Homework #3

Problems 2.2, 2.8, 2.10, 2.44, and 2.49

Problem 2.2

The circuit of Fig. P2.2 uses an op amp that is ideal except for having a finite gain *A*. Measurements indicate v_o = 4.0 V when v_I = 1.0 V. What is the op-amp gain *A*?

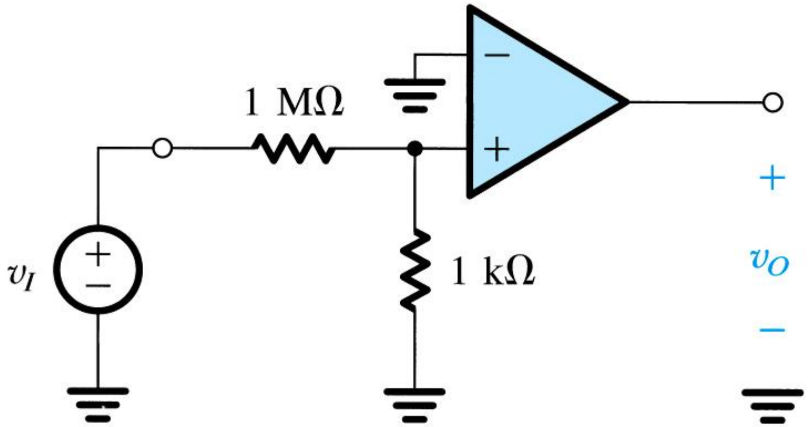


Figure P2.2

$$v_o = Av_+$$

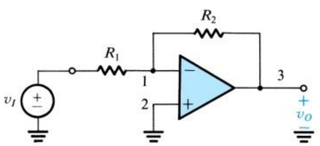
$$v_+ = v_I \frac{1k}{1k + 1M} = \frac{v_I}{1001}$$

$$\frac{v_o}{v_I} = \frac{4V}{1V} = \frac{A}{1001}$$

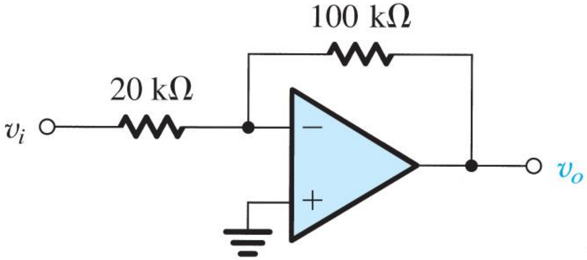
$$A = 4004\text{V/V}$$

Problem 2.8

Assuming ideal op amps, find the voltage gain v_O/v_I and input resistance R_{in} of each of the circuits in Fig. P2.8.

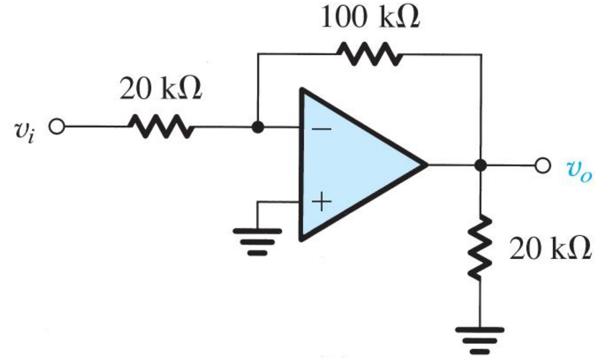


$$\frac{v_O}{v_I} = -\frac{R_2}{R_1}$$



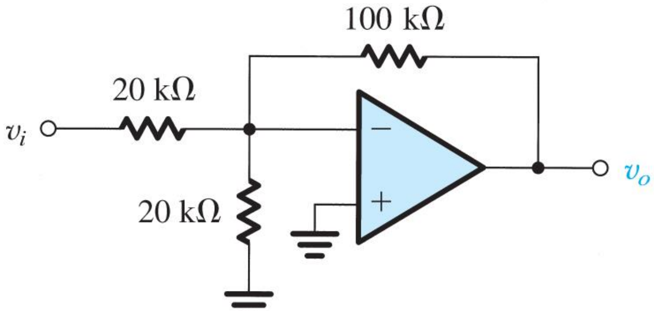
(a)

$$\frac{v_O}{v_I} = -\frac{100k}{20k} = -5\text{V/V}, R_{in} = 20\text{k}\Omega$$



