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 $\overline{V_o}$

  $$V_+ = \frac{27 \text{k}\Omega}{27 + 1.2 \text{k}\Omega} V_i = (9.570 \text{ mV}), \quad \overline{V_o} = \left(1 + \frac{27 \text{k}\Omega}{1.2 \text{k}\Omega}\right) V_+ = 23.500 \text{ V}_+ = 224.895 \text{ mV}$$

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

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

  $$V_o' = \left(1 + \frac{27 \text{k}\Omega}{1.2 \text{k}\Omega}\right) V_{OS} = 23.500 \times V_{OS} = 0.235 \text{ mV}$$

  $$V_o = \overline{V_o} + V_o' = 225.130 \text{ mV}$$

- 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.

  $$V_o' = -\left(1 + \frac{27 \text{k}\Omega}{1.2 \text{k}\Omega}\right) (R_1 \parallel R_2) I_B = -23.500 \times 1.149 \text{k}\Omega \times I_B = -0.270 \text{ mV}$$

  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 $I_B$.

  $$V_o'' = (27 \text{k}\Omega) I_B = 0.270 \text{ mV}$$

  $$V_o = \overline{V_o} + V_o' + V_o'' = 224.895 \text{ mV}$$
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, \( \bar{V}_o \)

\[
V_+ = \frac{29 \text{ k}\Omega}{29 + 3.5 \text{ k}\Omega} V_i = 0.892 V_i \quad \bar{V}_o = \left( 1 + \frac{29 \text{ k}\Omega}{3.5 \text{ k}\Omega} \right) V_+ = 9.286 V_+ = 8.283 V_i
\]

- 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 8.283 which is less than 40, so we get the specified gain.
  \( V_o = 8.283 \times (20 \text{ mV}) \cos(2\pi ft) \), and peak-peak voltage is \( 2 \times max(V_o) \).
  Answer: 331.3 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 8.283 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)

- 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 \( \zeta \)?

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- **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 \( \zeta \)?

  \[
  \omega_c = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{7.7 \text{ mH} \cdot 17.5 \text{ } \mu\text{F}}} = 2724.179 \text{ rad/s}, \quad f_c = 2\pi\omega_c = 17116.163 \text{ Hz}
  \]

  and,

  \[
  \zeta = \frac{R}{2} \sqrt{\frac{C}{L}} = \frac{287 \text{ k}\Omega}{2} \sqrt{\frac{17.5 \text{ } \mu\text{F}}{7.7 \text{ mH}}} = 6.841
  \]

- 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.