IMPEDANCE AT A NODE (GENERAL)
  (USE FOR R_{in}, R_{out} OF AMPLIFIER CIRCUITS)

PROCEDURE

① SUPPRESS (SET = 0) ALL INDEPENDENT SOURCES
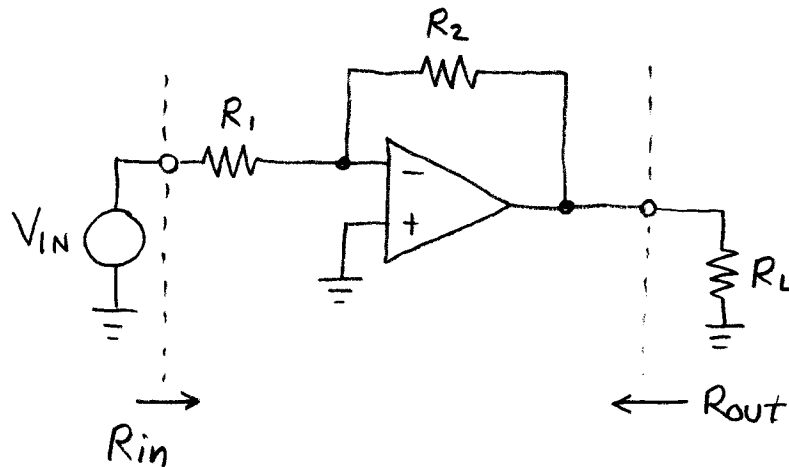
  V SOURCE → SHORT   NEED TO KEEP
  I SOURCE → OPEN   DEPENDENT SOURCES

② APPLY TEST SOURCE V_x ⎫ OR, IF EASIER,
                           ⎬   APPLY i_x AND
③ CALCULATE ASSOCIATED i_x ⎭   CALCULATE V_x
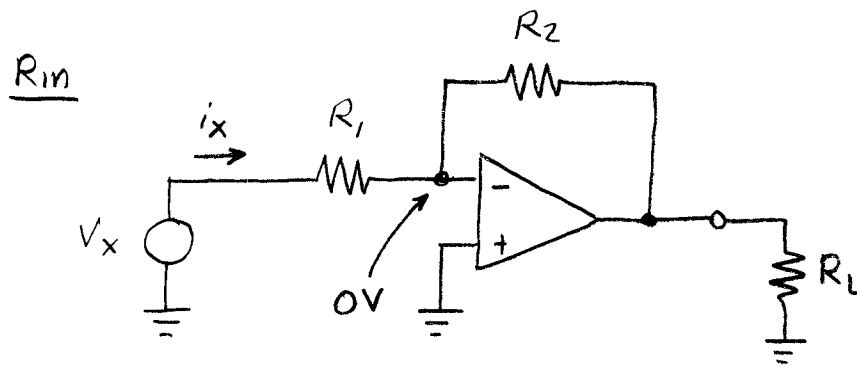
④ IMPEDANCE AT NODE ⇒ $Z = \dfrac{V_x}{i_x}$

EXAMPLE INVERTING OP-AMP CIRCUIT R_{in}, R_{out}

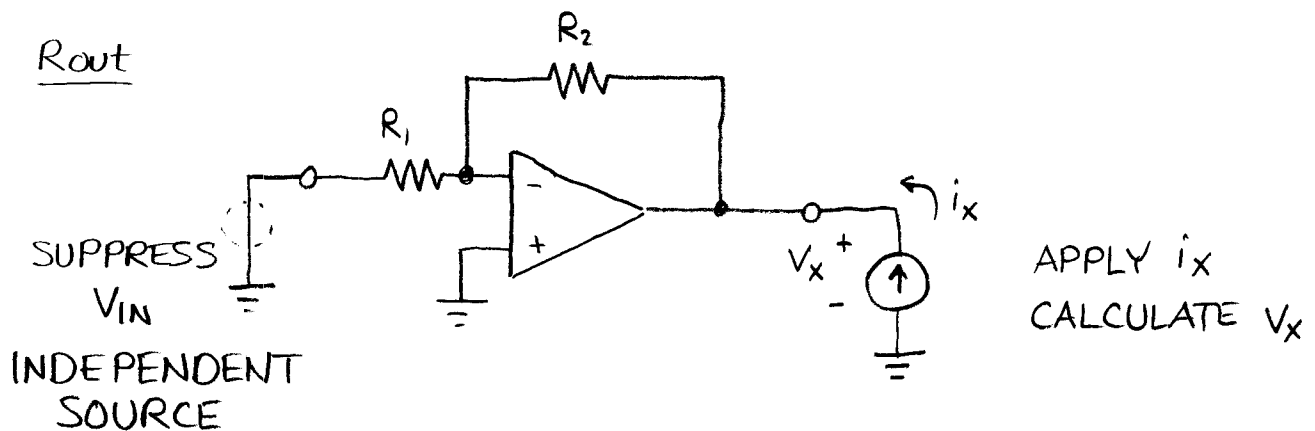WHAT R_{in} DOES   WHAT R_{out} IS
  V_{IN} SEE?   DRIVING LOAD R_L?

<u>Rin</u>

VIRTUAL GROUND: $V_- = 0$ (ASSUME IDEAL OP-AMP)

OHM'S LAW FOR R_1: $i_x = \dfrac{V_x - 0}{R_1} = \dfrac{V_x}{R_1}$

SOLVE FOR $\dfrac{V_x}{i_x} = R_1 \Rightarrow \boxed{R_{in} = R_1}$

<u>Rout</u>

SUPPRESS V_{IN} INDEPENDENT SOURCE

APPLY i_x CALCULATE V_x

INVERTING AMPLIFIER WITH ZERO INPUT:
  $V_x = 0$ REGARDLESS OF i_x

$\dfrac{V_x}{i_x} = 0 \Rightarrow \boxed{R_{out} = 0}$