

CSc 600-01 (SECTION 1)
Homework 1 - Syntax
prepared by Ilya Kopyl

CSC 600 HOMEWORK 1 - SYNTAX

February 15, 2018

Homework is prepared by: Ilya Kopyl.

It is formatted in LaTeX, using TeXShop editor (under GNU GPL license).

Syntax diagrams are created in LucidChart online editor (lucidchart.com).

1. Using BNF write the syntax definitions of the following objects:

a) Natural number (1, 2, 3, ...). The answer:

$$\begin{aligned}\langle \textit{natural number} \rangle &::= \langle \textit{non-zero digit} \rangle \mid \langle \textit{natural number} \rangle \langle \textit{digit} \rangle \\ \langle \textit{digit} \rangle &::= 0 \mid \langle \textit{non-zero digit} \rangle \\ \langle \textit{non-zero digit} \rangle &::= 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9\end{aligned}$$

b) Unsigned integer (0, 1, 2, 3, ...). The answer:

$$\begin{aligned}\langle \textit{unsigned integer} \rangle &::= \langle \textit{digit} \rangle \mid \langle \textit{unsigned integer} \rangle \langle \textit{digit} \rangle \\ \langle \textit{digit} \rangle &::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9\end{aligned}$$

Example of BNF definition of unsigned integer in languages that do not support leading zeroes (e.g. Python):

$$\begin{aligned}\langle \textit{unsigned integer} \rangle &::= 0 \mid \langle \textit{natural number} \rangle \\ \langle \textit{natural number} \rangle &::= \langle \textit{non-zero digit} \rangle \mid \langle \textit{natural number} \rangle \langle \textit{digit} \rangle \\ \langle \textit{digit} \rangle &::= 0 \mid \langle \textit{non-zero digit} \rangle \\ \langle \textit{non-zero digit} \rangle &::= 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9\end{aligned}$$

c) Integer (... , -2, -1, 0, 1, 2, ...). The answer:

$\langle integer \rangle$	$::= \langle sign \rangle \langle unsigned integer \rangle$
$\langle sign \rangle$	$::= + \mid - \mid \langle empty \rangle$
$\langle empty \rangle$	$::=$
$\langle unsigned integer \rangle$	$::= \langle digit \rangle \mid \langle unsigned integer \rangle \langle digit \rangle$
$\langle digit \rangle$	$::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

Example of BNF definition of an integer in languages that do not support leading zeroes (e.g. Python):

$\langle integer \rangle$	$::= \langle sign \rangle \langle unsigned integer \rangle$
$\langle sign \rangle$	$::= + \mid - \mid \langle empty \rangle$
$\langle empty \rangle$	$::=$
$\langle unsigned integer \rangle$	$::= 0 \mid \langle natural number \rangle$
$\langle natural number \rangle$	$::= \langle non-zero digit \rangle \mid \langle natural number \rangle \langle digit \rangle$
$\langle digit \rangle$	$::= 0 \mid \langle non-zero digit \rangle$
$\langle non-zero digit \rangle$	$::= 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

d) Odd number (... , -3, -1, 1, 3, ..., 101, ..., 2047, ...). The answer:

$\langle odd number \rangle$	$::= \langle sign \rangle \langle unsigned odd number \rangle$
$\langle sign \rangle$	$::= + \mid - \mid \langle empty \rangle$
$\langle empty \rangle$	$::=$
$\langle unsigned odd number \rangle$	$::= \langle odd digit \rangle \mid \langle unsigned integer \rangle \langle odd digit \rangle$
$\langle unsigned integer \rangle$	$::= \langle digit \rangle \mid \langle unsigned integer \rangle \langle digit \rangle$
$\langle digit \rangle$	$::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

Example of BNF definition of an odd number in languages that do not support leading zeroes (e.g. Python):

```

<odd number>      ::= <sign> <unsigned odd number>
<sign>            ::= + | - | <empty>
<empty>           ::=
<unsigned odd number> ::= <odd digit> | <natural number> <odd digit>
<natural number>  ::= <non-zero digit> | <natural number> <digit>
<digit>           ::= 0 | <non-zero digit>
<non-zero digit>  ::= 2 | 4 | 6 | 8 | <odd digit>
<odd digit>       ::= 1 | 3 | 5 | 7 | 9

