TDDE18 & 726G77

Functions & struct

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Last lecture we learned most things needed to actually write a functioning program.

From now on we only aim to make it *easier* for us to program!

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Functions

Blocks

```
{ // start of block

  // body of block

} // end of block
```

Functions

Blocks

- In C++, a block is a chunk of code surrounded by `{` and `}`.
- It represents a series of statements that are related.
- Good to use for creating sections.
- Is also closely related to a concept called *scope*...

Functions

Scope

```
int x{}; // global scope
int main()
{
  int y{}; // local scope
}
```

Functions

Scope

- A scope defines when and where a named entity (example: a variable) is accessible
- Two main categories of scope
- *global scope* is all entities that are accessible everywhere
- *local scope* is when the entity is only accessible in a part of the code (i.e. not everywhere)

Functions

Scope & Blocks

```
int x{0};
{
  int x{1};
  {
    cout << x << " ";
    int x{2};
    cout << x << " ";
  }
  cout << x << " ";
}
cout << x << " ";
```

Functions

Scope & Blocks

```
int x{0};
{
  int x{1};
  {
    cout << x << " ";
    int x{2};
    cout << x << " ";
  }
  cout << x << " ";
}
cout << x << " ";
```

```
$ ./a.out
1 2 1 0
```

Functions

Scope & Blocks

- A block always opens a new local scope
- Each named entity created inside the scope only exists until the end of the block
- All named entites defined outside of the scope is available as long as no other *more local* named entity has the same name
- Things not created inside a block is automatically defined in the *global scope*

Functions

Scope & Blocks

```
int x{0}; // global

int main()
{
  int y{1};
  {
    int z{2};
    cout << x << ' ' << y ' ' << z << endl;
  }
}
```

Functions

Scope & Blocks

- In the previous example:
- `x` is available in the entire program
- `y` is available in the entire `main` block
- `z` is only available inside the inner block

Functions

What is the difference between x and y in the previous example? Aren't both available in exactly the same parts of the program?

Functions

What is the difference between x and y in the previous example? Aren't both available in exactly the same parts of the program?

They are not, because of functions!

Functions

Functions

- A function is a named block that can be executed (called) in other parts of the program.
- Is only executed when called.
- Used to reduce repetition in the code.

Functions

(Tedious) Example

```
#include <iostream>
using namespace std;
int main()
{
  string name1;
  string name2;
  cout << "Person 1, your name: ";
  cin >> name1;
  cout << "Person 2, your name: ";
  cin >> name2;
}
```

Functions

(Tedious) Example

- In the previous example we are prompting people to enter their names.
- The code is almost identical for both people.
- Imagine that there are 100 people instead, now this would be annoying to write.
- Even worse: imagine you want to change something in the functionality? **Nightmare**

Functions

What are functions?

```
return_type function_name(parameters)
{
  // statements
  return result;
}
```

Functions

What are functions?

- A function has a *return type*, a name and *parameters*
- It takes data through the *parameters* and gives us a result by *returning* it
- Through the parameters we specify what we want to send to the function (what data types the values should be, how many values there are etc.)
- The return type specifies what type of data we get back from the function

Functions

Back to our example

```
string read_name(int i)
{
  string result{};
  cout << "Person " << i
       << ", your name: ";
  cin >> result;
  return result;
}
```

```
int main()
{
  string name1;
  string name2;
  name1 = read_name(1);
  name2 = read_name(2);
  return 0;
}
```

Functions

Back to our example

- A lot to unpack here.
- `i` is a parameter to `read_name`, which means it is a local variable that is only available inside the function.
- We call `read_name` by writing its name and then specifying what value `i` should have inside the function.
- `name1` and `name2` are only available in `main` while `i` and `result` are only available inside `read_name`.

Functions

Back to our example

- `read_name` gives back a `string` when it has been *called*.
- At the end of the function we specify which value should be handed back by *returning* a specific value (in this case whatever happens to be stored inside `result`).
- This is done with the `return` keyword.
- In `main` we are assigning the result of *different* calls to `read_name` to the variables `name1` and `name2`.

Functions

Back to our example

- Whenever a function is called, the execution of the program jumps into the called function and executes each line there.
- Once the function returns it takes the value with it and jumps back to the point where the function was called and continue from there.
- `main` is a function that the operating system calls when you start your program. The value returned from it is code to the operating system that signals how it went (`0` if everything went as expected).

Functions

Procedure

```
void foo()
{
  cout << "a procedure" << endl;
}
```

Functions

Procedure

- A function that doesn’t return a value.
- Doesn’t need a `return` statement.
- Has `void` as return-type.
- `void` is not a type we can assign to variables.

Functions

Declaration and definition

```
void function(); // declaration

// ...

void function()
{
  // ...
}
```

Functions

Declaration and definition

- C++ is processed by the compiler from top to bottom.
- We can tell the compiler that we intend to use a function before we definie it.
- This is done by *declaring* the function.
- Giving the function a body later on is called the functions *definition*.
- This allows us to separate our code.