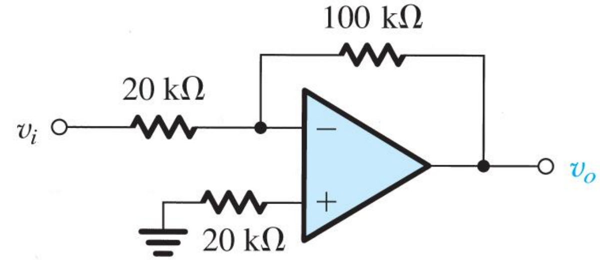
(b)

$$\frac{v_O}{v_I} = -5\text{V/V}, R_{in} = 20\text{k}\Omega$$



(c)

$$\frac{v_O}{v_I} = -5\text{V/V}, R_{in} = 20\text{k}\Omega$$



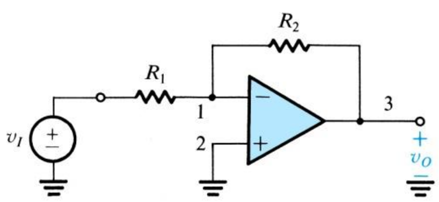
(d)

$$\frac{v_O}{v_I} = -5\text{V/V}, R_{in} = 20\text{k}\Omega$$

Figure P2.8

Problem 2.10

You are provided with an ideal op amp and three 10-kΩ resistors. Using series and parallel resistor combinations, how many different inverting-amplifier circuit topologies are possible? What is the largest (noninfinite) available voltage gain? What is the smallest (nonzero) available gain? What are the input resistances in these two cases?



$$\frac{v_O}{v_I} = -\frac{R_2}{R_1}$$

R_1	R_2	v_o/v_i	R_{in}
10kΩ	20kΩ	-2 V/V	10kΩ
10kΩ	5kΩ	-0.5 V/V	10kΩ
20kΩ	10kΩ	-0.5 V/V	20kΩ
5kΩ	10kΩ	-2 V/V	5kΩ

Problem 2.44

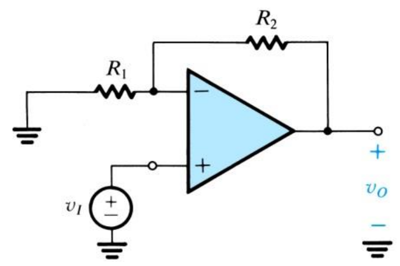
Given an ideal op amp to implement designs for the following closed-loop gains, what values of resistors (R_1,R_2) should be used? Where possible, use at least one 10-kΩ resistor as the smallest resistor in your design.

(a) +1 V/V $\quad R_2 = 0\ \text{k}\Omega,\ R_1 = 10\ \text{k}\Omega$ or $\infty\ \Omega$

(b) +2 V/V $\quad R_2 = 10\ \text{k}\Omega,\ R_1 = 10\ \text{k}\Omega$

(c) +21 V/V $\quad R_2 = 200\ \text{k}\Omega,\ R_1 = 10\ \text{k}\Omega$

(d) +100 V/V $\quad R_2 = 990\ \text{k}\Omega,\ R_1 = 10\ \text{k}\Omega$



$$\frac{v_O}{v_I} = 1 + \frac{R_2}{R_1}$$

Non-inverting amplifier

Problem 2.49

Derive an expression for the voltage gain, v_O/v_I, of the circuit in Fig. P2.49.

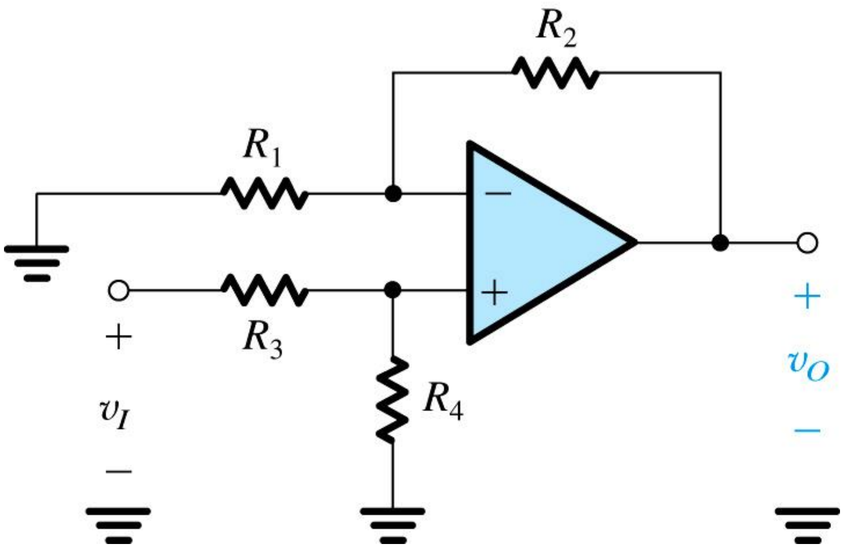


Figure P2.49

$$v_+ = v_I \frac{R_4}{R_4 + R_3} = v$$

$$v_- = v_o \frac{R_1}{R_1 + R_2} = v$$

$$v_I \frac{R_4}{R_4 + R_3} = v_o \frac{R_1}{R_1 + R_2}$$

$$\frac{v_o}{v_I} = \left(\frac{R_1 + R_2}{R_1}\right) \frac{R_4}{R_4 + R_3}$$

$$\frac{v_o}{v_I} = \frac{1 + R_2/R_1}{1 + R_3/R_4}$$