Structured programs – Elements of C language

Basics of Programming 1

DEPARTMENT OF
NETWORKED SYSTEMS
AND SERVICES

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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Finding zeros of functions

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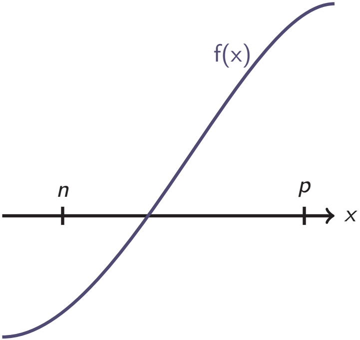


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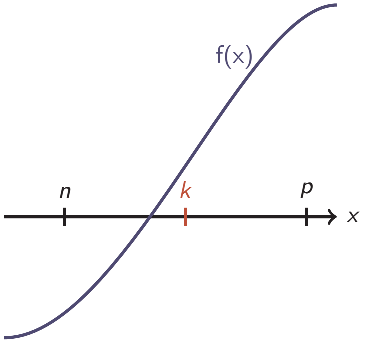


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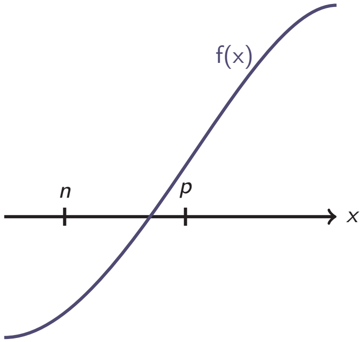


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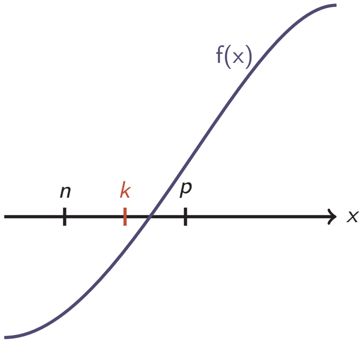


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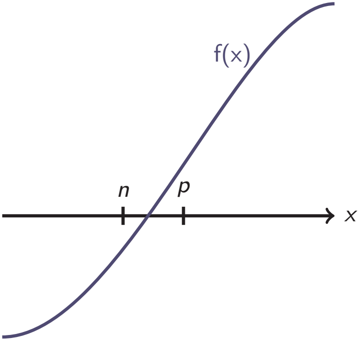


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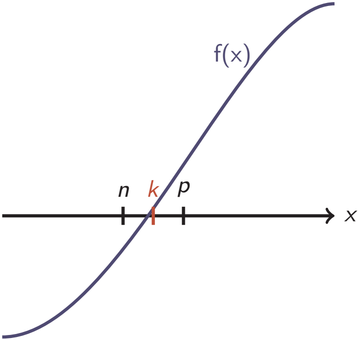


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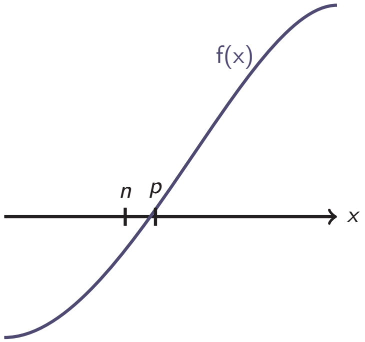


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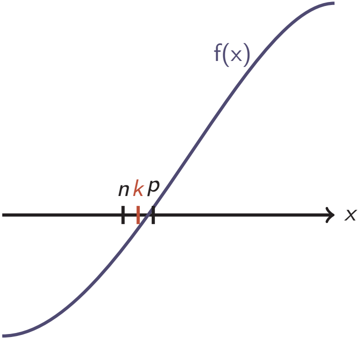


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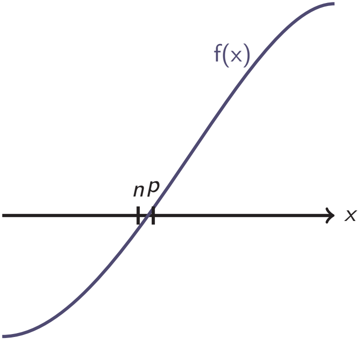


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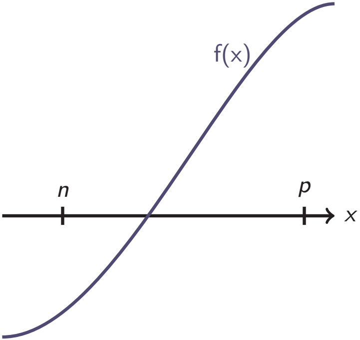


