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

PROCEDURE

1. SUPPRESS (SET = 0) ALL INDEPENDENT SOURCES
   V SOURCE $\Rightarrow$ SHORT
   I SOURCE $\Rightarrow$ OPEN
   NEED TO KEEP DEPENDENT SOURCES

2. APPLY TEST SOURCE $V_x$
   OR, IF EASIER, APPLY $I_x$ AND
   CALCULATE $V_x$

3. CALCULATE ASSOCIATED $I_x$

4. IMPEDANCE AT NODE $\Rightarrow Z = \frac{V_x}{I_x}$

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

WHAT $R_{in}$ DOES $V_{in}$ SEE?

WHAT $R_{out}$ IS DRIVING LOAD $R_L$?
VIRTUAL GROUND: $V_\text{r} = 0$ (ASSUME IDEAL OP-AMP)

OHM’S LAW FOR $R_1$: $i_x = \frac{V_x - 0}{R_1} = \frac{V_x}{R_1}$

SOLVE FOR $\frac{V_x}{i_x} = R_1 \Rightarrow R_{\text{in}} = R_1$

$R_{out}$

SUPPRESS $V_{\text{IN}}$

INDEPENDENT SOURCE

INVERTING AMPLIFIER WITH ZERO INPUT:

$V_x = 0$ REGARDLESS OF $i_x$

$\frac{V_x}{i_x} = 0 \Rightarrow R_{\text{out}} = 0$