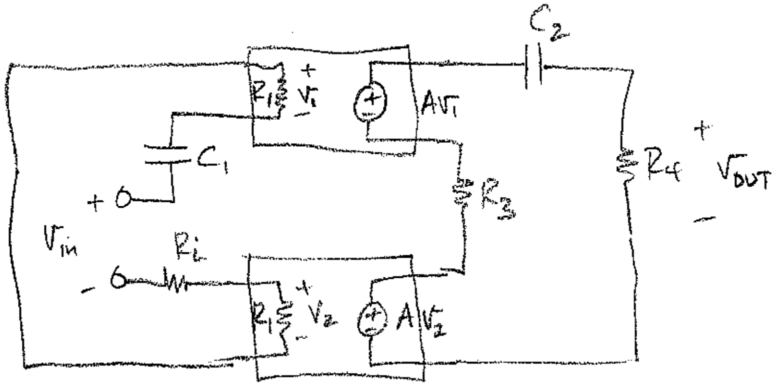
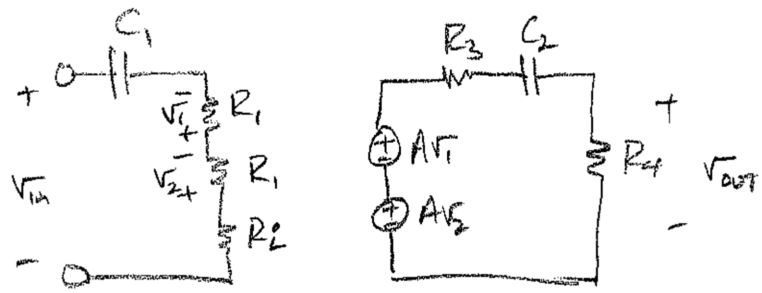
Exam 1

①

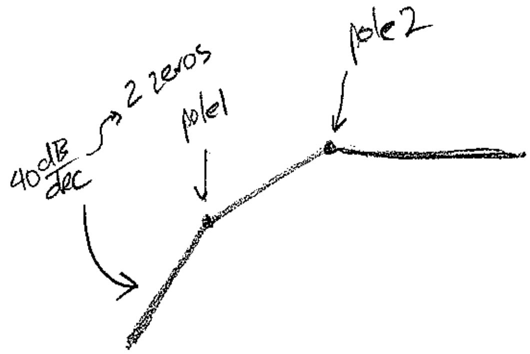




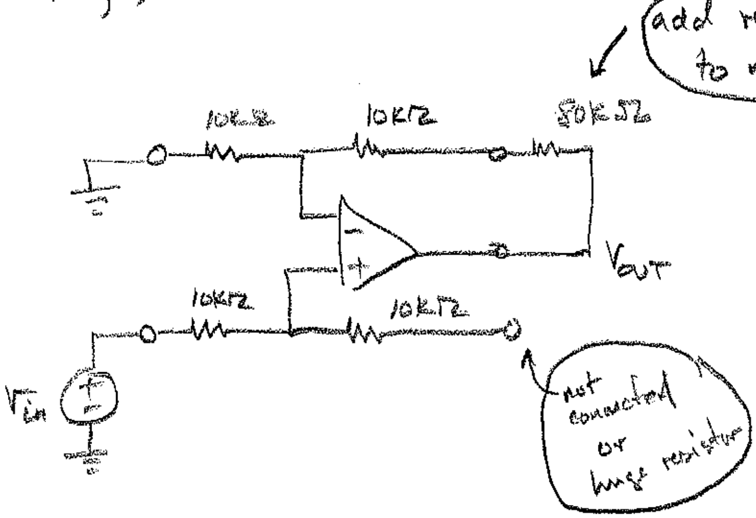
$$V_1 = V_2 = \frac{-V_{in} R_1}{2R_1 + R_i + \frac{1}{j\omega C_1}} = \frac{-V_{in}\, j\omega R_1 C_1}{1 + j\omega(2R_1 + R_i)C_1}$$

$$V_{OUT} = \frac{(AV_1 + AV_2)R_4}{R_3 + R_4 + \frac{1}{j\omega C_2}} = \frac{2AV_1 \cdot j\omega R_4 C_2}{1 + j\omega(R_3 + R_4)C_2}$$

$$\frac{V_{out}}{V_{in}} = \frac{-2A(j\omega R_1 C_1)(j\omega R_4 C_2)}{(1 + j\omega(2R_1 + R_i)C_1)(1 + j\omega(R_3 + R_4)C_2)}$$



