Express formally that $L$ is a longest sorted sublist of $M$ where

Let $T$ be the type of item in the lists.

(a) the sublist must be consecutive items (a segment).

Define relation $S$ so that $S L M$ says that list $L$ is a sorted segment of list $M$ as follows:

$$S = \langle L, M : [*T] \cdot \exists i, j : \text{nat} \cdot 0 \leq i < j \leq \#L \land L = M[i..j] \land \forall k, l : \text{nat} \cdot i \leq k \leq l \leq j \Rightarrow M[k] \leq M[l] \rangle$$

The answer is $S L M \land \neg \exists K : [*T] \cdot S K M \land \#K > \#L$.

This question can be interpreted differently. It might mean that $L$ is a sorted segment of $M$ that cannot be extended on either end to be a longer sorted segment. In other words, that it is locally longest, rather than globally longest.

(b) the sublist must be consecutive (a segment) and nonempty.

Define relation $S$ so that $S L M$ says that list $L$ is a sorted nonempty segment of list $M$ as follows ($T$ is the type of item in the lists):

$$S = \langle L, M : [*T] \cdot \exists i, j : \text{nat} \cdot 0 < i < j \leq \#L \land L = M[i..j] \land \forall k, l : \text{nat} \cdot i \leq k \leq l \leq j \Rightarrow M[k] \leq M[l] \rangle$$

The answer is $S L M \land \neg \exists K : [*T] \cdot S K M \land \#K > \#L$.

(c) the sublist contains items in their order of appearance in $M$, but not necessarily consecutively (not necessarily a segment).

Define (domains are lists)

$$S = \langle L, M : [*T] \cdot \#L = 0 \lor \exists i : \square M \cdot L_0 = M[i] \land S(L[1..\#L]) \land (M[i+1..\#M]) \rangle$$

so $S L M$ means that $L$ is a sublist of $M$ with items in the same order but not necessarily consecutively. Then the desired expression is

$$S L M \land \neg \exists K : [*T] \cdot S K M \land \#K > \#L$$

Another solution might be

$$\exists N : [*T] \cdot \#N = \#L \land \#N + \#N \leq \#M \land \forall i : \square L \cdot L_i = M((\#N[0..i+1]) + i)$$

but I'm not sure.