# 02393 Programming in C++ Module 3: Data Types

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## **Lecture Plan**

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1	1.2	Introduction	1
2	8.2	Basic C++	1
3	15.2	Data Types	2
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		Libraries and Interfaces	3
_5	29.2	Libraries and interfaces	
6	7.3	Classes and Objects I	4,9
7	14.3	Classes and Objects II	4,9
		Påskesferie	
8	4.4	Classes and Objects III	4,9
9	11.4	Recursive Programming	5-7
10	18.4	Lists and Trees	10.5, 11, 13.1
11	25.4	Trees	13
12	2.5	Graphs	16
13	9.5	Summary	
	17.5	Exam	

## **Outline**

- 1 Recap
  Basic data types
- 2 Data types
- Opening 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. unsigned int  $= [0,..,\mathsf{UINT\_MAX}] \subset \mathbb{Z};$
- 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**

- Recap
- 2 Data types
- Opening Properties

# 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/int(6.0), and float(9/6)?

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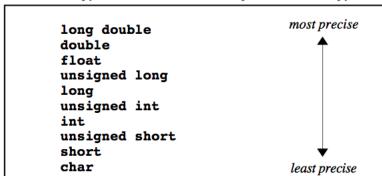
- 9/6?
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- 9/int(6.0), and float(9/6)?
- for an operator whose operands are of different types, the compiler converts the operands to a common type (when possible)
- the type that is more precise will be chosen
- result is always that of the arguments after any conversions are applied

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



# 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]. is Wall=(i==0||i==(n-1)||j==0||j==(m-1));
             if (playground[i][j].isWall)
                 playground[i][j].type=stone;
            else
                 playground[i][i].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

- 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**