Writing Program in C
Expressions and Control Structures (Selection Statements and Loops)

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Lecture 02

PRG(A) – C Programming Language

Overview of the Lecture

- Part 1 – Expressions
  - Operators – Arithmetic, Relational, Logical, Bitwise, and Other
  - Associativity and Precedence
  - Assignment

  K. N. King: chapter 4 and 20
- Part 2 – Control Structures: Selection Statements and Loops
  - Statements and Coding Styles
  - Selection Statements
  - Loops
  - Conditional Expression

  K. N. King: chapters 5 and 6
- Part 3 – Assignment HW 01

Part I

Part 1 – Expressions

Expressions

- **Expression** prescribes calculation using *operands*, *operators*, and *brackets*
- Expression consists of
  - literals
  - variables
  - constants
  - unary and binary operators
  - function call
  - brackets
- The order of operation evaluation is prescribed by the operator **precedence** and **associativity**.

```
10 + x * y      // order of the evaluation 10 + (x * y)
10 + x + y      // order of the evaluation (10 + x) + y
```

** has higher priority than +*
+ is associative from the left-to-right

- A particular order of evaluation can be precisely prescribed by **fully parenthesized expression**

Simply: If you are not sure, use brackets.

Operators

- Operators are selected characters (or sequences of characters) dedicated for writting expressions
- Five types of binary operators can be distinguished
  - **Arithmetic** operators – additive (addition/subtraction) and multiplicative (multiplication/division)
  - **Relational** operators – comparison of values (less than, ...)
  - **Logical** operators – logical `AND` and `OR`
  - **Bitwise** operators – bitwise `AND`, `OR`, `XOR`, bitwise shift (left, right)
  - Assignment operator $=$ – a variable (l-value) is on its left side
- Unary operators
  - Indicating positive/negative value: $+$ and $-$

    Operator $-$ modifies the sign of the expression
  - Modifying a variable : $++$ and $--$
  - Logical negation: **!**
  - Bitwise negation: $\sim$
- Ternary operator – conditional expression **? :**

Reminder

Arithmetic Operators

- Operands of arithmetic operators can be of any arithmetic type

*The only exception is the operator for the integer reminder % defined for the **int** type*

*	Multiplication	`x * y`	Multiplication of x and y
/	Division	`x / y`	Division of x and y
%	Reminder	`x % y`	Reminder from the x / y
+	Addition	`x + y`	Sum of x and y
-	Subtraction	`x - y`	Subtraction x and y
+	Unary plus	`+x`	Value of x
-	Unary minus	`-x`	Value of −x
++	Increment	`++x`/`x++`	Incrementation before/after the evaluation of the expression x
--	Decrement	`--x`/`x--`	Decrementation before/after the evaluation of the expression x

Integer Division

- The results of the division of the operands of the **int** type is the integer part of the division

  E.g.. 7/3 is 2 and −7/3 is −2

- For the integer reminder, it holds $x\%y = x - (x/y) * y$

  E.g., 7 % 3 is 1 *-7 % 3 is -1* *7 % -3 is 1* *-7 % -3 is -1*

- **C99**: The result of the integer division of negative values is the value closer to 0
  - It holds that (a/b)*b + a%b = a.

For older versions of C, the results depends on the compiler.

Implementation-Defined Behaviour

- The C standard deliberately leaves parts of the language unspecified
- Thus, some parts depend on the implementation, i.e., compiler, environment, computer architecture

E.g., Reminder behavior for negative values and version of the C prior C99.

- The reason for that is the focus of C on efficiency, i.e., match the hardware behavior

- Having this in mind, it is best rather to avoid writing programs that depend on implementation-defined behavior

K.N.King: Page 55

Unary Arithmetic Operators

- Unary operator ($++$ and $--$) change the value of its operand

  The operand must be the `l-value`, i.e., an expression that has memory space, where the value of the expression is stored, e.g., a variable.

