This is a non-inverting amplifier with a gain of $G = 1 + \frac{416}{147} = 284.0$.
With such a large gain, it will saturate when $V_i = \pm 10 \text{ V}/G = \pm 0.035 \text{ V}$.

Times when $|V_i| < 0.035$, are

$T_1 = \pm \frac{0.1 - 0.035}{5 \text{ V}/100 \text{ ms}} = \pm 1.300 \text{ ms}$.
$T_2 = \pm \frac{0.1 + 0.035}{5 \text{ V}/100 \text{ ms}} = \pm 2.700 \text{ ms}$.

- Sketch $V_o$.
  1) From start to $-2.700 \text{ ms}$, $V_o = -10 \text{ V}$
  2) From $-2.700 \text{ ms}$ to $-1.300 \text{ ms}$, $V_o$ transitions from $-10 \text{ V}$ to $+10 \text{ V}$
  3) From $-1.300 \text{ ms}$ to $0 \text{ ms}$, $V_o = +10 \text{ V}$
  4) From $0 \text{ ms}$ to $+1.300 \text{ ms}$, $V_o = -10 \text{ V}$
  5) From $+1.300 \text{ ms}$ to $+2.700 \text{ ms}$, $V_o$ transitions from $-10 \text{ V}$ to $+10 \text{ V}$
  6) From $+2.700 \text{ ms}$ to end, $V_o = +10 \text{ V}$

- At what times does $V_o$ reach $\pm 10 \text{ V}$?
  1) From start to $-2.700 \text{ ms}$, $V_o = -10 \text{ V}$
  3) From $-1.300 \text{ ms}$ to $0 \text{ ms}$, $V_o = +10 \text{ V}$
  4) From $0 \text{ ms}$ to $+1.300 \text{ ms}$, $V_o = -10 \text{ V}$
  6) From $+2.700 \text{ ms}$ to end, $V_o = +10 \text{ V}$

- Does this circuit suffer from multiple transitions?
  Yes
• 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 \( \pm \frac{1.39 \, k\Omega}{463 + 1.39 \, k\Omega} \times 10 \, V = \pm 0.030 \, V \).

Conditions:
1) If \( V_i < V_+ \implies V_o = +10 \, V \) and \( V_+ = +0.030 \, V \).
2) If \( V_i > V_+ \implies V_o = -10 \, V \) and \( V_+ = -0.030 \, V \).

• Sketch \( V_o \).
  1) Initially, \( V_o = +10 \, V \) and \( V_+ = +0.030 \, V \)
  2) when \( V_i \) crosses +0.030 V, then \( V_o = -10 \, V \) and \( V_+ = -0.030 \, V \)
  3) when \( V_i \) crosses -0.030 V, then \( V_o = +10 \, V \) and \( V_+ = +0.030 \, V \)
  4) when \( V_i \) crosses +0.030 V, then \( V_o = -10 \, V \) and \( V_+ = -0.030 \, V \)

• At what times does \( V_o \) reach \( \pm 10 \) V?
  Transitions at \( \pm \frac{0.1 - 0.030}{5 \, V/100 \, ms} = \pm 1.40 \, ms \).
  1) Beginning until \(-1.40 \, ms \implies V_o = +10 \, V \).
  2) \(-1.40 \, ms \) until 0 ms \( \implies V_o = -10 \, V \).
  3) 0 ms until +2.60 ms \( \implies V_o = +10 \, V \).
  4) +2.60 ms until end \( \implies V_o = -10 \, V \).

• 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 $G = \frac{-430 \text{k}\Omega}{19.6 \text{k}\Omega} = -21.94$.

With such a large gain, it will saturate when $V_i = \pm 10$ V $/ G = \pm 0.456$ V.

The time constant is $\tau = 430 \text{k}\Omega \times 440 \text{nF} = 189.2$ ms.

- At what times does $V_o$ reach $\pm 10$ V?
  Transitions at $\pm \frac{0.1 + 0.456}{5 \text{V}/100 \text{ms}} = \pm 11.1$ ms.
  Thus: 1) Beginning until $-11.1$ ms $\iff V_o = +10$ V.
  2) $+11.1$ ms until end $\iff V_o = -10$ V.

- Sketch $V_o$ (this is difficult because of the exponential – indicate the main features of the curve)

Beginning until $-11.1$ ms $\iff V_o = +10$ V. Then, from $+11.1$ ms until $-11.1$ 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 $+11.1$ ms until end $\iff V_o = -10$ 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 $RC = 189.2$ 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.