This is a non-inverting amplifier with a gain of $G = 1 + \frac{406}{190} = 214.7$. With such a large gain, it will saturate when $V_i = \pm 10 V/G = \pm 0.047 V$.

Times when $|V_i| < 0.047 V$, are

$T_1 = \pm \frac{0.1-0.047}{5V/100ms} = \pm 1.060 \text{ ms}$.

$T_2 = \pm \frac{0.1+0.047}{5V/100ms} = \pm 2.940 \text{ ms}$.

- 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 $\pm 10$ 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 $\pm \frac{1.35 \, \text{k}\Omega}{319 + 1.35 \, \text{k}\Omega} \times 10 \, \text{V} = \pm 0.042 \, \text{V}$.

Conditions:
1) If $V_i < V_+$ $\implies V_o = +10$ V and $V_+ = +0.042$ V.
2) If $V_i > V_+$ $\implies V_o = -10$ V and $V_+ = -0.042$ V.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.042$ V
  2) when $V_i$ crosses +0.042 V, then $V_o = -10$ and $V_+ = -0.042$ V
  3) when $V_i$ crosses −0.042 V, then $V_o = +10$ and $V_+ = +0.042$ V
  4) when $V_i$ crosses +0.042 V, then $V_o = -10$ and $V_+ = -0.042$ V

• At what times does $V_o$ reach $\pm 10$ V?
  Transitions at $\pm \frac{0.1 - 0.042}{5 \, \text{V} / 100 \, \text{ms}} = \pm 1.16 \, \text{ms}$.
  1) Beginning until $-1.16 \, \text{ms} \implies V_o = +10$ V.
  2) $-1.16 \, \text{ms}$ until $0$ ms $\implies V_o = -10$ V.
  3) $0$ ms until $+2.84$ ms $\implies V_o = +10$ V.
  4) $+2.84$ ms until end $\implies V_o = -10$ V.

• Does this circuit suffer from multiple transitions?
  Yes
This is a low pass filter with a gain of $G = \frac{-384 \text{k}\Omega}{10.8 \text{k}\Omega} = -35.56$.

With such a large gain, it will saturate when $V_i = \pm 10 V / G = \pm 0.281 V$.

The time constant is $\tau = 384 \text{k}\Omega \times 571 \text{nF} = 219.3 \text{ms}$.

- At what times does $V_o$ reach $\pm 10 V$?
  
  Transitions at $\pm \frac{0.1 + 0.281}{5 \text{V}/100 \text{ms}} = \pm 7.6 \text{ms}$.
  
  Thus: 1) Beginning until $-7.6 \text{ms} \implies V_o = +10 \text{V}$.
  
  2) $+7.6 \text{ms}$ 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 $-7.6 \text{ms} \implies V_o = +10 \text{V}$. Then, from $+7.6 \text{ms}$ until $-7.6 \text{ms}$ 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 $+7.6 \text{ms}$ 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 $RC = 219.3 \text{ ms}$. 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.