  - It can be used as **prefix** operator, e.g., $++\mathbf{x}$ and $--\mathbf{x}$
  - or as **postfix** operator, e.g., $\mathbf{x}++$ and $\mathbf{x}--$
  - In each case, the final value of the expression is different!

int i; int a;	**value of i**	**value of a**
i = 1; a = 9;	**1**	**9**
a = i++;	**2**	**1**
a = ++i;	**3**	**3**
a = ++(i++);	**Not allowed! Value of i++ is not the l-value**	

For the unary operator `i++`, it is necessary to store the previous value of `i` and then the variable `i` is incremented. The expression `++i` only increments the value of `i`. Therefore, `++i` can be more efficient.

Relational Operators

- Operands of relational operators can be of arithmetic type, pointers (of the same type) or one operand can be `NULL` or pointer of the `void` type

<	Less than	`x < y`	1 if x is less than y; otherwise 0
<=	Less than or equal	`x <= y`	1 if x is less then or equal to y; otherwise 0
>	Greater than	`x > y`	1 if x is greater than y; otherwise 0
>=	Greater than or equal	`x >= y`	1 if x is greater than or equal to y; otherwise 0
==	Equal	`x == y`	1 if x is equal to y; otherwise 0
!=	Not equal	`x != y`	1 if x is not equal to y; otherwise 0

Logical operators

- Operands can be of arithmetic type or pointers
- Resulting value `1` means `true`, `0` means `false`
- In the expressions `&&` (Logical AND) and `||` (Logical OR), the left operand is evaluated first
- If the results is defined by the left operand, the right operand is not evaluated

  Short-circuiting behavior *– it may speed evaluation of complex expressions in runtime.*

`&&`	Logical AND	`x && y`	1 if x and y is not 0; otherwise 0
`||`	Logical OR	`x || y`	1 if at least one of x, y is not 0; otherwise 0
`!`	Logical NOT	`!x`	1 if x is 0; otherwise 0

- **Operands && a || have the short-circuiting behavior**, i.e., the second operand is not evaluated if the result can be determined from the value of the first operand.

Example – Short-Circuiting Behaviour 1/2

```c
#include <stdio.h>
#include <stdlib.h>

int fce_a(int n);
int fce_b(int n);

int main(int argc, char *argv[])
{
   if (argc > 1 && fce_a(atoi(argv[1])) && fce_b(atoi(argv[1])) )
   {
      printf("Both functions fce_a and fce_b pass the test\n");
   } else {
      printf("One of the functions does not pass the test\n");
   }
   return 0;
}

int fce_a(int n)
{
   printf("Calling fce_a with the argument '%d'\n", n);
   return n % 2 == 0;
}

int fce_b(int n)
{
   printf("Calling fce_b with the argument '%d'\n", n);
   return n > 2;
}
```

lec02/demo-short_circuiting.c

Example – Short-Circuiting Behaviour 2/2 – Tasks

In the example `lec02/demo-short_circuiting.c`

- Test how the logical expressions (a function call) are evaluated
- Identify what functions `fce_a()` and `fce_b()` are implementing
- Rename the functions appropriately
- Identify the function headers and why they have to be stated above the main function
- Try to split implementation of the functions to a separate module

Bitwise Operators

- Bitwise operators treat operands as a series of bits

  Low-Level Programming – A programming language is low level when its programs require attention of the irrelevant. K.N.King: Chapter 20.

&	Bitwise AND	`x & y`	1 if x and y is equal to 1 (bit-by-bit)
|	Bitwise inclusive OR	`x | y`	1 if x or y is equal to 1 (bit-by-bit)
^	Bitwise exclusive or (XOR)	`x ^ y`	1 if only x or only y is 1 (bit-by-bit)
~	Bitwise complement (NOT)	`~x`	1 if x is 0 (bit-by-bit)
<<	Bitwise left shift	`x << y`	Shift of x by y bits to the left
>>	Bitwise right shift	`x >> y`	Shift of x by y bits to the right

Bitwise Shift Operators

- Bitwise shift operators shift the binary representation by a given number of bits to the left or right
  - Left shift – Each bit shifted off a zero bit enters at the right
  - Right shift – Each bit shift off
    - a zero bit enters at the left – for positive values or unsigned types
    - for negative values, the entered bit can be either 0 (logical shift) or 1 (arithmetic shift right). Depends on the compiler.
- Bitwise shift operators have lower precedence than the arithmetic operators!
  - `i << 2 + 1` means `i << (2 + 1)`

Do not be surprise – parenthesized the expression!

