For the circuit above, \( V_i = 10 \) mV:

- What is \( V_o \) if the amplifier is ideal?
- What is \( V_o \) if the offset voltage, \( V_{OS} = 10 \mu V \)?
- What is \( V_o \) if the bias current, \( I_B = 10 \) nA?

- What is \( V_o \) if the amplifier is ideal?
  
  Represent ideal as \( \bar{V}_o \)

  \[
  V_+ = \frac{28 \text{ k}\Omega}{28 + 1.6 \text{ k}\Omega} V_i = (9.460 \text{ mV}, \quad \bar{V}_o = \left( 1 + \frac{28 \text{ k}\Omega}{1.6 \text{ k}\Omega} \right) V_+ = 18.500 \text{ V}_+ = 175.010 \text{ mV}
  \]

- What is \( V_o \) if the offset voltage, \( V_{OS} = 10 \mu V \)?
  
  Use superposition to get \((V_o')\) then add to ideal \( V_{OS} \):

  \[
  V_o' = \left( 1 + \frac{28 \text{ k}\Omega}{1.6 \text{ k}\Omega} \right) V_{OS} = 18.500 \times V_{OS} = 0.185 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V_o' = 175.195 \text{ mV}
  \]

- What is \( V_o \) if the bias current, \( I_B = 10 \) nA?
  
  First, use superposition to get \((V_o'')\) for \( I_B \) into \( V_+ \). Current travels through parallel resistors.

  \[
  V_o'' = -\left( 1 + \frac{28 \text{ k}\Omega}{1.6 \text{ k}\Omega} \right) (R_1 \parallel R_2) I_B = -18.500 \times 1.514 \text{ k}\Omega \times I_B = -0.280 \text{ mV}
  \]

  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 \( I_B \).

  \[
  V_o''' = (28 \text{ k}\Omega) I_B = 0.280 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V_o' + V_o''' = 175.010 \text{ mV}
  \]
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, $V_o$

$$V_+ = \frac{25 \text{k}\Omega}{25 + 2.5 \text{k}\Omega} V_i = 0.909 V_i \quad V_o = \left(1 + \frac{25 \text{k}\Omega}{2.5 \text{k}\Omega}\right) V_+ = 11.000 V_+ = 9.999 V_i$$

- What is the peak-to-peak amplitude of $V_o$ if $f = 3 \text{ kHz}$?
  
  Given Gain-Bandwidth, maximum possible gain is $G = (G \cdot BW)/f = 120/3 = 40$.
  
  We specify a gain of 9.999 which is less than 40, so we get the specified gain.
  
  $V_o = 9.999 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times \max(V_o)$.
  
  Answer: 400.0 mV.

- What is the peak-to-peak amplitude of $V_o$ if $f = 30 \text{ kHz}$?
  
  Given Gain-Bandwidth, maximum possible gain is $G = (G \cdot BW)/f = 120/30 = 4$.
  
  We specify a gain of 9.999 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 ($\zeta$)?

\[
\omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8.0 \text{ mH} \cdot 12.6 \mu\text{F}}} = 3149.704 \text{ rad/s}, \quad f_c = 2\pi\omega_c = 19789.760 \text{ Hz}
\]

and,

\[
\zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{247 \text{ k}\Omega}{2} \sqrt{\frac{12.6 \mu\text{F}}{8.0 \text{ mH}}} = 4.901
\]

- 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.