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

![Diagram of op-amp circuit]

- 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 \(t = 4.2\, \text{ms}\)?

---

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 \(V_+ = 0.72 - 0.25 = 0.47\)
  - \(\Delta t = 4.2 - 1.3 = 2.9\)
  - \(\tau = RC = 25.1 \times 31.6 = 793.16\, \mu\text{s} = 0.79\, \text{ms}\)
  - \(V_+(4.2) = 0.47e^{-\Delta t/\tau} = 0.0120\)

- 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, \(G = 1 + 48/26 = 2.85\)
  - Waveform at \(V_o\) is an decreasing exponential, starting at \(V_+ = 2.85 \times 0.47 = 1.34\)

- What is \(V_o\) at \(t = 4.2\, \text{ms}\)?
  - \(V_+(4.2) = 1.34e^{-\Delta t/\tau} = 0.034\)
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 $t = 3.7 \text{ ms}$?

All voltages in mV

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  $V_+$ is the voltage-divider output from $V_i$.
  $V_+ = \frac{3.6}{3.6 + 25.1} V_o = 0.125 V_o$
  Thus, output goes from $V_+ = 0.125 \times 22.22 = 2.78$ to $V_+ = 0.125 \times 61.16 = 7.64$

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
  Gain, $G = G = 1 + \frac{1300||1300}{32} = 21.31$
  Thus, output goes from $V_o = 0.125 \times 22.22 \times G = 59.2$ to $V_o = 0.125 \times 61.16 \times G = 162.9$

- What is $V_o$ at $t = 3.7 \text{ ms}$?
  $V_o = 0.125 \times 61.16 \times G = 162.9$
The op-amp is ideal, with $V_{CC} = 15\,\text{V}$ and $V_{EE} = -15\,\text{V}$.
Input $V_A = -5\,\text{mV}$ (constant over time).

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

- What is $V_o$ at $t = 3.7\,\text{ms}$?

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

$$V_o = - \left( \frac{1200}{3.8} V_A + \frac{1200}{26} V_B \right) = -(315.8V_A + 46.2V_B)$$

Thus, the output goes from

$V_o = -\lceil 315.8(-5) + 46.2(27) \rceil = 332 = 0.33\,\text{V}$ to

$V_o = -\lceil 315.8(-5) + 46.2(34) \rceil = 8 = 0.01\,\text{V}$

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

- What is $V_o$ at $t = 3.7\,\text{ms}$?

$V_o = -(315.8(-5) + 46.2(34)) = 8 = 0.01\,\text{V}$