This is a non-inverting amplifier with a gain of \( G = 1 + \frac{431}{1.32} = 327.5 \). With such a large gain, it will saturate when \( V_i = \pm 10 \text{ V} / G = \pm 0.031 \text{ V} \).

Times when \( |V_i| < 0.031, \text{ V} \), are

\[
T_1 = \pm \frac{0.1 - 0.031}{5 \text{ V}/100 \text{ ms}} = \pm 1.380 \text{ ms},
\]

\[
T_2 = \pm \frac{0.1 + 0.031}{5 \text{ V}/100 \text{ ms}} = \pm 2.620 \text{ ms}.
\]

- 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 V/100 ms. Op amps are ideal)
• Sketch $V_o$.

• At what times does $V_o$ reach ±10 V?

• Does this circuit suffer from multiple transitions?

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

Thresholds at $\pm \frac{1.44 \text{k}\Omega}{566 + 1.44 \text{k}\Omega} \times 10 \text{ V} = \pm 0.025 \text{ V}.$

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \text{ V}$ and $V_+ = +0.025 \text{ V}$.
2) If $V_i > V_+ \implies V_o = -10 \text{ V}$ and $V_+ = -0.025 \text{ V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.025 \text{ V}$
  2) when $V_i$ crosses +0.025 V, then $V_o = -10$ and $V_+ = -0.025 \text{ V}$
  3) when $V_i$ crosses −0.025 V, then $V_o = +10$ and $V_+ = +0.025 \text{ V}$
  4) when $V_i$ crosses +0.025 V, then $V_o = -10$ and $V_+ = -0.025 \text{ V}$

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm \frac{0.1 - 0.025}{5 \text{ V}/100 \text{ ms}} = \pm 1.50 \text{ ms}$.
  1) Beginning until −1.50 ms $\implies V_o = +10 \text{ V}$.
  2) −1.50 ms until 0 ms $\implies V_o = -10 \text{ V}$.
  3) 0 ms until +2.50 ms $\implies V_o = +10 \text{ V}$.
  4) +2.50 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 $G = \frac{-396\, \text{k}\Omega}{15.1\, \text{k}\Omega} = -26.23$. With such a large gain, it will saturate when $V_i = \pm 10\, \text{V} / G = \pm 0.381\, \text{V}$.

The time constant is $\tau = 396\, \text{k}\Omega \times 397\, \text{nF} = 157.2\, \text{ms}$.

- At what times does $V_o$ reach $\pm 10\, \text{V}$?
  
  Transitions at $\pm 0.1 + 0.381 = \pm 9.6\, \text{ms}$.
  
  Thus: 1) Beginning until $-9.6\, \text{ms} \implies V_o = +10\, \text{V}$.
  
  2) $+9.6\, \text{ms}$ until end $\implies V_o = -10\, \text{V}$.

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

Begining until $-9.6\, \text{ms} \implies V_o = +10\, \text{V}$. Then, from $+9.6\, \text{ms}$ until $-9.6\, \text{ms}$ the will go from $+10$ to $-10\, \text{V}$, 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 $+9.6\, \text{ms}$ until end $\implies V_o = -10\, \text{V}$.

- 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 $RC = 157.2\, \text{ms}$. 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.