

Basic elements of the C language

Basics of Programming 1



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- History

- The first program

- Variables

- Scanning data, inputting

Chapter 1

Introduction

Contact



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 - Department of Electron Devices
- Márton Németh
 - email: nemeth.marton@vik.bme.hu
- Important webpages for the course:
 - The main webpage (slides, exercises, solutions):
<http://www.eet.bme.hu/bop>
 - The portal managing the assignments:
<https://cprog.eet.bme.hu>

Requirements

1 Laboratory practices

- Active participation on at least 70% of the labs
- Entrance test at the beginning of the labs
- Max. number of absences/failed entrance tests: 4
- Solutions to lab problems must be uploaded to CProg

2 Classroom practices

- Participation on at least 70% of the practices
- 6 mid-term “small tests” in total (10 pts each)
- The sum of best 4 must be above 20 pts
- No re-take available
- Small tests on 4th, 6th, 8th, 10th, 11th, 14th week’s practice

3 “Big test”

- There will be 2 mid-term “big tests”
- Option 1: sum of the scores $\geq 50\%$
- Option 2: the score of the second one $\geq 50\%$
- The one with lower score can be re-taken
- 1st midterm on 17th of October, from 18:15
- 2nd midterm on 7th of December, from 18:15

Requirements

1 Homework project

- Milestones will be published, extra score if deadlines are met
- Choice
- Specification
- Current state (AKA: Skeleton)
- Final submission (13th week)
- Face-to-face presentation is mandatory!
- Plagiarism check for every submission, it is an individual work!

Recommended literature

Any book about Standard C programming language
in your own language

Chapter 2

Basic terms

Programming



Programming

How to make ham and eggs?

Programming

How to make ham and eggs?

```
1 Bake some ham in hot vegetable oil
2 Add three eggs to it
3 ...
```

Programming

How to make ham and eggs?

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How to bake the ham in oil?

Programming

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How to bake the ham in oil?

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1 Get a frying pan
2 Put it on the stove (fire)
3 Add some vegetable oil to it
4 Bring it to boiling
5 Put some ham in it
6 Wait until the ham gets a bit brown
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Programming

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How to bring the oil to boiling?

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5 Put some ham in it
6 Wait until the ham gets a bit brown
```

How to bring the oil to boiling?

