Programming basics
(GKNB_INTA023)

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Square numbers

Task: print the squares of the first 10 natural numbers!

squares1.c

```
#include<stdio.h>
int main(void) {
   printf("Squares of natural numbers\n\n");
   printf("1^2=1\n");
   printf("2^2=4\n");
   printf("3^2=9\n");
   printf("4^2=16\n");
   printf("5^2=25\n");
   printf("6^2=36\n");
   printf("7^2=49\n");
   printf("8^2=64\n");
   printf("9^2=81\n");
   printf("10^2=100\n");
   return 0;
}
```

Square numbers

Output

```
Squares of natural numbers

1^2=1
2^2=4
3^2=9
4^2=16
5^2=25
6^2=36
7^2=49
8^2=64
9^2=81
10^2=100
```

Problems:

- We have calculated the results, not the computer!
- Too much repeating, similar lines of code
- Very easy to make mistakes, but hard to realize them

Square numbers

Task: do the computer calculate the square numbers!

squares2.c

```
1  #include<stdio.h>
2  int main(void) {
3     printf("Squares of natural numbers\n\n");
4     printf("%d^2=%d\n", 1, 1*1);
5     printf("%d^2=%d\n", 2, 2*2);
6     printf("%d^2=%d\n", 3, 3*3);
7     printf("%d^2=%d\n", 4, 4*4);
8     printf("%d^2=%d\n", 5, 5*5);
9     printf("%d^2=%d\n", 6, 6*6);

14    printf("%d^2=%d\n", 10, 10*10);
15    return 0;
16 }
```

Square numbers

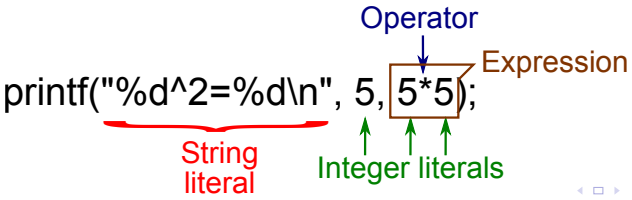
Output

```
Squares of natural numbers

1^2=1
2^2=4
3^2=9
4^2=16
5^2=25
6^2=36
7^2=49
8^2=64
9^2=81
10^2=100
```

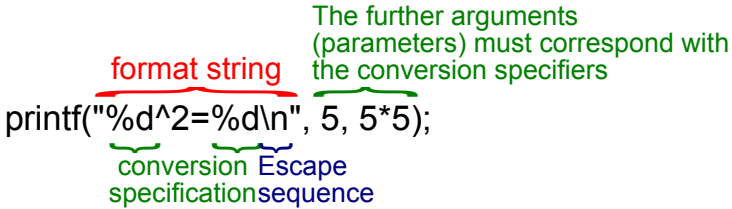
Literals: constant values typed in the source code

- Integer constants
- Character constants: between '-s
- String constants: between "-s



Square numbers

Expression: produces a value by using literals (constants), variables and operators



Some arithmetic operators

Operator	Description	Example
+	Addition	$5 + 3 == 8$
-	Subtraction	$5 - 3 == 2$
*	Multiplication	$5 * 3 == 15$
/	Integer division ($\rightarrow$ quotient)	$5/3 == 1$
%	Modulo ($\rightarrow$ remainder)	$5\%3 == 2$

Square numbers

squares3.c

```
1  #include<stdio.h>
2  int main(void) {
3    int base;
4    printf("Squares of natural numbers\n\n");
5    base = 1;
6    printf("%d^2=%d\n", base, base*base);
7    base = base + 1;
8    printf("%d^2=%d\n", base, base*base);
9    base = base + 1;
10   printf("%d^2=%d\n", base, base*base);
11   base = base + 1;

24   printf("%d^2=%d\n", base, base*base);
25   return 0;
26 }
```

Square numbers

Variables

- Eg. `int base;`
- type
  - the nature of data (numeric, text)
  - data representation
  - possible operations
- memory area
  - stores the value according to the type
  - the initial value of local variables (in blocks between { and }) is undefined, "garbage"
- name, id (should refer to its goal)

Square numbers

Naming rules

- Fist character: lower-, uppercase letter or _
- Further characters: the same set of characters and digits as well
- Cannot be a reserved keyword or identifier
- Case sensitive
- Recommendation: do not start the names with one or two _ characters
- Number of significant characters

What's the problem?

