This is a non-inverting amplifier with a gain of $G = 1 + \frac{579}{1.67} = 347.7$.

With such a large gain, it will saturate when $V_i = \pm 10 V / G = \pm 0.029 V$.

Times when $|V_i| < 0.029$, V, are

$T_1 = \pm \frac{0.1 - 0.029}{5 V/100 ms} = \pm 1.420$ ms.
$T_2 = \pm \frac{0.1 + 0.029}{5 V/100 ms} = \pm 2.580$ ms.

Sketch $V_o$.

1) From start to $-2.580$ ms, $V_o = -10$ V
2) From $-2.580$ ms to $-1.420$ ms, $V_o$ = transitions from $-10$ V to $+10$ V
3) From $-1.420$ ms to $0$ ms, $V_o = +10$ V
4) From $0$ ms to $+1.420$ ms, $V_o = -10$ V
5) From $+1.420$ ms to $+2.580$ ms, $V_o$ = transitions from $-10$ V to $+10$ V
6) From $+2.580$ ms to end, $V_o = +10$ V

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

1) From start to $-2.580$ ms, $V_o = -10$ V
3) From $-1.420$ ms to $0$ ms, $V_o = +10$ V
4) From $0$ ms to $+1.420$ ms, $V_o = -10$ V
6) From $+2.580$ ms to end, $V_o = +10$ V

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 $\pm \frac{1.93\,\text{k}\Omega}{324+1.93\,\text{k}\Omega} \times 10\,\text{V} = \pm 0.059\,\text{V}$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10\,\text{V}$ and $V_+ = +0.059\,\text{V}$.
2) If $V_i > V_+ \implies V_o = -10\,\text{V}$ and $V_+ = -0.059\,\text{V}$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.059\,\text{V}$
  2) when $V_i$ crosses +0.059 V, then $V_o = -10$ and $V_+ = -0.059\,\text{V}$
  3) when $V_i$ crosses −0.059 V, then $V_o = +10$ and $V_+ = +0.059\,\text{V}$
  4) when $V_i$ crosses +0.059 V, then $V_o = -10$ and $V_+ = -0.059\,\text{V}$

• At what times does $V_o$ reach ±10 V?
  Transitions at $\pm \frac{0.1-0.059}{5\,\text{V}/100\,\text{ms}} = \pm 0.82\,\text{ms}$.
  1) Beginning until $-0.82\,\text{ms} \implies V_o = +10\,\text{V}$.
  2) $-0.82\,\text{ms}$ until $0\,\text{ms} \implies V_o = -10\,\text{V}$.
  3) $0\,\text{ms}$ until $+3.18\,\text{ms} \implies V_o = +10\,\text{V}$.
  4) $+3.18\,\text{ms}$ 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 \( G = \frac{-557 \, \text{k}\Omega}{14.3 \, \text{k}\Omega} = -38.95 \).

With such a large gain, it will saturate when \( V_i = \pm 10 \, \text{V} / G = \pm 0.257 \, \text{V} \).

The time constant is \( \tau = 557 \, \text{k}\Omega \times 500 \, \text{nF} = 278.5 \, \text{ms} \).

- At what times does \( V_o \) reach \( \pm 10 \, \text{V} \)?
  
  Transitions at \( \pm \frac{0.1 + 0.257}{5 \, \text{V} / 100 \, \text{ms}} = \pm 7.1 \, \text{ms} \).
  
  Thus: 1) Beginning until \( -7.1 \, \text{ms} \implies V_o = +10 \, \text{V} \).  
  
  2) \( +7.1 \, \text{ms} \) 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)

  Beginng until \( -7.1 \, \text{ms} \implies V_o = +10 \, \text{V} \). Then, from \( +7.1 \, \text{ms} \) until \( -7.1 \, \text{ms} \) 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 \( +7.1 \, \text{ms} \) 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 \( RC = 278.5 \, \text{ms} \). 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.