```
1 Light the fire
2 Wait a little bit
3 Is the oil hot enough?
4 If not, go back to line 2
```

The impreative programming paradigm

The impreative programming paradigm

Programming

We tell the computer what to do

The imperative programming paradigm

Programming

We tell the computer what to do

Programming paradigms

These are the principles, that we use to create the program

- Imperative programming
- Functional programming
- Object-oriented programming
- etc. . .

The imperative programming paradigm

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Imperative programming

We tell the computer step-by-step, what to do

The impreative programming paradigm

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Programming paradigms

These are the principles, that we use to create the program

- **Imperative programming** ← This is what we learn
- Functional programming
- Object-oriented programming
- etc. . .

Imperative programming

We tell the computer step-by-step, what to do

- by defining an algorithm

The process of programming

We will always take these steps during the course:

- 1 We describe the task
- 2 We construct an algorithm for solving the task
- 3 We create the program – we create the code of the algorithm

The process of programming

In more details:

- 1 We describe the task
- 2 We give an exact specification of the task
- 3 We select the right data structure for modelling the problem
- 4 We construct an algorithm for solving the task
- 5 We select an effective programming language for coding (in this course: C)
- 6 We create the code of the algorithm (coding)
- 7 We test the program

Algorithm

Algorithm (method)

A finite sequence of steps, that can be performed mechanically and leads to the solution

Algorithm

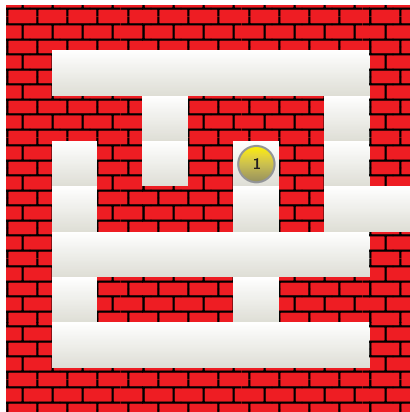
Algorithm (method)

A finite sequence of steps, that can be performed mechanically and leads to the solution

- Before coding we check if the algorithm
 - right – it gives solution to our problem (and not to something else)
 - complete – it gives solution in all possible cases
 - finite – it will end in finite number of steps
- It is not enough to try, you also have to prove it!

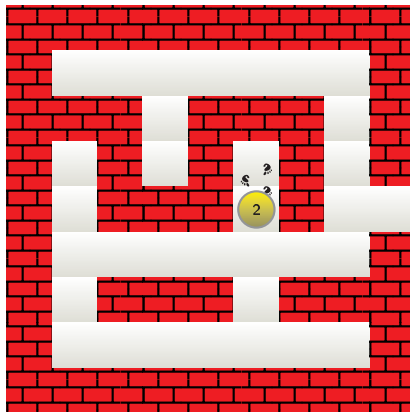
Algorithms

- Task: Escape from the dark maze (labyrinth)

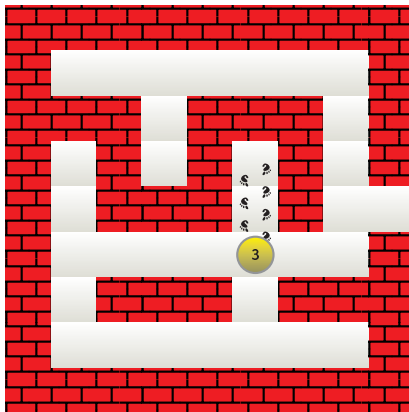


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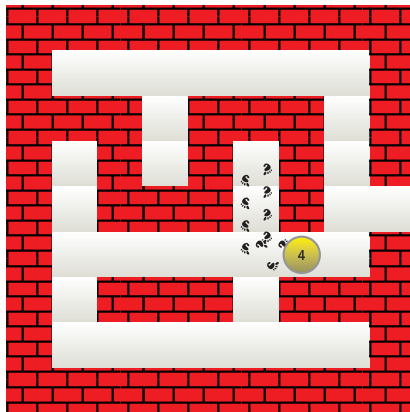


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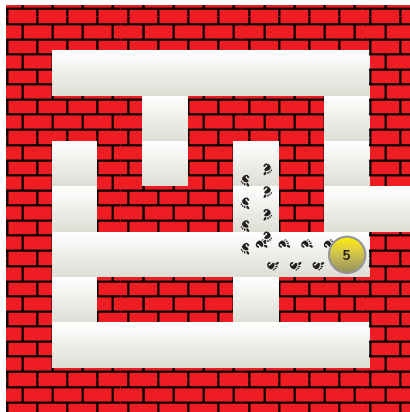
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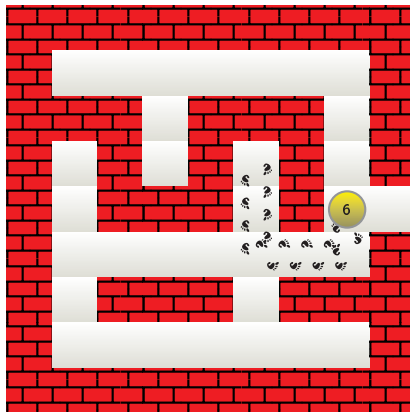
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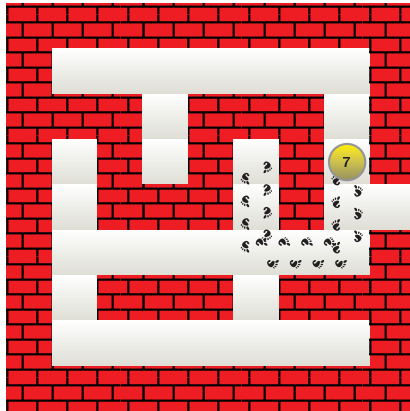
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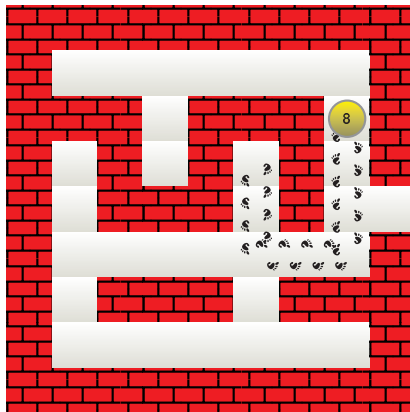
