1. Consider the following TSGs:
   \[ G_1: \]
   \[ S \rightarrow A \quad S \rightarrow A \quad T \rightarrow a \quad T \rightarrow b \]
   \[ G_2: \]
   \[ S \rightarrow A \quad A \rightarrow B \quad a \quad B \rightarrow B \quad b \]

We assume that these TSGs have both a start symbol, namely S. I.e., only trees with root symbol S are in the tree language.

(a) What are the string languages generated by the two TSGs?

Solution:
Both generate the same language, namely \( \{a^nb^k \mid n, k \geq 1\} \).

(b) Decide for each of the TSGs whether it can be strongly lexicalized, i.e., whether a lexicalized TSG exists that generates the same set of trees. If so, give such a TSG. If not, explain why not and give a strongly equivalent LTAG.

Solution:

\( G_1 \) can be strongly lexicalized:
\[ S \rightarrow A \quad S \rightarrow A \quad T \rightarrow a \quad T \rightarrow b \]
\[ \quad A \rightarrow a \quad B \rightarrow b \]

\( G_2 \) cannot be strongly lexicalized since for each \( n \), one can find a tree in the language with all path lengths being greater than \( n \).

Equivalent LTAG:
\[ S \rightarrow A \quad A \rightarrow B \quad a \quad B \rightarrow b \]
\[ \quad A \rightarrow a \quad B \rightarrow b \]

2. Consider the following direct question involving the object raising verb “consider”:

(1) \textit{Whom did Kim consider acceptable?}

(a) Give the elementary trees of an FTAG \( G \), that derives (1). Make use of the following features (such as in the lecture):

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP</td>
<td>indicates presence of complementizer (that, nil)</td>
</tr>
<tr>
<td>WH</td>
<td>indicates presence of wh-phrase</td>
</tr>
<tr>
<td>INV</td>
<td>indicates do-support</td>
</tr>
<tr>
<td>AGR</td>
<td>agreement of number and person</td>
</tr>
<tr>
<td>CASE</td>
<td>case agreement</td>
</tr>
<tr>
<td>CASE-ASSIGN</td>
<td>for exceptional case marking</td>
</tr>
</tbody>
</table>
Remember that, in the case of direct questions, the root node’s feature structure (after top-bottom unification) has to look like this:

\[
S \left[ \text{wh} + \right]
\]

Solution:

\[
S\left[ \right]
\]

\[
\text{NP} \left[ \right]
\]

\[
\text{VP} \left[ \right]
\]

\[
\text{V} \left[ \right]
\]

\[
\text{AUX} \left[ \right]
\]

\[
\text{S*} \left[ \right]
\]

\[
\text{S*} \left[ \right]
\]

\[
\text{S*} \left[ \right]
\]

\[
\text{S*} \left[ \right]
\]

(b) Give the derivation tree (including Gorn addresses) and the derived tree (either before or after top-bottom unification) of (1) according to \( G \).

Solution:

Derivation tree:

\[
\text{acceptable}
\]

\[
\text{whom} \]

\[
\text{consider}
\]

\[
\text{did}
\]

\[
\text{Kim}
\]

\[
\text{whom}
\]
3. Consider the following nominal phrase and the accompanied relative clause:

(2) the temperature at which Kim said ice melts

(a) Give the elementary trees of an FTAG $G$, that derives (2). Make use of the features in exercise 2 (such as in the lecture), if applicable.

Remember that relative clauses adjoin to NP nodes. Internally, however, we assume relative clauses to have the same structure as indirect questions!

Solution:

(b) Give the derivation tree (including Gorn addresses) and the derived tree (either before or after top-bottom unification) of (2) according to $G$.

Solution:
Viel Erfolg!