Welcome to MCS 360

1. About the Course
   - content
   - expectations
2. our first C++ program
   - using g++
   - input and output streams
   - the namespace `std`
3. Greatest Common Divisor
   - Euclid's algorithm
   - the while and do-while statements

MCS 360 Lecture 1
Introduction to Data Structures
Jan Verschelde, 13 January 2020

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Catalog Description

more or less up to date

MCS 360 - Introduction to Data Structures

Pointers and dynamic memory allocation in C/C++, recursion, stacks, queues, heaps, binary and multiway trees, graphs, hash tables. Sorting and searching algorithms.

Prerequisite(s): Grade of C or better in MCS 260 and Grade of C or better in MCS 275.

MCS 275 is still required.

Content of the Course

Text Book

The design of the course follows

Elliot B. Koffman and Paul A.T. Wolfgang:
Objects, Abstraction, Data Structures, and Design using C++, John Wiley and Sons, 2006.

Reading the textbook is recommended.
However, programming is a skill, acquired mainly by practice, practice, and lots of practice...

A natural sequel to MCS 360
is MCS 401/CS 401: computer algorithms.

Organization of the Material

along the text book

Five parts:

1. introduction to C++ (chapters P, 1, 2, 3)
2. vector, stack, list, queue and deque (chap 4, 5, 6)

first midterm on chapters P, 1, 2, 3, 4, 5, 6

3. recursion, trees, maps, hash tables (chap 7, 8, 9)
4. sorting algorithms, balancing trees (chap 10, 11)

second midterm on chapters 7, 8, 9, 10, 11

5. after the second midterm, we cover chapter 12 on graphs.

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Purpose of the Course

Goals of MCS 360 are threefold:

1. solve problems with algorithms using *right* data structures (programs = algorithms + data structures)
2. gain basic working knowledge of C++
3. application of the Standard Template Library (STL)

About C++

+ widespread use with good performance
– no framework language as Java or Python

Some important points:

- emphasis on five computer projects,
- active participation to the lab sessions.

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using g++

free and open source

The GNU compiler collection includes front ends for C, C++, ...
`g++` = GNU C++, a freely redistributable C++ compiler

By default installed on Unix, Linux, Mac OS X.

On windows: `www.mingw.org` or `www.cygwin.com`

Although object-oriented programming supports programming in the large, our programs will typically remain small.

Mikael Olsson: *C++17 Quick Syntax Reference. A Pocket Guide to the Language, APIs and Library.* Third Edition, Apress, 2018.

C++ is a compiled language

The compiler translates C++ code in `hello_world.cpp` into code the computer can execute.

At the command prompt $ we type

```
$ g++ -o hello_world hello_world.cpp
```

The output of `g++` is renamed into `hello_world`, with the extension `.exe` on Windows computers.

To run the program, type at the command prompt $

```
$ hello_world
Hello World!
$
```

Any editor can be used to write `.cpp` files.

our first program

Our first program writes `Hello World!` to screen.

A C++ program typically consists of

1. preprocessor directives
2. function definitions
3. type declaration of variables
4. control statements

Recommended way of working:

1. write basic version of code
2. compile and test, if done then stop
3. extend adding extra statements
4. go to step 2

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code for our first program

```
#include <iostream>

int main()
{
   std::cout << "Hello World!" << std::endl;
   return 0;
}
```

1. preprocessor directives start with `#`
2. including `iostream` is needed for *the insertion operator* `<<`.
3. the program is the definition of a function `main`
4. one statement sends `Hello World!` to screen, followed by the end of line (`endl`) symbol
5. the function returns zero if all went well

Comments and Blocks

The compiler ignores lines starting with `//`, e.g.:

```
// L-1 MCS 360 Mon 13 Jan 2020 : hello_world.cpp
```

Multiple lines of documentation are between `/*` and `*/`.

Code between curly braces defines a block.

```
int main()
{
   // omitted code
   return 0;
}
```

Every statement is terminated by semicolon `;`
indentation is optional, but strongly recommended.

our first interactive program

Our first interactive program

1. prompts the user to enter a name,
2. stores the entered name in a string,
3. writes a personalized greeting.

If we save the program in `hello_there` we run it at the prompt $ as

```
$ hello_there
Who is there ? me
Hello me!
$
```

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the namespace `std`

Instead of

```
std::cout << "Hello World!" << std::endl;
```

we can write

```
cout << "Hello World!" << endl;
```

if we insert

```
using namespace std;
```

after the preprocessor directives.

A *namespace* is a collection of names or identifiers defined together (like a Python module).
The C++ standard library is defined in namespace `std`.

code for the entire program

```
#include <iostream>
#include <string>

using namespace std;

int main()
{
   string name;

   cout << "Who is there ? "; // insertion operator
   cin >> name;     // >> is the extraction operator
   cout << "Hello " << name << "!" << endl;

   return 0;
}
```

C++ as a calculator

Exercise 1:

One kilogram (kg) is 2.20462 pounds (lb).

Write a C++ program which prompts the user for a weight in kilograms.

The program computes the weight measured in pounds and writes the corresponding pounds to the standard output.

A session with the program could go as follows:

```
Give a weight in kg : 50
The weight 50 in pounds is 110.231.
```

Note: the type for a floating-point number is `double`.