Example – Bitwise Expressions

```
#include <inttypes.h>

uint8_t a = 4;
uint8_t b = 5;

a     dec: 4 bin: 0100
b     dec: 5 bin: 0101
a & b dec: 4 bin: 0100
a | b dec: 5 bin: 0101
a ^ b dec: 1 bin: 0001

a >> 1 dec: 2 bin: 0010
a << 1 dec: 8 bin: 1000
```

lec02/bits.c

Operators for Accessing Memory

Here, for completeness, details in the further lectures.

- In C, we can directly access the memory address of the variable
- The access is realized through a pointer

It allows great options, but it also needs responsibility.

Operator	Name	Example	Result
&	Address	`&x`	Pointer to x
*	Indirection	`*p`	Variable (or function) addressed by the pointer p
[]	Array subscripting	`x[i]`	`*(x+i)` – item of the array x at the position i
.	Structure/union member	`s.x`	Member x of the struct/union s
->	Structure/union member	`p->x`	Member x of the struct/union addressed by the pointer p

*It is not allowed an operand of the & operator is a bit field or variable of the register class. Operator of the indirect address * allows to access to the memory using pointers.*

Other Operators

Operator	Name	Example	Result
()	Function call	`f(x)`	Call the function `f` with the argument `x`
(type)	Cast	`(int)x`	Change the type of `x` to `int`
sizeof	Size of the item	`sizeof(x)`	Size of `x` in bytes
? :	Conditional	`x ? y : z`	Do `y` if `x != 0`; otherwise `z`
,	Comma	`x, y`	Evaluate `x` and then `y`, the result is the result of the last expression

- The operand of `sizeof()` can be a type name or expression

```c
int a = 10;
printf("%lu %lu\n", sizeof(a), sizeof(a + 1.0));
```

lec02/sizeof.c

- Example of the **comma** operator

```c
for (c = 1, i = 0; i < 3; ++i, c += 2) {
   printf("i: %d c: %d\n", i, c);
}
```

Cast Operator

- Changing the variable type in runtime is called type case
- Explicit cast is written by the name of the type in `()`, e.g.,

```
int i;
float f = (float)i;
```

- Implicit cast is made automatically by the compiler during the program compilation
- If the new type can represent the original value, the value is preserved by the cast
- Operands of the `char`, `unsigned char`, `short`, `unsigned short`, and the bit field types can be used everywhere where it is allowed to use `int` or `unsigned int`.

  C expects at least values of the `int` type.

  - Operands are automatically cast to the `int` or `unsigned int`.

Operators Associativity and Precedence

- Binary operation op is **associative** on the set S if
$$(x \text{ op } y) \text{ op } z = x \text{ op}(y \text{ op } z), \text{ for each } x, y, z \in S$$
- For not associative operators, it is required to specify the order of evaluation
  - Left-associative – operations are grouped from the left
  $$E.g., 10 - 5 - 3 \textit{ is evaluated as } (10 - 5) - 3$$
  - Right-associative – operations are grouped from the right
  $$E.g.\ 3 + 5^2 \textit{ is } 28 \textit{ or } 3 \cdot 5^2 \textit{ is } 75 \textit{ vs } (3 \cdot 5)^2 \textit{ is } 225$$
- The assignment is right-associative
$$E.g., y=y+8$$
First, the whole right side of the operator = is evaluated, and then, the results are assigned to the variable on the left.
- The order of the operator evaluation can be defined by the fully parenthesized expression.

Summary of the Operators and Precedence 1/3

Precedence	Operator	Associativity	Name
1	++	L→R	Increment (postfix)
	−−		Decrementation (postfix)
	()		*Function call*
	[]		*Array subscripting*
	. −>		*Structure/union member*
2	++	R→L	Increment (prefix)
	−−		Decrementation (prefix)
	!		Logical negation
	~		Bitwise negation
	− +		Unary plus/minus
	*		*Indirection*
	&		*Address*
	sizeof		*Size*