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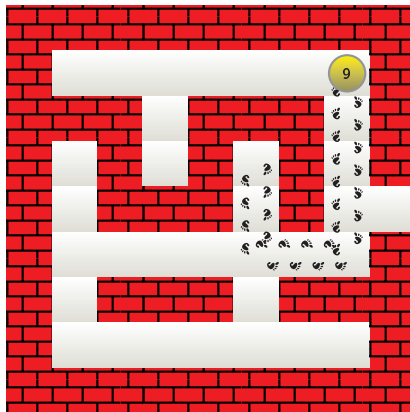
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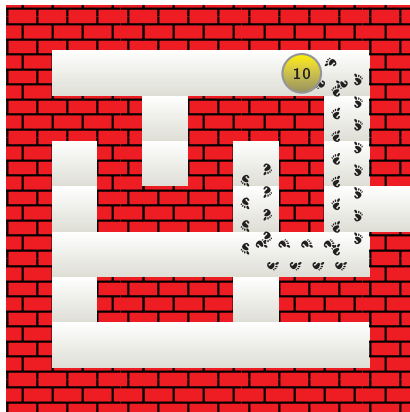
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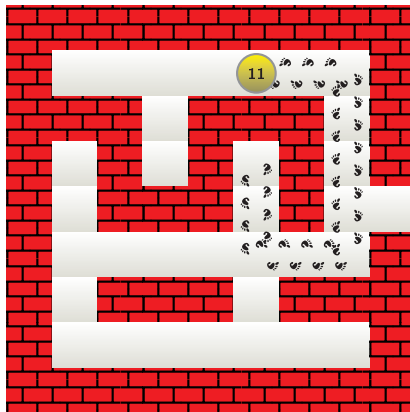
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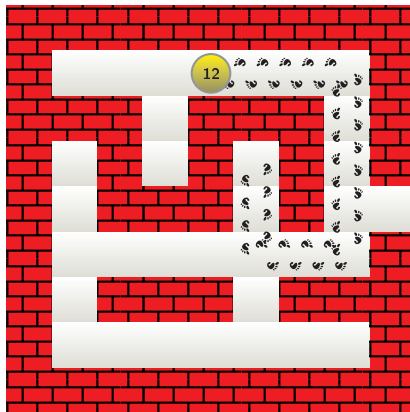
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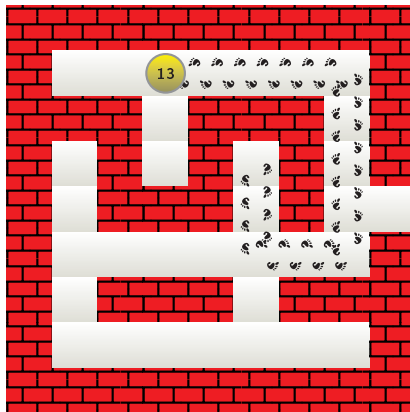
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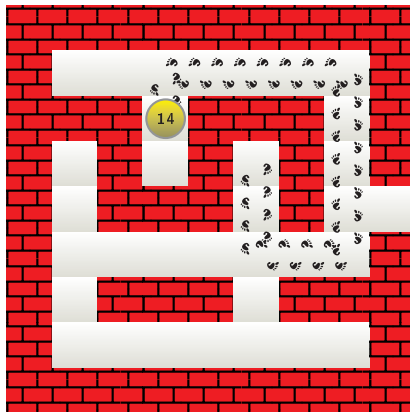
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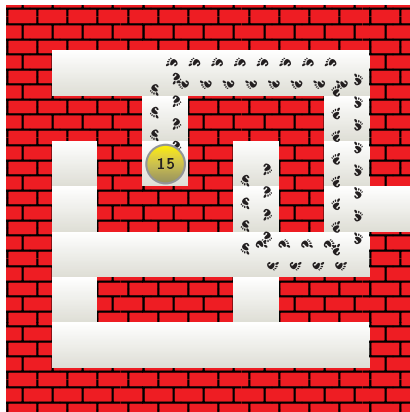
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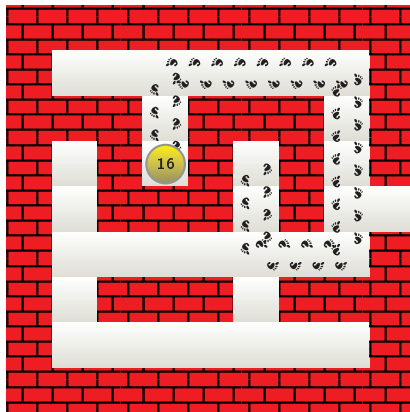
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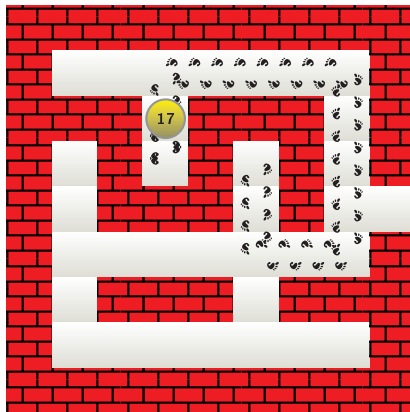
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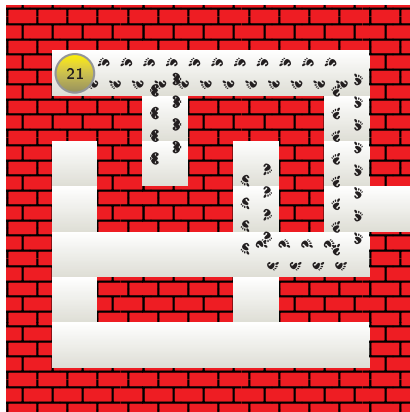


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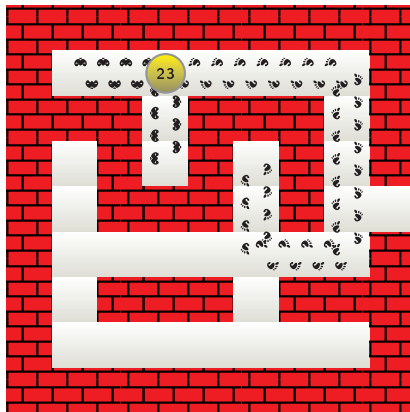
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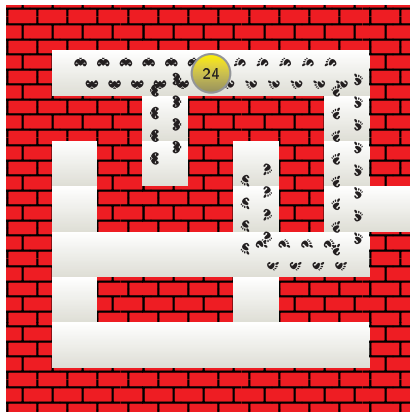
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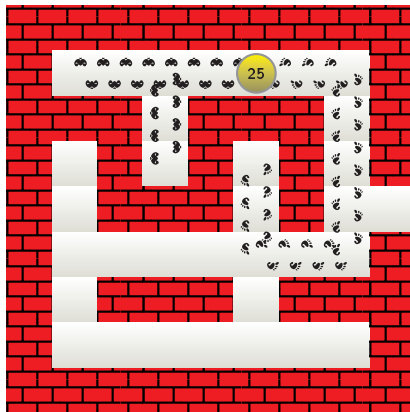


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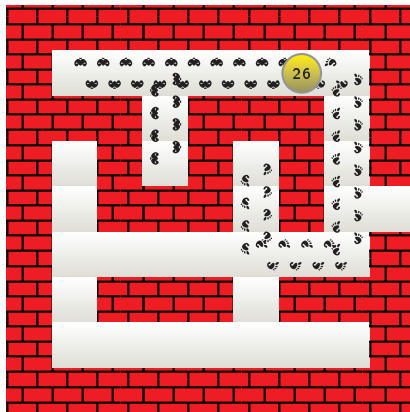


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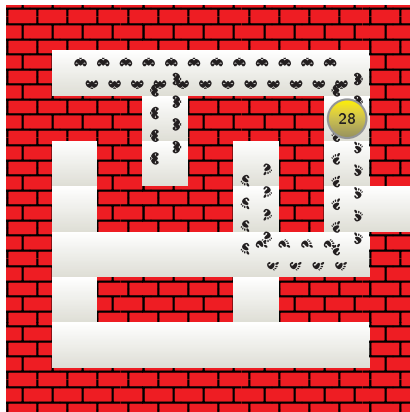
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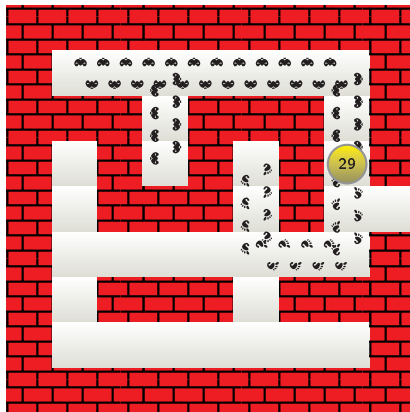
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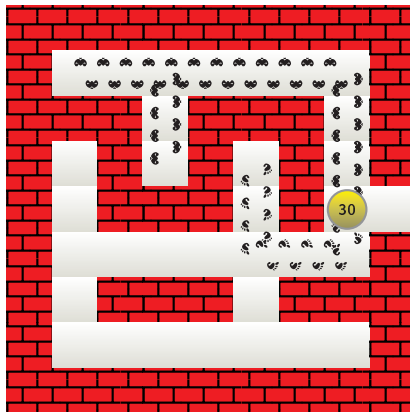
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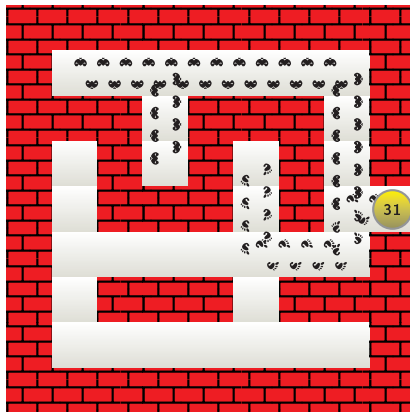
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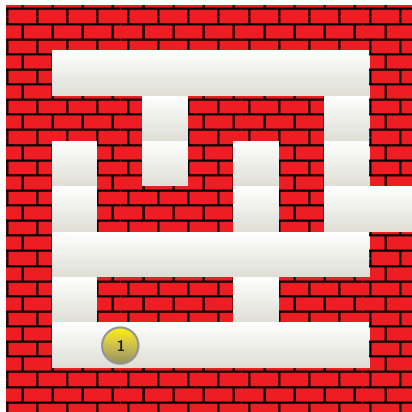
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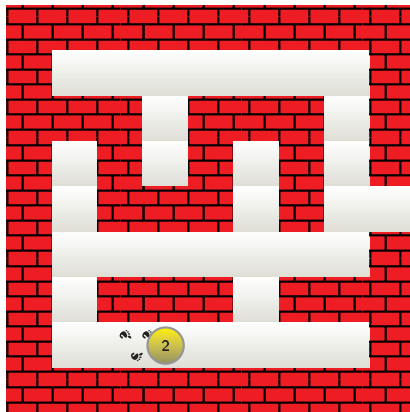
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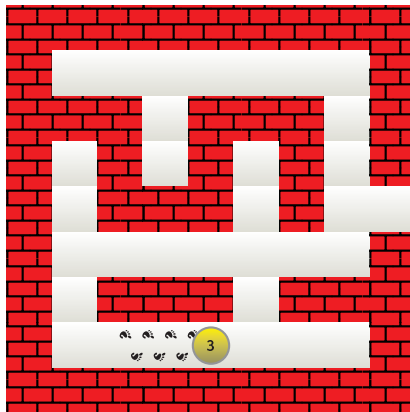
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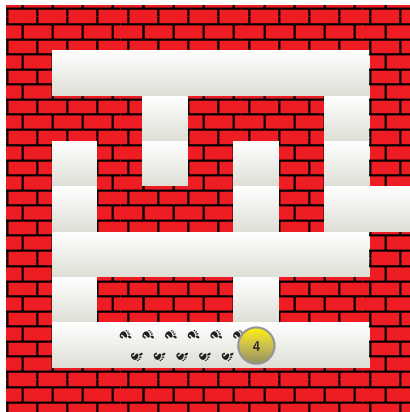
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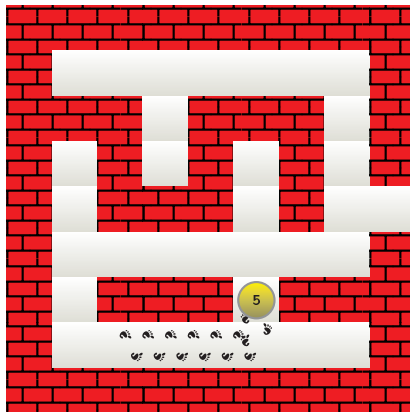
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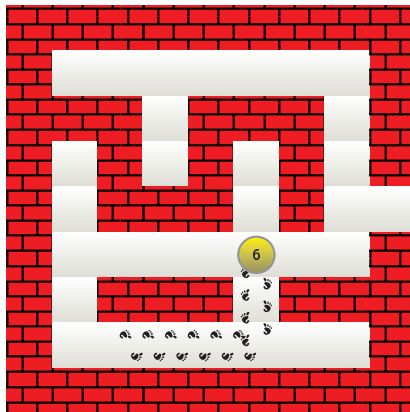
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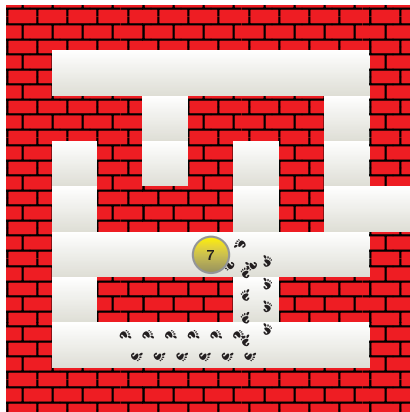
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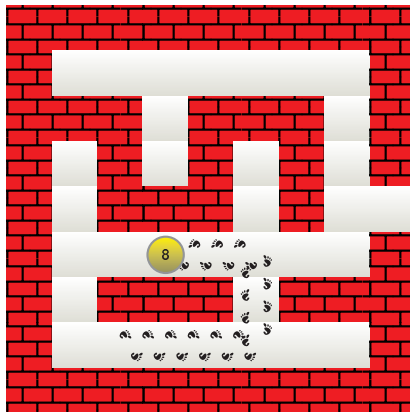
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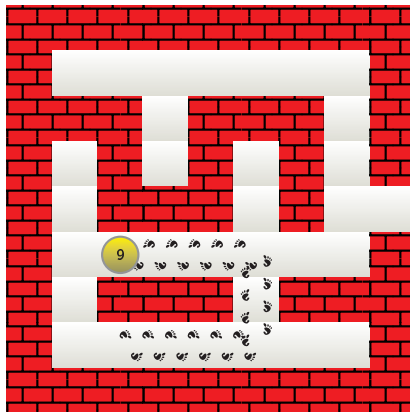
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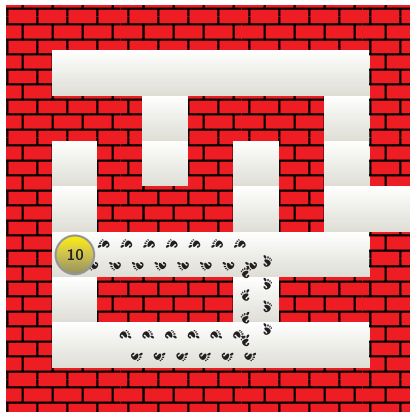
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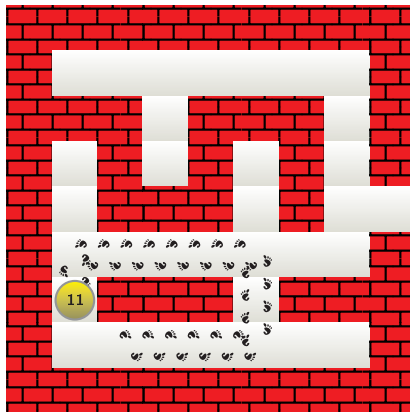
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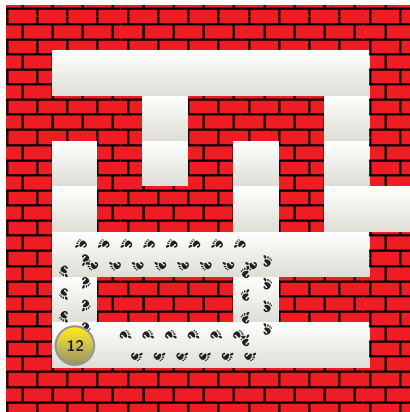
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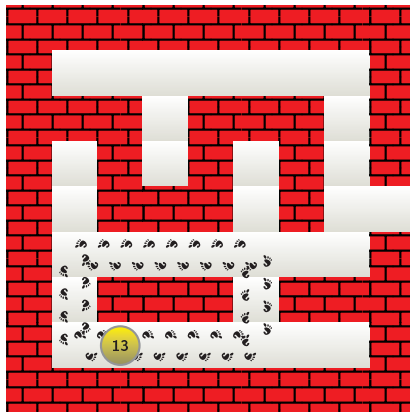
