HUMBOLDT-UNIVERSITÄT ZU BERLIN

LaTeX for Linguists

LaTeX 7: Math mode 2 & trees

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Contents

1. Math mode 2
   - Non-exhaustive lists of symbols
   - Example: Set theory
   - Example: Propositional Logic
   - Example: Quantifiers
   - Meaning brackets
   - Writing formulae
2. Trees
   - Loading forest
   - forest syntax
   - Trees in example environments
   - Abbreviating nodes
   - Glossing or translating
   - Sub- and superscript
   - Arrows
   - Marking nodes
   - Syllabic structures
   - Further features

1 Math mode 2

2 Trees

Non-exhaustive lists of symbols

Symbols you could need (the following lists are by no means exhaustive):

$=$	`=`	$\sim$	`\sim`	∞	`\infty`
$\pm$	`\pm`	$\approx$	`\approx`	$\emptyset$	`\emptyset`
$\cdot$	`\cdot`	$\subset$	`\subset`	$\Box$	`\Box`
$\times$	`\times`	$\supset$	`\supset`	$\%$	`\%`
$\circ$	`\circ`	$\subseteq$	`\subseteq`	$\$$	`\$`
$\in$	`\in`	$\cap$	`\cap`	$\&$	`\&`
$\ni$	`\ni`	$\cup$	`\cup`	$\#$	`\#`
$\neq$	`\neq`	$\forall$	`\forall`	$\backslash$	`\backslash`
$\leq$	`\leq`	$\exists$	`\exists`	$\dots$	`\dots`
$\geq$	`\geq`	$\land$	`\land`	$<$	`<`
$\ll$	`\ll`	$\lor$	`\lor`	$>$	`>`
$\gg$	`\gg`	$\lnot$	`\lnot`		

Table 1: Some non-specific symbols

$\rightarrow$	`\rightarrow`	$\Downarrow$	`\Downarrow`	$\{\}$	`\{\}`
$\leftarrow$	`\leftarrow`	$\mapsto$	`\mapsto`	$\mathcal{A}$	`\mathcal{A}`
$\leftrightarrow$	`\leftrightarrow`	$\leadsto$	`\leadsto`	$\mathfrak{A}$	`\mathfrak{A}`
$\Rightarrow$	`\Rightarrow`	$\xrightarrow[abc]{xyz}$	`\xrightarrow[abc]{xyz}`	$\mathbb{R}$	`\mathbb{R}`
$\Leftarrow$	`\Leftarrow`	$()$	`()`	$\aleph$	`\aleph`
$\Leftrightarrow$	`\Leftrightarrow`	$[]$	`[]`		

Table 2: Some arrows, brackets, fonts

α	`\alpha`	θ	`\theta`	ε	`\varepsilon`
γ	`\gamma`	ϕ	`\phi`	ϑ	`\vartheta`
δ	`\delta`	Γ	`\Gamma`	Φ	`\Phi`
ϵ	`\epsilon`	Δ	`\Delta`	φ	`\varphi`

Table 3: Some Greek letters and variants

$\tilde{a}$	`\tilde{a}`	$\notin$	`\notin`	$\widetilde{abc}$	`\widetilde{abc}`
$\bar{a}$	`\bar{a}`	$\dot{a}$	`\dot{a}`	$\overline{abc}$	`\overline{abc}`
$\vec{a}$	`\vec{a}`	$\ddot{a}$	`\ddot{a}`	$\overrightarrow{abc}$	`\overrightarrow{abc}`
$\hat{a}$	`\hat{a}`	$\dot{=}$	`\ddot{=}`	$\widehat{abc}$	`\widehat{}`

Table 4: Some combinations of symbols

Some lists of symbols for LaTeX:

- List of logic symbols (Wikipedia): `https://en.wikipedia.org/wiki/List_of_logic_symbols`
- LaTeX for Logicians: `http://www.logicmatters.net/latex-for-logicians/`
- The Great, Big List of LaTeX Symbols: Carlisle et al. (2001)
- The Comprehensive LaTeX Symbol List – Symbols accessible from LaTeX: Pakin (2017)