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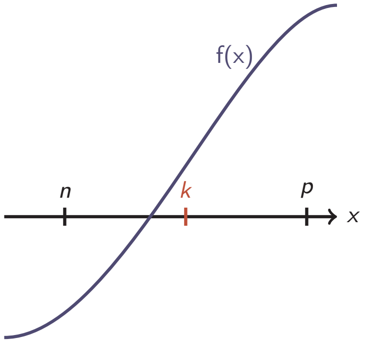


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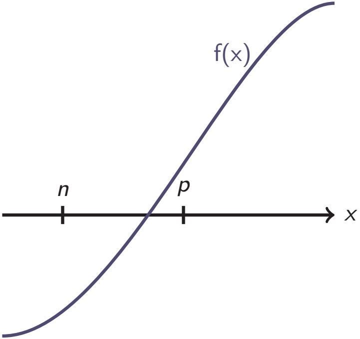


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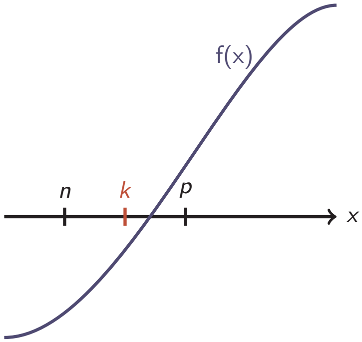


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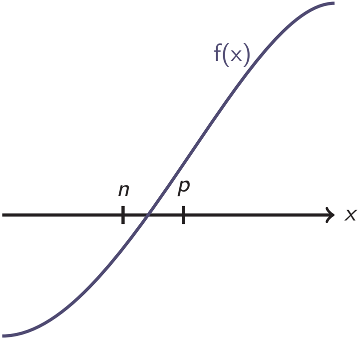


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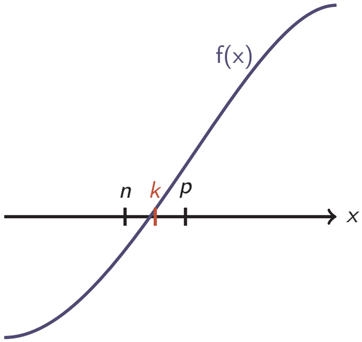


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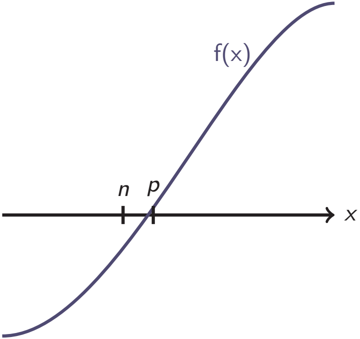


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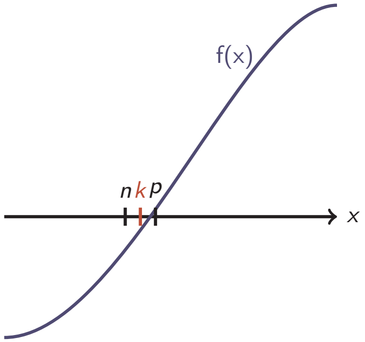


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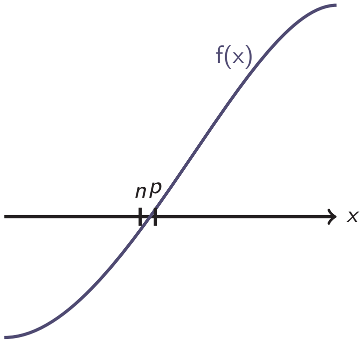


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Structured vs unstructured

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- Two programs of the same algorithm

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- Structured program
  - easy to maintain
  - complex control
  - higher level

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

Structured vs unstructured

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- 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

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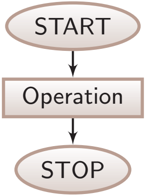

- All structured programs follow this simple scheme:
  - The structure of the program is determined by the inner structure (layout) of Operation.
    - Operation can be:
      - Elementary operation (action)
      - Sequence
      - Loop or repetition
      - Selection

Elements of structured programs

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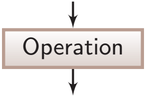
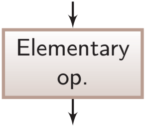
Elementary operation

that cannot be further expanded





`Elementary op.`

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

Elements of structured programs

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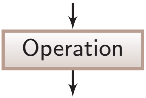
Sequence

Execution of two operations after eachother, in the given order



Elements of structured programs

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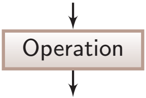

