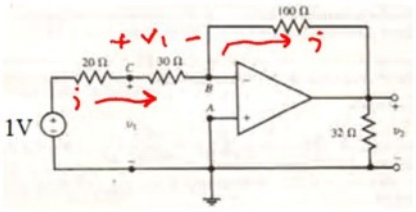
ENGR 12 Assignment 6 SOLUTIONS

Part I. Drills -- 1 point each

1) For the following circuit: What type of Op-Amp circuit is it? Inverting then, find V1 and V2



$V_p = V_n = 0$

$i = \frac{1-0}{20+30} = \frac{0-V_2}{100}$

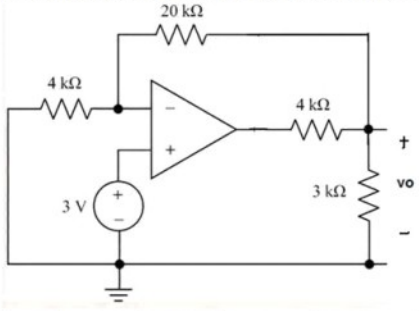
$V_2 = \frac{-100}{50} = -2V.$

KVL $-1 + 20i + V_1 = 0$

$V_1 = 1 - 20i =$

$V_1 = 1 - \frac{20}{50} = .6\ V$

2) For the following circuit: What type of Op-Amp circuit is it? Non-Inv then, find Vo



$V_p = +3 = V_n$

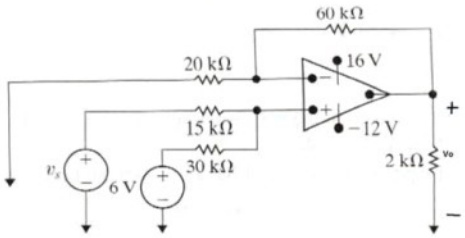
$\frac{V_n - 0}{4} + \frac{V_n - V_o}{20} = 0$

$5V_n + V_n - V_o = 0$

$V_o = 6V_n = 18\ V$

we assume linear operation since $\pm V_{cc}$ not provided.

3) For the following circuit: What type of Op-Amp circuit is it? Summing then, find Vo



1) NV at V_p:

$\frac{V_s - V_p}{15} + \frac{6 - V_p}{30} = 0, \quad 3V_p = 2V_s + 6$

$V_p = \frac{2}{3}V_s + 2$

2) NV at V_n:

$\frac{V_n}{20} + \frac{V_n - V_o}{60} = 0, \quad 4V_n = V_o$

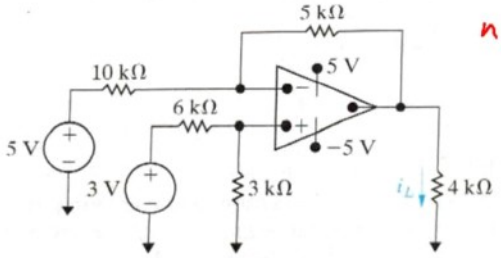
3) Assume linear ($V_n = V_p = \frac{2}{3}V_s + 2$)

$V_o = 4V_n = 4\left(\frac{2}{3}V_s + 2\right), \quad V_o = \frac{8}{3}V_s + 8$

4) Linear Range: $V_o = 16$ when $\frac{8}{3}V_s = 8, \ V_s = 3V, \ V_o = -12$ when $\frac{8}{3}V_s = -20, \ V_s = -7.5V$

∴ OpAmp is Linear when $-7.5 < V_s < 3$

4) For the following circuit: What type of Op-Amp circuit is it? Difference then, find iL in micro-Amperes

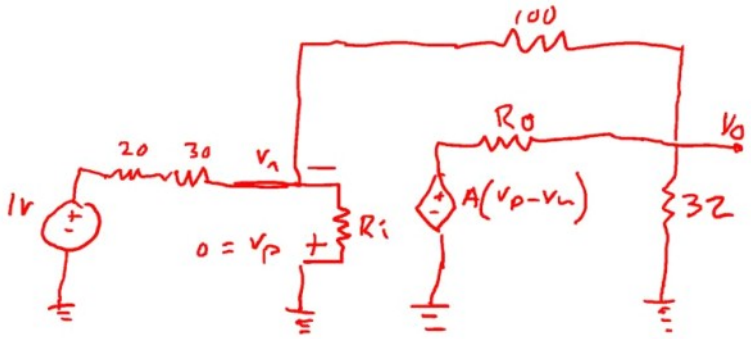


note: $\frac{10}{5} = \frac{6}{3}$ ∴ use simple formula:

$V_o = \frac{R_b}{R_a}(V_b - V_a) = \frac{5}{10}(3-5) = -1V$

$i_L = \frac{V_o}{4k} = -0.25\ mA$

5) Repeat #1 using non-ideal op-amp model. Take A = 100000, Ri = 500 kOhm, Ro = 75 Ohm [a CHALLENGE!!!]



