This is a non-inverting amplifier with a gain of \( G = 1 + \frac{565}{141} = 401.7 \).

With such a large gain, it will saturate when \( V_i = \pm \frac{10}{G} = \pm 0.025 \) V.

Times when \( |V_i| < 0.025 \), are

\[
T_1 = \pm \frac{0.1-0.025}{5\text{V/100ms}} = \pm 1.500 \text{ ms.}
\]

\[
T_2 = \pm \frac{0.1+0.025}{5\text{V/100ms}} = \pm 2.500 \text{ ms.}
\]

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

(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 $\pm \frac{1.88 \text{k} \Omega}{566 + 1.88 \text{k} \Omega} \times 10 \text{V} = \pm 0.033 \text{V}$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \text{V}$ and $V_+ = +0.033 \text{V}$.
2) If $V_i > V_+ \implies V_o = -10 \text{V}$ and $V_+ = -0.033 \text{V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.033 \text{V}$
  2) when $V_i$ crosses +0.033 V, then $V_o = -10$ and $V_+ = -0.033 \text{V}$
  3) when $V_i$ crosses −0.033 V, then $V_o = +10$ and $V_+ = +0.033 \text{V}$
  4) when $V_i$ crosses +0.033 V, then $V_o = -10$ and $V_+ = -0.033 \text{V}$

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm \frac{0.1 - 0.033}{5 \text{V}/100 \text{ms}} = \pm 1.34 \text{ms}$.
  1) Beginning until −1.34 ms $\implies V_o = +10 \text{V}$.
  2) −1.34 ms until 0 ms $\implies V_o = -10 \text{V}$.
  3) 0 ms until +2.66 ms $\implies V_o = +10 \text{V}$.
  4) +2.66 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 \( G = \frac{-571 \text{k}\Omega}{15.3 \text{k}\Omega} = -37.32 \).
With such a large gain, it will saturate when \( V_i = \pm 10 \text{V} / G = \pm 0.268 \text{V} \).
The time constant is \( \tau = 571 \text{k}\Omega \times 423 \text{nF} = 241.5 \text{ms} \).

- At what times does \( V_o \) reach \( \pm 10 \text{V} \)?
  Transitions at \( \pm \frac{0.1 + 0.268}{5 \text{V}/100 \text{ms}} = \pm 7.4 \text{ms} \).
  Thus: 1) Beginning until \( -7.4 \text{ms} \rightarrow V_o = +10 \text{V} \).
  2) \( +7.4 \text{ms} \) until end \( \rightarrow V_o = -10 \text{V} \).

- Sketch \( V_o \) (this is difficult because of the exponential – indicate the main features of the curve)
  Begining until \( -7.4 \text{ms} \rightarrow V_o = +10 \text{V} \). Then, from \( +7.4 \text{ms} \) until \( -7.4 \text{ms} \) the will go from \( +10 \text{V} \) 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 \( +7.4 \text{ms} \) until end \( \rightarrow V_o = -10 \text{V} \).

- 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 \( RC = 241.5 \text{ms} \). 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.