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 $\bar{V}_o$

  \[
  V_+ = \frac{25 \text{ k}\Omega}{25 + 1.2 \text{ k}\Omega} V_i = (9.540 \text{ mV}, \quad \bar{V}_o = \left(1 + \frac{25 \text{ k}\Omega}{1.2 \text{ k}\Omega}\right) V_+ = 21.833 \text{ mV} = 208.287 \text{ mV}
  \]

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

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

  \[
  V_o' = \left(1 + \frac{25 \text{ k}\Omega}{1.2 \text{ k}\Omega}\right) V_{OS} = 21.833 \times V_{OS} = 0.218 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V_o' = 208.505 \text{ mV}
  \]

- 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.

  \[
  V_o' = -\left(1 + \frac{25 \text{ k}\Omega}{1.2 \text{ k}\Omega}\right) (R_1 \parallel R_2) I_B = -21.833 \times 1.145 \text{ k}\Omega \times I_B = -0.250 \text{ mV}
  \]

  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 $I_B$.

  \[
  V_o'' = (25 \text{ k}\Omega) I_B = 0.250 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V_o' + V_o'' = 208.287 \text{ mV}
  \]
The op amp is ideal, except \( f_T (= \text{Gain-Bandwidth}) \) 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 \( f = 3 \text{ kHz} \)?
- What is the peak-to-peak amplitude of \( V_o \) if \( f = 30 \text{ kHz} \)?

First, analyse ideal gain, \( V_o \)

\[
V_+ = \frac{30 \text{ k}\Omega}{30 + 3.9 \text{ k}\Omega} V_i = 0.885 V_i \quad \bar{V}_o = \left(1 + \frac{30 \text{ k}\Omega}{3.9 \text{ k}\Omega}\right) V_+ = 8.692 V_+ = 7.692 V_i
\]

- What is the peak-to-peak amplitude of \( V_o \) if \( f = 3 \text{ kHz} \)?
  
  Given Gain-Bandwidth, maximum possible gain is \( G = \frac{G \cdot BW}{f} = \frac{120}{3} = 40 \).
  
  We specify a gain of 7.692 which is less than 40, so we get the specified gain.
  
  \( V_o = 7.692 \times (20 \text{ mV}) \cos(2\pi ft) \), and peak-peak voltage is \( 2 \times max(V_o) \).
  
  Answer: 307.7 mV.

- What is the peak-to-peak amplitude of \( V_o \) if \( f = 30 \text{ kHz} \)?
  
  Given Gain-Bandwidth, maximum possible gain is \( G = \frac{G \cdot BW}{f} = \frac{120}{30} = 4 \).
  
  We specify a gain of 7.692 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)
  
  This is a low pass filter

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

\[
\omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{6.6 \text{ mH} \cdot 19.4 \mu \text{F}}} = 2794.648 \text{ rad/s}, \quad f_c = 2\pi \omega_c = 17558.924 \text{ Hz}
\]

and,

\[
\zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{295 \text{ k}\Omega}{2} \sqrt{\frac{19.4 \mu \text{F}}{6.6 \text{ mH}}} = 7.997
\]

- Sketch the amplitude of \(\frac{V_o}{V_i}\) as a function of frequency. Label the passband, stopband and roll-off rate.

\(\frac{V_o}{V_i}\) starts near 1.0. After \(f_c\), graph decreases at 40 dB/decade.