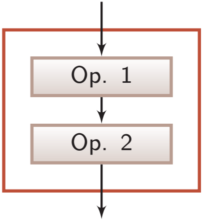


```
Op. 1
Op. 2
```

Elements of structured programs

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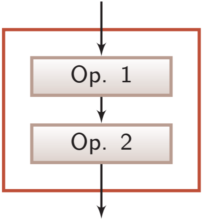
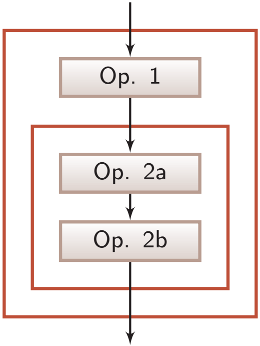
- Each element of the sequence itself is an operation, so they can be expanded into a sequence





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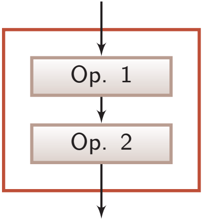
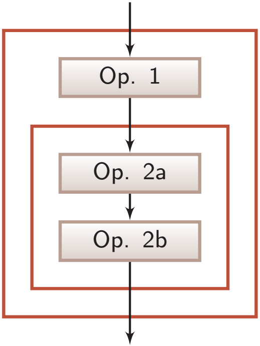


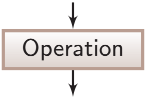


- The expansion can be continued, so a sequence can be an arbitrary long (finite) series of operations.

Elements of structured programs

Condition-based selection

Execution of one of two operations, depending on the logical value of a condition (true or false)



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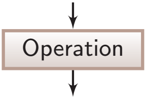
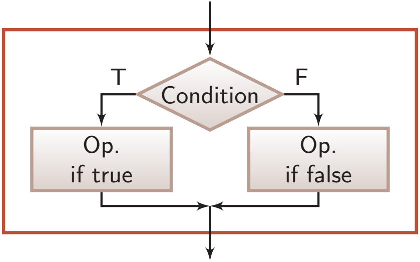
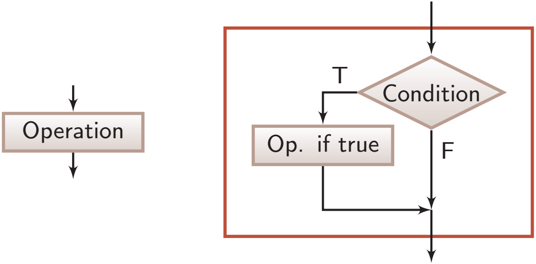





```
IF Condition
  Op. if true
ELSE
  Op. if false
```

Elements of structured programs

- One of the branches can also be empty.

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Elements of structured programs

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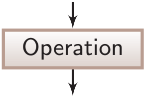
Top-test loop

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



Elements of structured programs

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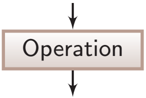

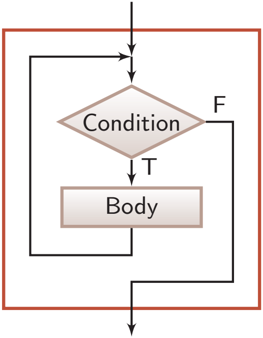


```
WHILE Condition
  Body of loop
```

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 unstrutured programs
  - can ba translated (compiled) into an unstructured program immediately (IF TRUE, JUMP)
  - structued 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

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

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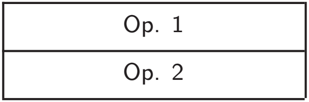
- it can be expanded into more rectangles with the elements below

- Sequence



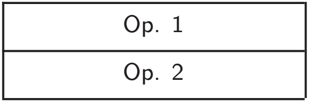
The structogram

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

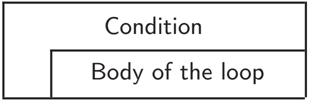
- The program is a rectangle

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

- Sequence



- Top-test loop



The structogram

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- The program is a rectangle

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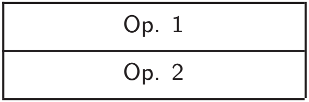
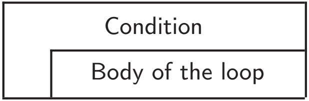
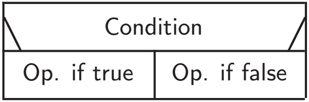