Functions

Declaration and definition

```
void hello(); // declaration

int main()
{
  hello();
}

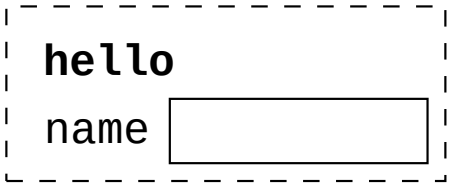
void hello() // definition
{
  cout << "hello" << endl;
}
```

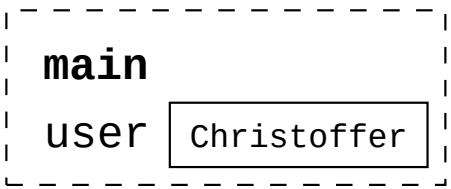
Functions

Parameter passing

```
void hello(string name)
{
  cout << "hello "
       << name << endl;
}

int main()
{
  string user{"Christoffer"};
  hello(user);
}
```



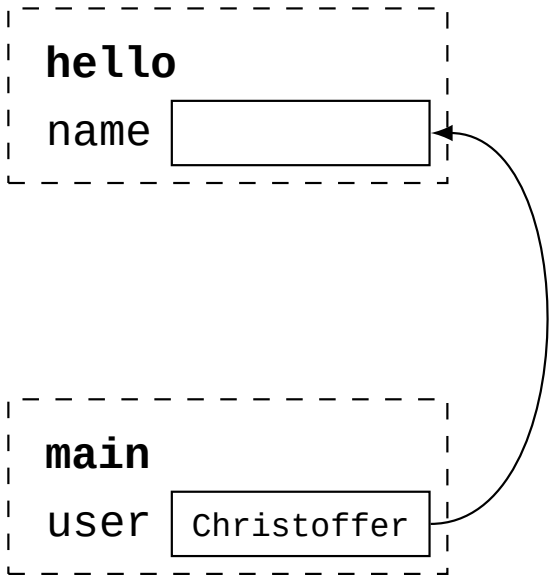


Functions

Parameter passing

```
void hello(string name)
{
  cout << "hello "
       << name << endl;
}

int main()
{
  string user{"Christoffer"};
  hello(user);
}
```

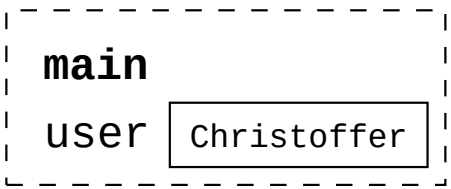


Functions

Parameter passing

```
void hello(string name)
{
  cout << "hello "
       << name << endl;
}

int main()
{
  string user{"Christoffer"};
  hello(user);
}
```



Functions

Parameter passing

- When passing a value to a function C++ will *copy* that value into the function.
- This means that inside the function you are free to modify the parameter without it changing the value outside of the function.

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More on variables

Data types

- built-in types
- Object types
- Pointers

More on variables

Data types

- built-in types
  - `int`
  - `double`
  - `bool`
  - etc.
- Object types
- Pointers

More on variables

Data types

- built-in types
- Object types
  - `string`
  - `struct` (today!)
  - `class` (later)
- Pointers

More on variables

Data types

- built-in types
- Object types
- Pointers
    - Comes later on!

More on variables

Compound data type

```
string name{};
int age{};
cout << "Enter your name and age: ";
cin >> name >> age;
cout << "Your name is " << name
     << " and you are " << age
     << " years old!" << endl;
```

More on variables

Compound data type

- This is a perfectly fine example of us storing information about a person!
- However, it might get a bit annoying if we want to store information about more people.

More on variables

Compound data type

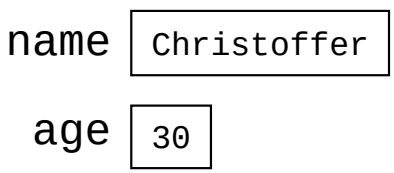
```
string name1{};
string name2{};
int age1{};
int age2{};
cout << "Person 1, enter your name and age: ";
cin >> name1 >> age1;
cout << "Person 2, enter your name and age: ";
cin >> name2 >> age2;
```

More on variables

Now imagine 100 people!

More on variables

Compound data type

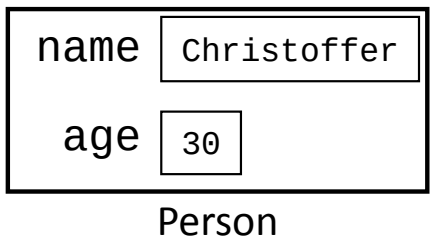



```
string name{};
int age{};

name = "Christoffer";
age  = 30;
```

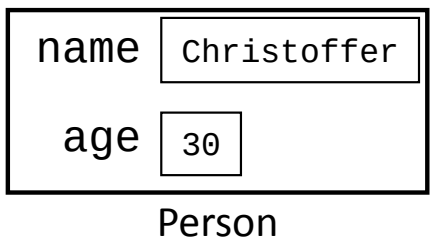
More on variables

Compound data type



More on variables

Compound data type




```
struct Person
{
  string name{};
  int age{};
};

Person p;

p.name = "Christoffer";
p.age  = 30;
```

More on variables

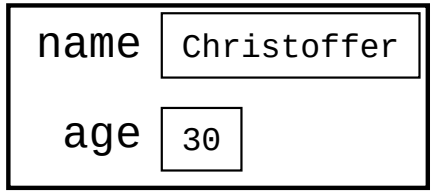
Compound data type

```
Person p1 {"Christoffer", 30};
Person p2 {"Oskar", 31};
```

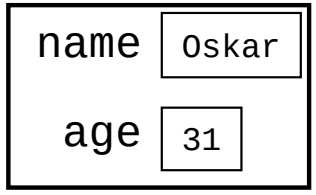
More on variables

Compound data type

```
Person p1 {"Christoffer", 30};
Person p2 {"Oskar", 31};
```