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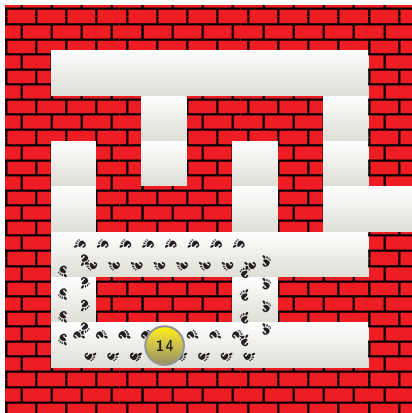
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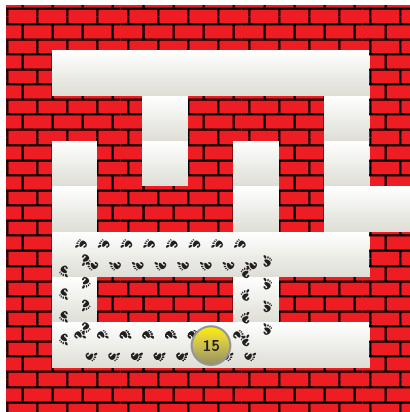
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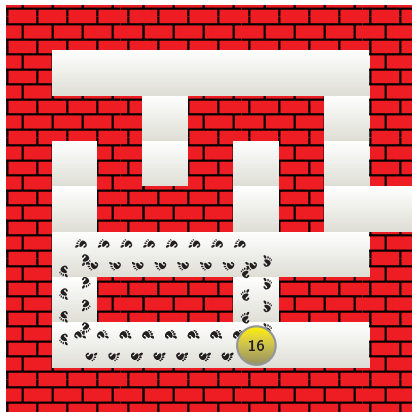
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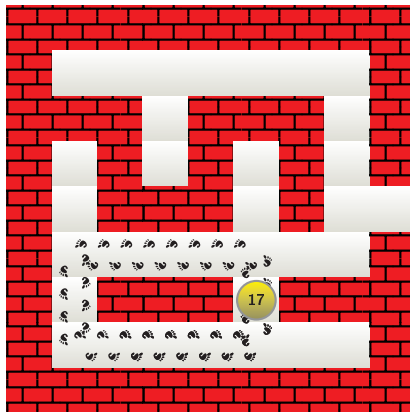
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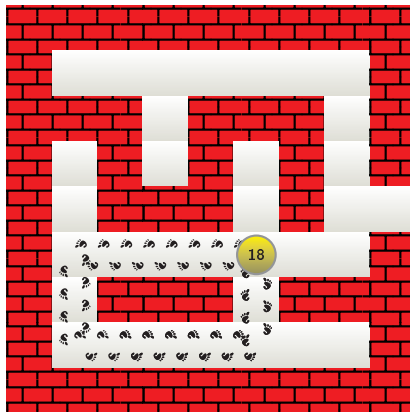
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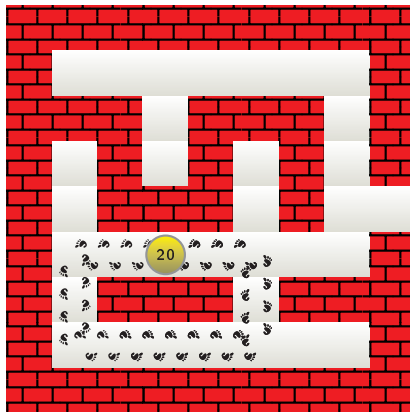
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Algorithms – examples

- Even if the algorithm is right, complete and finite, it might be not manageable (not tractable)

Algorithms – examples

- Even if the algorithm is right, complete and finite, it might be not manageable (not tractable)
- It is important to be finite also in practice, which means
 - should be finished within acceptable time
 - should work with reasonable amount of data

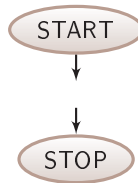
Description of algorithms

- Pseudo-code is a language independent way of describing algorithms
- it is written in a normal (human) language, but it is constructed precisely

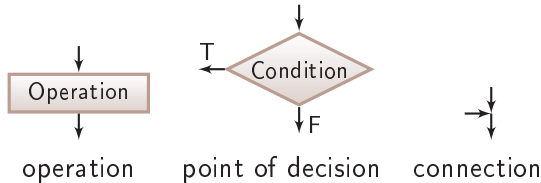
```
1  Get a frying pan
2  Put it on the stove (fire)
3  Add some vegetable oil to it
4  Light the fire
5  Wait a little bit
6  Is the oil hot enough?
7  If not, go back to line 5
8  Put some ham in it
9  Wait until the ham gets a bit brown
10 Add three eggs to it
```

Description of algorithms

- Flow-chart is a tool for describing algorithms in a graphical way
- The flow-chart of a program with one input and one output is placed between START and STOP elements



- A flow-chart consists of the following elements

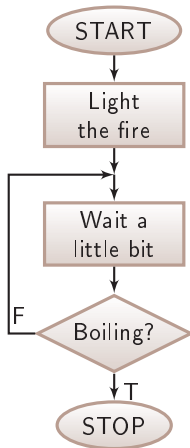


Flow-chart – example

- Construct the flow-chart of boiling water

Flow-chart – example

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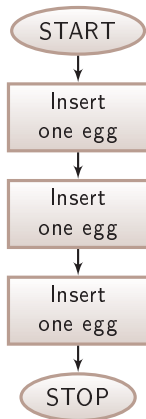


Flow-chart – example

- How do we insert 3 eggs?

Flow-chart – example

- How do we insert 3 eggs?



Flow-chart – example

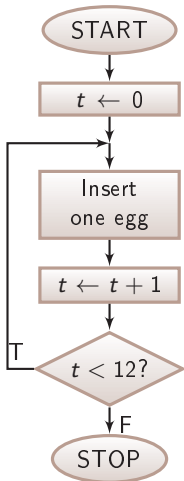
- How do we insert 12 eggs?

Flow-chart – example

- How do we insert 12 eggs?
- Let's use t for counting the number of eggs inserted!

Flow-chart – example

- How do we insert 12 eggs?
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What is data?

- Algorithm works on data, with data

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Data

Data is everything from the outside world that we somehow represent and store on our computer.

What is data?

- Algorithm works on data, with data

Data

Data is everything from the outside world that we somehow represent and store on our computer.

- The data has
 - type (number, letter, colour, ...)