- Top-test loop

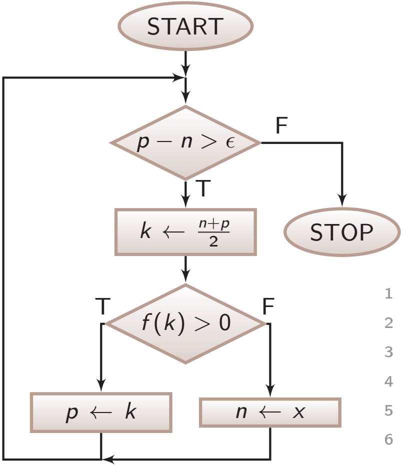


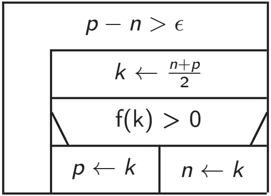
- Selection



The structogram

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






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

Chapter 2

Structured programming in C

Sequence in C

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Forming a sequence is listing instructions one after eachother

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

link

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

Selection control in C – the `if` statement

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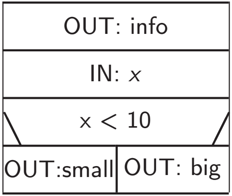
Let's write a program, that decides if the inputted integer number is small (< 10) or big (≥ 10)!

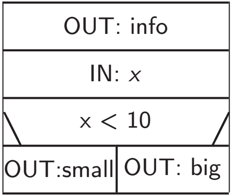
Selection control in C – the `if` statement

Let's write a program, that decides if the inputted integer number is small (< 10) or big (≥ 10)!



Selection control in C – the `if` statement

Let's write a program, that decides if the inputted integer number is small (< 10) or big (≥ 10)!

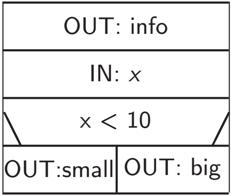



```
Let x be an integer
OUT: info
IN: x
IF x < 10
  OUT: small
OTHERWISE
  OUT: big
```

Selection control in C – the `if` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Let's write a program, that decides if the inputted integer number is small (< 10) or big (≥ 10)!




```
Let x be an integer
OUT: info
IN: x
IF x < 10
  OUT: small
OTHERWISE
  OUT: big
```

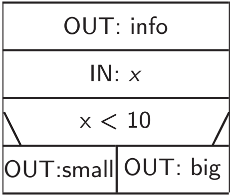
```c
#include <stdio.h>
int main()
{
  int x;
  printf("Please enter a number: ");
  scanf("%d", &x);
  if (x < 10)
/* condition */
    printf("small"); /*true branch*/
  else
    printf("big"); /*false branch*/
  return 0;
}
```

link

Selection control in C – the `if` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Let's write a program, that decides if the inputted integer number is small (< 10) or big (≥ 10)!




```
Let x be an integer
OUT: info
IN: x
IF x < 10
  OUT: small
OTHERWISE
  OUT: big
```

```c
#include <stdio.h>
int main()
{
  int x;
  printf("Please enter a number: ");
  scanf("%d", &x);
  if (x < 10)
/* condition */
    printf("small"); /*true branch*/
  else
    printf("big"); /*false branch*/
  return 0;
}
```

link

```
Please give an integer number: 5
small
```

Selection control – the if statement

Syntax of the if statement

if (<condition expression>) <statement if true>
[else <statement if false>]$_{opt}$

```
if (x < 10)           /* condition */
  printf("small"); /* true branch */
else
  printf("big"); /* false branch */
```

Selection control – the if statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the if statement

```
if (<condition expression>) <statement if true>
[ else <statement if false> ]opt
```

```c
if (x < 10)          /* condition */
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  printf("big"); /* false branch */
```

Selection control – the if statement

Syntax of the if statement

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if (x < 10)           /* condition */
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Selection control – the if statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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if (x < 10)            /* condition */
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Selection control – the if statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the if statement

```
if (<condition expression>) <statement if true>
[ else <statement if false> ]opt
```

```c
if (x < 10)           /* condition */
  printf("small"); /* true branch */
else
  printf("big"); /* false branch */
```

```c
if (a < 0)        /* creating absolute value */
  a = -a;
/* no false branch */
```

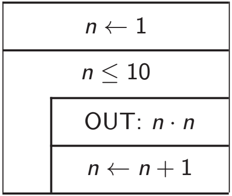
Top-test loop in C – the `while` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Let's print the square of the integer numbers between 1 and 10!

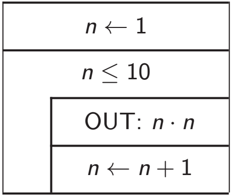
Top-test loop in C – the `while` statement

Let's print the square of the integer numbers between 1 and 10!



Top-test loop in C – the `while` statement

Let's print the square of the integer numbers between 1 and 10!

