

# 02393 Programming in C++

## Module 3: Data Types

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# Lecture Plan

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# Outline

## ① Recap

Basic data types

## ② Data types

## ③ Pointers

# Small Programming Exercises via CodeJudge

Some general observations:

- Use the test examples to check your input/output
- If it seems to refuse correct solutions...
  - ★ check thoroughly the input and output of the tests
  - ★ beware of imprecisions in the input/output format (e.g. blank spaces)
  - ★ beware of non-portability issues: try to write rock-solid code, e.g. initialise variables before using them (do not assume them to be initialised to 0).
  - ★ do not hesitate to contact us (me or the TAs).

Last week's exercises (to hand in today):

- Questions?
- Model solutions online (and discussed here)

## Recap: Last Programming Session

- Arithmetic imprecision, e.g.  $0.1 + 0.3 \neq 0.4$ ;
- Bounded numerical types, e.g.  $\text{unsigned int} = [0, \dots, \text{UINT\_MAX}] \subset \mathbb{Z}$ ;
- Stack limits, e.g. recursion may crash;
- Side effects vs arithmetic axioms;
- C++ functions are programs, not mathematical functions;
- First taste of functions, if/then's, loops, variables, etc.

# Outline

① Recap

② **Data types**

③ Pointers

# The hierarchy of data types

## Atomic/Fundamental types

- booleans **bool**
- characters **char**
- integer numbers: [**unsigned**] [**long**] **int**
- floating point numbers: [**unsigned**] **float**, **double**, **long double**
- define your own: **enum**

See <http://en.cppreference.com/w/cpp/language/types>

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## New types composed from the existing type

- ① **struct** (or record): a collection of data values
- ② **array**: sequence of data values of the same type
- ③ **pointer**: stores a memory address



# Mixed data types, casting

What's the type of

- $9/6$ ?
- $9.0/6$ ?
- $9/6.0$ ?
- $9/\text{int}(6.0)$ , and  $\text{float}(9/6)$ ?

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- for an operator whose operands are of different types, the compiler converts the operands to a common type (when possible)
- the type that is more precise will be chosen
- result is always that of the arguments after any conversions are applied

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**Table 1-5 Type conversion hierarchy for numeric types**

**long double**  
**double**  
**float**  
**unsigned long**  
**long**  
**unsigned int**  
**int**  
**unsigned short**  
**short**  
**char**

*most precise*



*least precise*

# Enum, structs, and arrays in a maze

```

typedef enum {wood, stone} material;

typedef struct {
    int x,y;
    bool isWall;
    material type;
} field;

int main(){
    ...
    field playground[n][m];
    for (int i=0; i<n; i++){
        for (int j=0; j<m; j++){
            playground[i][j].x=i;
            playground[i][j].y=j;
            playground[i][j].isWall=(i==0||i==(n-1)||j==0||j==(m-1));
            if (playground[i][j].isWall)
                playground[i][j].type=stone;
            else
                playground[i][j].type=wood;
        }
    }
    ...

```

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- **Arrays** are also a universal concept. Note however in C++:
  - ★ Arrays range from  $[0]$  to  $[n - 1]$  when the size is  $n$
  - ★ The size of the array is not stored with the array! (It is your responsibility to keep track if it.)
  - ★ If you access outside the boundaries of the array, the compiler will not stop you; this may produce hard-to-find errors!
  - ★ The size of an array cannot be changed.
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  - ★ Passing arrays as function arguments can be tricky (more later).
- Next week: C++ offers a data-structure **vector** in the library that overcomes many of the problems with arrays.
  - ★ Usually a vector is preferable over an array!



# Outline

- 1 Recap
- 2 Data types
- 3 Pointers**

# Pointers

- A pointer is a variable which contains a memory address
- Access to, and manipulation of, pointers by a program allows some interesting applications:
  - ★ Great way to screw up your code! Use with care!
  - ★ Classic way (pre 90's) to implement call-by-reference
    - ▶ We discuss an example; for most applications use modern C++ call-by-reference.
  - ★ Dynamic memory allocation:
    - ▶ the program asks the system for more memory with **new**.
    - ▶ the system answers with a pointer to the memory block
    - ▶ must be explicitly given back with **delete**—there is no garbage collection.
  - ★ Based on dynamic memory: recursive data structures (in 3rd part of course).

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## Pointer operations

- **&**: address-of. Takes a variable and returns the corresponding memory address
- **\***: value-pointed-to, returns the variable, or the **pointee**, the pointer points to.

# Live Programming