5.2 Find $i_o$ in the circuit in Fig. P5.2 if the op amp is ideal.

**Figure P5.2**

5.3 The op amp in the circuit in Fig. P5.3 is ideal.

a) Calculate $v_o$ if $v_a = 4 \text{ V}$ and $v_b = 0 \text{ V}$.
b) Calculate $v_o$ if $v_a = -2 \text{ V}$ and $v_b = -1 \text{ V}$.
c) Calculate $v_o$ if $v_a = 2 \text{ V}$ and $v_b = 1 \text{ V}$.
d) Calculate $v_o$ if $v_a = 1 \text{ V}$ and $v_b = -2 \text{ V}$.
e) Calculate $v_o$ if $v_a = 1.5 \text{ V}$ and $v_b = 4 \text{ V}$.
f) If $v_b = 1.6 \text{ V}$, specify the range of $v_a$ such that the amplifier does not saturate.

**Figure P5.3**

5.6 The op amp in the circuit in Fig. P5.6 is ideal. Calculate the following:

a) $v_1$
b) $v_o$
c) $i_2$
d) $i_o$

**Figure P5.6**

5.9 The op amp in the circuit in Fig. P5.9 is ideal.

a) Find the range of values for $\sigma$ in which the op amp does not saturate.
b) Find $i_o$ (in microamperes) when $\sigma = 0.272$.

**Figure P5.9**

5.12 The op amp in Fig. P5.12 is ideal.

a) What circuit configuration is shown in this figure?
b) Find $v_o$ if $v_1 = 1 \text{ V}$, $v_2 = -1.5 \text{ V}$, and $v_2 = -4 \text{ V}$.
c) The voltages $v_1$ and $v_2$ remain at 1.5 V and -4 V, respectively. What are the limits on $v_o$ if the op amp operates within its linear region?

**Figure P5.12**

5.17 The op amp in the circuit of Fig. P5.17 is ideal.

a) What op amp circuit configuration is this?
b) Find $v_o$ in terms of $v_i$.
c) Find the range of values for $v_i$ such that $v_o$ does not saturate and the op amp remains in its linear region of operation.

**Figure P5.17**
5.20 The op amp in the circuit of Fig. P5.20 is ideal.
   a) What op amp circuit configuration is this?
   b) Find $v_o$ in terms of $v_x$.
   c) Find the range of values for $v_x$ such that $v_o$ does not saturate and the op amp remains in its linear region of operation.

![Figure P5.20](image)

5.23 The op amp in the noninverting summing amplifier of Fig. P5.23 is ideal.
   a) Specify the values of $R_i$, $R_b$, and $R_c$ so that
      $$v_o = 6v_a + 3v_b + 4v_c.$$  
   b) Using the values found in part (a) for $R_i$, $R_b$, and $R_c$, find (in microamperes) $i_a$, $i_b$, $i_c$, $i_s$, and $i_e$ when $v_a = 0.5 \, \text{V}$, $v_b = 2.5 \, \text{V}$, and $v_c = 1 \, \text{V}$.

![Figure P5.23](image)

5.31 The resistor $R_t$ in the circuit in Fig. P5.31 is adjusted until the ideal op amp saturates. Specify $R_t$ in kilohms.

![Figure P5.31](image)

5.41 The two op amps in the circuit in Fig. P5.41 are ideal. Calculate $v_{o1}$ and $v_{o2}$.

![Figure P5.41](image)