```

e) Even number (... , -4, -2, 0, 2, 4, ..., 332, ..., 1022, ...). The answer:

```

<even number>      ::= <sign> <unsigned even number>
<sign>            ::= + | - | <empty>
<empty>           ::=
<unsigned even number> ::= <even digit> | <unsigned integer> <even digit>
<unsigned integer>  ::= <digit> | <unsigned integer> <digit>
<digit>           ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

```

Example of BNF definition of an even number in languages that do not support leading zeroes (e.g. Python):

```

<even number>      ::= <sign> <unsigned even number>
<sign>            ::= + | - | <empty>
<empty>           ::=
<unsigned even number> ::= <even digit> | <natural number> <even digit>
<natural number>  ::= <non-zero digit> | <natural number> <digit>
<digit>           ::= 0 | <non-zero digit>
<non-zero digit>  ::= 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
<even digit>      ::= 0 | 2 | 4 | 6 | 8

```

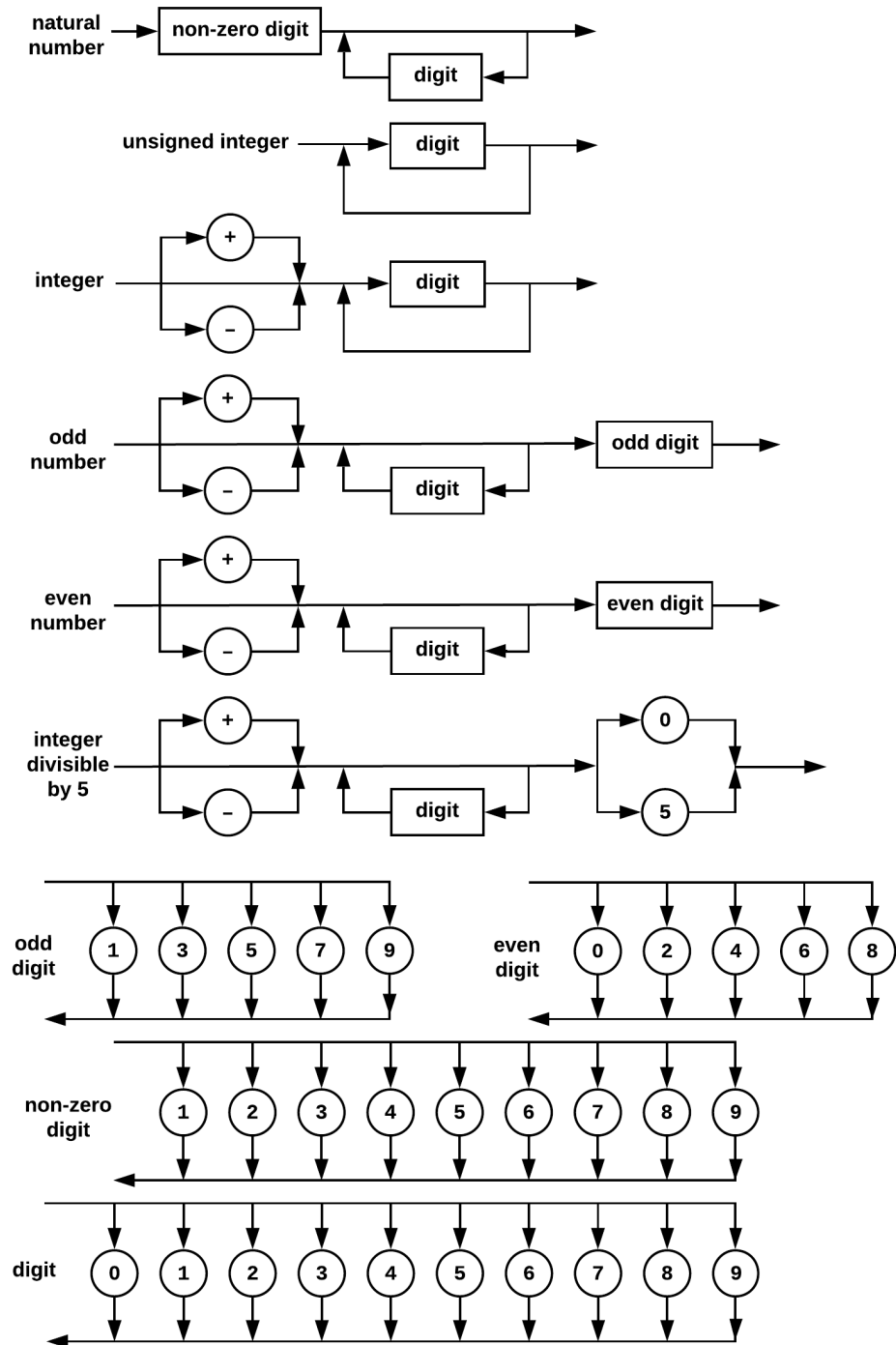
f) Integer divisible by five (... , -10, 5, 0, 5, 10, ...). The answer:

