The op-amp is ideal, with $V_{CC} = 10\, \text{V}$ and $V_{EE} = -10\, \text{V}$.

\begin{figure}[h]
  \centering
  \includegraphics[width=0.5\textwidth]{figure.png}
  \caption{Op-amp circuit diagram.}
\end{figure}

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
- What is $V_o$ at $t = 3.9\, \text{ms}$?

All voltages in V

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  Waveform at $V_+$ is an decreasing exponential, starting at $V_+ = 0.58 - 0.15 = 0.43$
  \[
  \Delta t = 3.9 - 1.8 = 2.1
  \]
  \[
  \tau = RC = 34.0 \times 21.7 = 737.8\, \mu\text{s} = 0.74\, \text{ms}
  \]
  \[
  V_+(3.9) = 0.43e^{-\Delta t/\tau} = 0.0252
  \]

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
  From $V_+$ to $V_o$ is a non-inverting amplifier of gain, $G = 1 + \frac{77}{33} = 3.33$
  Waveform at $V_o$ is an decreasing exponential, starting at $V_+ = 3.33 \times 0.43 = 1.43$

- What is $V_o$ at $t = 3.9\, \text{ms}$?
  \[
  V_+(3.9) = 1.43e^{-\Delta t/\tau} = 0.084
  \]
The op-amp is ideal, with $V_{CC} = 10 \text{ V}$ and $V_{EE} = -10 \text{ V}$.

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
- What is $V_o$ at $t = 2.9 \text{ ms}$?

All voltages in mV

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  
  $V_+$ is the voltage-divider output from $V_i$.
  
  $V_+ = \left[\frac{5.8}{5.8 + 34.0}\right] V_o = 0.146V_o$

  Thus, output goes from $V_+ = 0.146 \times 20.81 = 3.04$ to $V_+ = 0.146 \times 63.28 = 9.24$

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
  
  Gain, $G = G = 1 + \frac{(1600||1600)}{27} = 30.63$

  Thus, output goes from $V_o = 0.146 \times 20.81 \times 9.31$ to $V_o = 0.146 \times 63.28 \times 283.0$

- What is $V_o$ at $t = 2.9 \text{ ms}$?
  
  $V_o = 0.146 \times 63.28 \times G = 283.0$
The op-amp is ideal, with $V_{CC} = 15\,\text{V}$ and $V_{EE} = -15\,\text{V}$.
Input $V_A = -10\,\text{mV}$ (constant over time).

![Diagram](image)

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
- What is $V_o$ at $t = 2.9\,\text{ms}$?

All voltages in mV
- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)

This is an added circuit

$$V_o = -\left(\frac{1900}{5.1}V_A + \frac{1900}{33}V_B\right) = -(372.5V_A + 57.6V_B)$$

Thus, the output goes from

$V_o = -[372.5(-10) + 57.6(17)] = 2746 = 2.75\,\text{V}$ to
$V_o = -[372.5(-10) + 57.6(20)] = 2573 = 2.57\,\text{V}$

**Test:** Is $V_o \geq V_{CC}$ or $V_o \leq V_{EE}$?

- What is $V_o$ at $t = 2.9\,\text{ms}$?

$V_o = -(372.5(-10) + 57.6(20)) = 2573 = 2.57\,\text{V}$