This is a non-inverting amplifier with a gain of $G = 1 + \frac{526}{143} = 368.8$. With such a large gain, it will saturate when $V_i = \pm 10 V/G = \pm 0.027 V$.

Times when $|V_i| < 0.027$, V, are

$T_1 = \pm \frac{0.1-0.027}{5/V/100\text{ms}} = \pm 1.460 \text{ms}$.
$T_2 = \pm \frac{0.1+0.027}{5/V/100\text{ms}} = \pm 2.540 \text{ms}$.

• Sketch $V_o$.
  1) From start to $-2.540 \text{ ms}$, $V_o = -10 V$
  2) From $-2.540 \text{ ms}$ to $-1.460 \text{ ms}$, $V_o$ = transitions from $-10 V$ to $+10 V$
  3) From $-1.460 \text{ ms}$ to $0 \text{ ms}$, $V_o = +10 V$
  4) From $0 \text{ ms}$ to $+1.460 \text{ ms}$, $V_o = -10 V$
  5) From $+1.460 \text{ ms}$ to $+2.540 \text{ ms}$, $V_o$ = transitions from $-10 V$ to $+10 V$
  6) From $+2.540 \text{ ms}$ to end, $V_o = +10 V$

• At what times does $V_o$ reach $\pm 10 V$?
  1) From start to $-2.540 \text{ ms}$, $V_o = -10 V$
  3) From $-1.460 \text{ ms}$ to $0 \text{ ms}$, $V_o = +10 V$
  4) From $0 \text{ ms}$ to $+1.460 \text{ ms}$, $V_o = -10 V$
  6) From $+2.540 \text{ ms}$ to end, $V_o = +10 V$

• 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 $\pm \frac{1.75\,k\Omega}{505 + 1.75\,k\Omega} \times 10\,V = \pm 0.035\,V$.

Conditions:
1) If $V_i < V_+ \implies V_o = +10\,V$ and $V_+ = +0.035\,V$.
2) If $V_i > V_+ \implies V_o = -10\,V$ and $V_+ = -0.035\,V$.

• Sketch $V_o$.
  1) Initially, $V_o = +10$ and $V_+ = +0.035\,V$
  2) when $V_i$ crosses $+0.035\,V$, then $V_o = -10$ and $V_+ = -0.035\,V$
  3) when $V_i$ crosses $-0.035\,V$, then $V_o = +10$ and $V_+ = +0.035\,V$
  4) when $V_i$ crosses $+0.035\,V$, then $V_o = -10$ and $V_+ = -0.035\,V$

• At what times does $V_o$ reach $\pm 10\,V$?
  Transitions at $\pm \frac{0.1 - 0.035}{5\,V/100\,ms} = \pm 1.30\,ms$.
    1) Beginning until $-1.30\,ms \implies V_o = +10\,V$.
    2) $-1.30\,ms$ until $0\,ms \implies V_o = -10\,V$.
    3) $0\,ms$ until $+2.70\,ms \implies V_o = +10\,V$.
    4) $+2.70\,ms$ 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 \( G = \frac{-512 \, k\Omega}{14.6 \, k\Omega} = -35.07 \).

With such a large gain, it will saturate when \( V_i = \pm 10 \, V / G = \pm 0.285 \, V \).

The time constant is \( \tau = 512 \, k\Omega \times 429 \, nF = 219.6 \, ms \).

- At what times does \( V_o \) reach \( \pm 10 \, V \)?
  
  Transitions at \( \pm \frac{0.1 + 0.285}{5 \, V / 100 \, ms} = \pm 7.7 \, ms \).
  
  Thus: 1) Begining until \(-7.7 \, ms \implies V_o = +10 \, V \).
  
  2) \(+7.7 \, ms \) until end \( \implies V_o = -10 \, V \).

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

  Begining until \(-7.7 \, ms \implies V_o = +10 \, V \). Then, from \(+7.7 \, ms \) until \(-7.7 \, ms \) the will go from \(+10 \, V \) 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 \(+7.7 \, ms \) 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 \( RC = 219.6 \, ms \). 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.