Draw the symbol and get the code:

- `http://detexify.kirelabs.org`

Set theory

```
$\{\textrm{a}\} \subset \{\textrm{a,e}\}$
```

(1) $\{\textrm{a}\} \subset \{\textrm{a,e}\}$

```
$\emptyset \subseteq \{\textrm{a,b}\}$
```

(2) $\emptyset \subseteq \{\textrm{a,b}\}$

```
$\# \{\emptyset, \textrm{a} \} = 2$
```

(3) $\# \{\emptyset, \textrm{a} \} = 2$

```
$\emptyset \in \{\emptyset, \textrm{a} \}$
```

(4) $\emptyset \in \{\emptyset, \textrm{a} \}$

```
$\emptyset \notin \{\textrm{a}\}$
```

(5) $\emptyset \notin \{\textrm{a}\}$

```
If $|\textrm{A}| = n$ then $|\mathfrak{P}(\textrm{A})|=2^{n}$
```

(6) If $|\textrm{A}| = n$ then $|\mathfrak{P}(\textrm{A})|=2^{n}$

```
$\{\textrm{a, e}\} \setminus \{\textrm{e, u}\} = \{\textrm{a}\}$
```

(7) $\{\textrm{a, e}\} \setminus \{\textrm{e, u}\} = \{\textrm{a}\}$

```
DeMorgan: $ \overline{[ \textrm{A} \cup \textrm{B} ]} =
[ \overline{\textrm{A}} \cap \overline{\textrm{B}} ] $
```

(8) DeMorgan: $\overline{[\textrm{A} \cup \textrm{B}]} = [\overline{\textrm{A}} \cap \overline{\textrm{B}}]$

Propositional Logic

```
DeMorgan’s law:
$\lnot (P \lor Q ) \Leftrightarrow
(\lnot P \wedge \lnot Q)$

Biconditional law:
$(P \leftrightarrow P) \Leftrightarrow
((P \rightarrow Q) \wedge (Q \rightarrow P))$

Logical consequence:
$((p \rightarrow q) \wedge p) \Rightarrow q$
```

Propositional Logic

```
DeMorgan’s law:
$\lnot (P \lor Q ) \Leftrightarrow
(\lnot P \wedge \lnot Q)$

Biconditional law:
$(P \leftrightarrow P) \Leftrightarrow
((P \rightarrow Q) \wedge (Q \rightarrow P))$

Logical consequence:
$((p \rightarrow q) \wedge p) \Rightarrow q$
```

(9) DeMorgan’s law: $\neg(P \lor Q) \Leftrightarrow (\neg P \land \neg Q)$

(10) Biconditional law: $(P \leftrightarrow P) \Leftrightarrow ((P \rightarrow Q) \land (Q \rightarrow P))$

(11) Logical consequence: $((p \rightarrow q) \land p) \Rightarrow q$

Quantifiers

```
$\exists x [$\textsc{woman}$(x)$ $\land$ \textsc{sleep}$(x)]$

$\forall x [$\textsc{woman}$(x)$ $\rightarrow$ \textsc{sleep}$(x)]$
```

Quantifiers

```
$\exists x [$\textsc{woman}$(x)$ $\land$ \textsc{sleep}$(x)]$

$\forall x [$\textsc{woman}$(x)$ $\rightarrow$ \textsc{sleep}$(x)]$
```

(12) **Existential quantifier:** *A woman sleeps.*
$\exists x[\textsc{woman}(x) \land \textsc{sleep}(x)]$
$\nrightarrow$ There is only one sleeper.

Quantifiers

```
$\exists x [$\textsc{woman}$(x)$ $\land$ \textsc{sleep}$(x)]$

$\forall x [$\textsc{woman}$(x)$ $\rightarrow$ \textsc{sleep}$(x)]$
```

(12) **Existential quantifier:** *A woman sleeps.*
$\exists x[\textsc{woman}(x) \land \textsc{sleep}(x)]$
$\nrightarrow$ There is only one sleeper.

(13) **Universal quantifier:** *Every woman sleeps.*
$\forall x[\textsc{woman}(x) \rightarrow \textsc{sleep}(x)]$
$\nrightarrow$ Only women are sleepers.

