

- Terminals are simply written out: `while`
- Nonterminals are enclosed in angle brackets: `<statement>`
- Productions are in the form:
 - `<nonterminal> ::= <sequence of terminals or nonterminals>`
 - `<sentence> ::= <noun phrase><verb phrase>`
- We can use `|` to represent or

Simple Example

```
<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
<integer> ::= <digit> | <digit><integer>
<floating point> ::= <integer>.<integer>
```

More Complex Example

```
<statement> ::= <if-statement> | <while-statement> |
               <assignment> | <block>
<assignment> ::= <variable>=<expression>
<if-statement> ::= if (<condition>) <statement> |
                  if (<condition>) <statement> else <statement>
<while-statement> ::= while (<condition>) <statement>
<block> ::= { <statement-sequence> }
<statement-sequence> ::= <statement> | <statement><statement-sequence>
```

Lexical vs Phrase Structure

- Lexical structure is the structure of valid tokens in a language:
 - numbers
 - identifiers
- Phrase structure is the larger structure of sentences and programs.
- We usually use separate grammars to handle these because grammars for both get very complex.
- Compilers and interpreters usually also handle these separately

Parse Trees

○ A diagram of the structure of a language fragment, given a grammar



$\langle \text{digit} \rangle \rightarrow 0/1/2/3/4/5/6/7/8/9$
 $\langle \text{nat} \rangle \rightarrow \langle \text{digit} \rangle$
 $\quad \quad \quad | \langle \text{digit} \rangle \langle \text{nat} \rangle$

$\langle \text{nat} \rangle \Rightarrow \langle \text{digit} \rangle \langle \text{nat} \rangle$
 $\quad \Rightarrow 9 \langle \text{nat} \rangle$
 $\quad \Rightarrow 9 \langle \text{digit} \rangle \langle \text{nat} \rangle$
 $\quad \Rightarrow 93 \langle \text{nat} \rangle$
 $\quad \Rightarrow 93 \langle \text{digit} \rangle$
 $\quad \Rightarrow 930$

$\langle \text{nat} \rangle \rightarrow \langle \text{digit} \rangle$
 $\quad \quad \quad | \langle \text{nonzero} \rangle \langle \text{digits} \rangle$
 $\langle \text{digits} \rangle \rightarrow \langle \text{digit} \rangle$
 $\quad \quad \quad | \langle \text{digit} \rangle \langle \text{digits} \rangle$
 $\langle \text{digit} \rangle \rightarrow 0 / \langle \text{nonzero} \rangle$
 $\langle \text{nonzero} \rangle \rightarrow 1/2/3/4/5/6/7/8/9$

1st case example

$\langle \text{sentence} \rangle :: \langle \text{subject} \rangle \langle \text{predicate} \rangle$

$\langle \text{subject} \rangle :: \langle \text{article} \rangle \langle \text{noun} \rangle$

$\langle \text{article} \rangle :: \text{the} / \text{a}$

$\langle \text{noun} \rangle :: \text{boy} / \text{girl}$

$\langle \text{predicate} \rangle :: \langle \text{verb} \rangle \langle \text{noun} \rangle$

$\langle \text{verb} \rangle :: \text{kicks} / \text{sees}$

$\langle \text{noun} \rangle :: \text{boy} / \text{girl}$

1. The boy sees girl = valid
2. A girl kicks boy = valid
3. Boy sees boy = invalid