John Doe
12_Monkeys
Cool!
auto

OK

john_doe
John_Doe
johnDoe

Square numbers

The most important integer types (fixed point arithmetic)

Type	Description
`char`	Generally signed, 8 bit integer
`signed char`	Signed 8 bit integer
`unsigned char`	Unsigned (non negative) 8 bit integer

`short`
`signed short`
`signed short int`
	Signed short integer

`unsigned short` `unsigned short int`	Unsigned short integer

`signed`
`int`
`signed int`
	Signed integer

`unsigned` `unsigned int`	Unsigned integer

`long`
`signed long`
`signed long int`
	Signed long integer

`unsigned long` `unsigned long int`	Unsigned long integer

Square numbers

Remarks:

- (Type) modifiers: `signed/unsigned`, `short/long`
- Storage of integer literals: `int`
- Size of type `char` is always 1 byte, but character literals are stored as `int`!
- Sign of `char` depends on the platform / compiler, but it is usually signed (can be modified)
- `1 == sizeof(char) <= sizeof(short) <= sizeof(int) <= sizeof(long) <= sizeof(long long)`, where `sizeof` is an operator that specifies the size of a type / variable in bytes

Square numbers

Variable definition

- General usage: *type variable_list;*
- Defines a name, type and allocates memory to store the data
- Eg. `int x; int i, j, k; unsigned int y;`

Assignment

- Operator: =
- *lvalue* = *rvalue*;
- changes the value of *lvalue* to *rvalue*
- *lvalue*: generally a variable (it cannot be a literal or an array, but a specific element of an array is allowed)

Result: the rows of our program are very similar, can be copied
Problem: many repeating code parts → let the computer repeat the same parts!

Square numbers

squares4.c

```
#include<stdio.h>
int main(void) {
  int base;
  printf("Squares of natural numbers\n\n");
  base = 1;
  while(base <= 10) {
    printf("%d^2=%d\n", base, base*base);
    base = base + 1;
  }
  return 0;
}
```

Relational operators

Operator	Description
==	Equal to
!=	Not equal to
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to

Square numbers

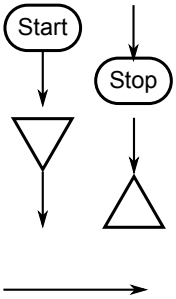
while loop (tests the condition *before* executing the loop body)

```
while(condition) {
    activities
}
```

The *body* (repeated part) of the loop may contain

- a single statement
- a group of statements (block between { and })

Flow charts



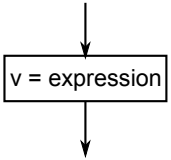
Signals of start and end

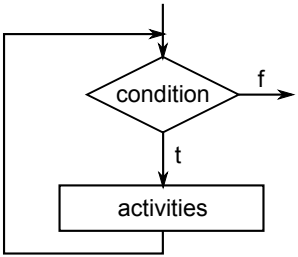
- Triangle version: description of algorithm parts
- A program must contain exactly one start and one end point
- The start point must have a sole outgoing arrow only. The end point...