 - value

What is data?

- Algorithm works on data, with data

Data

Data is everything from the outside world that we somehow represent and store on our computer.

- The data has
 - type (number, letter, colour, ...)
 - value
- The data determines
 - the set of values the data may have
 - the operations that can be performed on the data

Types – examples

type	values	operations
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expression	type	value	remark
$2 + 3$	number	5	
$-a$	number	-3	if $a = 3$
$2 * (a - 2)$	number	2	if $a = 3$
true AND false	logical	false	

Expressions

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$(2 < 3) + 5$	logical + number

Programming languages

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Mathematical formalism that can be interpreted by the computer

- It is similar to spoken languages, in order to be easily understandable and to be easily constructed
- Small vocabulary, very strict grammar (syntax)

Syntax and semantics

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 - We don't follow the rules of the programming language, the program is not interpretable, it is not executable.
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 - In most of the cases it can be corrected easily, quickly.
- Semantic error (interpretation error)
 - The program is executable, it performs something, but it does not do exactly what we have specified.
 - Semantic error is typically hard to detect and hard to correct.
 - Program testing is a profession.

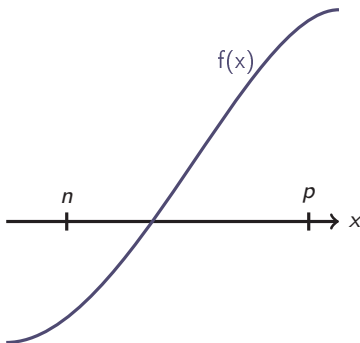
Chapter 3

Structured programming

Algorithms

Finding zeros of functions

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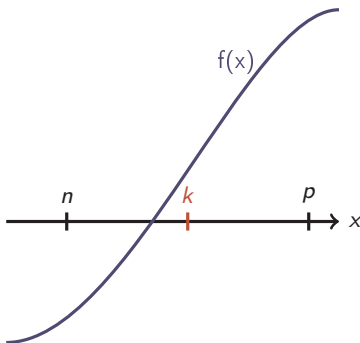


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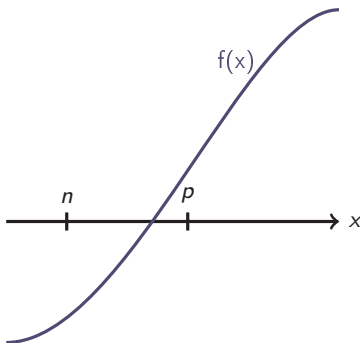


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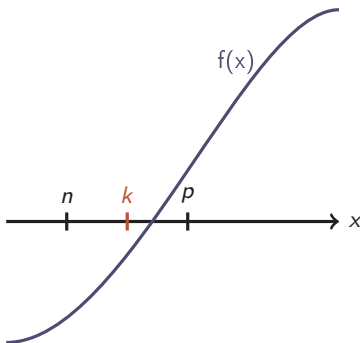


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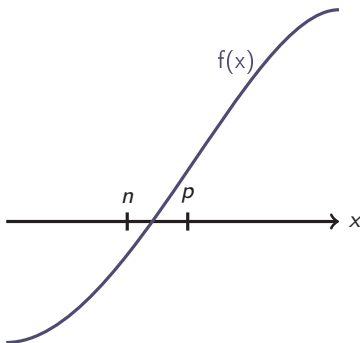


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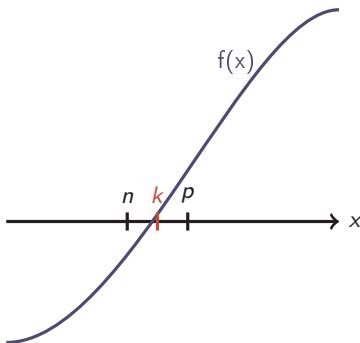


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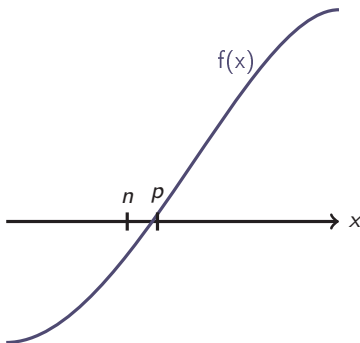


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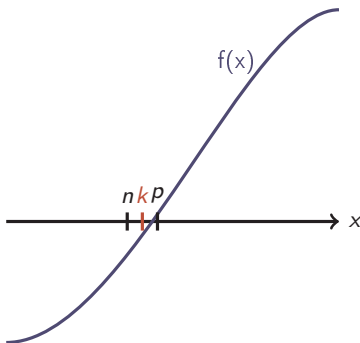


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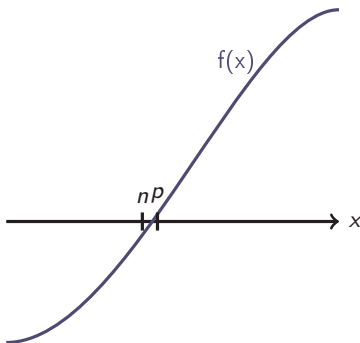


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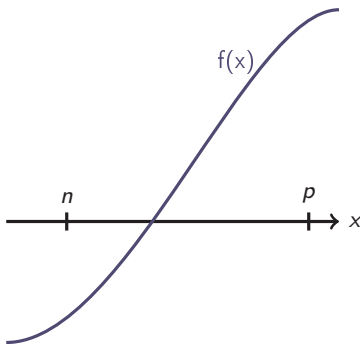


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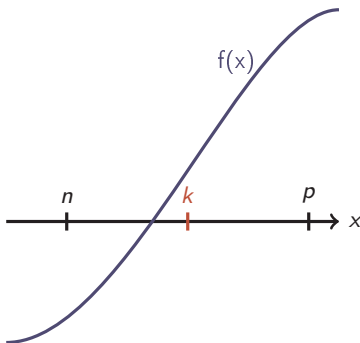


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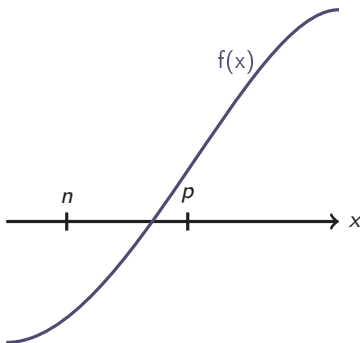


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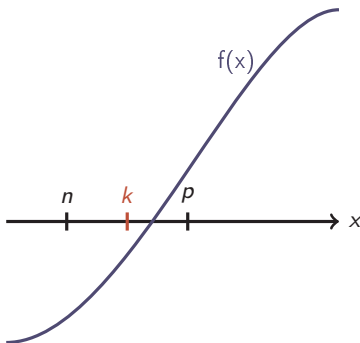


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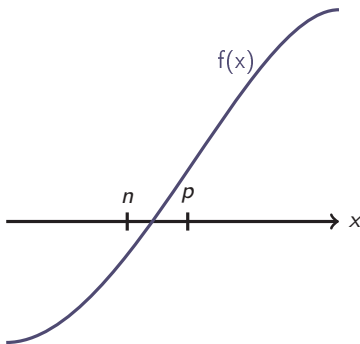