1) NV V_n: $\frac{V_n - 1}{50} + \frac{V_n - V_o}{100} + \frac{V_n}{R_i} = 0$, $2V_n - 2 + V_n - V_o + \frac{100V_n}{R_i} = 0$

2) NV at V_o: $\frac{V_o - V_n}{100} + \frac{V_o - A(0 - V_n)}{R_o} + \frac{V_o}{32} = 0$

$8V_o - 8V_n + \frac{800}{R_o}(V_o + AV_n) + 25V_o = 0$

1) $V_n\left(3 + \frac{100}{R_i}\right) - V_o = 2$, $(R_i = 500K) \rightarrow V_o = V_n(3.0002) - 2$

2) $V_n\left(-8 + \frac{800}{R_o}A\right) + V_o\left(8 + \frac{800}{R_o} + 25\right) = 0$, $\begin{pmatrix} R_o = 75 \\ A = 100000 \end{pmatrix} \rightarrow V_n(-1.067 \times 10^6) + 43.67V_o = 0$

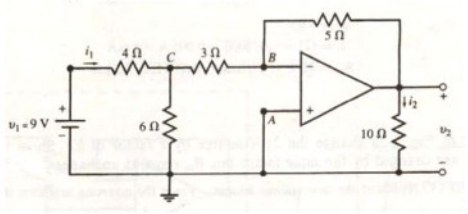
substituting: $V_n(1.067 \times 10^6) + 43.67(3.0002V_n - 2) = 0$

$V_n = \frac{+87.34}{(43.67 \cdot 3.0002 + 1.067 \times 10^6)} = +8.184 \times 10^{-5}\ V$

$V_o = -1.9998\ V$

Part II. Assisted Problem Solving – 2 pts each

6 Find Vc, i1, Rin (input Resistance seen by 9V source), v2, i2



$v_B = v_A = 0$

Nvat C: $\frac{v_c - 9}{4} + \frac{v_c}{6} + \frac{v_c}{3} = 0$

$3v_c + 2v_c + 4v_c = 27,\ v_c = 3$

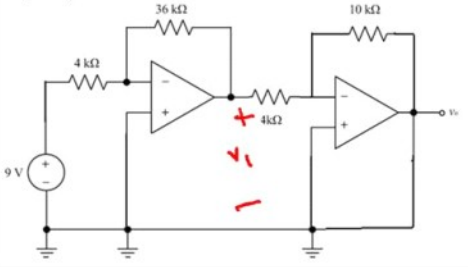
$i_1 = \frac{9-3}{4} = 1.5$

$R_{in} = \frac{9}{i_1} = \frac{9}{1.5} = 6\,\Omega$

Inv Amp $\rightarrow v_2 = -\frac{5}{3} v_c = -5V$

$i_2 = \frac{v_2}{10} = -0.5A$ (going "up")

7 Find Vo for the following 2 stage amplifier. What is the total gain of the amplifier? (G = vo/Vin)



Both Inverting Op Amps.

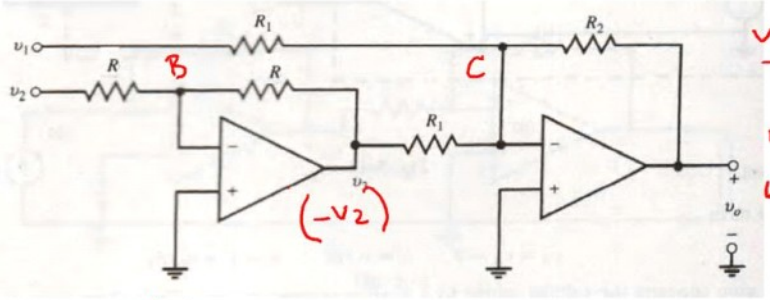
$v_1 = -\frac{36}{4} v_{in} = -81V.$

$v_o = -\frac{10}{4}(-81) = 202.5$

$Gain = \frac{v_{out}}{v_{in}} = \frac{202.5}{9} = 22.5$

Part III. Unassisted Problem Solving – 3 points each

8) Find vo for the following circuit:



1) 1st: Inv, 2nd Summ

note $V_B = 0$: $v_3 = -\frac{R}{R} v_2 = -v_2$

2) NVE C : note $v_c = 0$ too

$\frac{v_c - v_1}{R_1} + \frac{(v_c - v_2)}{R_1} + \frac{v_c - v_o}{R_2} = 0$

mult by $R_1 R_2$:

$v_c R_2 + (v_c + v_2) R_2 + R_1 (v_c - v_o) = R_2 v_1$

$(v_c = 0)$

$v_2 R_2 - v_1 R_2 = R_1 v_o$

$v_o = \frac{(v_2 R_2 - v_1 R_2)}{R_1}$

$v_o = \frac{R_2}{R_1}(v_2 - v_1)$