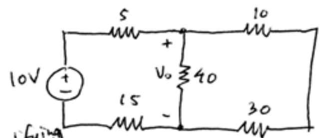
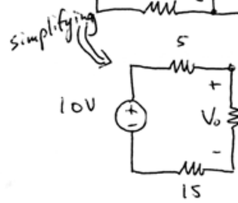
4.89 For the 10 V source,



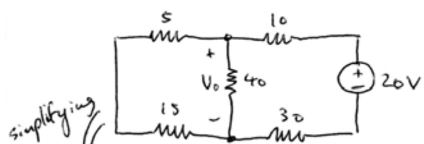


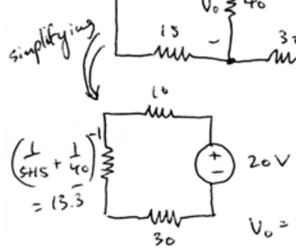
$\left(\frac{1}{10+30}+\frac{1}{40}\right)^{-1} = 20$

$V_o = 10 \times \left(\frac{20}{5+20+15}\right)$

$= 5\text{ V}$

For the 20V source,



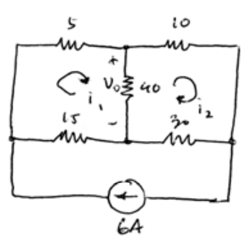


$\left(\frac{1}{5+15}+\frac{1}{40}\right)^{-1} = 13.\bar{3}$

$V_o = 20 \times \left(\frac{13.\bar{3}}{13.\bar{3}+10+30}\right)$

$= 5\text{ V}$

For the 6A source,



$-5i_1 - 40(i_1 - i_2) - 15(i_1 - 6) = 0$

$-10i_2 - 30(i_2 - 6) - 40(i_2 - i_1) = 0$

$-60i_1 + 40i_2 = 90$

$40i_1 - 80i_2 = 180$

$i_1 = -4.5A \quad i_2 = -4.5A$

$V_o = 0 \qquad V_o(\text{total}) = 5 + 5 + 0$

$= 10V$

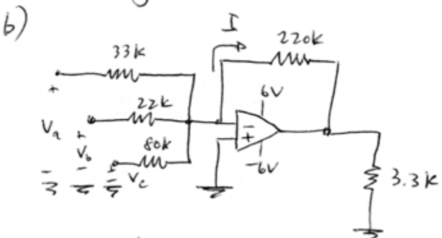
5.7 a) non-inverting

b) $V_o = \frac{40k + 80k}{40k}(3)$

$= 9V$

5.16 a) summing

b)



$I = \frac{1.2}{33000} + \frac{-1.5}{22000} + \frac{4}{80000}$

$= 0.01\bar{8}\text{ mA}$

$V_o = -(0.01\bar{8}\text{ mA})(220k)$

$= -4V$

c) $|V_{max}| = |V_{min}| = 6V$

$I_{max} = \frac{6}{220000} = 0.02\bar{7}\text{ mA}$

$= |I_{min}|$

$I_{max} = \frac{1.2}{33000} + \frac{V_b(max)}{22000} + \frac{4}{80000}$

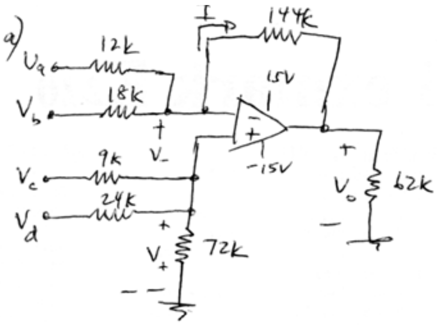
$V_b(max) = -1.3V$

$I_{min} = \frac{1.2}{33000} + \frac{V_b(min)}{22000} + \frac{4}{80000}$

$V_b(min) = -2.5V$

$-2.5V < V_b < -1.3V$

5.30 a)