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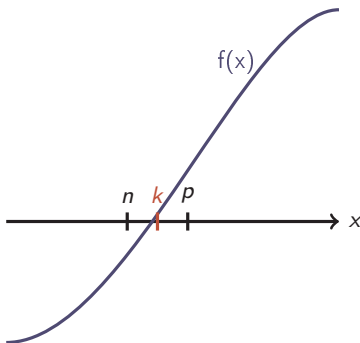


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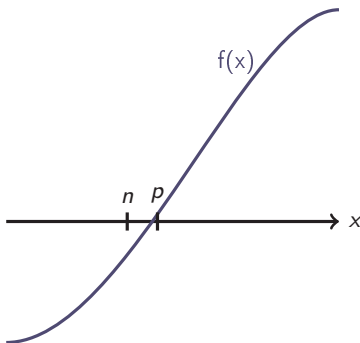


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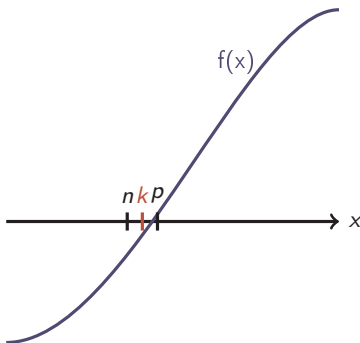


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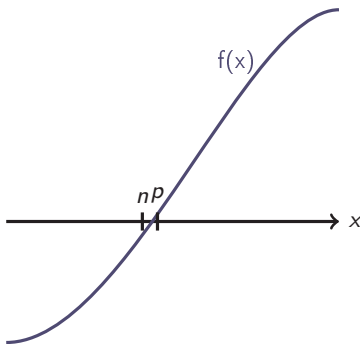


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■ Structured program

- easy to maintain
- complex control
- higher level

■ Unstructured program

- spaghetti-code
- easy control
- "hardware-level"

Structured vs unstructured

- Hardware level languages
 - Lot of simple instructions
 - Easy control (JUMP; IF TRUE, JUMP)
 - Unstructured layout
 - The processor can interpret only this
- Higher level languages
 - Rather few, but complex instructions
 - More difficult control (WHILE...REPEAT...;
IF...THEN...ELSE...)
 - Structured layout
 - The processor is unable to interpret it.
- The compiler transforms a high level structured program into a hardware level program, that is equivalent to the original one.
- We create a high level structured program, we use the compiler to translate it, and we execute the hardware level code.

Elements of structured programs

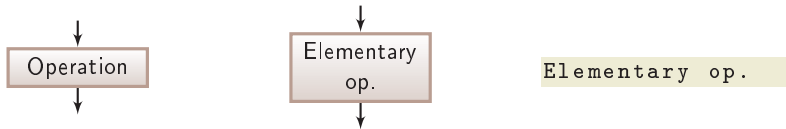


- All structured programs follow this simple scheme:
- The structure of the program is determined by the **inner structure (layout)** of Operation.
- Operation can be:
 - Elementary operation (action)
 - Sequence
 - Loop or repetition
 - Selection

Elements of structured programs

Elementary operation

that cannot be further expanded



- The empty operation (don't do anything) is also an elementary operation



Elements of structured programs

Sequence

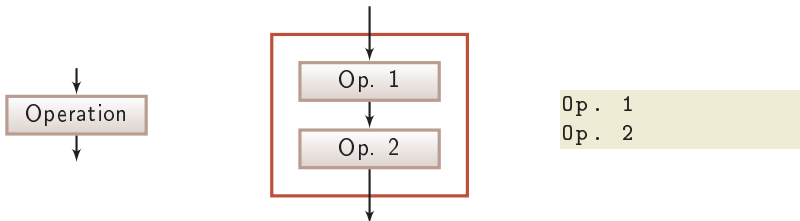
Execution of two operations after each other, in the given order



Elements of structured programs

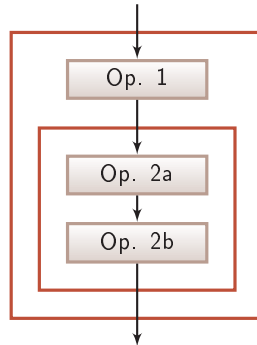
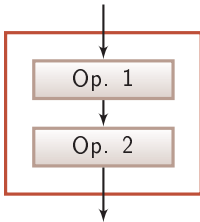
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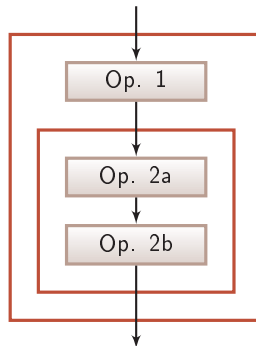
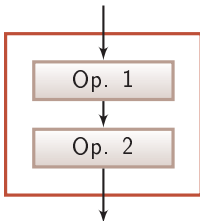
Elements of structured programs

- Each element of the sequence itself is an operation, so they can be expanded into a sequence



Elements of structured programs

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- The expansion can be continued, so a sequence can be an arbitrary long (finite) series of operations.

Elements of structured programs

Condition-based selection

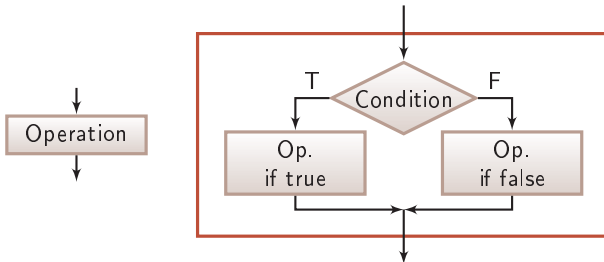
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Elements of structured programs

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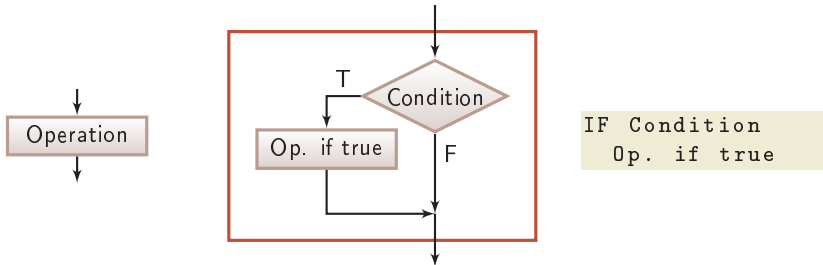
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```
IF Condition
    Op. if true
ELSE
    Op. if false
```