Summary of the Operators and Precedence 2/3

Precedence	Operator	Associativity	Name
3	()	R→L	*Cast*
4	*, /, %	L→R	Multiplicative
5	+ −		Additive
6	>>, <<		Bitwise shift
7	<, >, <=, >=		Relational
8	==, !=		Equality
9	&		Bitwise AND
10	^		Bitwise exclusive OR (XOR)
11	|		Bitwise inclusive OR (OR)
12	&&		Logical AND
13	||		Logical OR

Summary of the Operators and Precedence 3/3

Precedence	Operator	Associativity	Name
14	? :	R→L	Conditional
15	=		Assignment
	+=, -=		additive
	*=, /=, %=	R→L	multiplicative
	<<=, >>=		bitwise shift
	&=, ^=, |=		Bitwise AND, XOR, OR
15	,	L→R	Comma

K. N. King: Page 735

http://en.cppreference.com/w/c/language/operator_precedence

Simple Assignment

- Set the value to the variable

  Store the value into the memory space referenced by the variable name.

- The form of the assignment operator is

  $$\langle \textbf{variable} \rangle = \langle \textbf{expression} \rangle$$

  Expression is literal, variable, function call, ...

- C is statically typed programming language
  - A value of an expression can be assigned only to a variable of the same type

    Otherwise the type cast is necessary

  - Example of the implicit type cast

```
int i = 320.4; // implicit conversion from 'double' to 'int' changes value from
    320.4 to 320 [-Wliteral-conversion]

char c = i;    // implicit truncation 320 -> 64
```

- C is type safe only within a limited context of the compilation, e.g., for `printf("%d\n", 10.1);` a compiler reports an error
- In general, C is not type safe *In runtime, it is possible to write out of the allocated memory space.*

Compound Assignment

- A short version of the assignment to compute a new value of the variable from itself:

$$\langle \textbf{variable} \rangle = \langle \textbf{variable} \rangle \ \langle \textbf{operator} \rangle \ \langle \textbf{expression} \rangle$$

- can be written as

$$\langle \textbf{variable} \rangle \ \langle \textbf{operator} \rangle = \langle \textbf{expression} \rangle$$

Example

```
int i = 10;
double j = 12.6;

i = i + 1;
j = j / 0.2;
```

```
int i = 10;
double j = 12.6;

i += 1;
j /= 0.2;
```

- Notice, assignment is an expression

The assignment of the value to the variable is a side effect

```
int x, y;

x = 6;
y = x = x + 6;
```

Assignment Expression and Assignment Statement

- The statement performs some action and it is terminated by ;

```
robot_heading = -10.23;
robot_heading = fabs(robot_heading);
printf("Robot heading: %f\n", robot_heading);
```

- Expression has **type and value**

23	**int** type, value is 23
14+16/2	**int** type, value is 22
y=8	**int** type, value is 8

- Assignment is an expression and its value is assigned to the left side
- The assignment expression becomes the assignment statement by adding **the semicolon**

Undefined Behaviour

- There are some statements that can cause **undefined behavior** according to the C standard.
  - `c = (b = a + 2) - (b - 1);`
  - `j = i * i++;`
- The program may behaves differently according to the used compiler, but may also not compile or may not run; or it may even crash and behave erratically or produce meaningless results
- It may also happened if variables are used without initialization

- Avoid statements that may produce undefined behavior!

Example of Undefined Behaviour

- C standard does not define the behaviour for the overflow of the integer value (`signed`)
  - E.g., for the complement representation, the expression can be `127 + 1` of the `char` equal to `-128` (see `lec02/demo-loop_byte.c`)
  - Representation of integer values may depend on the architecture and can be different, e.g., when binary or inverse code is used
- Implementation of the defined behaviour can be computationally expensive, and thus the behaviour is not defined by the standard
- Behaviour is not defined and depends on the compiler, e.g. `clang` and `gcc` without/with the optimization `-O2`
  - ```
    for (int i = 2147483640; i >= 0; ++i) {
        printf("%i %x\n", i, i);
    }
    ```
    lec02/int_overflow-1.c

    Without the optimization, the program prints 8 lines, for `-O2`, the program compiled by `clang` prints 9 lines and `gcc` produces infinite loop.
  - ```
    for (int i = 2147483640; i >= 0; i += 4) {
        printf("%i %x\n", i, i);
    }
    ```
    lec02/int_overflow-2.c

    Program compiled by `gcc` and `-O2` crashed. *Take a look to the asm code using the compiler parameter* `-S`

Part II

Part 2 – Control Structures: Selection Statements and Loops

Statement and Compound Statement (Block)

- Statement is terminated by ;

Statement consisting only of the semicolon is empty statement.