Person p1



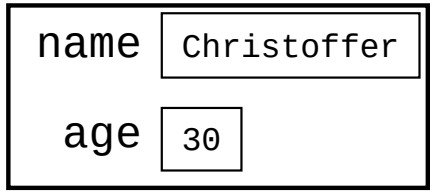
Person p2

More on variables

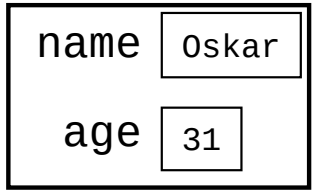
Compound data type

```
Person p1 {"Christoffer", 30};
Person p2 {"Oskar", 31};

p1.age++;
```



Person p1



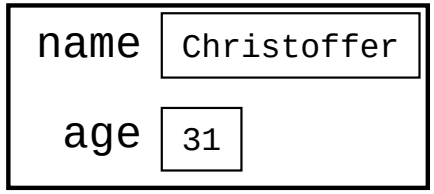
Person p2

More on variables

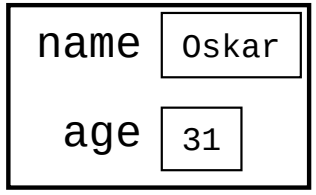
Compound data type

```
Person p1 {"Christoffer", 30};
Person p2 {"Oskar", 31};

p1.age++;
```



Person p1



Person p2

More on variables

Compound data type

- A `struct` defines a type.
- You can create several variables of a `struct` that has its own collection of values.
- Such a variable is called an *object*.
- You can access each variable (field) inside the object with the `.` operator.
- You can also modify these fields as you do with normal variables.

More on variables

Copy

```
Person teacher{"Christoffer", 30};
Person copied_teacher{teacher};

copied_teacher.age++;

cout << teacher.age << endl;
```

More on variables

Copy

- It is possible to copy variables, including `structs`.
- This will create a new instance which has the same values as the original.
- However, changing the copy will leave the original intact and likewise vice versa.

More on variables

References

```
string word{"hello"};
string& greeting{word};

greeting = "hi";

cout << word << endl;
```

More on variables

References

```
string word{"hello"};
string& greeting{word};

greeting = "hi";

cout << word << endl;
```

What will be printed?

More on variables

References

- We can create an *alias* to a variable through references.
- An *alias* is a different name to the same entity; so in the example we have two names for the same variable: `word` and `greeting` (where `greeting` is the alias).
- This is quite powerful when used together with functions (as we will see later)!

More on variables

Constant references

```
string word{"hello"};
string const& greeting{word};

word = "hi"; // works
greeting = "hello"; // Compilation error
```

More on variables

Constant references

- Constant references are *aliases* which disallows changes through them.
- This means that we can modify the value through the original variable but not through the alias.
- Useful if we want to have a read-only variant of a variable.

More on variables

Rule of thumb: Always add `const`, and remove it **only** if you have to modify the value!

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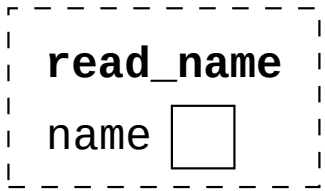
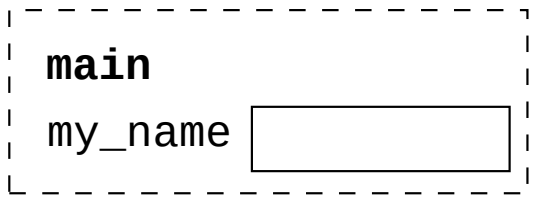
More on functions

Parameter Passing

```
void read_name(string& name)
{
  cout << "Your name: ";
  cin >> name;
}

int main()
{
  string my_name;
  read_name(my_name);
  cout << my_name << endl;
}
```



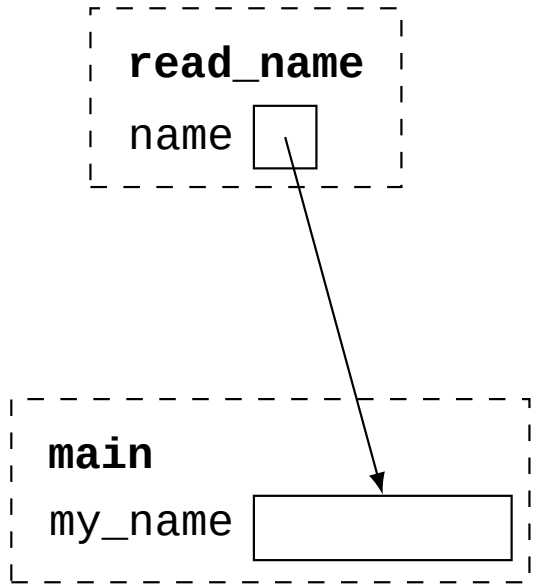


More on functions

Parameter Passing

```
void read_name(string& name)
{
  cout << "Your name: ";
  cin >> name;
}

int main()
{
  string my_name;
  read_name(my_name);
  cout << my_name << endl;
}
```