Elements of structured programs

- One of the branches can also be empty.



Elements of structured programs

Top-test loop

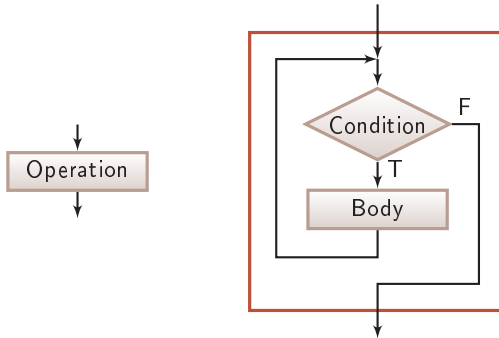
Repetition of an operation as long as a condition is true.



Elements of structured programs

Top-test loop

Repetition of an operation as long as a condition is true.



```
WHILE Condition  
  Body of loop
```

Elements of structured programming

Theorem of structured programming

By using only

- elementary operation,
- sequence,
- selection, and
- loop

ALL algorithms can be constructed.

The structogram

- The flowchart
 - a tool for describing unstructured programs
 - can be translated (compiled) into an unstructured program immediately (IF TRUE, JUMP)
 - structured elements (esp. loops) are hard to recognize within it
- The structogram
 - a tool for representing structured programs
 - only a structured program can be represented by it
 - it is easily translated into a structured program

The structogram

- The program is a rectangle



The structogram

- The program is a rectangle



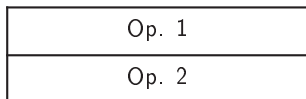
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The structogram

- The program is a rectangle



- it can be expanded into more rectangles with the elements below
- Sequence



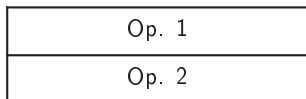
The structogram

- The program is a rectangle

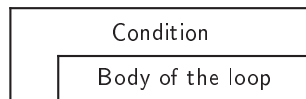


- it can be expanded into more rectangles with the elements below

- Sequence



- Top-test loop



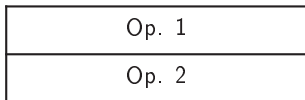
The structogram

- The program is a rectangle

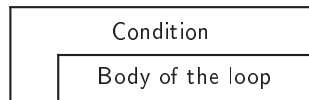


- it can be expanded into more rectangles with the elements below

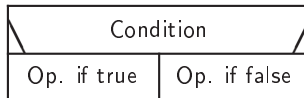
- Sequence



- Top-test loop

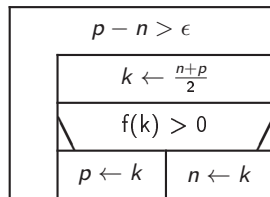
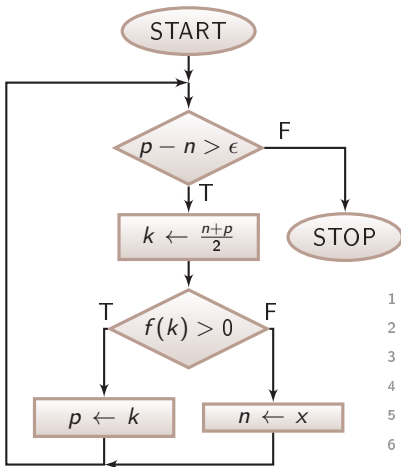


- Selection



The structogram

■ Finding zeros – flowchart, structogram, structured pseudo-code



```

1  WHILE p-n > eps, repeat
2      k ← (n+p) / 2
3      IF f(k) > 0
4          p ← k;
5      OTHERWISE
6          n ← k;
  
```

Chapter 4

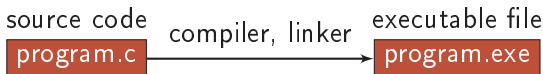
C language basics

Short history of C programming language

- 1972: Start of development at AT&T Bell Labs
Most of the UNIX kernel was created in C
- 1978: K&R C – Brian Kernigham, Dennis Ritchie:
The C Programming Language
- 1989: Standardization: ANSI X3.159-1989
- 1999: C99-standard:
new data types (complex)
international character encoding
arrays with variable sizes
...
- 2007–: C1X standard, 2011: C11 standard
C++ compatibility
multi-thread programs
...

