

Problem 7

a) Assumptions/Notation:

- All additions/subtractions are done modulo 1024.
- $[a, a + b]$ is the range of values $a, a + 1, a + 2, \dots, a + b$.
- “The next in-order packet that the receiver is expecting has sequence number k ”
 \Rightarrow the receiver has successfully received packet $k - 1$.

Case: All ACKs are received

Sender received ACK for packet $k - 1$.

Sender's window: $[k, k + 2]$.

Case: No ACK received

Sequence numbers in receiver's window $[k - 3, k - 1]$.

\Rightarrow ACKs transmitted but not received $[k - 3, k - 1]$.

Sender's window: $[k - 3, k - 1]$.

Therefore, the possible ranges are: $[k - 3, k - 1]$, $[k - 2, k]$, $[k - 1, k + 1]$, $[k, k + 2]$.

b) ACK k cannot be propagating at time t .

Minimum sequence number in sender's window: $k - 3$ (second case in part (a)) implies that ACK $(k - 4)$ has been received, and ACKs $k - 3, k - 2, k - 1$ are in transit.

Note that **another** ACK $(k - 4)$ may be in transit if the sender timed out, re-sent packet $(k - 4)$, and both the original and duplicate packets arrived intact at the receiver. The first reception would advance the receiver's window, and the second reception would trigger the propagating ACK $(k - 4)$.

Thus, the range of in-flight ACKs: $[k - 4, k - 1]$.
