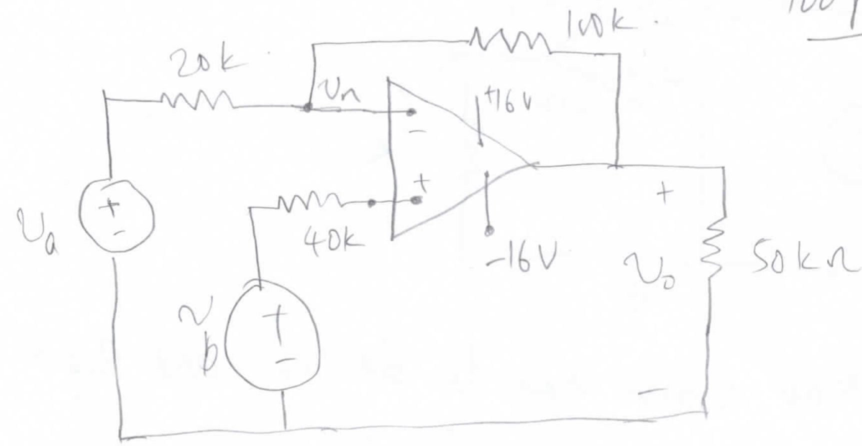
Ch 5 Homework Solutions

100 points

5.4
25



Since the op-amp is ideal, $v_n = v_p$
Also, since $i_n = i_p = 0$, that means $v_p = v_b$. So $v_n = v_b$

Writing KCL at node v_n:
$$\frac{v_n - v_a}{20k} + \frac{v_n - v_o}{100k} + i_n = 0$$

i.e.
$$\frac{v_b - v_a}{20k} + \frac{v_b - v_o}{100k} = 0$$

$$5v_b - 5v_a + v_b - v_o = 0$$

or $\quad v_o = 6v_b - 5v_a \rightarrow (1)$

a) $v_a = 4V$, $v_b = 0V$; so $v_o = -16V$ (Saturation).
b) $v_a = 2V$, $v_b = 0V$; So $v_o = -10V$
c) $v_a = 2V$, $v_b = 1V$; so $v_o = -4V$
d) $v_a = 1V$, $v_b = 2V$, so $v_o = 7V$

e). $v_b = 1.6V$, fixed
Rewriting (1), $v_o = 9.6 - 5v_a$.
At $v_o = +16$, $v_a = -1.28V$
Or $v_o = -16$, $v_a = 5.12V$.
So, v_a must be: $-1.28 \le v_a \le 5.12$ Volts to avoid saturation

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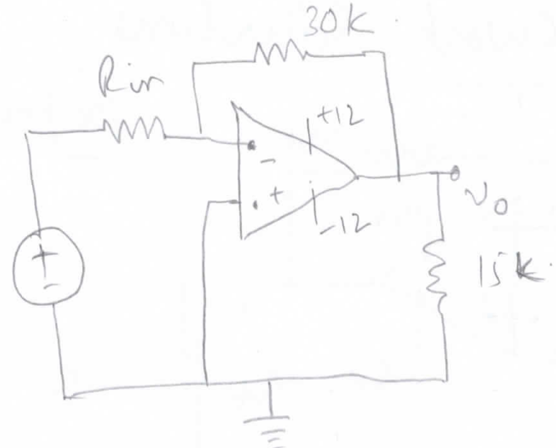

a) Given that Gain has to be 4, and $R_f = 30k$,

so $R_{in} = \frac{30,000}{4} = 750$ or $7.5 k\Omega$

b). at saturation, v_o is V_{cc}. $(v_o = -4 v_{in})$.

so, at $v_o = +12 = -4 v_{in}$, so $v_{in} = -3V$.

at $v_o = -12 = -4 v_{in}$, $v_{in} = 3V$.

Hence, $-3V \le v_{in} \le 3V$.

c). to amplify a +2V signal to the highest value means going as high as $v_o = -12V$ (or $-V_{cc}$).