Main features of C

- Compiled language



- "small language": few (10) instructions, a lot of (>50) operators
- concise syntax ("zipped")
 - hard to read (must pay attention)
 - easy to make a mistake
 - hard to find a mistake
- it gives a code that can be optimized efficiently and runs fast
- easy to implement for different platforms

The first C program

■ The source code of the minimum-program

```
1  /* first.c -- The first program */
2
3  int main()
4  {
5      return 0;
6  }
```

[link](#)

The first C program

■ The source code of the minimum-program

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[link](#)

■ The program starts, and after that it ends (finishes its run)

The first C program

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[link](#)

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- between `/*` and `*/` there are comments: messages for the programmer

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[link](#)

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- between `/*` and `*/` there are comments: messages for the programmer
- `int main()` – All C programs starts like this

The first C program

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[link](#)

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 - `int Main()` – and not like this. C is "case sensitive"

The first C program

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[link](#)

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- `{ }` – block, it encloses the program body

The first C program

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[link](#)

- The program starts, and after that it ends (finishes its run)
- between `/*` and `*/` there are comments: messages for the programmer
- `int main()` – All C programs starts like this
 - `int Main()` – and not like this. C is "case sensitive"
- `{ }` – block, it encloses the program body
- `return 0;` – It marks the end of the program

The first C program

■ ...that actually does something

```
1  /* Helloworld.c -- My first program */
2  #include <stdio.h> /* needed for printf */
3
4  /* The main program */
5  int main()
6  {
7      printf("Hello world!\n"); /* Printing */
8      return 0;
9  }
```

[link](#)

■ After compiling and running it gives the following output:

```
Hello world!
```

The first C program

- ...that actually does something

```
1  /* Helloworld.c -- My first program */
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[link](#)

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```
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- `#include` – to insert other C program parts

The first C program

- ...that actually does something

```
1  /* Helloworld.c -- My first program */
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5  int main()
6  {
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8      return 0;
9  }
```

[link](#)

- After compiling and running it gives the following output:

```
Hello world!
```

- `#include` – to insert other C program parts
- `printf` – printing, `\n` – new line (line feed)

A more complicated one

■ Instructions in a sequence

```
1  /* football.c -- football fans */
2  #include <stdio.h>
3  int main()
4  {
5      printf("Are you"); /* no new line here */
6      printf(" blind?\n"); /* here is new line */
7      printf("Go Bayern, go!");
8      return 0;
9  }
```

[link](#)

```
Are you blind?
Go Bayern, go!
```

Printing the value of a variable

```
1 #include <stdio.h>
2 int main()
3 {
4     int n;           /* declaring an integer var., called n */
5     n = 2;           /* n <- 2 assignement of value */
6     printf("The value is: %d\n", n); /* printing */
7     n = -5;          /* n <- -5 assignement of value */
8     printf("The value is: %d\n", n); /* printing */
9     return 0;
10 }
```

[link](#)

```
The value is: 2
The value is: -5
```

Printing the value of a variable

```
1 #include <stdio.h>
2 int main()
3 {
4     int n;           /* declaring an integer var., called n */
5     n = 2;           /* n <- 2 assignement of value */
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8     printf("The value is: %d\n", n); /* printing */
9     return 0;
10 }
```

[link](#)

```
The value is: 2
```

```
The value is: -5
```

- `int n` – declaration of variable.
`int` (integer number) is the type, `n` is the identifier

Printing the value of a variable

```
1 #include <stdio.h>
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4     int n;           /* declaring an integer var., called n */
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9     return 0;
10 }
```

[link](#)

```
The value is: 2
```

```
The value is: -5
```

- `int n` – declaration of variable.
`int` (integer number) is the type, `n` is the identifier
- `n = 2` – assignment of value, variable `n` takes value of expression "2"

... continued

```
1 #include <stdio.h>
2 int main()
3 {
4     int n;           /* declaring an integer var., called n */
5     n = 2;           /* n <- 2 assignment of value */
6     printf("The value is: %d\n", n); /* printing */
7     n = -5;          /* n <- -5 assignment of value */
8     printf("The value is: %d\n", n); /* printing */
9     return 0;
10 }
```

[link](#)

- `printf(<format>, <what>)` –
printing the value of expression `<what>` in the given `<format>`
format
 - `%d` – decimal (decimal number system)

Block and declaration

Structure of the block

```
{  
    <declarations>  
    <instructions>  
}
```

```
1 {  
2     /* declarations */  
3     int n;  
4  
5     /* instructions */  
6     n = 2;  
7     printf("%d\n", n);  
8 }
```

Block and declaration

Structure of declaration

```
<type name> <identifier> [ = <initial value> ]opt;
```

```
1 int n; /* not initialized */  
2 int number_of_dogs = 2; /* initialized */
```

- value of `n` is garbage from memory at the beginning
- value of `number_of_dogs` is 2 at the beginning

Inputting data

```
1  /* square.c -- square of a number */
2  #include <stdio.h>
3  int main()
4  {
5      int num;          /* declaring an integer var. */
6      printf("Please give an integer value: "); /* info */
7      scanf("%d", &num);          /* inputting */
8      /* printing the value of 2 expressions */
9      printf("The square of %d is: %d\n", num, num*num);
10     return 0;
11 }
```

[link](#)

```
Please give an integer value:  8
The square of 8 is:  64
```

Inputting data

```
1  /* square.c -- square of a number */
2  #include <stdio.h>
3  int main()
4  {
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8      /* printing the value of 2 expressions */
9      printf("The square of %d is: %d\n", num, num*num);
10     return 0;
11 }
```

[link](#)

```
Please give an integer value: 8
The square of 8 is: 64
```

- `scanf(<format>, &<where to>)` –
Inputting (scanning) data in `<format>` format and putting it
into `<where to>` variable

Inputting data

- This is another option, that gives the same result.

```
1 #include<stdio.h>int main(){int num; printf
2 ("Please give an integer value: ");scanf("%d",
3     &num);printf("The square of %d is: %d\n",
4     num,num*num);return
5     0;}
```

[link](#)

Inputting data

- This is another option, that gives the same result.

```
1 #include<stdio.h>int main(){int num; printf
2 ("Please give an integer value: ");scanf("%d",
3     &num);printf("The square of %d is: %d\n",
4     num,num*num);return
5     0;}
```

[link](#)

- Not recommended, unmanagable

Thank you for your attention.