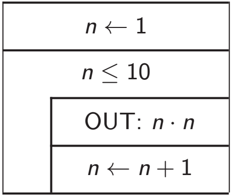



```
Let n be an integer
n ← 1
WHILE n <= 10
  OUT: n*n
  n ← n+1
```

Top-test loop in C – the `while` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Let's print the square of the integer numbers between 1 and 10!




```
Let n be an integer
n ← 1
WHILE n <= 10
  OUT: n*n
  n ← n+1
```

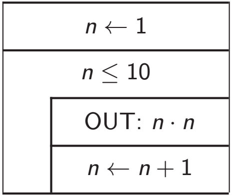
```c
#include <stdio.h>
int main()
{
  int n;
  n = 1; /* initialization */
  while (n <= 10) /* condition */
  {
    printf("%d ", n*n);/* printing */
    n = n+1;
/* increment */
  }
  return 0;
}
```

link

Top-test loop in C – the while statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Let's print the square of the integer numbers between 1 and 10!




```
Let n be an integer
n ← 1
WHILE n <= 10
  OUT: n*n
  n ← n+1
```

```c
#include <stdio.h>
int main()
{
  int n;
  n = 1; /* initialization */
  while (n <= 10) /* condition */
  {
    printf("%d ", n*n);/* printing */
    n = n+1; /* increment */
  }
  return 0;
}
```

link

```
1 4 9 16 25 36 49 64 81 100
```

Top-testing loop – the while statement

Syntax of the while statement

```
while (<condition expression>) <instruction>
```

- If `<instruction>` is a sequence, we enclose it in a {block}:

```c
while (n <= 10)
{
  printf("%d ", n*n);
  n = n+1;
}
```

Top-testing loop – the while statement

Syntax of the while statement

```
while (<condition expression>) <instruction>
```

- If <instruction> is a sequence, we enclose it in a {block}:

```
while (n <= 10)
{
  printf("%d ", n*n);
  n = n+1;
}
```

- In language C an instruction always can be replaced with a block.

Top-testing loop – the while statement

Syntax of the while statement

```
while (<condition expression>) <instruction>
```

- If <instruction> is a sequence, we enclose it in a {block}:

```c
while (n <= 10)
{
  printf("%d ", n*n);
  n = n+1;
}
```

- In language C an instruction always can be replaced with a block.

Top-testing loop – the while statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the while statement

```
while (<condition expression>) <instruction>
```

- If <instruction> is a sequence, we enclose it in a {block}:

```
while (n <= 10)
{
  printf("%d ", n*n);
  n = n+1;
}
```

- In language C an instruction always can be replaced with a block.

A complex application

- By using sequence, loop and selection, we can construct everything!

A complex application

- By using sequence, loop and selection, we can construct everything!
- We know enough to construct the algorithm of finding the zeros in C!

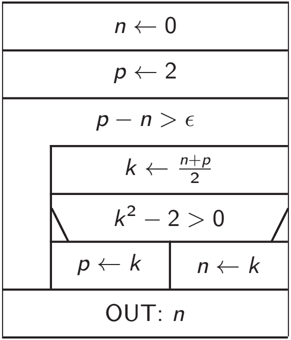
A complex application

- By using sequence, loop and selection, we can construct everything!
- We know enough to construct the algorithm of finding the zeros in C!
- A new element: a type for storing real numbers is called `double` type (to be learned later)

```
double a;            /* the real number */
a = 2.0;             /* assignement of value */
printf("%f", a);     /* printing */
```

Finding zero of a function

We are searching the zeros of function $f(x) = x^2 - 2$, between points $n = 0$ and $p = 2$, with $\epsilon = 0{,}001$ accuracy.



Finding zero of a function

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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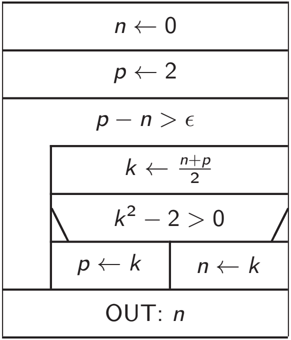



```c
#include <stdio.h>

int main()
{
  double n = 0.0, p = 2.0;
  while (p-n > 0.001)
  {
    double k = (n+p)/2.0;
    if (k*k-2.0 > 0.0)
      p = k;
    else
      n = k;
  }
  printf("The zero is: %f", n);

  return 0;
}
```

link

Chapter 3

Other structured elements

Elements of structured programs

- We have seen that the structured elements we had learned so far are enough for everything.
- Only for a higher comfort, we introduce new elements, that of course origin from the earlier ones.