so: $-\frac{R_f}{750} \times 2 = -12$; $R_f = 45000$
$= 45 k\Omega$ ✓

then Gain becomes, again $\frac{R_f}{R_{in}} = \frac{45000}{750} = 6$

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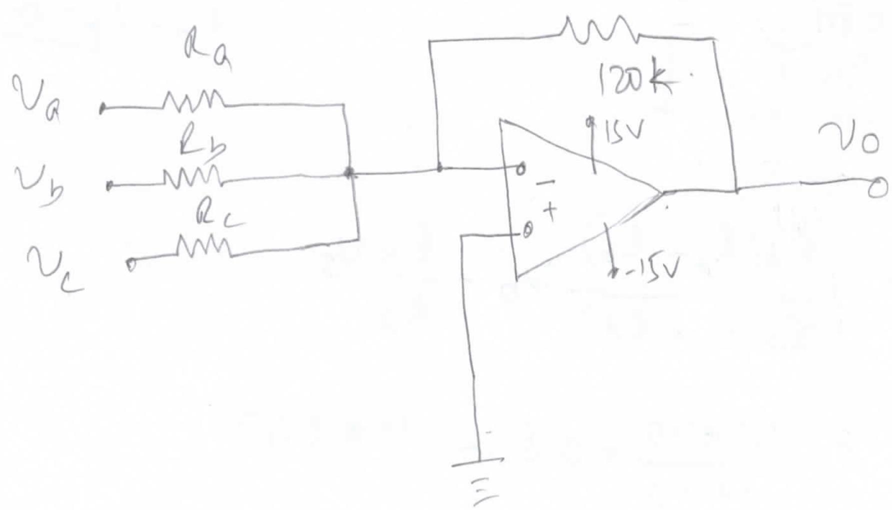
$$v_o = -(8v_a + 5v_b + 12v_c)$$

$$R_f = 120\,k\Omega$$



a). So, $\frac{120k}{R_a} = 8$; $R_a = 15k$.

$\frac{120k}{R_b} = 5$ $\quad R_b = 24k$

$\frac{120k}{R_c} = 12$ $\quad R_c = 10k$

b). Given $v_a = 2V$, $v_c = -1V$,

$V_o = -16 - 5v_b + 12$ or $v_o = -4 - 5v_b$

At saturation $v_o = +$ or $-V_{cc}$ i.e $\pm 15V$.

at $-15V$, the eqn is $-4 - 5v_b = -15$, $v_b = 2.2V$.

$+15V$, " " $-4 - 5v_b = 15$, $v_b = -3.8V$.

Hence, v_b can be $-3.8V \le v_b \le 2.2V$

5.27
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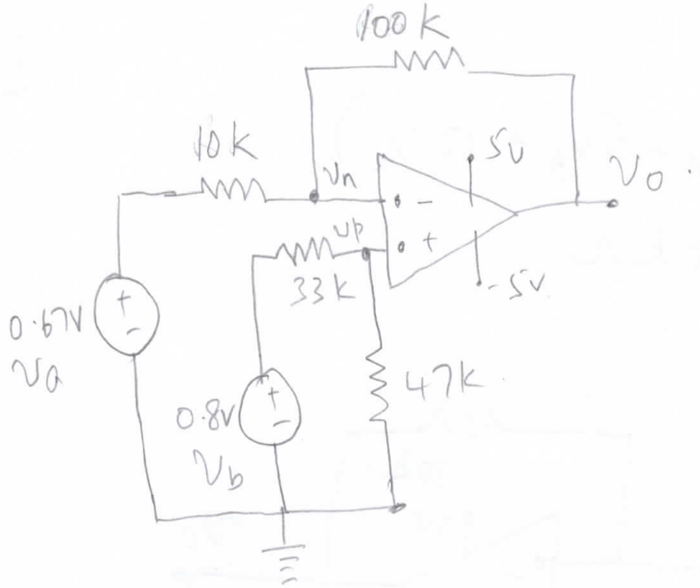

$v_n = v_p$
$i_n = i_p = 0.$

a). $v_o = \frac{R_d(R_a + R_b)}{R_a(R_c + R_d)} v_b - \frac{R_b}{R_a} v_a$

$= \frac{47*110}{10*80} * 0.8 - 10*0.67$

$= 5.17 - 6.70 =$

$= -1.53$ Volts

b). the Resistance seen by v_a is

$R_{in_a} = \frac{v_a}{i_a}$ Also, $i_a = \frac{v_n - v_a}{10k}$

$v_n = v_p$ for ideal op Amp

$v_p = \frac{47}{47+33} * 0.8 = .470$ V

Hence $i_a = \frac{0.470 - 0.67}{10k} = \frac{-.2}{10000} = 0.02$ mA

So ; $R_{in_a} = \frac{0.67}{0.02 \times 10^{-3}} = 33.5 \times 10^3$ ohms

c). $R_{in_b} = 33k + 47k$. They are in Series, since $i_p = 0$

So $R_{in_b} = 80k\Omega$