$$\begin{aligned}
\langle \text{integer div-by-5} \rangle &::= \langle \text{sign} \rangle \langle \text{unsigned int div-by-5} \rangle \\
\langle \text{sign} \rangle &::= + \mid - \mid \langle \text{empty} \rangle \\
\langle \text{empty} \rangle &::= \\
\langle \text{unsigned int div-by-5} \rangle &::= \langle \text{div-by-5 suffix} \rangle \mid \langle \text{unsigned integer} \rangle \langle \text{div-by-5 suffix} \rangle \\
\langle \text{unsigned integer} \rangle &::= \langle \text{digit} \rangle \mid \langle \text{unsigned integer} \rangle \langle \text{digit} \rangle \\
\langle \text{div-by-5 suffix} \rangle &::= 0 \mid 5 \\
\langle \text{digit} \rangle &::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9
\end{aligned}$$

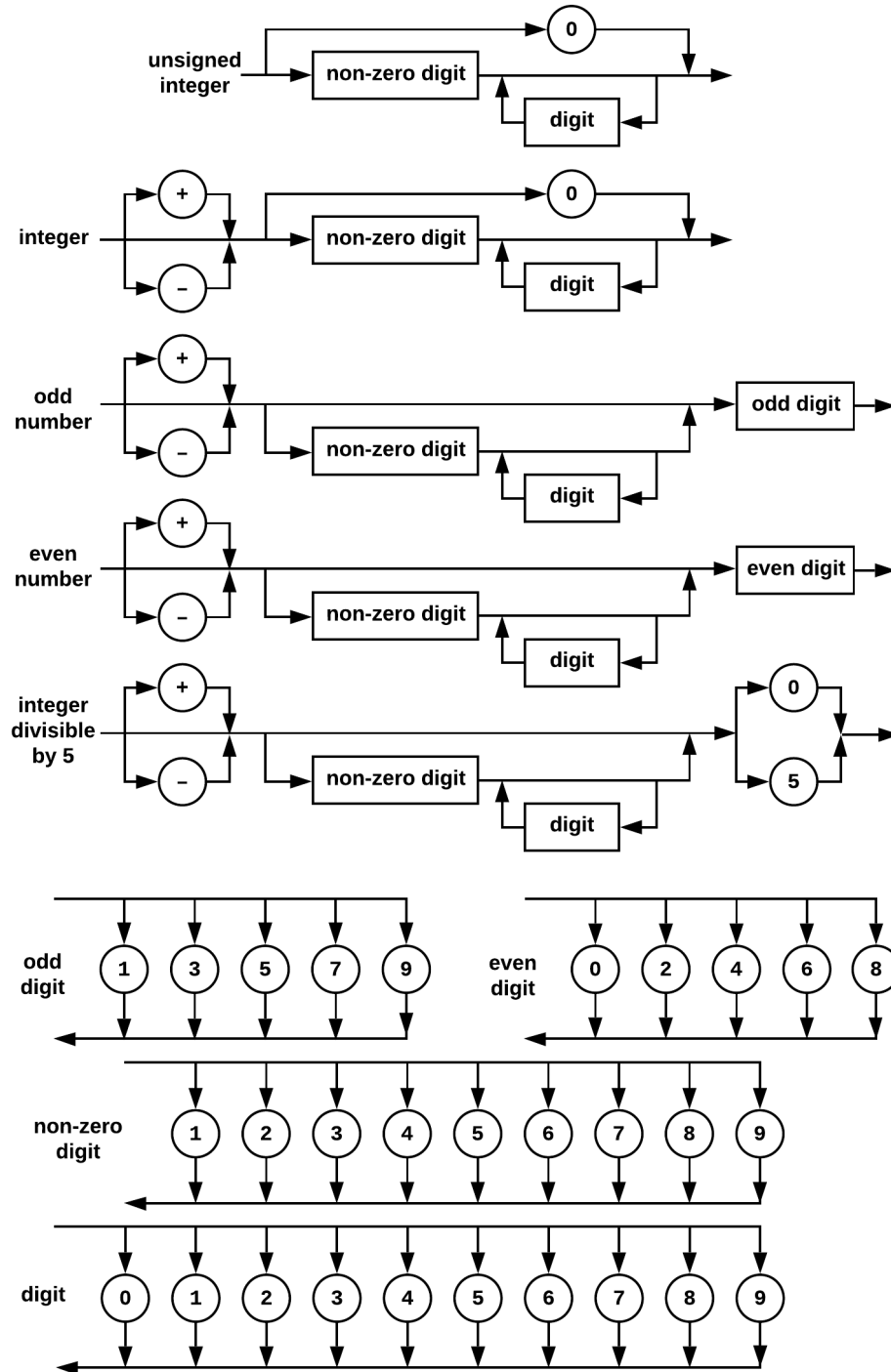
Example of BNF definition of an integer divisible by 5 in languages that do not support leading zeroes (e.g. Python):