Node-voltage

$$\frac{V_+ - V_c}{9000} + \frac{V_+ - V_d}{24000} + \frac{V_+}{72000} = 0$$

$$8V_+ - 8V_c + 3V_+ - 3V_d + V_+ = 0$$

$$12V_+ = 8V_c + 3V_d$$

$$V_+ = 0.6\ V$$

$$= V_-$$

$$I = \frac{V_a - V_-}{12000} + \frac{V_b - V_-}{18000}$$

$$= \frac{0.5-0.6}{12000} + \frac{0.3-0.6}{18000}$$

$$= -0.025\ mA$$

$$V_o = (0.025mA)(144k) + 0.6$$

$$= 4.2V$$

b) Derive equation for V_o

Superposition V_a and V_b on
V_c and V_d off

$\Rightarrow$ summing amp

$$V_o = -\frac{144000}{12000}V_a - \frac{144000}{18000}V_b$$

$$= -12V_a - 8V_b$$

V_a and V_b off
V_c and V_d on

from part (a)

$$12V_+ = 8V_c + 3V_d$$

$$V_+ = \frac{2}{3}V_c + \frac{1}{4}V_d$$

$$I = -\frac{V_+}{12000} + \frac{-V_+}{18000}$$

$$= -\frac{V_+}{7200}$$

$$V_o = \frac{V_+}{7200}(144000) + V_+$$

$$= 21V_+$$

$$= 14V_c + 5.25V_d$$

$$V_o(\text{total}) = -12V_a - 8V_b + 14V_c + 5.25V_d$$

plug in for V_a, V_b, V_d

$$V_o(\text{total}) = 14V_c - 4.2$$

$$V_{max} = |V_{min}| = 15V$$

$$V_c(max) = 1.371\ V$$

$$V_c(min) = -0.771\ V$$

$$-0.771V \le V_c \le 1.371V$$

5.40 a) Using equation 5.55, pg. 200 (7th ed)

$$\frac{V_o}{V_g} = \frac{[(R_f+R_s)+(R_sR_o/AR_i)]}{R_s + \frac{R_o}{A}(1+K_r) + \frac{R_fR_s + (R_f+R_s)(R_i+R_g)}{AR_i}}$$

$$K_r = \frac{R_s+R_g}{R_i} + \frac{R_f+R_s}{R_L} + \frac{R_fR_s+R_fR_g+R_gR_s}{R_iR_L}$$

$R_s = 40k$ $R_i = 400k$ $R_L = 4$
$R_g = 100k$ $R_f = 80k$ $R_o = 5k$
$A = 20000$

$K_r = 39500.35$

$$\frac{V_o}{V_g} = 2.406$$

b) $V_g = 1\,V$ $V_o = 2.406\,V$

equation 5.50, pg. 199

$$\frac{V_n}{R_s} + \frac{V_n - V_g}{R_g+R_i} + \frac{V_n - V_o}{R_f} = 0$$

$$\frac{V_n}{40000} + \frac{V_n - \text{[redacted]}}{100000+400000} + \frac{V_n - 2.406}{80000} = 0$$

$100V_n + 8V_n - 8 + 50V_n - 120.281 = 0$
$V_n = 812\,mV$

equation 5.52, pg. 200

$$\frac{V_p - V_g}{R_g} = \frac{V_n - V_g}{R_i + R_g}$$

$$V_p = \left(\frac{V_n - V_g}{R_i+R_g}\right)R_g + V_g$$

$$= \left(\frac{0.812 - 1}{400000+100000}\right)100000 + 1$$

$= 962\,mV$

c) $V_p - V_n = 150476\,\mu V$

d) $\frac{V_g - V_p}{100000} = 376191\,pA$

e) a) $\frac{V_o}{V_g} = \frac{80k+40k}{40k} = 3$

b) $V_p = V_n = 1V = 1000mV$

c) $V_p - V_n = 0\mu V$

d) no current drain

Note: If you used a 4kΩ resistor in place of the 4Ω resistor you will get:

a) 2.9986

b) $V_n = 999.567mV$
$V_p = 999.9134mV$

c) $346.4\mu V$

d) 866 pA

e) Same as for 4Ω resistor