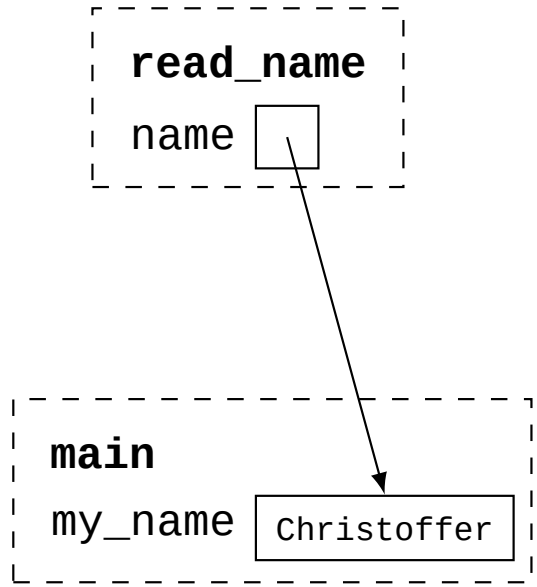


More on functions

Parameter Passing

```
void read_name(string& name)
{
  cout << "Your name: ";
  cin >> name;
}

int main()
{
  string my_name;
  read_name(my_name);
  cout << my_name << endl;
}
```



More on functions

Parameter Passing

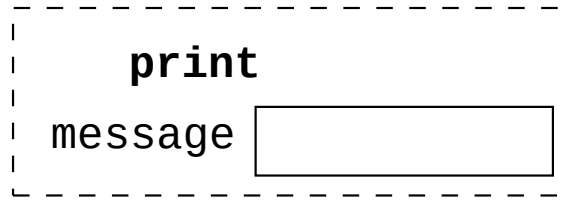
- If a parameter is declared as a reference then it becomes an alias for a variable from outside the scope of the function.
- This means that we can read and modify `my_name` from inside the `read_name` function by just modifying the `name` alias.

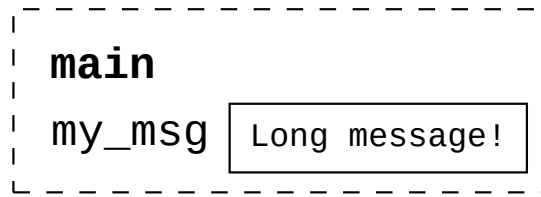
More on functions

Constant Reference

```
void print(string message)
{
  cout << message << endl;
}

int main()
{
  string my_msg{"Long message!"};
  print(my_msg);
}
```





More on functions

Constant Reference

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void print(string message)
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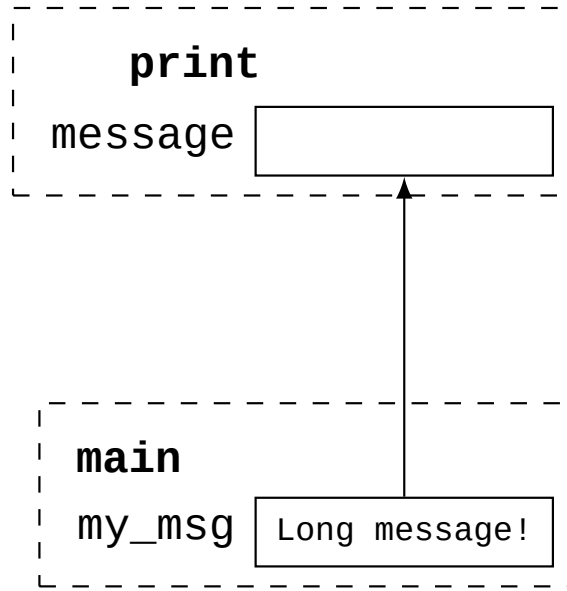
  cout << message << endl;
}

int main()
{
  string my_msg{"Long message!"};
  print(my_msg);
}
```

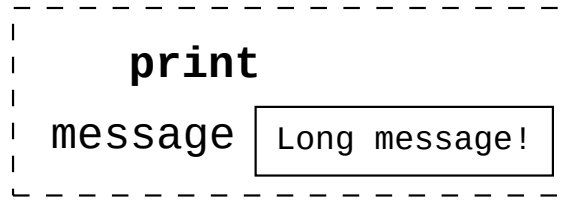


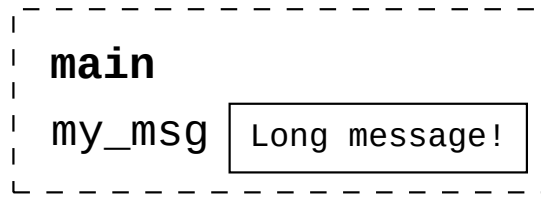
More on functions

Constant Reference

```
void print(string message)
{
  cout << message << endl;
}

int main()
{
  string my_msg{"Long message!"};
  print(my_msg);
}
```



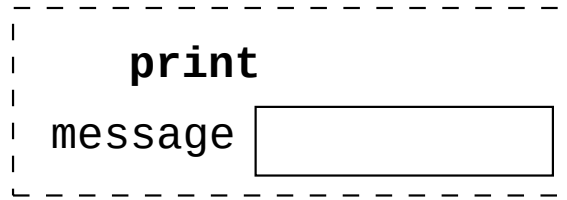


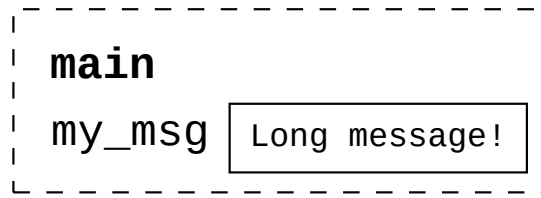
More on functions

Constant Reference

