For the circuit above, $V_i = 10\, \text{mV}$:

- What is $V_o$ if the amplifier is ideal?

- What is $V_o$ if the offset voltage, $V_{OS} = 10\, \mu\text{V}$?

- What is $V_o$ if the bias current, $I_B = 10\, \text{nA}$?

- What is $V_o$ if the amplifier is ideal?

Represent ideal as $\bar{V}_o$

\[
V_+ = \frac{24\, \text{k} \Omega}{24 + 2.4\, \text{k} \Omega} V_i = (9.090\, \text{mV}, \quad \bar{V}_o = \left(1 + \frac{24\, \text{k} \Omega}{2.4\, \text{k} \Omega}\right) V_+ = 11.000\, \bar{V}_o = 99.990\, \text{mV}
\]

- What is $V_o$ if the offset voltage, $V_{OS} = 10\, \mu\text{V}$?

Use superposition to get $(V'_o)$ then add to ideal $V_{OS}$:

\[
V'_o = \left(1 + \frac{24\, \text{k} \Omega}{2.4\, \text{k} \Omega}\right) V_{OS} = 11.000 \times V_{OS} = 0.110\, \text{mV}
\]

\[
V_o = \bar{V}_o + V'_o = 100.100\, \text{mV}
\]

- What is $V_o$ if the bias current, $I_B = 10\, \text{nA}$?

First, use superposition to get $(V'_o)$ for $I_B$ into $V_+$. Current travels through parallel resistors.

\[
V'_o = -\left(1 + \frac{24\, \text{k} \Omega}{2.4\, \text{k} \Omega}\right) (R_1 \parallel R_2) I_B = -11.000 \times 2.182\, \text{k} \Omega \times I_B = -0.240\, \text{mV}
\]

Next, use superposition to get $(V''_o)$ for $I_B$ into $V_-$. Current through $R_1$, since FB keeps $V_-$ at ground. Note that this resistor configuration cancels $I_B$.

\[
V''_o = (24\, \text{k} \Omega) I_B = 0.240\, \text{mV}
\]

\[
V_o = \bar{V}_o + V'_o + V''_o = 99.990\, \text{mV}
\]
The op amp is ideal, except $f_T$ (= Gain-Bandwidth) is 120 kHz.

For the circuit above, $V_i = (20 \text{ mV}) \cos(2\pi ft)$:

- What is the peak-to-peak amplitude of $V_o$ if $f = 3$ kHz?
- What is the peak-to-peak amplitude of $V_o$ if $f = 30$ kHz?

First, analyse ideal gain, $\bar{V}_o$

$$V_+ = \frac{21 \text{ k}\Omega}{21 + 2.8 \text{ k}\Omega} V_i = 0.882 V_i \quad \bar{V}_o = \left(1 + \frac{21 \text{ k}\Omega}{2.8 \text{ k}\Omega}\right) V_+ = 8.500 V_+ = 7.497 V_i$$

- What is the peak-to-peak amplitude of $V_o$ if $f = 3$ kHz?
  
  Given Gain-Bandwidth, maximum possible gain is $G = (G \cdot BW)/f = 120/3 = 40$. We specify a gain of 7.497 which is less than 40, so we get the specified gain.
  
  $V_o = 7.497 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times \max(V_o)$.
  
  Answer: 299.9 mV.

- What is the peak-to-peak amplitude of $V_o$ if $f = 30$ kHz?
  
  Given Gain-Bandwidth, maximum possible gain is $G = (G \cdot BW)/f = 120/30 = 4$. We specify a gain of 7.497 which is greater than 4, so we only get a gain of 4.
  
  $V_o = 4 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times \max(V_o)$.
  
  Answer: 160.0 mV.
For the circuit above:

- **What type of filter is this?** (high pass, low pass, band pass, band stop)
- Sketch the amplitude of $V_o/V_i$ as a function of frequency. Label the passband, stopband and roll-off rate.
- What is the cut-off frequency ($f_c$) and damping constant ($\zeta$)?

**What type of filter is this?** (high pass, low pass, band pass, band stop)

This is a low pass filter

- What is the cut-off frequency ($f_c$) and damping constant ($\zeta$)?

\[
\omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{6.1 \text{ mH} \cdot 14.1 \mu\text{F}}} = 3409.773 \text{ rad/s}, \quad f_c = 2\pi \omega_c = 21423.787 \text{ Hz}
\]

and,

\[
\zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{208 \text{ k}\Omega}{2} \sqrt{\frac{14.1 \mu\text{F}}{6.1 \text{ mH}}} = 5.000
\]

- Sketch the amplitude of $V_o/V_i$ as a function of frequency. Label the passband, stopband and roll-off rate.

$V_o/V_i$ starts near 1.0. After $f_c$, graph decreases at 40 dB/decade.