This is a non-inverting amplifier with a gain of $G = 1 + \frac{558}{1.83} = 305.9$. With such a large gain, it will saturate when $V_i = \pm10 V / G = \pm 0.033 V$.

Times when $|V_i| < 0.033$ V, are

$T_1 = \pm \frac{0.1-0.033}{5 V/100 \text{ ms}} = \pm 1.340 \text{ ms}$.

$T_2 = \pm \frac{0.1+0.033}{5 V/100 \text{ ms}} = \pm 2.660 \text{ ms}$.

- Sketch $V_o$.
  
- At what times does $V_o$ reach $\pm10$ 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)

\[
\text{Thresholds at } \pm \frac{1.86\, k\Omega}{560+1.86\, k\Omega} \times 10\, V = \pm 0.033\, V.
\]

Conditions:
1) If $V_i < V_+$ \(\Rightarrow\) $V_o = +10\, V$ and $V_+ = +0.033\, V$.
2) If $V_i > V_+$ \(\Rightarrow\) $V_o = -10\, V$ and $V_+ = -0.033\, V$.

• Sketch $V_o$.

1) Initially, $V_o = +10$ and $V_+ = +0.033\, V$
2) when $V_i$ crosses $+0.033\, V$, then $V_o = -10$ and $V_+ = -0.033\, V$
3) when $V_i$ crosses $-0.033\, V$, then $V_o = +10$ and $V_+ = +0.033\, V$
4) when $V_i$ crosses $+0.033\, V$, then $V_o = -10$ and $V_+ = -0.033\, V$

• At what times does $V_o$ reach $\pm 10\, V$?

Transitions at $\pm \frac{0.1-0.033}{5\, V/100\, ms} = \pm 1.34\, ms$.
1) Beginning until $-1.34\, ms \Rightarrow V_o = +10\, V$.
2) $-1.34\, ms$ until $0\, ms \Rightarrow V_o = -10\, V$.
3) $0\, ms$ until $+2.66\, ms \Rightarrow V_o = +10\, V$.
4) $+2.66\, ms$ until end \(\Rightarrow\) $V_o = -10\, V$.

• Does this circuit suffer from multiple transitions?

Yes
This is a low pass filter with a gain of $G = \frac{-326 \text{k}\Omega}{16.9 \text{k}\Omega} = -19.29$. With such a large gain, it will saturate when $V_i = \pm 10 \text{ V} / G = \pm 0.518 \text{ V}$.

The time constant is $\tau = 326 \text{k}\Omega \times 550 \text{nF} = 179.3 \text{ ms}$.

- At what times does $V_o$ reach $\pm 10 \text{ V}$?
  
  Transitions at $\pm \frac{0.1+0.518}{5 \text{ V}/100 \text{ ms}} = \pm 12.4 \text{ ms}$.
  
  Thus: 1) Beginning until $-12.4 \text{ ms} \implies V_o = +10 \text{ V}$.
  
  2) $+12.4 \text{ ms}$ 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 $-12.4 \text{ ms} \implies V_o = +10 \text{ V}$. Then, from $+12.4 \text{ ms}$ until $-12.4 \text{ ms}$ 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 $+12.4 \text{ ms}$ 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 $RC = 179.3 \text{ ms}$. 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.