```
void print(string const& message)
{
  cout << message << endl;
}

int main()
{
  string my_msg{"Long message!"};
  print(my_msg);
}
```



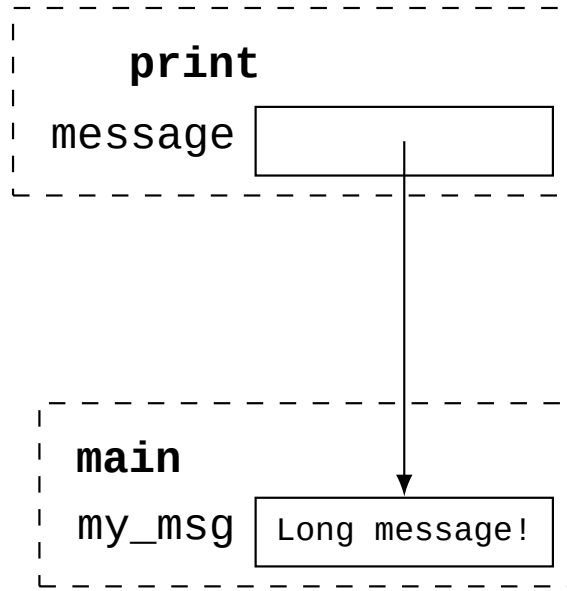


More on functions

Constant Reference

```
void print(string const& message)
{
  cout << message << endl;
}

int main()
{
  string my_msg{"Long message!"};
  print(my_msg);
}
```



More on functions

Constant Reference

- Some types, for example `string` are quite expensive to copy.
- `string` must copy each character, and if it is a long text that will be quite a lot of copying.
- In that case it might be better to share a variable with a function instead of copying.

More on functions

Constant Reference

- However, it should not be a normal reference since we do not want to accidentally overwrite or change the value of the original variable.
- In that case it is good to use `const&`.
- **Rule of thumb:** if it is a non-builtin type you should never pass it as a copy, use `const&` instead.

More on functions

Function overloading

```
// version 1
int add(int a, int b)
{
  return a + b;
}

// version 2
double add(double a,
           double b)
{
  return a + b;
}
```

```
int main()
{
  // will call version 1
  add(1, 2);

  // will call version 2
  add(3.4, 5.6);
}
```

More on functions

Function overloading

```
// version 1
int add(int a, int b)
{
  return a + b;
}

// version 2
double add(double a,
           double b)
{
  return a + b;
}
```

- Functions can have the same name in C++.
- But then the compiler must be able to determine which version should be called.
- This means that the parameters matter.

More on functions

Function overloading

```
// version 1
int add(int a, int b)
{
  return a + b;
}

// version 2
double add(double a,
           double b)
{
  return a + b;
}
```

- The compiler will pick version 1 if we pass in `int` as parameters and version 2 if we pass in `double`.
- Each overload must have a unique set of parameter types.

More on functions

Function overloading

```
// version 1
int add(int a, int b)
{
  return a + b;
}

// version 2
double add(double a,
           double b)
{
  return a + b;
}
```

- **Note:** the compiler cannot distinguish the return type of the function so the compiler doesn't take it into consideration.

More on functions

Which version?

```
double triangle_area(int base , double height);                 // a
double triangle_area(int side1, int side2    , int side3);      // b
double triangle_area(int side1, int side2    , double angle);   // c
double triangle_area(int side , double angle1, double angle2); // d
```

```
triangle_area(1, 1, 1);
triangle_area(1, 1);
triangle_area(1, 1.0, 1.0);
triangle_area(1, 1, 1.0);
```

More on functions

Which version?

```
double triangle_area(int base , double height);                 // a
double triangle_area(int side1, int side2    , int side3);      // b
double triangle_area(int side1, int side2    , double angle);   // c
double triangle_area(int side , double angle1, double angle2); // d
```

```
triangle_area(1, 1, 1);     // b
triangle_area(1, 1);        // a
triangle_area(1, 1.0, 1.0); // d
triangle_area(1, 1, 1.0);   // c
```

More on functions

Which version?

- Note that the compiler looks at the amount of parameters and the types.
- The compiler deduces this information based on the values passed into the function when we are calling it.

More on functions

Default-parameters

```
void ignore(int n, char stop)
{
  cin.ignore(n, stop);
}
```

```
ignore(100, ':');
```

More on functions

Default-parameters

```
void ignore(int n)
{
  ignore(n, '\n');
}
```

```
ignore(100, ':');
ignore(100);
```

More on functions

Default-parameters

```
void ignore()
{
  ignore(1024);
}
```

```
ignore(100, ':');
ignore(100);
ignore();
```

More on functions

Default-parameters

```
void ignore(int n = 1024, char stop = '\n')
{
  cin.ignore(n, stop);
}
```

```
ignore(100, ':');
ignore(100);
ignore();
```

More on functions

Default-parameters

- Sometimes we want optional parameters.
- Useful if there are some default-values we can assign to these parameters, but still want the caller to be able to give their own values.
- One way we can do this is to create different overloads where some parameters are missing.
- However this gets tedious pretty quickly.
- Therefore we can use something called *default-parameters*.

More on functions

Default-parameters

- default-parameters must be at the end of the parameter list.
- They are declared by assigning a default value to the parameter in the parameter list.
- The compiler will match the parameters from left to right, meaning we can only have optional parameters in a sequence at the end of the list.
- Default parameters should only be in the declaration, not the definition.

More on functions

Default-parameters

```
void ignore(int n = 1024, char stop = '\n');

int main()
{
  ignore(100, ':');
  ignore(100);
  ignore();
}

void ignore(int n, char stop)
{
  cin.ignore(n, stop);
}
```

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Operator Overloading

Example