(2) $H(j\omega) = 100$

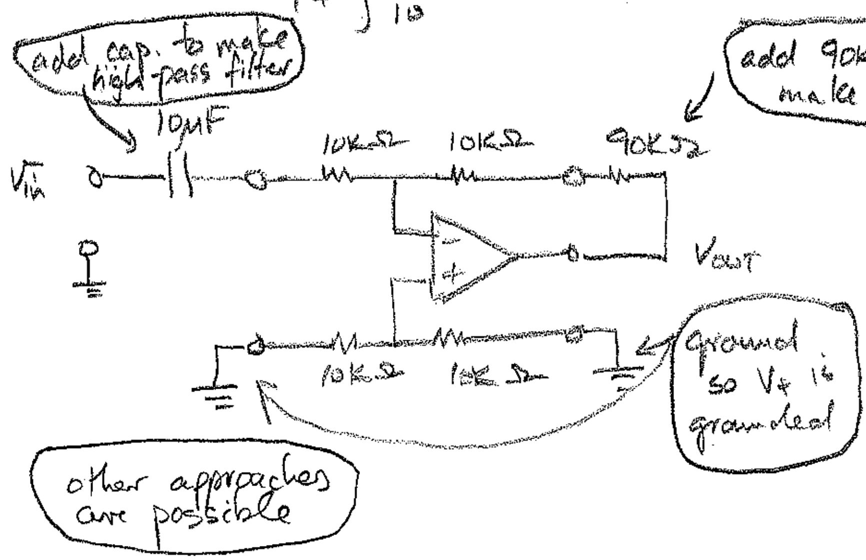


$$\left(1+\frac{R_f}{R_1}\right) = 10$$

$$\frac{R_f}{R_1} = 9$$

$$R_f = 90K\Omega$$

$$H(j\omega) = \frac{-100\left(j\frac{\omega}{10}\right)}{1+j\frac{\omega}{10}}$$



$$\frac{1}{RC} = 10\ \frac{rad}{sec}$$

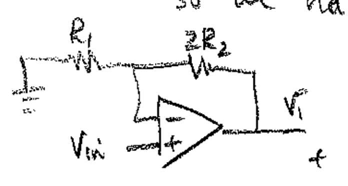
$$C = \frac{1}{R \cdot 10}$$

$$C = \frac{1}{10{,}000 \cdot 10} = \frac{1}{100{,}000}$$

$$C = 10^{-5} = 10\mu F$$

(b) since no current flows through the $5R_1$ resistor $V_+ = V_- = V_{in}$ for both amplifiers.

so we have:



$$V_1 = V_{in}\left(1+\frac{2R_2}{R_1}\right)$$

$$V_2 = V_{in}\left(1+\frac{R_2}{R_1}\right)$$

$$V_o = V_1 - V_2$$

$$\frac{V_o}{V_{in}} = \left(1+\frac{2R_2}{R_1}\right) - \left(1+\frac{R_2}{R_1}\right)$$

$$= \frac{R_2}{R_1}$$

(3)

$$\text{CMRR} = \sout{\text{Ad}}\ 20\log_{10}\frac{|A_d|}{|A_{cm}|} = 60$$

$$\frac{|A_d|}{|A_{cm}|} = 10^3$$

$$|A_d| = \frac{R_2}{R_1} = 10^2 \longrightarrow \frac{10^2}{|A_{cm}|} = 10^3$$

$$|A_{cm}| = 10^{-1} = 0.1$$

$$\left(\frac{R_4}{R_4 + 1\,k\Omega}\right)\left(1 - \frac{100\,k\Omega}{1\,k\Omega}\cdot\frac{1\,k\Omega}{R_4}\right) = 0.1$$

