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

- What is $V_o$ if the amplifier is ideal?
  
  $$V_+ = \frac{29 \text{ k}\Omega}{29 + 2.0 \text{ k}\Omega} V_i = \left(9.350 \text{ mV}, \quad V_o = \left(1 + \frac{29 \text{ k}\Omega}{2.0 \text{ k}\Omega}\right) V_+ = 15.500 \text{ V}_+ = 144.925 \text{ mV} \right)$$

- What is $V_o$ if the offset voltage, $V_{OS} = 10 \mu V$?
  
  Use superposition to get ($V'_o$) then add to ideal $V_{OS}$:
  
  $$V'_o = \left(1 + \frac{29 \text{ k}\Omega}{2.0 \text{ k}\Omega}\right) V_{OS} = 15.500 \times V_{OS} = 0.155 \text{ mV}$$
  
  $$V_o = V_o + V'_o = 145.080 \text{ mV}$$

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

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, $\bar{V}_o$

\[
V_+ = \frac{22 \text{ k}\Omega}{22 + 2.6 \text{ k}\Omega} V_i = 0.894 V_i \quad \bar{V}_o = \left(1 + \frac{22 \text{ k}\Omega}{2.6 \text{ k}\Omega}\right)V_+ = 9.462 V_+ = 8.459 V_i
\]

- What is the peak-to-peak amplitude of $V_o$ if $f = 3 \text{ kHz}$?
  Given Gain-Bandwidth, maximum possible gain is $G = \left(G \cdot BW\right)/f = 120/3 = 40$.
  We specify a gain of 8.459 which is less than 40, so we get the specified gain.
  $V_o = 8.459 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times max(V_o)$.
  Answer: 338.4 mV.

- What is the peak-to-peak amplitude of $V_o$ if $f = 30 \text{ kHz}$?
  Given Gain-Bandwidth, maximum possible gain is $G = \left(G \cdot BW\right)/f = 120/30 = 4$.
  We specify a gain of 8.459 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 \( \zeta \)?

  \[
  \omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8.3 \, \text{mH} \cdot 13.2 \, \mu\text{F}}} = 3021.162 \, \text{rad/s}, \quad f_c = 2\pi \omega_c = 18982.123 \, \text{Hz}
  \]

  and,

  \[
  \zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{221 \, \text{k}\Omega}{2} \sqrt{\frac{13.2 \, \mu\text{F}}{8.3 \, \text{mH}}} = 4.407
  \]

- 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.