```
struct Person
{
  string first_name;
  string last_name;
};
```

Operator Overloading

Example

```
int main()
{
  Person p1{"Christoffer", "Holm"};
  Person p2{"Klas", "Arvidsson"};

  if (p1.first_name < p2.first_name)
  {
    cout << p1.first_name << " "
         << p1.last_name << endl;
  }
}
```

Operator Overloading

Easier way

```
int main()
{
  Person p1{"Christoffer", "Holm"};
  Person p2{"Klas", "Arvidsson"};

  if (p1 < p2)
  {
    cout << p1 << endl;
  }
}
```

Operator Overloading

Easier way

- We can define how the normal operators are supposed to work with our `struct`.
- This allows us to create code that is easier to understand,
- since now we can specify for example what is means to see if one person is < another.
- This is useful to determine how these objects could be sorted.

Operator Overloading

To make it work

```
bool operator<(Person const& p1, Person const& p2)
{
  return p1.first_name < p2.first_name;
}
```

Operator Overloading

To make it work

- Not all operators can be overloaded.
- Here is a list: `https://en.cppreference.com/w/cpp/language/operators`
- An operator overload is just a function with a special name.
- Every operator is defined with the name `operator` followed by the operator you wish to overload.
- For example `operator`+, `operator`==, `operator`<< etc.

Operator Overloading

To make it work

- The type of the first parameter to the operator is usually the object you want to overload this operator for.
- The return type and the rest of the arguments depend on the specific operator.
- Two types of operator: *Unary* and *Binary*.

Operator Overloading

How does it work?

```
if (p1 < p2)
{
  // ...
}
```

Operator Overloading

How does it work?

```
if (p1 < p2)
{
  // ...
}
```

```
if (operator<(p1, p2))
{
  // ...
}
```

Operator Overloading

How does it work?

- When the compiler sees an expression involving an operator it will look for a function with the special `operator` name.
- If it exists, the compiler will the translate the operator expression to a function call to that special `operator` function.
- Note that normal function rules apply to operators as well.

Operator Overloading

Binary operator

```
My_Type a;
My_Type b;
a+b;
a<b;
a==b;
```

Operator Overloading

Binary operator

```
My_Type a;
My_Type b;
a+b;
a<b;
a==b;
```

```
My_Type a;
My_Type b;
operator +(a, b);
operator <(a, b);
operator==(a, b);
```

Operator Overloading

Binary operator

- Binary operators are those operators that involves two values (`a` and `b` in the previous example).
- These operators take two parameters: the first corresponds to the value to the left of the operator while the second corresponds to the value right of the operator.
- The return type can be whatever you want, but it should make sense!

Operator Overloading

Unary operator

```
My_Type a;
-a;
++a;
a++;
```

Operator Overloading

Unary operator

```
My_Type a;
-a;
++a;
a++;
```

```
My_Type a;
operator-(a);
operator++(a);
operator++(a);
```

Operator Overloading

Unary operator

```
My_Type a;
-a;
++a;
a++;
```

- ++a and a++ are not the same expression.
- So their operator-overload should be different.
- But how?
- C++ has a solution.

Operator Overloading

Unary operator

```
My_Type a;
-a;
++a;
a++;
```

```
My_Type a;
operator-(a);
operator++(a);
operator++(a, 0);
```

Operator Overloading

Unary operator

```
My_Type a;
-a;
++a;
a++;
```

- The compiler adds a `0` as the second parameter to the postfix-version of all increment and decrement operators.
- This is only so that the operator overloading between these versions can be distinguished.
- The `0` does not mean anything.

Operator Overloading

Unary operator example

```
struct My_Int
{
  int data;
};

My_Int& operator++(My_Int& i);
My_Int  operator++(My_Int& i, int);
```

Operator Overloading

Unary operator example

```
My_Int& operator++(My_Int& i)
{
  ++i.data;
  return i;
}
```

Operator Overloading

Unary operator example

```
My_Int operator++(My_Int& i, int)
{
  My_Int tmp{i};
  ++i;
  return tmp;
}
```

Operator Overloading

Unary operator example

- Prefix increment (and decrement) will increment (or decrement) the value and then return the new value.
- C++ dictates that the return type should be a reference in this case, as to reduce copies.
- Postfix increment (and decrement) will increment (or decrement) the value and then return the previous value.
- Therefore we must return a copy of the object since the original object has changed value.

Operator Overloading

Operator Overloading

- It is a good idea to add your logic in as few operators as possible and then reuse these operators to implement the others.
- In the previous example we implemented the increment logic in the prefix-increment operator and then in the postfix-increment operator we simply use the prefix-version.
- This way if we have to change the behaviour it is enough to do it in one place.

Operator Overloading

Overloading printing operators

```
Person p1{"Christoffer Holm"};
cout << p1 << endl;
```

Operator Overloading

Overloading printing operators

```
Person p1{"Christoffer Holm"};
((cout << p1) << endl);
```

Operator Overloading

Overloading printing operators

```
Person p1{"Christoffer Holm"};
(operator<<(cout, p1)) << endl);
```

Operator Overloading

Overloading printing operators

```
Person p1{"Christoffer Holm"};
operator<<(operator<<(cout, p1), endl);
```

Operator Overloading

Overloading printing operators

```
Person p1{"Christoffer Holm"};
operator<<(operator<<(cout, p1), endl);
```

What should our `operator<<` return to make it work?

Operator Overloading

What is `cout`?

- The type of `cout` is `ostream`.
- We need to capture `cout` and return it in our `operator<<`.

Operator Overloading

Overloading printing operators

