2.4

Experiments 4, 5, and 6 show that the gain is approximately 200 V/V.

The missing entry for experiment #3 can be predicted as follows:

#	v_1	v_2	$v_d = v_2 - v_1$	v_O	v_O/v_d
1	0.00	0.00	0.00	0.00	–
2	−1.00	−1.00	0.00	0.00	–
3	(b)	−1.00	(a)	−1.00	
4	1.00	1.02	0.02	4.01	200.5
5	2.01	2.00	–0.01	–1.99	199
6	1.99	2.00	0.01	2.00	200
7	5.10	(d)	(c)	–5.10	

(a) $v_d = \dfrac{v_O}{A} = \dfrac{-1.00}{200} = -0.005$ V.

(b) $v_1 = v_2 - v_d = -1.00 - (-0.005)$

$= -0.995$ V

The missing entries for experiment #7:

(c) $v_d = \dfrac{-5.10}{200} = -0.026$ V

(d) $v_2 = v_1 + v_d = 5.10 - 0.026 = 5.074$ V

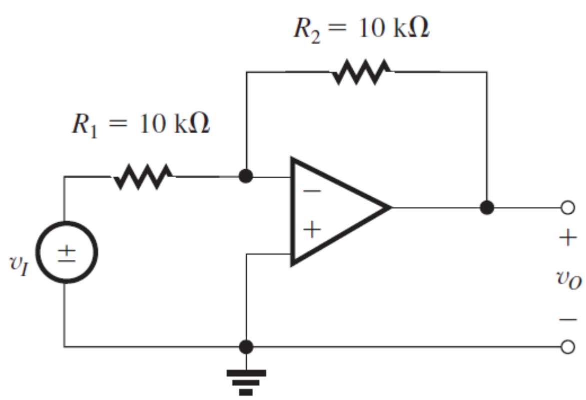
All the results seem to be reasonable.

2.9

Circuit	v_o/v_i(V/V)	R_{in} (kΩ)
a	$\frac{-90}{16} = -6$	15
b	–6	15
c	–6	15
d	–6	15

Note that in circuit (b) the 15-kΩ load resistance has no effect on the closed-loop gain because of the zero output resistance of the ideal op amp. In circuit (c), no current flows in the 15-kΩ resistor connected between the negative input terminal and ground (because of the virtual ground at the inverting input terminal). In circuit (d), zero current flows in the 15-kΩ resistor connected in series with the positive input terminal.

2.10



Closed-loop gain is

$$\frac{v_O}{v_I} = -\frac{R_2}{R_1} = -\frac{10\text{ k}\Omega}{10\text{ k}\Omega}$$

$= -1$ V/V

For $v_I = +1.00$ V,

$v_O = -1 \times 1.00$

$= -\ 1.00$ V

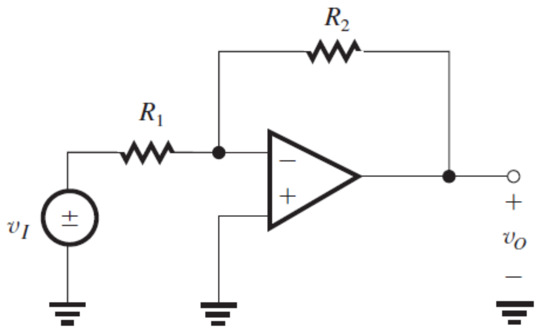
The two resistors are 1% resistors

$$\left|\frac{v_O}{v_I}\right|_{\min} = \frac{10(1-0.01)}{10(1+0.01)} = 0.98\text{ V/V}$$

$$\left|\frac{v_O}{v_I}\right|_{max} = \frac{10(1+0.01)}{10(1-0.01)} = 1.02\text{ V/V}$$

Thus the measured output voltage will range from -0.98 V to -1.02 V.

2.15 Gain is 26 dB



$26\text{ dB} = 20\log|G|$

$|G| = 20$

$\therefore \dfrac{v_O}{v_I} = -20\text{ V/V} = -\dfrac{R_2}{R_1}$

$\Rightarrow R_2 = 20R_1 \le 100\text{ k}\Omega$

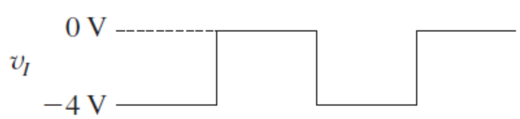
For the largest possible input resistance, choose

$R_2 = 100\text{ k}\Omega$

$R_1 = \dfrac{100\text{ k}\Omega}{20} = 5\text{ k}\Omega$

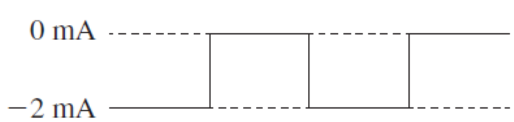
$R_{\text{in}} = R_1 = 5\text{ k}\Omega$

2.16



Average = −2 V
Highest = 0 V
Lowest = −4 V

The current through R_1 is V_I/R_1.



2.18 The inverting amplifier has a gain of −10 V/V resulting in an output voltage of +10 V. Thus, there is 2 mA current in R_L. With $R_2 = 10\text{ k}\Omega$, as shown in Fig. P2.17, there is 1 mA current in R_2 for a total of 3 mA coming from the ideal op-amp output. If the output current must be limited to 2.5 mA with the same gain, the output voltage must remain +10 V and the current in R_2 must be limited to $2.5 - 2 = 0.5$ mA. This requires,

$$R_2 = \frac{10}{0.5} = 20\text{ k}\Omega$$

To keep the same gain, $-R_2/R_1 = -10$. Hence,

$$R_1 = \frac{R_2}{10} = 2\text{ k}\Omega$$