Meaning brackets

In order to use the meaning brackets ⟦⟧ you can

1. (using XeLaTeX) copy the Unicode symbol,
2. make an own command for the symbol to use the Unicode symbol,
3. use the package `MnSymbol`. It provides the meaning brackets a.o. symbols.

```
\usepackage{MnSymbol}
```

Meaning brackets can be used **only in math mode**:

```
$\lsem \alpha \beta \rsem = \lsem \beta \rsem (\lsem \alpha \rsem)$
```

(14) $\llbracket \alpha\beta \rrbracket = \llbracket \beta \rrbracket (\llbracket \alpha \rrbracket)$ [Function application]

Writing formulae

```
\ea $\lsem [_{\textrm{PP}}$\emph{in Amsterdam}$] \rsem (s’)
   = \lambda P \lambda x [P(x) \land [x \textrm{ is in Amsterdam in } s’]]$
\z
```

(15) $[\![[_{\mathrm{PP}} \textit{in Amsterdam}]]\!](s') = \lambda P \lambda x [P(x) \land [x \textrm{ is in Amsterdam in } s']]$

- *in Amsterdam*: object language
- s', x, P: variables
- $\textrm{is in Amsterdam}$: invariable predicate
- PP: Index

1 Math mode 2

2 Trees

Trees

There are different packages for drawing trees:

- qtree
- pstrees (complex syntax, but more powerful than qtree)
- tikz-qtree
- forest (simple syntax, more powerful than pstrees and qtree, based on tikz)
- ...

Loading forest

```
\usepackage{forest}
```

`forest` provides many features for trees needed in linguistics.

These features can be loaded specifying the **option** `linguistics`.

```
\usepackage[linguistics]{forest}
```

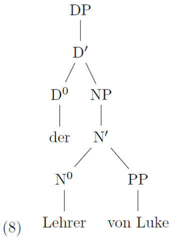


Fig. 1: without `linguistics`

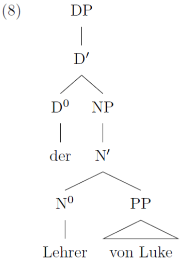


Fig. 2: with `linguistics`

`gb4e` re-defines some commands needed for `forest`. If you are using `gb4e`, you must load `forest` first and `gb4e` after.

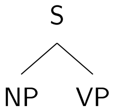
```
\usepackage[linguistics]{forest}

\usepackage{gb4e}
```

forest syntax

1. Use the `forest` **environment**.
2. Inside the `forest` environment, write the **bracket notation** for your tree.
3. Do **not** use **empty lines**!

```
\begin{forest}
[S [NP] [VP]]
\end{forest}
```

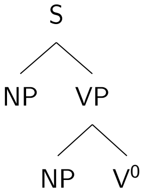
(16)



- Practice the bracket notation: `http://ironcreek.net/phpsyntaxtree/`

For bigger trees, it is useful – for the sake of clarity – not to write the bracket notation linearly.

```
\begin{forest}
[S
  [NP]
  [VP
    [NP]
    [V$^{0}$]
  ]
]
\end{forest}
```



vs.

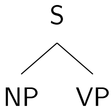
```
\begin{forest}
[S [NP] [VP [NP] [V$^{0}$]]]
\end{forest}
```

Trees in example environments

When using the option `linguistics`, you can embed the tree in an example environment.

```
\ea
\begin{forest}
[S [NP] [VP]]
\end{forest}
\z
```

(17)

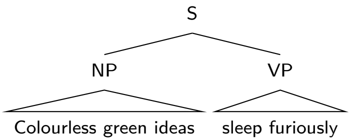


Abbreviating nodes

With the option `roof`, you can abbreviate nodes.

```
\ea
\begin{forest}
[S
  [NP [Colourless green ideas, roof]]
  [VP [sleep furiously, roof]]
]
\end{forest}
\z
```

(18)

