This is a non-inverting amplifier with a gain of \( G = 1 + \frac{314}{1.67} = 189.0 \).

With such a large gain, it will saturate when \( V_i = \pm 10 \text{ V} / G = \pm 0.053 \text{ V} \).

Times when \( |V_i| < 0.053 \), are

\[
T_1 = \pm \frac{0.1 - 0.053}{5 \text{ V/100 ms}} = \pm 0.940 \text{ ms}.
\]

\[
T_2 = \pm \frac{0.1 + 0.053}{5 \text{ V/100 ms}} = \pm 3.060 \text{ ms}.
\]

- Sketch \( V_o \).
- At what times does \( V_o \) reach \( \pm 10 \text{ V} \)?
- Does this circuit suffer from multiple transitions?

(Note: 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 \( \pm \frac{1.05 \text{k}\Omega}{543 + 1.05 \text{k}\Omega} \times 10 \text{V} = \pm 0.019 \text{V} \).

Conditions:
1) If \( V_i < V_+ \implies V_o = +10 \text{V} \) and \( V_+ = +0.019 \text{V} \).
2) If \( V_i > V_+ \implies V_o = -10 \text{V} \) and \( V_+ = -0.019 \text{V} \).

• Sketch \( V_o \).
  
  1) Initially, \( V_o = +10 \) and \( V_+ = +0.019 \text{V} \)
  
  2) when \( V_i \) crosses +0.019 V, then \( V_o = -10 \) and \( V_+ = -0.019 \text{V} \)
  
  3) when \( V_i \) crosses -0.019 V, then \( V_o = +10 \) and \( V_+ = +0.019 \text{V} \)
  
  4) when \( V_i \) crosses +0.019 V, then \( V_o = -10 \) and \( V_+ = -0.019 \text{V} \)

• At what times does \( V_o \) reach \( \pm 10 \) V?

  Transitions at \( \pm \frac{0.1 - 0.019}{5 \text{V}/100 \text{ms}} = \pm 1.62 \text{ms} \).

  1) Beginning until \(-1.62 \text{ms} \implies V_o = +10 \text{V} \).

  2) \(-1.62 \text{ms} \) until \(0 \text{ms} \implies V_o = -10 \text{V} \).

  3) \(0 \text{ms} \) until \(+2.38 \text{ms} \implies V_o = +10 \text{V} \).

  4) \(+2.38 \text{ms} \) 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 $\pm 10$ 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 $G = -\frac{312 \, \text{k}\Omega}{17.2 \, \text{k}\Omega} = -18.14$.
With such a large gain, it will saturate when $V_i = \pm 10$ V/$G = \pm 0.551$ V.
The time constant is $\tau = 312 \, \text{k}\Omega \times 502 \, \text{nF} = 156.6$ ms.

• At what times does $V_o$ reach $\pm 10$ V?
  Transitions at $\pm 0.1 + 0.551 = \pm 13.0$ ms.
  Thus: 1) Beginning until $-13.0$ ms $\implies V_o = +10$ V.
       2) $+13.0$ ms until end $\implies V_o = -10$ V.

• Sketch $V_o$ (this is difficult because of the exponential – indicate the main features of the curve)
  Beginning until $-13.0$ ms $\implies V_o = +10$ V. Then, from $+13.0$ ms until $-13.0$ 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 $+13.0$ ms until end $\implies V_o = -10$ 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 $RC = 156.6$ 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.