```
ostream& operator<<(ostream& os, Person const& p)
{
  os << p.first_name << " " << p.last_name;
  return os;
}
```

Operator Overloading

This is called chaining

```
Person p1{"Christoffer Holm"};
cout << p1 << endl;
```

Operator Overloading

This is called chaining

```
Person p1{"Christoffer Holm"};
((cout << p1) << endl);
```

Operator Overloading

This is called chaining

```
Person p1{"Christoffer Holm"};
(operator<<(cout, p1)) << endl);
```

Operator Overloading

This is called chaining

```
Person p1{"Christoffer Holm"};
cout << endl;
```

Operator Overloading

Overloading reading operator

```
Person p;
int x;
cin >> p >> x;
```

Operator Overloading

Overloading reading operator

```
Person p;
int x;
((cin >> p) >> x);
```

Operator Overloading

Overloading reading operator

```
Person p;
int x;
((operator>>(cin, p)) >> x);
```

Operator Overloading

Overloading reading operator

```
Person p;
int x;
operator>>((operator>>(cin, p), x);
```

Operator Overloading

Overloading reading operator

- `cin` is of type `istream`.
- Just as with the printing operator, we want chaining for our operator.
- We are reading into variables, so every parameter should be a reference.

Operator Overloading

Overloading reading operator

```
istream& operator>>(istream& is, Person& p)
{
  is >> p.first_name >> p.last_name;
  return is;
}
```

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Stream flags

What happens?

```
int x;
string word;
cout << "Enter int: ";
cin >> x;
cout << x << endl;
cout << "Enter word: ";
cin >> word;
cout << word << endl;
```

Stream flags

What happens?

```
int x;
string word;
cout << "Enter int: ";
cin >> x;
cout << x << endl;
cout << "Enter word: ";
cin >> word;
cout << word << endl;
```

```
Enter int: 5
5
Enter word: hello
hello
```

Stream flags

What happens?

```
int x;
string word;
cout << "Enter int: ";
cin >> x;
cout << x << endl;
cout << "Enter word: ";
cin >> word;
cout << word << endl;
```

```
Enter int: a
0
Enter word:
```

Stream flags

What happens?

```
int x;
string word;
cout << "Enter int: ";
cin >> x;
cout << x << endl;
cout << "Enter word: ";
cin >> word;
cout << word << endl;
```

Why does this happen?

Stream flags

Why does this happen?

- If an operation fails; in this case trying to read an `int` but finding the letter `'a'` instead,
- then an error flag is raised inside the stream,
- as long as this flag is raised the operations will immediately fail meaning nothing will happen.

Stream flags

What flags are there?

`fail`	Stream operation failed
`eof`	device has reached the end
`bad`	irrecoverable stream error
`good`	no errors

Stream flags

What flags are there?

- Multiple flags can be set at once,
- except `good`; it is set when no other flag is set.
- This means that several errors can occur at once
- Do note that these flags are set *after* a stream operation fails.
- The stream does not magically detect an error if no operation has been performed.

Stream flags

So how do we fix it?

```
int x;
string word;
cin >> x;
cin.clear();
cin >> word;
```

Stream flags

So how do we fix it?

- `cin.clear()` will clear any and all flags that are raised.
- You can also check if a specific flag is raised:

Stream flags

Checking for specific flag

```
if (cin.fail())
{
  // the fail flag
}
if (cin.eof())
{
  // the eof flag
}
if (cin.bad())
{
  // the bad flag
}
```

Stream flags

Setting the flags

```
cin.setstate(ios_base::failbit);
cin.setstate(ios_base::eofbit);
cin.setstate(ios_base::badbit);
cin.setstate(ios_base::goodbit);
```

Stream flags

Setting the flags

- When creating your own `operator>>` you may want to set error flags.
- This is done with `cin.setstate`.
- You can set the flags by passing in specific values called `failbit`, `eofbit`, `badbit` and `goodbit`.

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File separation

Modular thinking

- Related functions can be gathered inside a file.
- This is called a *module* (Not to be confused with the new *C++20 Modules*).
- Modules can be compiled separately from the main program, this will result in an *object file*.
- The declaration of functions that should be available in your module are placed in a *header file*.

File separation

Modular thinking

- The actual definition of these functions are placed in an *implementation file*.
- Header files and implementation should have the same name, except for the file extension.
- Then all modules can be compiled together with your program to create an *executable file*.

File separation

Types of files

- Implementation files (.cc)
- Executable files

File separation

Types of files

- Implementation files (.cc)
- Executable files
- Header files (.h)

File separation

Types of files

- Implementation files (.cc)
- Executable files
- Header files (.h)
- Object file (.o)

File separation

Types of files

- Implementation files contains definitions.
- Header files contains declarations.
- Executable files are the actual programs the computer can run.
- Object files are smaller parts of the program that has been precompiled. They cannot run on their own, but can be combined together to create an executable file.

File separation

Example

test.h

```
#ifndef TEST_H
#define TEST_H
void test(int x = 0); // declaration
#endif//TEST_H
```

test.cc

```
#include "test.h"
#include <iostream>
using namespace std;
void test(int x) // definition
{
  cout << x << endl;
}
```

main.cc