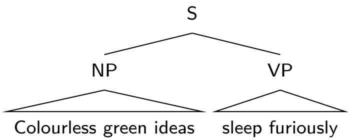


Abbreviating nodes

With the option `roof`, you can abbreviate nodes.

```
\ea
\begin{forest}
[S
  [NP [Colourless green ideas, roof]]
  [VP [sleep furiously, roof]]
]
\end{forest}
\z
```

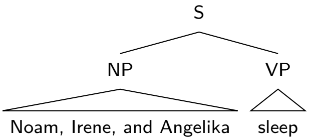
(18)



Take into account that options in `forest` (based on `TikZ`) are given by a **comma**. That means, you can use commas only when you **protect** them.

```
\ea
\begin{forest}
[S [NP [Noam{,} Irene{,} and Angelika,
    roof]] [VP [sleep, roof]]]
\end{forest}
\z
```

(19)

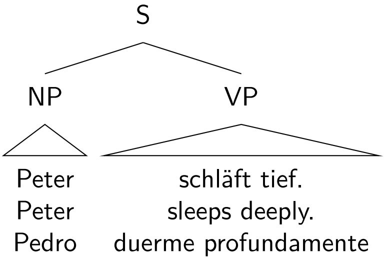


Glossing or translating

With \\, you can add **glosses or translations** to your tree.

```
\begin{forest}
[S
  [NP
    [Peter \\ Peter \\ Pedro, roof]
  ]
  [VP
    [schläft tief. \\ sleeps deeply. \\
          duerme profundamente, roof]
  ]
]
\end{forest}
```

(20)



Sub- and superscript

The characters ^ and _ are used in **math mode** for sub- and superscript, respectively.

```
$x^1$

$x_1$
```

(21) x^1

(22) x_1

Sub- and superscript

The characters ^ and _ are used in **math mode** for sub- and superscript, respectively.

```
$x^1$

$x_1$
```

(21) x^1

(22) x_1

The **default scope** of ^ and _ is only one character (23), use { } to **expand** it, see (24).

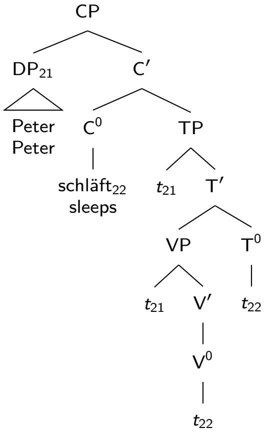
```
\ea X$^1$ Y$^21$ X$_1$ Y$_21$ \label{ex:SubSup1}

\ex X$^{1}$ Y$^{21}$ X$_{1}$ Y$_{21}$ \label{ex:SubSup2}
\z
```

(23) X^1 Y^{2}1 X$_1$ Y$_2$1

(24) X^1 Y^{21} X$_1$ Y$_{21}$

Tree with sub- and superscripts

```
[CP
  [DP$_{21}$ [Peter \\ Peter, roof]]
  [C$^{\prime}$
    [C$^{0}$ [schläft$_{22}$ \\ sleeps
         ]]
    [TP
      [$t_{21}$]
      [T$'$
        [VP
          [$t_{21}$]
          [V$^{\prime}$
            [V$^{0}$ [$t_{22}$]]
          ]
        ]
        [T$^{0}$ [$t_{22}$]]
      ]
    ]
  ]
]
```



Arrows

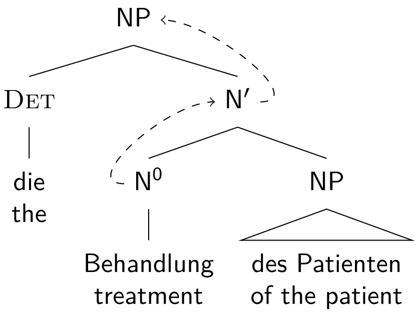
Arrows/lines **from node to node** (e.g. for movement, projection, etc.) can be drawn easily.