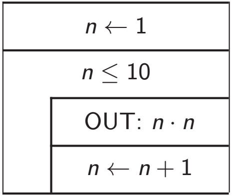
Top-test loop in C – the `for` statement

Let's print the square of the integer numbers between 1 and 10!

Top-test loop in C – the `for` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

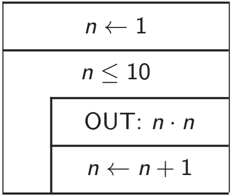
Let's print the square of the integer numbers between 1 and 10!




```
Let n be an integer
n ← 1
WHILE n <= 10
  OUT: n*n
  n ← n+1
```

Top-test loop in C – the for statement

Let's print the square of the integer numbers between 1 and 10!




```
Let n be an integer
n ← 1
WHILE n <= 10
  OUT: n*n
  n ← n+1
```

Because the structure of

- Initializations
- As long as Condition is TRUE
  - Operation
  - Increment

is very common in programming, we simplify its application with a new statement.

Top-test loop in C – the for statement

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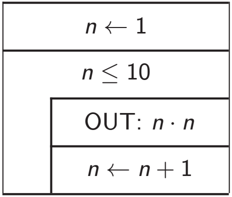
Let's print the square of the integer numbers between 1 and 10!




```
Let n be integer
from n=1, WHILE n<=10, one-by-one
  OUT: n*n
```

```c
#include <stdio.h>
int main()
{
  int n;
  for (n = 1; n <= 10; n = n+1)
    printf("%d ", n*n);
  return 0;
}
```

link

```
1 4 9 16 25 36 49 64 81 100
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

Top-test loop in C – the `for` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 1

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 1

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 1

```
1
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 2

```
1
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 2

```
1
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
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```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 2

```
1 4
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 3

```
1 4
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 3

```
1 4
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 3

```
1 4 9
```

Top-test loop in C – the `for` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the `for` statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

```
n:  4
```

```
1 4 9
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 4

```
1 4 9
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 4

```
1 4 9 16
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 5

```
1 4 9 16
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 5

```
1 4 9 16
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 5

```
1 4 9 16 25
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 6

```
1 4 9 16 25
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 6

```
1 4 9 16 25
```

Top-test loop in C – the `for` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the `for` statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 6

```
1 4 9 16 25 36
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
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```

- Post-operation is performed after execution of the instruction.

n: 7

```
1 4 9 16 25 36
```

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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1 4 9 16 25 36
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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
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```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 7

```
1 4 9 16 25 36 49
```

Top-test loop in C – the for statement

Syntax of the for statement

```
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<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 8

```
1 4 9 16 25 36 49
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 8

```
1 4 9 16 25 36 49
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 8

```
1 4 9 16 25 36 49 64
```

Top-test loop in C – the `for` statement

Syntax of the `for` statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 9

```
1 4 9 16 25 36 49 64
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
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- Post-operation is performed after execution of the instruction.

n: 9

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1 4 9 16 25 36 49 64
```

Top-test loop in C – the for statement

Syntax of the for statement

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for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
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```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 9

```
1 4 9 16 25 36 49 64 81
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
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```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 10

```
1 4 9 16 25 36 49 64 81
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 10

```
1 4 9 16 25 36 49 64 81
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 10

```
1 4 9 16 25 36 49 64 81 100
```

Top-test loop in C – the for statement

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 11

```
1 4 9 16 25 36 49 64 81 100
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```c
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

```
n:  11
```

```
1 4 9 16 25 36 49 64 81 100
```

Top-test loop in C – the for statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the for statement

```
for (<init exp>; <cond exp>; <post-op exp>)
<instruction>
```

```
for (n = 1; n <= 10; n = n+1)
  printf("%d ", n*n);
```

- Post-operation is performed after execution of the instruction.

n: 11

```
1 4 9 16 25 36 49 64 81 100
```

Multiplication table

Let's print the $10 \cdot 10$ multiplication table!

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Multiplication table

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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- In every row
  - we print into 10 columns (`col = 1, 2, 3, ...10`)
  - In every column
    - We print the value of `row*col`
  - After this we have to start a new line

```
int row;
for (row = 1; row <= 10; row=row+1)
{
  int col;      /* declaration at beginning of block */
  for (col = 1; col <= 10; col=col+1)
    printf("%4d", row*col); /* printing with size 4 */
  printf("\n"); /* this is not inside the for */
}
```

link

Multiplication table

- It might be advantageous to enclose in a block even one single instruction, because it might make the code more understandable!

