

CSc 600-01 (SECTION 1)  
**Homework 1 - Syntax**  
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# CSC 600 HOMEWORK 1 - SYNTAX

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*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

```

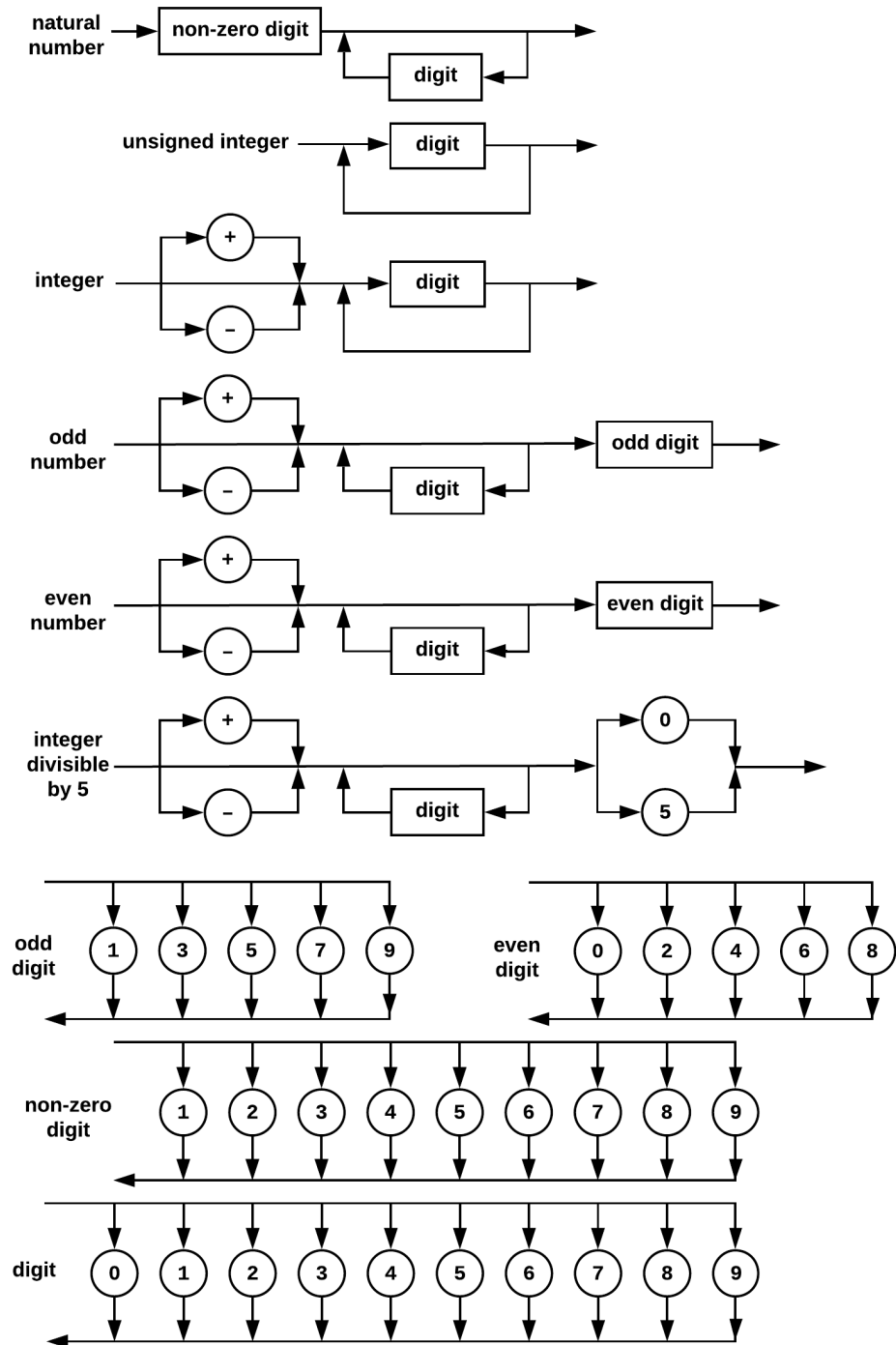
f) Integer divisible by five (... , -10, 5, 0, 5, 10, ...). The answer:

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