$$\begin{aligned}
\langle \text{integer div-by-5} \rangle &::= \langle \text{sign} \rangle \langle \text{unsigned int div-by-5} \rangle \\
\langle \text{sign} \rangle &::= + \mid - \mid \langle \text{empty} \rangle \\
\langle \text{empty} \rangle &::= \\
\langle \text{unsigned int div-by-5} \rangle &::= \langle \text{div-by-5 suffix} \rangle \mid \langle \text{natural number} \rangle \langle \text{div-by-5 suffix} \rangle \\
\langle \text{natural number} \rangle &::= \langle \text{non-zero digit} \rangle \mid \langle \text{natural number} \rangle \langle \text{digit} \rangle \\
\langle \text{div-by-5 suffix} \rangle &::= 0 \mid 5 \\
\langle \text{digit} \rangle &::= 0 \mid \langle \text{non-zero digit} \rangle \\
\langle \text{non-zero digit} \rangle &::= 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9
\end{aligned}$$

2. Show syntax diagrams for questions (a), ..., (f) of problem 1.



Example of syntax diagrams for integers with no support of leading zeroes.



3. Write a BNF definition of the syntax of (all possible) input statements in C++.

Following is an example of input statement in C++:

```
cin » sclr » vec[2 * i - 1] » mat[f(i)][j + k] » t[i/3][j][k];
```

The answer:

"There are only two hard things in Computer Science: cache invalidation and naming things." – Phil Karlton.

$\langle \text{input statement} \rangle$	$::= \text{cin } \langle \text{input arguments} \rangle ;$
$\langle \text{input arguments} \rangle$	$::= \gg \langle \text{input value} \rangle \mid \langle \text{input arguments} \rangle \gg \langle \text{input value} \rangle$
$\langle \text{input value} \rangle$	$::= \langle \text{variable} \rangle \mid \langle \text{array element} \rangle \mid \langle \text{struct member} \rangle$
$\langle \text{variable} \rangle$	$::= \langle \text{identifier} \rangle$
$\langle \text{array element} \rangle$	$::= \langle \text{identifier} \rangle \langle \text{array indices} \rangle$
$\langle \text{identifier} \rangle$	$::= \langle \text{non-digit character} \rangle \mid \langle \text{identifier} \rangle \langle \text{digit} \rangle$
$\langle \text{array indices} \rangle$	$::= \langle \text{array index} \rangle \mid \langle \text{array indices} \rangle \langle \text{array index} \rangle$
$\langle \text{array index} \rangle$	$::= [\langle \text{expression} \rangle]$
$\langle \text{expression} \rangle$	$::= \langle \text{arithmetic expression} \rangle$ $\mid \langle \text{function call} \rangle$ $\mid \langle \text{identifier} \rangle$ $\mid \langle \text{void} \rangle$