Signal of direction

- May diverge only at conditions
- Shows the execution order of instructions

Flow charts





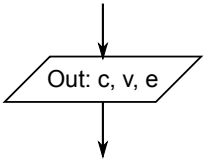
Signal of assignment

- One arrow comes in, one goes out
- The value and type of the *expression* must be defined, then this value is going to be assigned to variable *v*
- Multiple assignments can be grouped together

Loop (tests the condition before executing the loop body)

- Loop body: the repeated activities
- The loop body must affect the condition $\rightarrow$ infinite loop?
- The loop body may never be executed

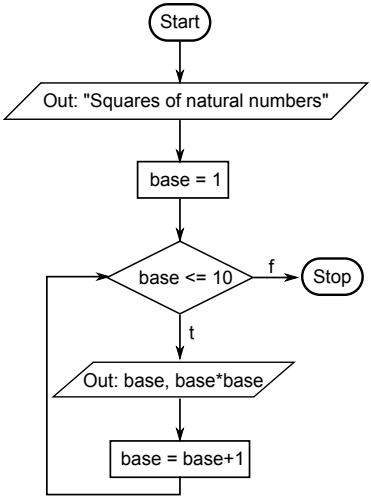
Flow charts



Signal of output activity (print)

- One arrow comes in, one goes out
- The values of the *c* constant, *v* variable and *e* expression must be printed

Square numbers



Square numbers

Table of data structure: the flow chart defines neither the type nor the goal of variables

Goal	Name	Type	Nature
Base of power	base	integer	work/output

Even, odd

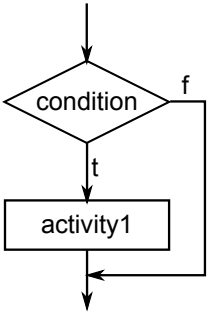
Make a decision: is a specific number odd or even?

even1.c

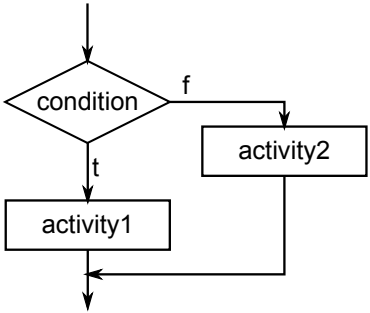
```
#include<stdio.h>

int main(void) {
  int number;
  number = 42;
  if(number%2 == 0) {
    printf("The number is even.\n");
  } else {
    printf("The number is odd.\n");
  }
  return 0;
}
```

Conditions



if(condition) activity1



if(condition) activity1
else activity2

Nested if-else statements are possible for multiple outcomes

Pointers

What is a *pointer*, and what is it good for?

- A type suitable to store a memory address
- Several subtypes exist to express the type of the stored data
- In the technical sense, they are non-negative integer numbers
- Pointer definition: *base_type* name*;

Example

```
int i;          // integer variable

int* pi;        // pointer variable that stores
                // the address of an integer variable
```

Pointers

The *address* of a variable can be obtained by operator &
The *content* of a variable *at a specific address* can be obtained by operator *
(indirection, dereference)

pointer.c

```c
#include<stdio.h>
int main(void) {
  int i;
  int* pi;
  i = 42;
  printf("The value of 'i' is: %d\n", i);
  printf("The address of 'i' is: %p\n", &i);
  pi = &i;
  printf("The value at address 'pi' is: %d\n", *pi);
  printf("The value of 'pi' is: %p\n", pi);
  printf("The address of 'pi' is: %p\n", &pi);
  return 0;
}
```