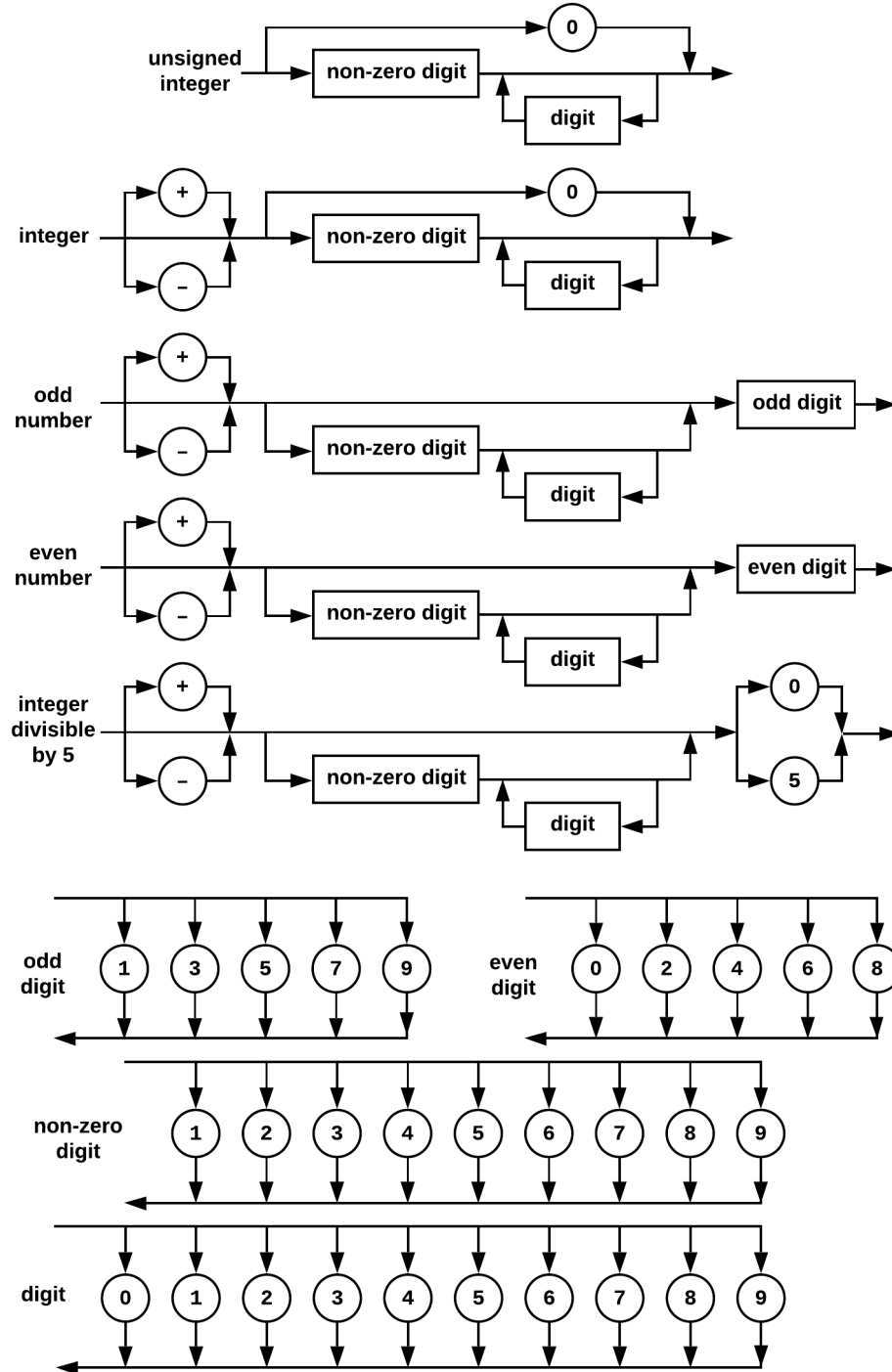
Example of BNF definition of an integer divisible by 5 in languages that do not support leading zeroes (e.g. Python):

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

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:

$\langle \text{input statement} \rangle ::= \text{cin } \langle \text{input statement list} \rangle ;$