- Block consists of sequences of declarations and statements
- **ANSI C, C89, C90**: Declarations must be placed prior other statements

It is not necessary for C99

- Start and end of the block is marked by the { and }
- A block can be inside other block

```
void function(void)
{ /* function block start */
   {/* inner block */
      for (i = 0; i < 10; ++i)
      {
      //inner for-loop block
      }
   }
}
```

```
void function(void) { /* function block start */
   { /* inner block */
      for (int i = 0; i < 10; ++i) {
      //inner for-loop block
      }
   }
}
```

Notice the coding styles.

Coding Style

- It supports clarity and readability of the source code

  https://www.gnu.org/prep/standards/html_node/Writing-C.html

- Formatting of the code is the fundamental step

  Setup automatic formatting in your text editor

- Appropriate identifiers
- Train yourself in coding style even at the cost of slower coding
- Readability and clarity is important, especially during debugging
- Recommend coding style (PRG)

Notice, sometimes it can be better to start from scratch

```
1 void function(void)
2 { /* function block start */
3    for (int i = 0; i < 10; ++i) {
4       //inner for-loop block
5       if (i == 5) {
6          break;
7       }
8    }
9 }
```

- Use English, especially for identifiers
- Use nouns for variables
- Use verbs for function names

Lecturer's preference: indent shift 3, space characters rather than tabular.

Coding Styles – Links

- There are many different coding styles
- Inspire yourself by existing recommendations
- Inspire yourself by reading representative source codes

http://users.ece.cmu.edu/~eno/coding/CCodingStandard.html

https://www.doc.ic.ac.uk/lab/cplus/cstyle.html

http://en.wikipedia.org/wiki/Indent_style

https://google.github.io/styleguide/cppguide.html

https://www.kernel.org/doc/Documentation/CodingStyle

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https://google.github.io/styleguide/cppguide.html

Control Statements

- Selection Statement
  - Selection Statement: `if ()` or `if () ... else`
  - Switch Statement: `switch () case ...`
- Control Loops
  - `for ()`
  - `while ()`
  - `do ... while ()`
- Jump statements (unconditional program branching)
  - `continue`
  - `break`
  - `return`
  - `goto`

Selection Statement – if

- `if (expression) statement1; else statement2`
- For `expression != 0` the $\texttt{statement}_1$ is executed; otherwise $\texttt{statement}_2$

The statement can be the compound statement

- The `else` part is optional
- Selection statements can be nested and cascaded

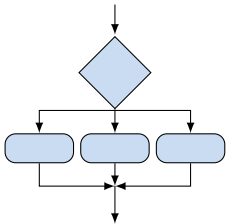
```
int max;
if (a > b) {
   if (a > c) {
      max = a;
   }
}
```

```
int max;
if (a > b) {
   ...
} else if (a < c) {
   ...
} else if (a == b) {
   ...
} else {
   ...
}
```

The `switch` Statement

- Allows to branch the program based on the value of the expression of the enumerate (integer) type, e.g., **int**, **char**, **short**, **enum**
- The form is

```
switch (expression) {
    case constant_1: statements_1; break;
    case constant_2: statements_2; break;
    ...
    case constant_n: statements_n; break;
    default: statements_def; break;
}
```



where *constants* are of the same type as the *expression* and $statements_i$ is a list of statements

- Switch statements can be nested

Semantics: First the expression value is calculated. Then, the statements under the same value are executed. If none of the branch is selected, $statements_{def}$ under `default` branch as performed (optional)

The switch Statement – Example

```c
switch (v) {
   case 'A':
      printf("Upper 'A'\n");
      break;
   case 'a':
      printf("Lower 'a'\n");
      break;
   default:
      printf(
      "It is not 'A' nor 'a'\n");
      break;
}
```

```c
if (v == 'A') {
   printf("Upper 'A'\n");
} else if (v == 'a') {
   printf("Lower 'a'\n");
} else {
   printf(
   "It is not 'A' nor 'a'\n");
}
```

lec02/switch.c

The Role of the break Statement

- The statement **break** terminates the branch. If not presented, the execution continues with the statement of the next `case` label

