This is a non-inverting amplifier with a gain of $G = 1 + \frac{315}{1.26} = 251.0$. With such a large gain, it will saturate when $V_i = \pm 10 V / G = \pm 0.040 V$.

Times when $|V_i| < 0.040$, V, are

$T_1 = \pm \frac{0.1-0.040}{5\,V/100\,ms} = \pm 1.200$ ms.
$T_2 = \pm \frac{0.1+0.040}{5\,V/100\,ms} = \pm 2.800$ 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 $\pm 10$ 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)

Thresholds at $\pm \frac{1.05 \, k\Omega}{508+1.05 \, k\Omega} \times 10 \, V = \pm 0.021 \, V$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \, V$ and $V_+ = +0.021 \, V$.
2) If $V_i > V_+ \implies V_o = -10 \, V$ and $V_+ = -0.021 \, V$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.021$ V
  2) when $V_i$ crosses $+0.021 \, V$, then $V_o = -10$ and $V_+ = -0.021 \, V$
  3) when $V_i$ crosses $-0.021 \, V$, then $V_o = +10$ and $V_+ = +0.021 \, V$
  4) when $V_i$ crosses $+0.021 \, V$, then $V_o = -10$ and $V_+ = -0.021 \, V$

• At what times does $V_o$ reach $\pm 10$ V?
  Transitions at $\pm \frac{0.1-0.021}{5 \, V/100 \, ms} = \pm 1.58 \, ms$.
  1) Beginning until $-1.58 \, ms \implies V_o = +10 \, V$.
  2) $-1.58 \, ms$ until $0 \, ms \implies V_o = -10 \, V$.
  3) $0 \, ms$ until $+2.42 \, ms \implies V_o = +10 \, V$.
  4) $+2.42 \, ms$ until end $\implies V_o = -10 \, V$.

• Does this circuit suffer from multiple transitions?
  Yes
• Sketch $V_o$ (this is difficult because of the exponential – indicate the main features of the curve)

• 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)

This is a low pass filter with a gain of $G = -\frac{510 \text{k} \Omega}{14.7 \text{k} \Omega} = -34.69$. With such a large gain, it will saturate when $V_i = \pm 10$ V/$G = \pm 0.288$ V. The time constant is $\tau = 510 \text{k} \Omega \times 377 \text{nF} = 192.3$ ms.

• At what times does $V_o$ reach $\pm 10$ V?
  Transitions at $\pm 0.1 + 0.288 = \pm 7.8$ ms.
  Thus: 1) Beginning until $-7.8$ ms $\Rightarrow V_o = +10$ V.
  2) $+7.8$ ms until end $\Rightarrow V_o = -10$ V.

• Sketch $V_o$ (this is difficult because of the exponential – indicate the main features of the curve)
  Beginning until $-7.8$ ms $\Rightarrow V_o = +10$ 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 $\Rightarrow V_o = -10$ 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 $RC = 192.3$ 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.