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 $\bar{V}_o$

  
  $$V_+ = \frac{29 \text{ k}\Omega}{29 + 2.0 \text{ k}\Omega} V_i = (9.350 \text{ mV}), \quad \bar{V}_o = \left(1 + \frac{29 \text{ k}\Omega}{2.0 \text{ k}\Omega}\right) V_+ = 15.500 V_+ = 144.925 \text{ mV}$$

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

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

  $$V_o' = \left(1 + \frac{29 \text{ k}\Omega}{2.0 \text{ k}\Omega}\right) V_{OS} = 15.500 \times V_{OS} = 0.155 \text{ mV}$$

  $$V_o = \bar{V}_o + V_o' = 145.080 \text{ mV}$$

- 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.

  $$V_o'' = -\left(1 + \frac{29 \text{ k}\Omega}{2.0 \text{ k}\Omega}\right) (R_1 \parallel R_2) I_B = -15.500 \times 1.871 \text{ k}\Omega \times I_B = -0.290 \text{ mV}$$

  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 $I_B$.

  $$V_o'' = (29 \text{ k}\Omega) I_B = 0.290 \text{ mV}$$

  $$V_o = \bar{V}_o + V_o' + V_o''' = 144.925 \text{ mV}$$
The op amp is ideal, except $f_T$ (Gain-Bandwidth) is 120 kHz.

\[ V_+ = \frac{20 \text{k}\Omega}{20 + 3.1 \text{k}\Omega} V_i = 0.866 V_i \quad \bar{V}_o = \left(1 + \frac{20 \text{k}\Omega}{3.1 \text{k}\Omega}\right) V_+ = 7.452 V_+ = 6.453 V_i \]

- 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 6.453 which is less than 40, so we get the specified gain. $V_o = 6.453 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times \max(V_o)$. Answer: 258.1 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 6.453 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 \( (\zeta) \)?

  \[
  \omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8.3 \text{ mH} \cdot 15.7 \mu\text{F}}} = 2770.200 \text{ rad/s}, \quad f_c = 2\pi\omega_c = 17405.316 \text{ Hz}
  \]

  and,

  \[
  \zeta = \frac{R}{2\sqrt{C/L}} = \frac{204 \text{ k}\Omega}{2\sqrt{\frac{15.7 \mu\text{F}}{8.3 \text{ mH}}}} = 4.436
  \]

- 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.