Example

```
1  int part = ?
2  switch(part) {
3     case 1:
4        printf("Branch 1\n");
5        break;
6     case 2:
7        printf("Branch 2\n");
8     case 3:
9        printf("Branch 3\n");
10       break;
11    case 4:
12       printf("Branch 4\n");
13       break;
14    default:
15       printf("Default branch\n");
16       break;
17 }
```

- part ← 1
  Branch 1
- part ← 2
  Branch 2
  Branch 3
- part ← 3
  Branch 3
- part ← 4
  Branch 4
- part ← 5
  Default branch

lec02/demo-switch_break.c

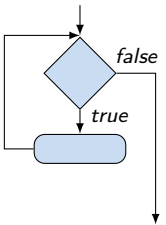
Loops

- The **for** and **while** loop statements test the controlling expression before the enter to the loop body
  - **for** – initialization, condition, change of the controlling variable can be a part of the syntax

```
for (int i = 0; i < 5; ++i) {
   ...
}
```

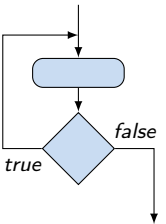
  - **while** – controlling variable out of the syntax

```
int i = 0;
while (i < 5) {
   ...
   i += 1;
}
```



- The **do** loop tests the controlling expression after the first loop is performed

```
int i = -1;
do {
   ...
   i += 1;
} while (i < 5);
```



The **for** Loop

- The basic form is

  `for (expr1; expr2; expr3) statement`

- All `expri` are expressions and typically they are used for
  1. `expr1` – initialization of the controlling variable (side effect of the assignment expression)
  2. `expr2` – Test of the controlling expression
  3. If `expr2 !=0` the `statement` is executed; Otherwise the loop is terminated
  4. `expr3` – updated of the controlling variable (performed at the end of the loop
- Any of the expressions `expri` can be omitted
- **break** statement – force termination of the loop
- **continue** – force end of the current iteration of the loop

  The expression `expr3` is evaluated and test of the loop is performed.

- An infinity loop can be written by omitting the expressions

  `for (;;) {...}`

The continue Statement

- It transfers the control to the evaluation of the controlling expression
- The `continue` statement can be used inside the body of the loops
  - `for ()`
  - `while ()`
  - `do...while ()`
- Examples

```
int i;
for (i = 0; i < 20; ++i) {
   if (i % 2 == 0) {
      continue;
   }
   printf("%d\n", i);
}
```

lec02/continue.c

```
for (int i = 0; i < 10; ++i) {
   printf("i: %i ", i);
   if (i % 3 != 0) {
      continue;
   }
   printf("\n");
}
```

lec02/demo-continue.c

```
clang demo-continue.c
./a.out
i:0
i:1 i:2 i:3
i:4 i:5 i:6
i:7 i:8 i:9
```

The break Statement – Force Termination of the Loop

- The program continue with the next statement after the loop
- Example in the while loop

```c
int i = 10;
while (i > 0) {
   if (i == 5) {
      printf("i reaches 5, leave the loop\n");
      break;
   }
   i--;
   printf("End of the while loop i: %d\n", i);
}
```

lec02/break.c

- Example in the for loop

```c
for (int i = 0; i < 10; ++i) {
   printf("i: %i ", i);
   if (i % 3 != 0) {
      continue;
   }
   printf("\n");
   if (i > 5) {
      break;
   }
}
```

```
clang demo-break.c
./a.out
i:0
i:1 i:2 i:3
i:4 i:5 i:6
```

lec02/demo-break.c

The goto Statement

- Allows to transfers the control to the defined label

It can be used only within a function body

- Syntax `goto label;`
- The jump `goto` can jump only outside of the particular block
- It can be used only within a function block

```
1  int test = 3;
2  for (int i = 0; i < 3; ++i) {
3     for (int j = 0; j < 5; ++j) {
4        if (j == test) {
5           goto loop_out;
6        }
7        fprintf(stdout, "Loop i: %d j: %d\n", i, j);
8     }
9  }
10 return 0;
11 loop_out:
12 fprintf(stdout, "After loop\n");
13 return -1;
```

lec02/goto.c

Nested Loops

- The **break** statement terminates the inner loop

```
for (int i = 0; i < 3; ++i) {
   for (int j = 0; j < 3; ++j) {
      printf("i-j: %i-%i\n", i, j);
      if (j == 1) {
         break;
      }
   }
}
```

```
i-j: 0-0
i-j: 0-1
i-j: 1-0
i-j: 1-1
i-j: 2-0
i-j: 2-1
```

