This is a non-inverting amplifier with a gain of \( G = 1 + \frac{513}{1.91} = 269.6 \)  
With such a large gain, it will saturate when \( V_i = \pm 10 V/G = \pm 0.037 V \).

Times when \( |V_i| < 0.037, V \), are
\[
T_1 = \pm \frac{0.1 - 0.037}{5 \text{V}/100 \text{ms}} = \pm 1.260 \text{ ms}.
\]
\[
T_2 = \pm \frac{0.1 + 0.037}{5 \text{V}/100 \text{ms}} = \pm 2.740 \text{ ms}.
\]

- 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)

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Thresholds at $\pm 1.71 \text{ k}\Omega \times 313 \text{ k}\Omega = \pm 0.054 \text{ V}$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \text{ V}$ and $V_+ = +0.054 \text{ V}$.
2) If $V_i > V_+ \implies V_o = -10 \text{ V}$ and $V_+ = -0.054 \text{ V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.054 \text{ V}$
  2) when $V_i$ crosses +0.054 V, then $V_o = -10$ and $V_+ = -0.054 \text{ V}$
  3) when $V_i$ crosses -0.054 V, then $V_o = +10$ and $V_+ = +0.054 \text{ V}$
  4) when $V_i$ crosses +0.054 V, then $V_o = -10$ and $V_+ = -0.054 \text{ V}$

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm 0.1 - 0.054 = \pm 0.92 \text{ ms}$.
  1) Beginning until -0.92 ms $\implies V_o = +10 \text{ V}$.
  2) -0.92 ms until 0 ms $\implies V_o = -10 \text{ V}$.
  3) 0 ms until +3.08 ms $\implies V_o = +10 \text{ V}$.
  4) +3.08 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 $G = -\frac{389 \, \text{k}\Omega}{13.3 \, \text{k}\Omega} = -29.25$.
With such a large gain, it will saturate when $V_i = \pm 10 \, \text{V} / G = \pm 0.342 \, \text{V}$.
The time constant is $\tau = 389 \, \text{k}\Omega \times 572 \, \text{nF} = 222.5 \, \text{ms}$.

- At what times does $V_o$ reach $\pm 10 \, \text{V}$?
  Transitions at $\pm \frac{0.1 + 0.342}{5 \, \text{V} / 100 \, \text{ms}} = \pm 8.8 \, \text{ms}$.
  Thus: 1) Beginning until $-8.8 \, \text{ms} \implies V_o = +10 \, \text{V}$.
  2) $+8.8 \, \text{ms}$ 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 $-8.8 \, \text{ms} \implies V_o = +10 \, \text{V}$. Then, from $+8.8 \, \text{ms}$ until $-8.8 \, \text{ms}$ 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 $+8.8 \, \text{ms}$ 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 $RC = 222.5 \, \text{ms}$. 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.