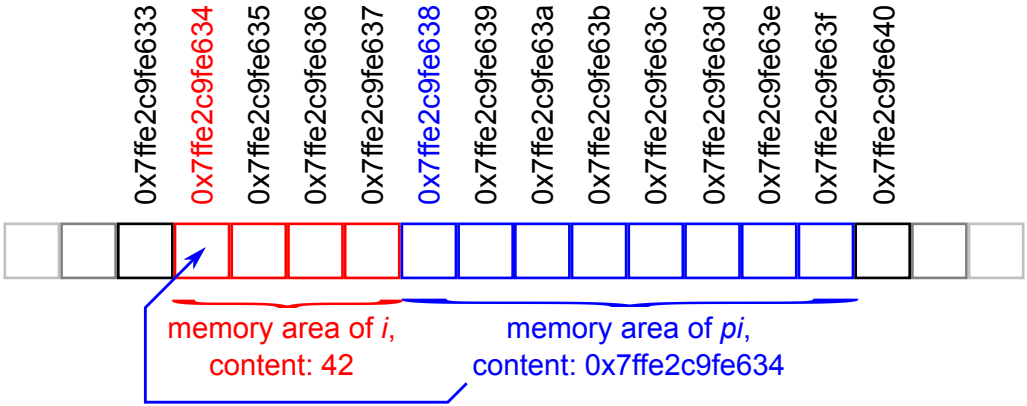
Output

```
The value of 'i' is: 42
The address of 'i' is: 0x7ffe2c9fe634
The value at address 'pi' is: 42
The value of 'pi' is: 0x7ffe2c9fe634
The address of 'pi' is: 0x7ffe2c9fe638
```

The format specifier of a pointer is: %p

```
printf("The address of 'i' is: %p\n", &i);
```

Pointers


0x7ffe2c9fe633
0x7ffe2c9fe634
0x7ffe2c9fe635
0x7ffe2c9fe636
0x7ffe2c9fe637
0x7ffe2c9fe638
0x7ffe2c9fe639
0x7ffe2c9fe63a
0x7ffe2c9fe63b
0x7ffe2c9fe63c
0x7ffe2c9fe63d
0x7ffe2c9fe63e
0x7ffe2c9fe63f
0x7ffe2c9fe640
memory area of i,
content: 42
memory area of pi,
content: 0x7ffe2c9fe634

Even, odd

Task: let the program read the number to analize!

even2.c

```
#include<stdio.h>

int main(void) {
  int number;
  printf("Type an integer and the program decides "
         "is it even or odd.\n\n");
  scanf("%d", &number);
  if(number%2 == 0) {
    printf("The number is even.\n");
  } else {
    printf("The number is odd.\n");
  }
  return 0;
}
```

Even, odd

```
printf("Type an integer and the program decides "
       "is it even or odd.\n\n");
```

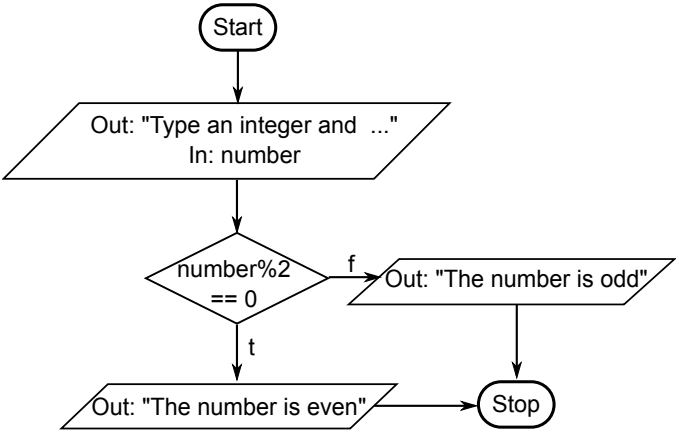
The preprocessor merges the string literals if they are separated by only a *whitespace* character.

```
scanf("%d", &number);
```

Reading from the standard input

- `scanf` is the "inverse" of printf
- Its first argument is the format string (similarly to `printf`)
- The following arguments must match the applied format specifiers
- The *address* of variables that store the read, converted values must be given

Even, odd


Start
Out: "Type an integer and ..."
In: number
number%2
== 0
f
Out: "The number is odd"
t
Out: "The number is even"
Stop

Even, odd

Order of instructions (expressions)

- parenthesis
- precedence

Operator	Associativity
sizeof	right to left
* / %	left to right
+ -	left to right
< <= > >=	left to right
== !=	left to right
=	right to left

Control structures

- Sequence (Statements are executed in a specified order. No statement is skipped and no statement is executed more than once.)
- Repetition (loop, iteration)
- Selection (condition)