Question 3 by Dan Nguyen (z5206032)

A string, S, of size n is constructed from an alphabet, A, of size k. S has all k characters of the alphabet appear at least once.

Let s be the *substring* of S which is a contiguous sequence of characters within S.

Use a modified sliding window algorithm which has an expected time-complexity $O(n)$.

Let there be a variable, U, to keep count of unique characters, and is initially zero.

Let the sliding window, W, have a capacity, m, with an initial size, k. For each character, c, in W, if c has not been encountered before in W, increment U. This will have an expected time-complexity of $O(m) \leq O(n)$.

When U is equal to k, then W will contain all k unique characters and the length of the shortest *substring* is m.

If S has been completely screened, and U is not equal to k, then increment the capacity of W, and re-screen S until $m > n$. This will have an expected time-complexity of $O(n - m) \leq O(n)$. Therefore, giving a final expected time-complexity of $O(n)$.