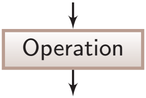
```c
int row;
for (row = 1; row <= 10; row=row+1)
{
  int col;      /* declaration at beginning of block */
  for (col = 1; col <= 10; col=col+1)
  {
    printf("%4d", row*col); /* printing with size 4 */
  }
  printf("\n");
}
```

link

Elements of structured programs

Bottom-test loop

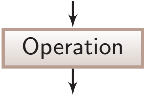
Repetition of an operation as long as a condition is true.

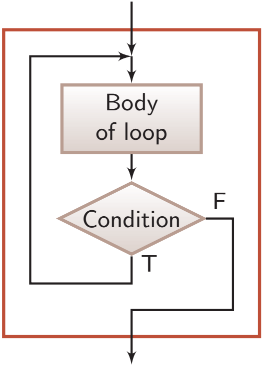


Elements of structured programs

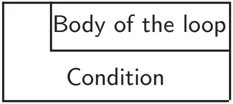
Bottom-test loop

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



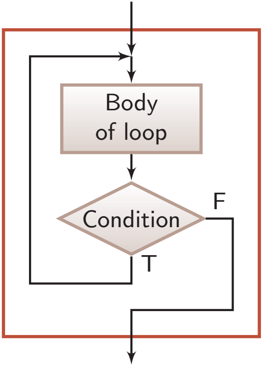


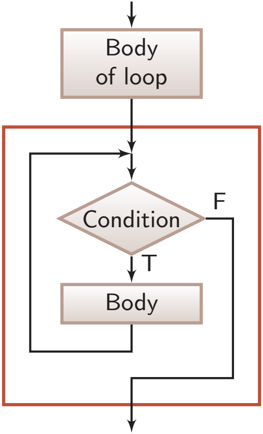

```
REPEAT
  Body of loop
WHILE Condition
```



Elements of structured programs

- It can be traced back to sequence and a top-test loop





Bottom-test loop – the do statement

Let's read positive integer numbers! We stop if the sum of the numbers is larger than 10.

Bottom-test loop – the do statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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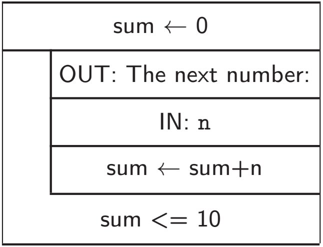
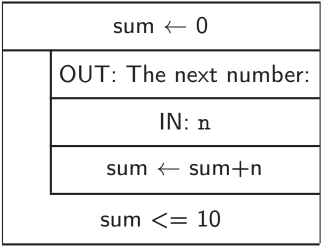


Bottom-test loop – the do statement

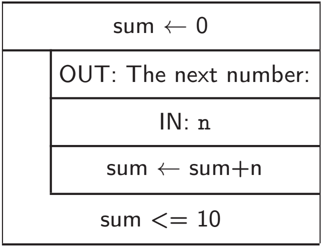
Let's read positive integer numbers! We stop if the sum of the numbers is larger than 10.




```
sum ← 0
REPEAT
  OUT: Info
  IN: n
  sum ← sum+n
WHILE sum ≤ 10
```

Bottom-test loop – the do statement

Let's read positive integer numbers! We stop if the sum of the numbers is larger than 10.




```
sum ← 0
REPEAT
  OUT: Info
  IN: n
  sum ← sum+n
WHILE sum ≤ 10
```

```c
#include <stdio.h>
int main()
{
  int sum = 0, n;
  do
  {
    printf("The next number: ");
    scanf("%d", &n);
    sum = sum+n;
  }
  while (sum <= 10);
  return 0;
}
```

link

Bottom-test loop – the do statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the do statement

```
do <instruction> while (<condition expression>);
```

```c
do
{
  printf("The next number: ");
  scanf("%d", &n);
  sum = sum+n;
}
while (sum <= 10);
```

Bottom-test loop – the do statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

Syntax of the do statement

```
do <instruction> while (<condition expression>);
```

```
do
{
  printf("The next number: ");
  scanf("%d", &n);
  sum = sum+n;
}
while (sum <= 10);
```

Bottom-test loop – the do statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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```
do <instruction> while (<condition expression>);
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```c
do
{
  printf("The next number: ");
  scanf("%d", &n);
  sum = sum+n;
}
while (sum <= 10);
```

Bottom-test loop – the do statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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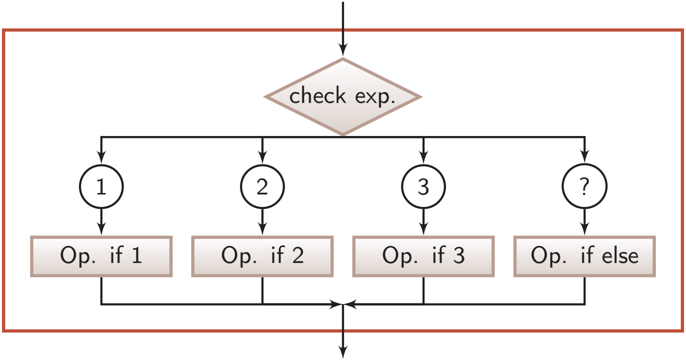
```

```c
do
{
  printf("The next number: ");
  scanf("%d", &n);
  sum = sum+n;
}
while (sum <= 10);
```

