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 \( \bar{V}_o \)

  \[
  V_+ = \frac{29 \text{k}\Omega}{29 + 1.4 \text{k}\Omega} V_i = (9.540 \text{ mV}) \quad \bar{V}_o = \left(1 + \frac{29 \text{k}\Omega}{1.4 \text{k}\Omega}\right) V_+ = 21.714 \text{ mV} = 207.152 \text{ mV}
  \]

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

  \[
  V'_o = \left(1 + \frac{29 \text{k}\Omega}{1.4 \text{k}\Omega}\right) V_{OS} = 21.714 \times V_{OS} = 0.217 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V'_o = 207.369 \text{ mV}
  \]

- 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.

  \[
  V'_o = -\left(1 + \frac{29 \text{k}\Omega}{1.4 \text{k}\Omega}\right) (R_1 \parallel R_2) I_B = -21.714 \times 1.336 \text{k}\Omega \times I_B = -0.290 \text{ mV}
  \]

  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 \( I_B \).

  \[
  V''_o = (29 \text{k}\Omega) I_B = 0.290 \text{ mV}
  \]

  \[
  V_o = \bar{V}_o + V'_o + V''_o = 207.152 \text{ mV}
  \]
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, \( \bar{V}_o \)

\[
V_+ = \frac{23 \text{ k}\Omega}{23 + 2.3 \text{ k}\Omega} V_i = 0.909 V_i \quad \bar{V}_o = \left(1 + \frac{23 \text{ k}\Omega}{2.3 \text{ k}\Omega}\right) V_+ = 11.000 V_+ = 9.999 V_i
\]

- 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 \( 2 \times \text{max}(V_o) \).
  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 \( 2 \times \text{max}(V_o) \).
  Answer: 160.0 mV.
For the circuit above:

- **What type of filter is this?** (high pass, low pass, band pass, band stop)

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

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

- **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 \( (\zeta) \)?

\[
\omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8.5 \text{ mH} \cdot 11.3 \mu \text{F}}} = 3226.646 \text{ rad/s}, \quad f_c = 2\pi\omega_c = 20273.190 \text{ Hz}
\]

and,

\[
\zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{227 \text{ k}\Omega}{2} \sqrt{\frac{11.3 \mu \text{F}}{8.5 \text{ mH}}} = 4.138
\]

- 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.