Give the nodes a **name** (command: `, name=`) and draw an arrow with the following command:

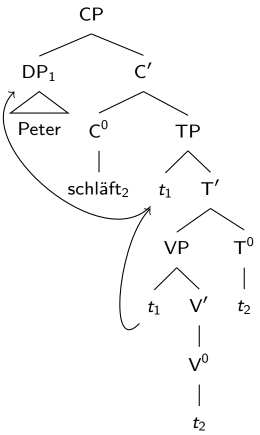
```
\draw[X] (Y) to[out=V, in=W] (Z);

\draw[->] (T10) to[out=south west, in=south west](T11);
```

- X: type of arrow/line (`->` `<-` `<->` `-`)
- Y: name of start node
- Z: name of end node
- V: starting position of the arrow at the start node (`south`/`north` + `east`/`west`)
- W: end position of the arrow at the end node (`south`/`north` + `east`/`west`)
- ;: end of the command

```
[NP, name=N2
  [\textsc{Det} [die \\ the]]
  [N$’$, name=N1
    [N$ˆ0$, name=N0 [Behandlung \\ treatment]]
    [NP [des Patienten \\ of the patient, roof]]
  ]
]
\draw[->,dashed] (N0) to[out=west,in=west] (N1);
\draw[->,dashed] (N1) to[out=east,in=east] (N2);
```



```
[CP
  [DP$_{1}$, name=T12 [Peter, roof]]
  [C$^{\prime}$
    [C$^{0}$ [schläft$_{2}$, name=T22]]
    [TP
      [$t_{1}$, name=T11]
      [T$^{\prime}$
        [VP
          [$t_{1}$, name=T10]
          [V$^{\prime}$
            [V$^{0}$ [$t_{2}$, name=T20]]
          ]
        ]
        [T$^{0}$ [$t_{2}$, name=T21]]
      ]
    ]
  ]
]
\draw[->] (T10)
to[out=south west, in=south west](T11);
\draw[->] (T11)
to[out=south west, in=south west](T12);
```

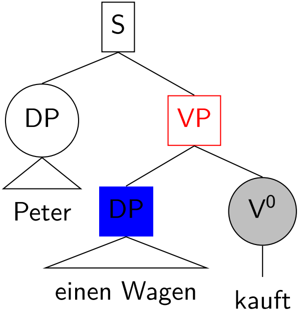


Marking nodes

Some options:

- draw: square
- circle, draw: circle
- red: marking node with red
- fill=X: fill background of node with colour *X*
- circle, draw, fill=lightgray: circle around node, background in grey

```
[S, draw
  [DP, circle, draw
    [Peter, roof]]
  [VP, draw, red
    [DP, fill=blue
      [einen Wagen, roof]]
    [V$^{0}$, circle, draw, fill=lightgray
      [kauft]]
  ]
]
```



Syllabic structures

The forest offers the style GP1 for syllabic structures.

```
\begin{forest} GP1, [
[$\sigma$
  [O
    [[C[\textipa{l}]]]
  ]
  [R  [N
        [V[\textipa{a}]]
      ]
  ]]
  [$\sigma$
    [O [ [ C[\textipa{t}] ] ] ]
    [R
      [N [V [\textipa{E}] ] ]
      [K [C [\textipa{\c{c}}] ] ]
]]
]
\end{forest}
```

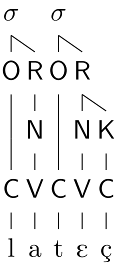


Fig. 3: Two syllables with GP1

```
\begin{forest} GP1
[ [$\sigma$
    [O
      [[C[\textipa{S}]]]
      [[C[\textipa{t}]]]
      [[C[\textipa{\textscr}]]]
    ]
    [R
      [N
        [V[\textipa{U}]]
      ]
      [K
        [C[\textipa{m}]]
        [C[\textipa{\t{pf}}]]
        [C[\textipa{s}]]
        [C[\textipa{t}]]
      ]
    ]
  ]
]
\end{forest}
```

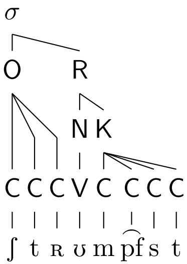


Fig. 4: Complex syllable with GP1

Without using `GP1`, you can draw your syllabic structures with `forest`. You will need the (`TikZ`) commands `, phantom` and `, tier=word`.

```
\begin{forest}
[,phantom
  [$\sigma$
    [O
      [x, tier=word[\textipa{f}]]
      [x, tier=word
        [\textipa{\textscr }]
      ]
    ]
    [R
      [N
        [x, tier=word
          [\textipa{E}]
        ]
      ]
      [K [x[\textipa{\c{c}}]]]]
      ]
]
\end{forest}
```