$$R_4 - 100\,k\Omega = 0.1 \cdot R_4 + 0.1 \cdot 1\,k\Omega$$

$$0.9 \cdot R_4 = 100\,k\Omega + 100\,\Omega$$

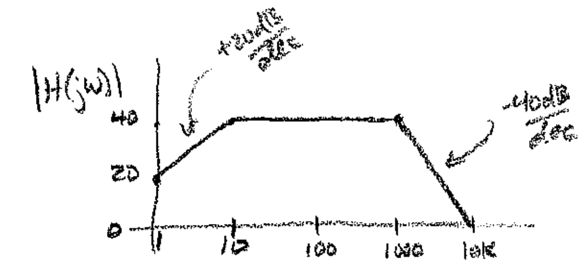
$$R_4 = \frac{100.1\,k\Omega}{0.9}$$

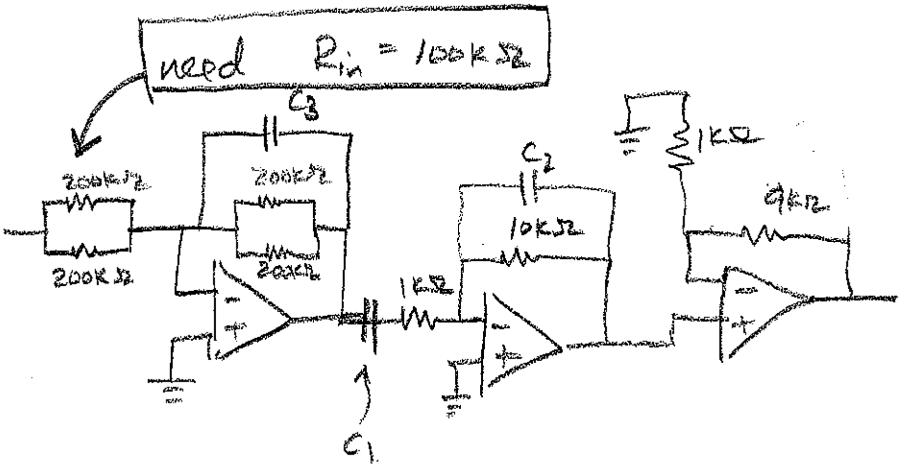
$$\boxed{R_4 = 111.\overline{2}\,k\Omega}$$

yes, long-division still works! →

111222
9) 1001000
9
10
9
11
9
20
18
2

(4)





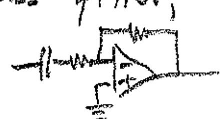
$\left(1+\frac{R_2}{R_1}\right)$

$$\frac{1}{C_2 \cdot 10k\Omega} = 1000\ \frac{rad}{sec} \rightarrow C_2 = 10^{-7}\ F$$

$$\frac{1}{C_3 \cdot 100k\Omega} = 1000\ \frac{rad}{sec} \rightarrow C_3 = \frac{1}{10^8}\ F = 10\ nF$$

$$\frac{1}{C_1 \cdot 1k\Omega} = 10\ \frac{rad}{sec} \rightarrow C_1 = \frac{1}{10^4} = 10^{-4}\ F = 100\mu F$$

$$H(j\omega) = \frac{100\ j\frac{\omega}{10}}{\left(1+j\frac{\omega}{10}\right)\left(1+j\frac{\omega}{1000}\right)^2}$$

$\dfrac{j\frac{\omega}{10}}{1+j\frac{\omega}{10}}$ is a low-pass filter, such as 

$\dfrac{1}{\left(1+j\frac{\omega}{1000}\right)^2}$ is a cascaded low-pass filter, such as

other approaches are possible