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 $t = 4.7\, \text{ms}$?

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 $V_+ = 0.86 - 0.35 = 0.51$
  $\Delta t = 4.7 - 1.7 = 3$
  $\tau = RC = 28.2 \times 21.7 = 611.94\, \mu\text{s} = 0.61\, \text{ms}$
  $V_+(4.7) = 0.51e^{-\Delta t/\tau} = 0.0037$

- 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, $G = 1 + 57/34 = 2.68$
  Waveform at $V_o$ is an decreasing exponential, starting at $V_+ = 2.68 \times 0.51 = 1.37$

- What is $V_o$ at $t = 4.7\, \text{ms}$?
  $V_+(4.7) = 1.37e^{-\Delta t/\tau} = 0.010$
The op-amp is ideal, with $V_{CC} = 10\, \text{V}$ and $V_{EE} = -10\, \text{V}$.

![Op-amp schematic diagram]

- 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 $t = 3.9\, \text{ms}$?

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All voltages in mV

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  $V_+$ is the voltage-divider output from $V_i$.
  
  \[ V_+ = \frac{4.2}{4.2 + 28.2} V_o = 0.130V_o \]
  
  Thus, output goes from $V_+ = 0.130 \times 23.61 = 3.07$ to $V_+ = 0.130 \times 62.99 = 8.19$

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
  
  Gain, $G = G = 1 + (1700||1700)/38 = 23.37$
  
  Thus, output goes from $V_o = 0.130 \times 23.61 \times G = 71.7$ to $V_o = 0.130 \times 62.99 \times G = 191.4$

- What is $V_o$ at $t = 3.9\, \text{ms}$?
  
  $V_o = 0.130 \times 62.99 \times G = 191.4$
The op-amp is ideal, with $V_{CC} = 15\, \text{V}$ and $V_{EE} = -15\, \text{V}$.
Input $V_A = -9\, \text{mV}$ (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 $t = 3.9\, \text{ms}$?

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

$$V_o = -\left( \frac{1400}{4.2} V_A + \frac{1400}{34} V_B \right) = -(333.3V_A + 41.2V_B)$$

Thus, the output goes from
$V_o = -[333.3(-9) + 41.2(37)] = 1475 = 1.48\, \text{V}$ to
$V_o = -[333.3(-9) + 41.2(48)] = 1022 = 1.02\, \text{V}$

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

- What is $V_o$ at $t = 3.9\, \text{ms}$?

$$V_o = -(333.3(-9) + 41.2(48)) = 1022 = 1.02\, \text{V}$$