4.9 Determine the gain of the amplifier. Determine $I_0$.

![Circuit Diagram]

Because of ideal assumptions

- The circuit is a non-inverting voltage amplifier.
- The formula for the gain is:

$$\frac{V_0}{V_{IN}} = 1 + \frac{R_2}{R_1}$$

- We can use the gain to find the output voltage, $V_0$

$$\frac{V_0}{V_{IN}} = 7.06 \Rightarrow V_0 = 7.06 \cdot V_{IN} = 7.06 \cdot 2V = 14.12V$$

- Since no current flows into the negative terminal, using Ohm's law:

$$V = I \cdot R$$

$$V_0 = I_0 \cdot (R_2 + R_1)$$

$$I_0 = \frac{V_0}{R_2 + R_1} = \frac{14.12V}{20k\Omega + 33k\Omega}$$

$$I_0 = 606 \mu A$$
4.10  Find the gain.
Find \( I_0 \).

\[ V_0 \]

\[ R_2 = 20k\Omega \]
\[ R_1 = 3.3k\Omega \]
\[ V_S = 2V \]

- **The circuit is an inverting voltage amplifier.**

The gain can be calculated by:

\[
\frac{V_0}{V_S} = -\frac{R_2}{R_1} = -\frac{20k\Omega}{3.3k\Omega}
\]

\[
\frac{V_0}{V_S} = -6.06
\]

- **Using the gain,**

\[ V_0 = -6.06 \cdot V_S = -12.12V \]

- **Since no current flows to the negative terminal,**

\[
I_0 = \frac{V_0}{R_2} = \frac{-12.12V}{20k\Omega}
\]

\[ I_0 = -606\mu A \]
Using Ideal Op-Amp Assumptions Determine \( I_1, I_2, \) and \( I_3 \)

* Using the Ideal Op-Amp Assumptions,
  
  \[ V_1 \approx V_- \quad \text{and} \quad I_+ = I_+ = 0 \]

  \[ \Rightarrow I_2 = I_- = 0 \]

* Since no current flows into the inverting input \( I_- \), there is only one path for the current.

  \[ \Rightarrow I_1 = 1 \text{mA} \quad \text{(from diagram)} \]

  \[-I_1 + I_2 + I_3 = 0 \]

  \[ I_3 = I_1 = 1 \text{mA} \]

<table>
<thead>
<tr>
<th>( I_1 )</th>
<th>( I_2 )</th>
<th>( I_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mA</td>
<td>0 mA</td>
<td>1 mA</td>
</tr>
</tbody>
</table>
Find $V_0$

- We note the **inverting op-amp configuration**, and **virtual ground** at the op-amp's negative node.

\[
\frac{V_0}{V_{TN}} = \frac{-5k\Omega}{1k\Omega} = -5
\]

\[
V_0 = -5 \cdot 1V = -5V
\]
FIND $\frac{V_0}{i_s}$

- **We note the inverting op-amp configuration and virtual ground at the op-amp's negative terminal.**

- **Using KCL**

  $$-i_s - i_1 + i_- = 0$$

  $$-i_s = i_1$$

  $$i_1 = \frac{V_0}{R}$$

  $$-i_s = \frac{V_0}{1\Omega}$$

  $$-1 = \frac{V_0}{i_s}$$