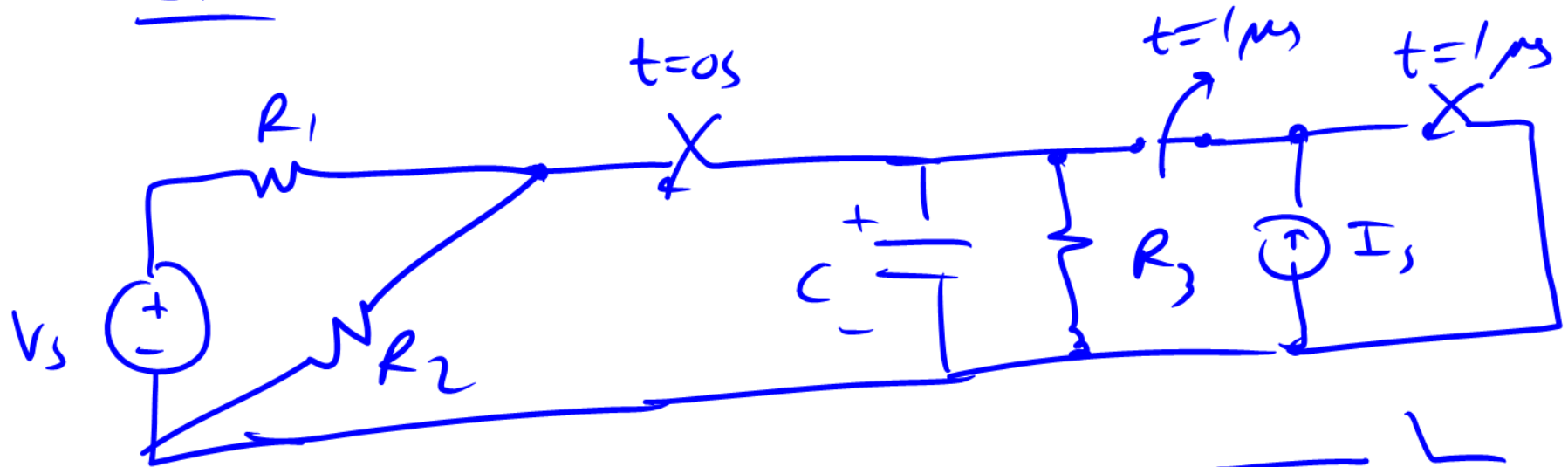
$$R_{out} = 0 \Omega$$

$$A =$$

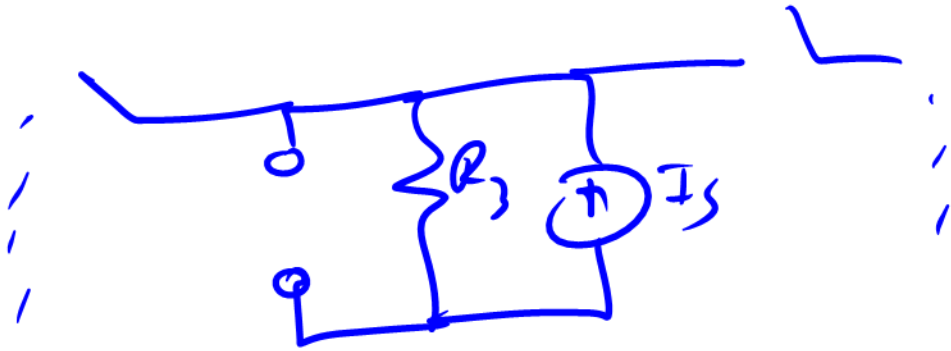




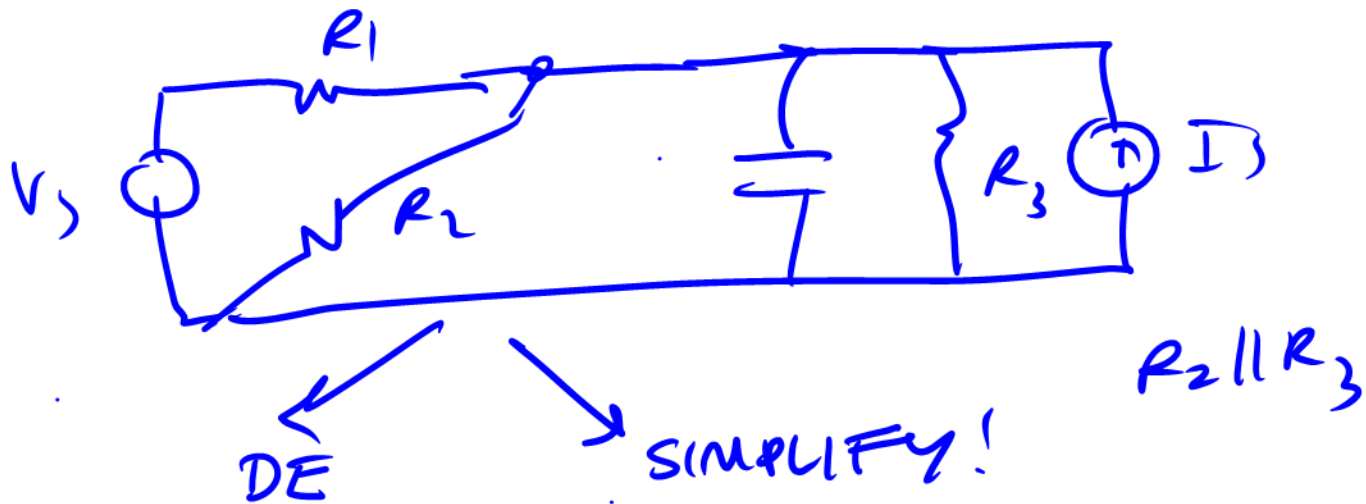
EX

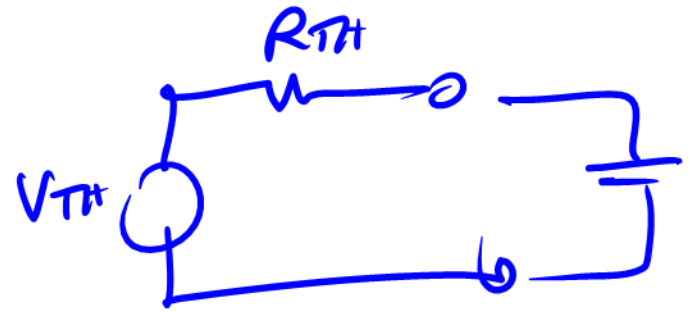


I.C.  $V_C(0) = I_s \cdot R_3$



$0 \leq t \leq 1\text{ms}$



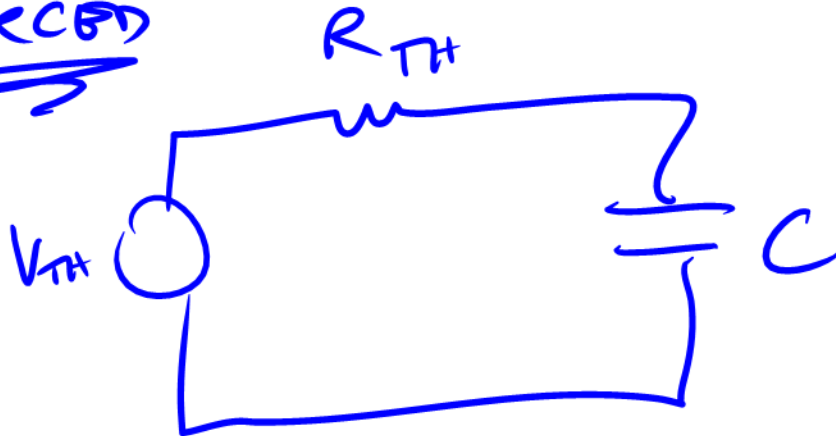


$$V_T = V_{OC} = \frac{R_2 \parallel R_3}{R_2 \parallel R_3 + R_1} \cdot V_s + (R_1 \parallel R_2 \parallel R_3) I_s$$

$$R_{TH} = R_1 \parallel R_2 \parallel R_3$$

$V_s$  &  $I_s$  ARE  
CONSTANT:

FORCED