Elements of structured programs

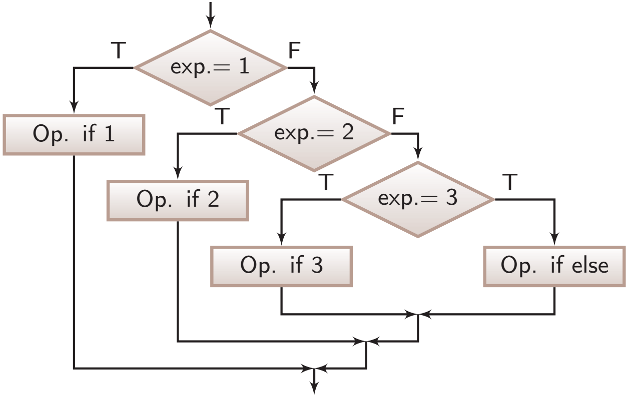
Integer-value based selection

Execution of operations depending on the value of an integer expression



Elements of structured programs

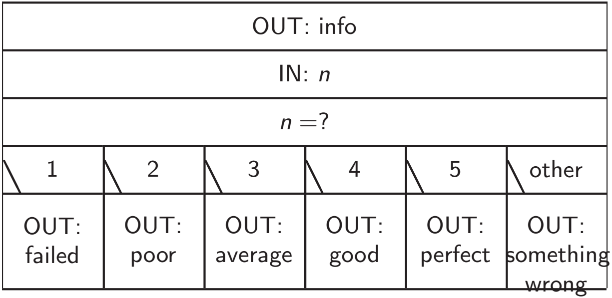
- It can be constructed as nested selections



Integer-value based selection – the `switch` statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- Let's assign (connect) written evaluations to grades given in numbers!



Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- Let's assign (connect) written evaluations to grades given in numbers!

```c
#include <stdio.h>
int main() {
  int n;
  printf("Please enter the grade: ");
  scanf("%d", &n);
  switch (n)
  {
    case 1: printf("failed"); break;
    case 2: printf("poor"); break;
    case 3: printf("average"); break;
    case 4: printf("good"); break;
    case 5: printf("perfect"); break;
    default: printf("something wrong");
  }
  return 0;
}
```

link

Integer-value based selection – the switch statement

Syntax of the switch statement

```
switch(<integer expression>) {
  case <constant exp1>:  <instruction 1>
  [case <constant exp2>:  <instruction 2> ...]opt
  [default:  <default instruction> ]opt
}
```

```
switch (n)
{
  case 1: printf("failed"); break;
  case 2: printf("poor"); break;
  case 3: printf("average"); break;
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  default: printf("something wrong");
}
```

Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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switch(<integer expression>) {
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switch (n)
{
  case 1: printf("failed"); break;
  case 2: printf("poor"); break;
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Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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}
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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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switch (n)
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DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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```

Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

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}
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```c
switch (n)
{
  case 1: printf("failed"); break;
  case 2: printf("poor"); break;
  case 3: printf("average"); break;
  case 4: printf("good"); break;
  case 5: printf("perfect"); break;
  default: printf("something wrong");
}
```

Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- The `break` instructions are not part of the syntax. If we omit them, the `switch` will remain syntactically correct, but it will not provide the same result as before:

```c
switch (n)
{
  case 1: printf("failed");
  case 2: printf("poor");
  case 3: printf("average");
  case 4: printf("good");
  case 5: printf("perfect");
  default: printf("something wrong");
}
```

link

```
Please enter the grade:  2
pooraveragegoodperfectsomething wrong
```

Integer-value based selection – the switch statement

DEPARTMENT OF NETWORKED SYSTEMS AND SERVICES

- The constant expressions are only entry points, and from this point on, all instructions are executed until the first `break` or until the enf of the block:

```c
switch (n)
{
  case 1: printf("failed"); break;
  case 2:
  case 3:
  case 4:
  case 5: printf("passed"); break;
  default: printf("something wrong");
}
```

link

```
Please enter the grade:  2
passed
```

Thank you for your attention.