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 $t = 4.5\, \text{ms}$?

All voltages in $\text{V}$

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  
  Waveform at $V_+$ is an decreasing exponential, starting at $V_+ = 0.62 - 0.16 = 0.46$
  
  $\Delta t = 4.5 - 1.6 = 2.9$
  
  $\tau = RC = 31.3 \times 20.7 = 647.91\, \mu\text{s} = 0.65\, \text{ms}$
  
  $V_+(4.5) = 0.46e^{-\Delta t/\tau} = 0.0053$

- 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, $G = 1 + 74/30 = 3.47$
  
  Waveform at $V_o$ is an decreasing exponential, starting at $V_+ = 3.47 \times 0.46 = 1.60$

- What is $V_o$ at $t = 4.5\, \text{ms}$?
  
  $V_+(4.5) = 1.60e^{-\Delta t/\tau} = 0.018$
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 $t = 4.5\, \text{ms}$?

All voltages in mV

- Sketch the input $V_+$ as a function of the voltage input $V_i$.
  $V_+$ is the voltage-divider output from $V_i$.
  $V_+ = \left[\frac{5.6}{5.6 + 31.3}\right] V_o = 0.152V_o$
  Thus, output goes from $V_+ = 0.152 \times 21.25 = 3.23$ to $V_+ = 0.152 \times 62.37 = 9.48$

- Sketch the output $V_o$ as a function of the voltage input $V_i$. (label times and voltages)
  Gain, $G = G = 1 + \frac{1500||1500}{28} = 27.79$
  Thus, output goes from $V_o = 0.152 \times 21.25 \times 89.8$ to $V_o = 0.152 \times 62.37 \times 263.5$

- What is $V_o$ at $t = 4.5\, \text{ms}$?
  $V_o = 0.152 \times 62.37 \times 263.5$
The op-amp is ideal, with $V_{CC} = 15\, \text{V}$ and $V_{EE} = -15\, \text{V}$.

Input $V_A = -8\, \text{mV}$ (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 $t = 4.5\, \text{ms}$?

### 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

$$V_o = -\left( \frac{1900}{4.7} V_A + \frac{1900}{30} V_B \right) = -(404.3V_A + 63.3V_B)$$

Thus, the output goes from

$V_o = -[404.3(-8) + 63.3(18)] = 2095 = 2.10\, \text{V}$

$V_o = -[404.3(-8) + 63.3(24)] = 1715 = 1.71\, \text{V}$

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

- What is $V_o$ at $t = 4.5\, \text{ms}$?

$V_o = -(404.3(-8) + 63.3(24)) = 1715 = 1.71\, \text{V}$