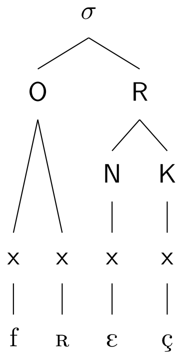


Fig. 5: Syllable without GP1

```
\begin{forest}
[,phantom
  [$\sigma$
    [O
      [x, tier=word [\textipa{f}]]
      [x, tier=word[\textipa{K}]]]
    [R
      [N
        [x, tier=word[\textipa{\
             textopeno}]]]
      [K
        [x[\textipa{s}]]]]
  ]
  [$\sigma$
    [O
      [x, tier=word [\textipa{t}]]]
    [R
      [N [x[\textipa{I}]]]
      [K[x[\c{c}]]]]
  ]
]
\end{forest}
```

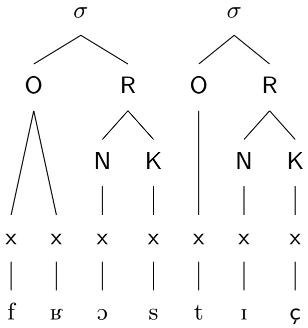


Fig. 6: Two syllables

```
\begin{forest}
[,phantom
  [$\sigma$
    [O
      [x, tier=word
        [\textipa{P}]]]
    [R
      [N
        [x, tier=word
          [\textipa{\t{aU}}, name=aU] ]
        [x, name=x]
      ]
      [K
        [x [\textipa{x}] ] ] ]
  ]
]
{\draw[black] (aU.north)--(x.south);}
\end{forest}
```

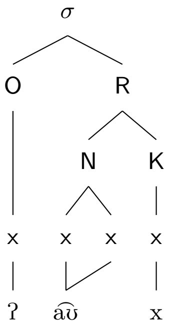


Fig. 7: Diphthongs and long vowels

```
\begin{forest}
[,phantom
  [$\sigma$
    [O [x, tier=word [\textipa{t}] ]
    ]
    [R
      [N [x, tier=word [\textipa{I}] ]
           ]
      [K [x, name=x [\textipa{k}] ] ]
    ]
  ]
  [$\sigma$
    [O, name=onset]
    [R
      [N [x [\textipa{@}] ] ]
      [K [x [\textipa{n}] ] ] ]
    ]
  ]
\draw[black] (x.north)--(onset.south);
\end{forest}
```

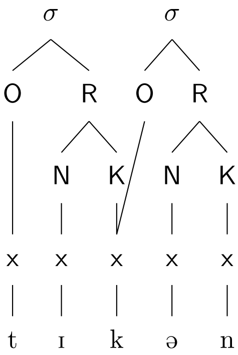


Fig. 8: Ambisyllabic consonant

Further features

- `forest` is a very powerful package. Check the package documentation (Živanovi, 2017) to see all of its benefits.
- Also, check the *Quick start guide* for linguists (Vanden Wyngaerd, 2016).

Exercise

Go to `https://github.com/langsci/latex4linguists/blob/master/4-1.md` and `https://github.com/langsci/latex4linguists/blob/master/4-2.md` and follow the instructions of **all blocks** in your `.tex` file.

Internet sources I

- Link: Akzente und Sonderzeichen in LaTeX.
  `https://de.wikibooks.org/wiki/LaTeX/_Akzente_und_Sonderzeichen`
  [Access: 10/10/2017]
- Link: Detexify
  `http://detexify.kirelabs.org`
  [Access: 08/12/2017]
- Link: LaTeX/Special Characters.
  `https://en.wikibooks.org/wiki/LaTeX/Special_Characters`
  [Access: 02/01/2019]
- Link: List of logic symbols – Wikipedia
  `https://en.wikipedia.org/wiki/List_of_logic_symbols`
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