- The outer loop can be terminated by the `goto` statement

```
for (int i = 0; i < 5; ++i) {
   for (int j = 0; j < 3; ++i) {
      printf("i-j: %i-%i\n", i, j);
      if (j == 2) {
         goto outer;
      }
   }
}
outer:
```

```
i-j: 0-0
i-j: 0-1
i-j: 0-2
```

lec02/demo-goto.c

Example – isPrimeNumber() 1/2

```c
#include <stdbool.h>
#include <math.h>

_Bool isPrimeNumber(int n)
{
   _Bool ret = true;
   for (int i = 2; i <= (int)sqrt((double)n); ++i) {
      if (n % i == 0) {
         ret = false;
         break;
      }
   }
   return ret;
}
```

lec02/demo-prime.c

- Once the first factor is found, call `break` to terminate the loop

It is not necessary to test other numbers

Example – isPrimeNumber() 2/2

- The value of `(int)sqrt((double)n)` is not changing in the loop

```
for (int i = 2; i <= (int)sqrt((double)n); ++i) {
    ...
}
```

- We can use the comma operator to initialize the `maxBound` variable

```
for (int i = 2, maxBound = (int)sqrt((double)n);
      i <= maxBound; ++i) {
    ...
```

- Or, we can declare `maxBound` as a constant variable

```
_Bool ret = true;
const int maxBound = (int)sqrt((double)n);
for (int i = 2; i <= maxBound ; ++i) {
    ...
}
```

E.g., Compile and run `demo-prime.c`: `clang demo-prime.c -lm; ./a.out 13`

Conditional Expression – Example Greatest Common Divisor

```
1  int getGreatestCommonDivisor(int x, int y)
2  {
3     int d;
4     if (x < y) {
5        d = x;
6     } else {
7        d = y;
8     }
9     while ( (x % d != 0) || (y % d ! = 0)) {
10       d = d - 1;
11    }
12    return d;
13 }
```

- The same with the conditional expression: $\mathbf{expr_1}$? $\mathbf{expr_2}$: $\mathbf{expr_3}$

```
1  int getGreatestCommonDivisor(int x, int y)
2  {
3     int d = x < y ? x : y;
4     while ( (x % d != 0) || (y % d ! = 0)) {
5        d = d - 1;
6     }
7     return d;
8  }
```

lec02/demo-gcd.c

Part III

Part 3 – Assignment HW 01

HW 01 / HW 1 – Assignment

Topic: **ASCII art**

(B3B36PRG) Mandatory: **2 points**; Optional: none; Bonus : none

(BAB36PRGA) Mandatory: **3 points**; Optional: none; Bonus : none

- **Motivation**: Have a fun with loops and user parametrization of the program
- **Goal**: Acquire experience using loops and inner loops
- **Assignment** https://cw.fel.cvut.cz/wiki/courses/b3b36prg/hw/hw01
  https://cw.fel.cvut.cz/wiki/courses/bab36prga/hw/hw1
  - Read parameters specifying a picture of small house using selected ASCII chars
    https://en.wikipedia.org/wiki/ASCII_art
  - Assesment of the input values
- (B3B36PRG) Deadline: 05.03.2022, 23:59 AoE
- (BAB36PRGA) Deadline: 12.03.2022, 23:59 AoE

AoE – Anywhere on Earth

Summary of the Lecture

Topics Discussed

- Expressions
  - Operators – Arithmetic, Relational, Logical, Bitwise, and others
  - Operator Associativity and Precedence
  - Assignment and Compound Assignment
  - Implementation-Defined Behaviour
  - Undefined Behaviour
- Coding Styles
- Select Statements
- Loops
- Conditional Expression

- Next: Data types, memory storage classes, function call