Homework from Chapter 11

11.7

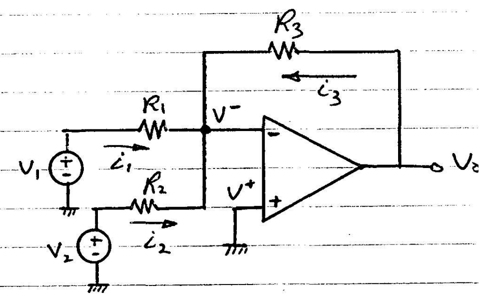
This is an inverting amplifier, so we can use the known formulas directly.

$$\boxed{A_v = -\frac{R_2}{R_1}, \quad R_{in} = R_1, \quad R_{out} = 0}$$

a. $A_v = -46.8 \Rightarrow |A_v| = 33.4\ dB$
$R_{in} = 4.7k, \quad R_o = 0\ \Omega$

b. $A_v = -46.8 \Rightarrow |A_v| = 33.4\ dB$
$R_{in} = 47K, \quad R_o = 0\ \Omega$

11.13



For an ideal op-amp
$V^- = V^+ = 0\ V$

We've $i_1 + i_2 + i_3 = 0$

but $i_1 = V_1/R_1, \quad i_2 = V_2/R_2, \quad i_3 = V_o/R_3$

$\therefore V_1/R_1 + V_2/R_2 + V_3/R_3 = 0 \Rightarrow V_3 = -\frac{R_3}{R_1}V_1 - \frac{R_3}{R_2}V_2$

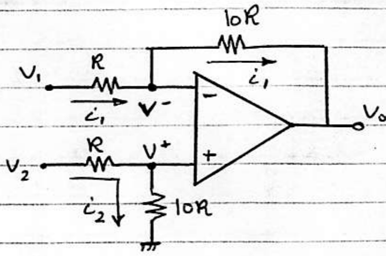
$\therefore V_o(t) = -51(0.01 \sin 3770t) - 25.5(0.04 \sin 10000t)$

$\Rightarrow V_o(t) = 0.51 \sin 3770t - 1.02 \sin 10000t \quad V$

& $V^-(t) = 0$ (virtual ground)

Hilroy

11.15



For the ideal opamp $V^- = V^+$

but $V^+ = \frac{10R}{10R+R} V_2 = \frac{10V_2}{11}$

& $V^- = V_1 - i_1 R$, $i_1 = \frac{V_1 - V_0}{R + 10R}$

$\therefore V^- = V_1 - \frac{V_1 - V_0}{11} = \frac{10V_1}{11} + \frac{V_0}{11}$

a. $V^- = V^+ \Rightarrow \frac{10V_2}{11} = \frac{10V_1}{11} + \frac{V_0}{11} \Rightarrow V_0 = -10(V_1 - V_2)$

$\Rightarrow A_v = \frac{V_0}{V_1 - V_2} = -10$

b. $R_{i2} = \left.\frac{V_2}{i_2}\right|_{V_1=0} = 11R = 110k\Omega$

$R_{i1} = \left.\frac{V_1}{i_1}\right|_{V_2=0}$

when $V_2 = 0$, $i_2 = 0$ & $V^+ = 0 \Rightarrow V^- = 0$

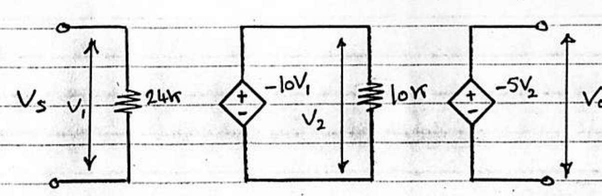
$\therefore i_1 = V_1/R \Rightarrow R_{i1} = R = 10k\Omega$

11.41

For stage 1: $A_v = -\frac{240k}{24k} = -10$, $R_{in} = 24k$

For stage 2: $A_v = -\frac{50k}{10k} = -5$, $R_{in} = 10k$

a. So now we can draw the two-port representation for each stage



Hilroy

b. $\frac{V_o}{V_s} = \frac{V_o}{V_2} \cdot \frac{V_2}{V_s} = -5 \cdot -10 = 50$

$R_{in} = 24k$ & $R_o = 0\ \Omega$

11.58

Check section 11.4 before solving this problem.

$$V_{th} = V_s \left(-\frac{R_2}{R_1}\right)\left(\frac{A\beta}{1+A\beta}\right)$$

where $A = 5\times10^4$ is the open loop gain

& $\beta = \frac{R_1}{R_1+R_2}$ is the feedback factor

$$\Rightarrow \quad V_{th} = -16.2\ V_s$$

$$R_{th} = R_{out} = \frac{R_o}{1+A\beta} = 85.9\ m\Omega$$

For $A\beta \gg 1$, we can use the following apx.

$$V_{th} \simeq V_s\left(-\frac{R_2}{R_1}\right) \quad \& \quad R_{th} \simeq \frac{R_o}{A\beta}$$

11.78

This is an inverting amplifier with ~~open loop~~ gain $-\frac{6.2k}{1k} = -6.2$ as long as $|V_o| \leq 10V$, which is the limit of the opamp supply voltages.

a. $V_i = 1V \Rightarrow V_o = -6.2V$, $V_- = 0V$ (due to feedback)

b. $V_i = -3V \Rightarrow V_o = 18.6V$ which can't be, so V_o remains at $10V$ & the feedback loop is broken, so V^- is calculated using superposition

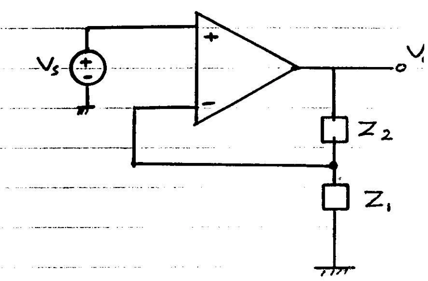
$$V^- = -3\frac{6.2k}{1k+6.2k} + 10\frac{1k}{1k+6.2k} = -1.19\ V$$

Hilroy

11.87

The circuit can be redrawn as shown.

where $Z_1 = R_1$ & $Z_2 = R_2 // C$



$$\therefore Z_2 = \frac{R_2 \cdot (1/sC)}{R_2 + 1/sC} = \frac{R_2}{1 + sCR_2}$$

we've $V^+ = V^- = V^s$

Using voltage division : $V_s = V_o \dfrac{Z_1}{Z_1 + Z_2}$

$$\therefore A_v = \frac{V_o}{V_s} = \frac{Z_1 + Z_2}{Z_1} = \left(R_1 + \frac{R_2}{1 + sCR_2}\right) / R_1$$

$$= \frac{R_1 + sCR_1R_2 + R_2}{R_1 + sCR_1R_2} = \frac{(R_1 + R_2)\left(1 + sC\frac{R_1R_2}{R_1+R_2}\right)}{R_1 \quad (1 + sCR_2)}$$

$$\Rightarrow \quad A_v = \left(1 + \frac{R_2}{R_1}\right) \frac{1 + sC(R_1 // R_2)}{1 + sCR_2}$$