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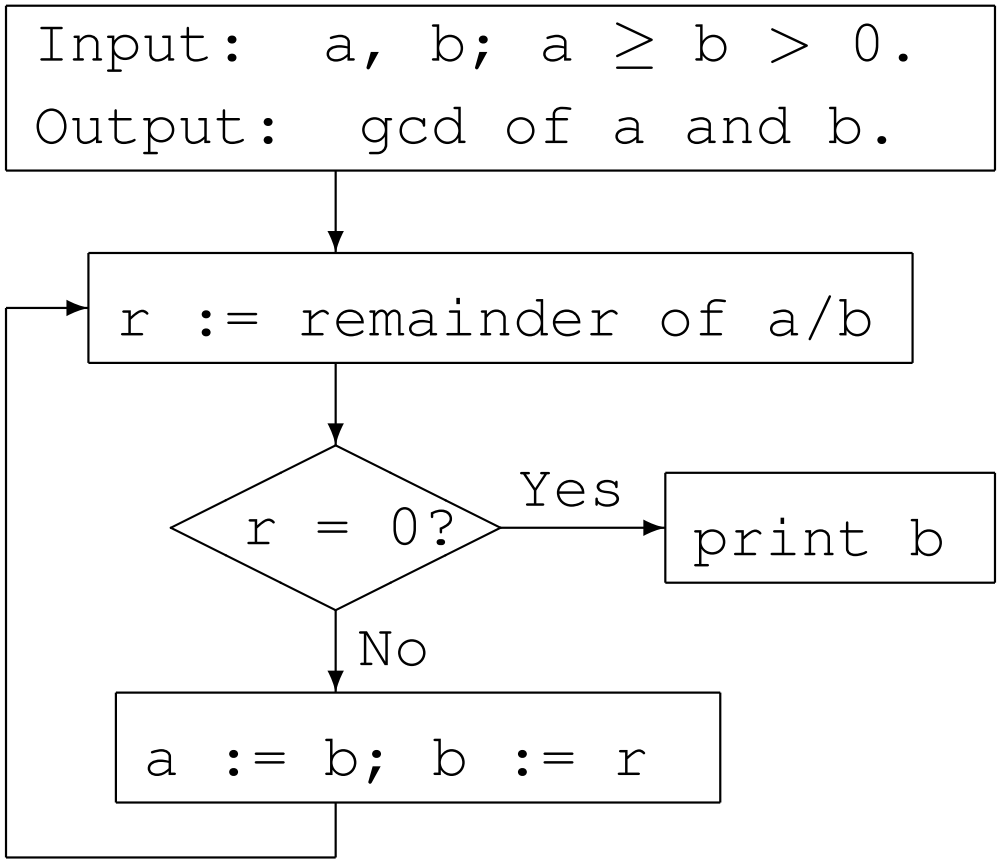
Euclid's Algorithm

flowchart



computing a GCD

```
$ gcd_dowhile1
Welcome to our Greatest Common Divisor
   give a positive integer x : 468
   give a positive integer y : 864
computing the gcd of 468 and 864 ...
   x = 468   y = 864   r = 468
   x = 864   y = 468   r = 396
   x = 468   y = 396   r = 72
   x = 396   y = 72    r = 36
   x = 72    y = 36    r = 0
gcd(468,864) = 36
$
```

- confirm input before and after computations
- intermediate output to monitor progress

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while and do-while

Either first test the condition in `while` ***before*** executing the statements:

```
< initialization >
while( < condition > )
{
    < statements >
}
```

Or test the condition in `while` ***after*** executing the statements:

```
< initialization >
do
{
    < statements >
} while( < condition > );
```

reading numbers

```
#include <iostream>
#include <sstream>
using namespace std;

int main()
{
   int x,y;

   cout << "Welcome to our Greatest Common Divisor\n";
   cout << "  give a positive integer x : ";
   cin >> x;
   cout << "  give a positive integer y : ";
   cin >> y;
   cout << "computing the gcd of "
        << x << " and " << y << " ..." << endl;

   ostringstream s;  // write to a string
   s << "gcd(" << x << "," << y << ") = ";
```

computing the GCD

```
    int r;

    do
    {
        r = x % y;  // remainder calculation
        cout << "  x = " << x
             << "  y = " << y
             << "  r = " << r << endl;
        x = y;
        y = r;
    } while (r != 0);          // stop test

    cout << s.str() << x << endl;

    return 0;
}
```

computing the binary expansion of a number

Exercise 2:

Write a C++ program which prompts the user
for a positive integer number.

The program writes the input number and
prints the bits in the binary decomposition of the number,
in reverse order, printing the least significant bit first.

A session with the program could go as follows:

```
Give a number : 360
The bits in 360 : 0 0 0 1 0 1 1 0 1.
```

Summary + Additional Exercises

In this lecture we covered first three sections of Chapter P.

On Tuesday or Thursday go to the computer lab,

- make sure your netid is working,
- there will be a quiz at the end.

Additional exercises:

3. Install `g++` on your laptop or home computer.
4. Do `g++ -E hello_world.cpp` (our first C++ program).
   What happens? What is this option `-E`?
5. Extend `gcd_dowhile1.cpp` with a check that the greatest divisor reported after the loop really divides the two given numbers.
6. Instead of `do-while`,
   use a `while-do` statement to encode Euclid's algorithm.