FORCED SOLUTION:

$$V_F = K \text{ (CONST)}$$

$V_F \rightarrow DE \rightarrow K \text{ SOLVED}$   
 $K = V_{TH}$

Homo

$$V_H = k e^{-t/\tau}$$

$$\left\{ \begin{array}{l} \tau = R_{TH} \cdot C \\ k \text{ NOT KNOWN YET} \end{array} \right.$$

IC

$$V_C = V_F + V_H$$

$$V_C(0) = V_F(0) + V_H(0)$$

$$= V_{TH} + k = I_S R_3$$

$$t = 1\mu s$$

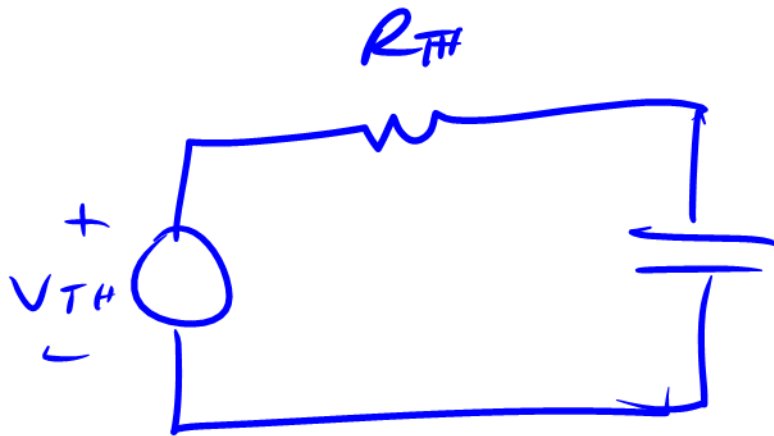


$$I_S = 0A$$

ALL IT  
Flows INTO  
SHORT

$$I_S = 0$$
$$V_{TH}$$

$$I_S = 0$$
$$R_{TH}$$



$$V_C(t = 1\mu s) = \text{PLUG IN FROM PREV. SOLUTION}$$

