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 $\bar{V}_o$

  $$V_+ = \frac{25 \text{ kΩ}}{25 + 1.4 \text{ kΩ}} V_i = (9.470 \text{ mV}), \quad \bar{V}_o = \left(1 + \frac{25 \text{ kΩ}}{1.4 \text{ kΩ}}\right) V_+ = 18.857 \bar{V}_o + 178.576 \text{ mV}$$

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

  $$V_o' = \left(1 + \frac{25 \text{ kΩ}}{1.4 \text{ kΩ}}\right) V_{OS} = 18.857 \times V_{OS} = 0.189 \text{ mV}$$

  $$V_o = \bar{V}_o + V_o' = 178.765 \text{ mV}$$

- 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.

  $$V_o' = -\left(1 + \frac{25 \text{ kΩ}}{1.4 \text{ kΩ}}\right) (R_1 || R_2) I_B = -18.857 \times 1.326 \text{ kΩ} \times I_B = -0.250 \text{ mV}$$

  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 $I_B$.

  $$V_o''' = (25 \text{ kΩ}) I_B = 0.250 \text{ mV}$$

  $$V_o = \bar{V}_o + V_o' + V_o''' = 178.576 \text{ mV}$$
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, $\bar{V}_o$

$$V_+ = \frac{28 \text{ k}\Omega}{28 + 2.1 \text{ k}\Omega} V_i = 0.930 \ V_i \quad V_o = \left(1 + \frac{28 \text{ k}\Omega}{2.1 \text{ k}\Omega}\right) V_+ = 14.333 \ V_+ = 13.330 \ V_i$$

- 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 13.330 which is less than 40, so we get the specified gain.
  
  $V_o = 13.330 \times (20 \text{ mV}) \cos(2\pi ft)$, and peak-peak voltage is $2 \times max(V_o)$.
  
  Answer: 533.2 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 13.330 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 \( \zeta \)?
  
  \[
  \omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{6.4 \text{ mH} \cdot 10.6 \mu \text{F}}} = 3839.344 \text{ rad/s, } \quad f_c = 2\pi \omega_c = 24122.805 \text{ Hz}
  \]
  
  \[
  \zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{284 \text{ k}\Omega}{2} \sqrt{\frac{10.6 \mu \text{F}}{6.4 \text{ mH}}} = 5.779
  \]
  
  - 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.