This is a non-inverting amplifier with a gain of $G = 1 + \frac{378}{191} = 198.9$. With such a large gain, it will saturate when $V_i = \pm 10 V / G = \pm 0.050 V$.

Times when $|V_i| < 0.050$, V, are

$T_1 = \pm \frac{0.1 - 0.050}{5 V/100 ms} = \pm 1.000$ ms.
$T_2 = \pm \frac{0.1 + 0.050}{5 V/100 ms} = \pm 3.000$ ms.

- Sketch $V_o$.
  1) From start to $-3.000$ ms, $V_o = -10 V$
  2) From $-3.000$ ms to $-1.000$ ms, $V_o$ = transitions from $-10 V$ to $+10 V$
  3) From $-1.000$ ms to 0 ms, $V_o = +10 V$
  4) From 0 ms to $+1.000$ ms, $V_o = -10 V$
  5) From $+1.000$ ms to $+3.000$ ms, $V_o$ = transitions from $-10 V$ to $+10 V$
  6) From $+3.000$ ms to end, $V_o = +10 V$

- At what times does $V_o$ reach $\pm 10 V$?
  1) From start to $-3.000$ ms, $V_o = -10 V$
  3) From $-1.000$ ms to 0 ms, $V_o = +10 V$
  4) From 0 ms to $+1.000$ ms, $V_o = -10 V$
  6) From $+3.000$ 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 ±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 $\pm \frac{1.26 \text{k}\Omega}{365 + 1.26 \text{k}\Omega} \times 10 \text{V} = \pm 0.034 \text{V}$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10 \text{V}$ and $V_+ = +0.034 \text{V}$.
2) If $V_i > V_+ \implies V_o = -10 \text{V}$ and $V_+ = -0.034 \text{V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.034 \text{V}$
  2) when $V_i$ crosses $+0.034 \text{V}$, then $V_o = -10$ and $V_+ = -0.034 \text{V}$
  3) when $V_i$ crosses $-0.034 \text{V}$, then $V_o = +10$ and $V_+ = +0.034 \text{V}$
  4) when $V_i$ crosses $+0.034 \text{V}$, then $V_o = -10$ and $V_+ = -0.034 \text{V}$

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm \frac{0.1 - 0.034}{5 \text{V}/100 \text{ms}} = \pm 1.32 \text{ms}$.
  1) Beginning until $-1.32 \text{ms} \implies V_o = +10 \text{V}$.
  2) $-1.32 \text{ms}$ until $0 \text{ms} \implies V_o = -10 \text{V}$.
  3) $0 \text{ms}$ until $+2.68 \text{ms} \implies V_o = +10 \text{V}$.
  4) $+2.68 \text{ms}$ until end $\implies V_o = -10 \text{V}$.

• 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 ±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 $G = \frac{-465 \, \text{k}\Omega}{17.5 \, \text{k}\Omega} = -26.57$.
With such a large gain, it will saturate when $V_i = \pm 10 \, \text{V} / G = \pm 0.376 \, \text{V}$.
The time constant is $\tau = 465 \, \text{k}\Omega \times 573 \, \text{nF} = 266.4 \, \text{ms}$.

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm \frac{0.1 + 0.376}{5 \, \text{V/100 ms}} = \pm 9.5 \, \text{ms}$.
  Thus: 1) Beginning until $-9.5 \, \text{ms} \implies V_o = +10 \, \text{V}$.  
    2) +9.5 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)
  Beginning until $-9.5 \, \text{ms} \implies V_o = +10 \, \text{V}$. Then, from +9.5 ms until −9.5 ms the will go from +10 to −10 V, following the flipped 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 +9.5 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 $RC = 266.4 \, \text{ms}$. 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.