This is a non-inverting amplifier with a gain of \( G = 1 + \frac{423}{1.05} = 403.9 \).
With such a large gain, it will saturate when \( V_i = \pm 0.025 \) V.

Times when \( |V_i| < 0.025 \) V, are:
\[
T_1 = \pm \frac{0.1 - 0.025}{5\text{ V/100 ms}} = \pm 1.500 \text{ ms.}
\]
\[
T_2 = \pm \frac{0.1 + 0.025}{5\text{ V/100 ms}} = \pm 2.500 \text{ ms.}
\]

- Sketch \( V_o \).
- At what times does \( V_o \) reach \( \pm 10 \) V?
- Does this circuit suffer from multiple transitions?

\( V_o \) reaches \( \pm 10 \) V:

- From start to \(-2.500 \) ms, \( V_o = -10 \) V
- From \(-2.500 \) ms to \(-1.500 \) ms, \( V_o = \) transitions from \(-10 \) V to \(+10 \) V
- From \(-1.500 \) ms to \(0 \) ms, \( V_o = +10 \) V
- From \(0 \) ms to \(+1.500 \) ms, \( V_o = -10 \) V
- From \(+1.500 \) ms to \(+2.500 \) ms, \( V_o = \) transitions from \(-10 \) V to \(+10 \) V
- From \(+2.500 \) ms to end, \( V_o = +10 \) V

\( V_o \) reaches \( \pm 10 \) V:

- From start to \(-2.500 \) ms, \( V_o = -10 \) V
- From \(-1.500 \) ms to \(0 \) ms, \( V_o = +10 \) V
- From \(0 \) ms to \(+1.500 \) ms, \( V_o = -10 \) V
- From \(+2.500 \) ms to end, \( V_o = +10 \) V

- Does this circuit suffer from multiple transitions?
  Yes
• Sketch $V_o$.

• At what times does $V_o$ reach $\pm 10 \text{ V}$?

• Does this circuit suffer from multiple transitions?

(Notes: voltage axis not to scale. The slope of the voltage may be approximated as $5 \text{ V/100 ms}$. Op amps are ideal)

Thresholds at $\pm \frac{1.41 \text{ k}\Omega}{348+1.41 \text{ k}\Omega} \times 10 \text{ V} = \pm 0.040 \text{ V}$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \text{ V}$ and $V_+ = +0.040 \text{ V}$.
2) If $V_i > V_+ \implies V_o = -10 \text{ V}$ and $V_+ = -0.040 \text{ V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.040 \text{ V}$
  2) when $V_i$ crosses $+0.040 \text{ V}$, then $V_o = -10$ and $V_+ = -0.040 \text{ V}$
  3) when $V_i$ crosses $-0.040 \text{ V}$, then $V_o = +10$ and $V_+ = +0.040 \text{ V}$
  4) when $V_i$ crosses $+0.040 \text{ V}$, then $V_o = -10$ and $V_+ = -0.040 \text{ V}$

• At what times does $V_o$ reach $\pm 10 \text{ V}$?
  Transitions at $\pm \frac{0.1-0.040}{5\text{V/100ms}} = \pm 1.20 \text{ ms}$.
  1) Beginning until $-1.20 \text{ ms} \implies V_o = +10 \text{ V}$.
  2) $-1.20 \text{ ms}$ until $0 \text{ ms} \implies V_o = -10 \text{ V}$.
  3) $0 \text{ ms}$ until $+2.80 \text{ ms} \implies V_o = +10 \text{ V}$.
  4) $+2.80 \text{ ms}$ until end $\implies V_o = -10 \text{ V}$.

• Does this circuit suffer from multiple transitions? [Yes]
This is a low pass filter with a gain of $G = -\frac{541\,k\Omega}{15.6\,k\Omega} = -34.68$.
With such a large gain, it will saturate when $V_i = \pm 10\,V / G = \pm 0.288\,V$.
The time constant is $\tau = 541\,k\Omega \times 315\,nF = 170.4\,ms$.

• At what times does $V_o$ reach $\pm 10\,V$?

Transitions at $\pm 0.1 + 0.288 = \pm 7.8\,ms$.
Thus: 1) Begining until $-7.8\,ms \implies V_o = +10\,V$.
2) $+7.8\,ms$ until end $\implies V_o = -10\,V$.

• Sketch $V_o$ (this is difficult because of the exponential – indicate the main features of the curve)

Begining until $-7.8\,ms \implies V_o = +10\,V$. Then, from $+7.8\,ms$ until $-7.8\,ms$ the will go from $+10$ to $-10\,V$, following the flipped the blue line (with gain) but with a slight delay. However, it will only deviate slightly at the zigzag. The time constant $\tau$ is longer than the gap in the zigzag. Finally, from $+7.8\,ms$ until end $\implies V_o = -10\,V$.

• Does this circuit suffer from multiple transitions?

[No]

Explanation: In the above case, the response is linear throughout the +/-0.1V transition of the input signal. The addition of the capacitor turns the circuit into a “lossy integrator”. Its step response would be an exponential with time constant $RC = 170.4\,ms$. We don’t have exactly a step at the input; however, if the input transitions are short compared to the time constant we can approximate the output as an exponential (perhaps with a “bump” $V_i$ briefly changes sign). assuming the input transitions are short compared to $RC$, then $V_o$ will NOT suffer from multiple transitions.