```
#include "test.h"

int main()
{
  test();
  test(1);
}
```

terminal

```
$ g++ test.cc main.cc
$ ./a.out
0
1
```

File separation

Example

- `test.h` has what is known as a header-guard.
- `#ifndef TEST_H` means: if the symbol TEST_H is not defined, then compile everything, otherwise skip to the `#endif` and continue compilation from there.
- `#define TEST_H` creates the symbol TEST_H.
- This is done to ensure that we doesn't accidentally declare the same things twice. Which happens if we accidentally include the same file more than once.

File separation

Example

- `#include "test.h"` is replaced with the content of the `test.h` file.
- This is how importing modules works, the compiler will recieve a list of declarations (i.e. functions, structs and other things that will be available).
- **Note:** these things are only declared, not defined.

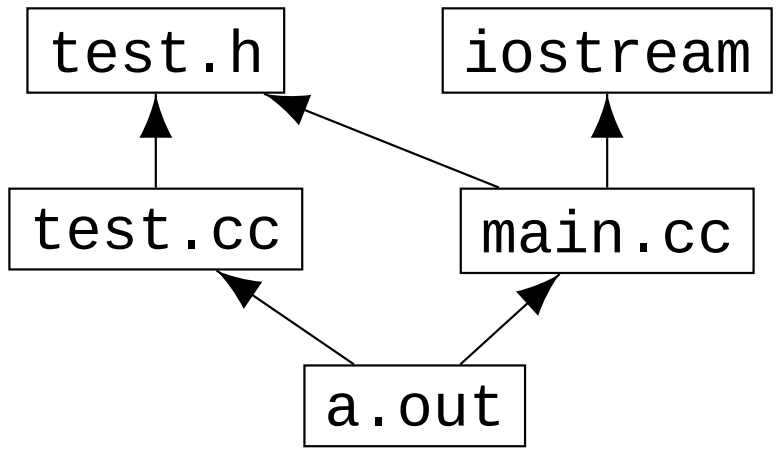
File separation

Example

- The definition of these things are done inside a separate implementation file (`test.cc` in this example).
- We also have the `main.cc` file which contains our program that uses the `test` module.
- Both of these files includes the header file (`test.h`) but only one of them gives the definition of the things declared.

File separation

Dependency graph



File separation

Dependancy graph

- In the previous image we can see how it all comes together.
- `test.cc` includes `test.h`
- `main.cc` includes `test.h` and `iostream`
- These cc-files can then be compiled together to create an executable file `a.out`
- We have two modules: `test` and `main`

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Testing

- When writing modules we should test them before we use them.
- This is to make sure that they work in all cases.
- This can be done manually by creating a main-program that allows the user to enter inputs that tests each functionality.
- However this is tedious work which we probably can do better, and more accurately.

Testing

Testing modules

```
#include "Person.h"
#include <iostream>
using namespace std;
int main()
{
  Person p1{"a", "a"};
  Person p2{"b", "b"};
  Person p3{"a", "a"};
  if (p1 < p2)
  {
    cout << "operator< works!" << endl;
  }

  if (p1 == p3 && p1 != p2)
  {
    cout << "operator== works!" << endl;
  }
}
```

Testing

Testing modules

- We should always test all functionality in our modules.
- This can be done by writing alot examples where we test various functions and functionality.

Testing

Testing stream operations

```
#include "Person.h"
#include <iostream>

using namespace std;
int main()
{
  Person ans{"Christoffer", "Holm"};
  Person p;
  cout << "Enter 'Christoffer Holm': ";
  cin >> p;
  if (p == ans)
  {
    cout << "operator>> works!" << endl;
  }
}
```

Testing

Testing stream operations

```
#include "Person.h"
#include <iostream>
#include <sstream>
using namespace std;
int main()
{
  Person ans{"Christoffer", "Holm"};
  Person p;
  istringstream iss{"Christoffer Holm"};
  iss >> p;
  if (p == ans)
  {
    cout << "operator>> works!" << endl;
  }
}
```

Testing

Testing stream operations

- You could test stream operators by letting the user enter appropriate data and see that it works.
- However, after a while this gets tedious since we have to test all cases over and over again, writing the same things over and over again into the terminal.
- What we can do then is to simulate `cin` and `cout` to automatically test `operator>>` and `operator<<`.

Testing

Testing stream operations

- `cin` can be simulated with `istringstream`.
- It is defined in `<sstream>`.
- It works exactly like `cin`, with the difference that you specify what has been entered into the simulated `cin` when you create `istringstream`.

Testing

Testing stream operations

```
#include <iostream>
#include <sstream>
using namespace std;
int main()
{
  Person p{"Christoffer", "Holm"};
  ostringstream oss{};
  oss << p;
  if (oss.str() == "Christoffer Holm")
  {
    cout << "operator<< works!" << endl;
  }
}
```

Testing

Testing stream operations

- You can simulate `cout` with `ostringstream`.
- It works exactly like `cout` with the exception that it prints to a string instead of to the terminal.
- This allows us to retrieve the written output with `oss.str()` and to check that it was correct.

Testing

`cath.hpp`

```
#define CATCH_CONFIG_MAIN
#include "catch.hpp"

TEST_CASE("testing < and ==")
{
  Person p1{"a", "a"};
  Person p2{"b", "b"};
  Person p3{"a", "b"};
  CHECK(p1 == p3);
  CHECK_FALSE(p1 == p2);
  CHECK(p1 < p2);
  CHECK_FALSE(p2 < p1);
}
```

Testing

`cath.hpp`

```
#define CATCH_CONFIG_MAIN
#include "catch.hpp"

TEST_CASE("testing < and ==")
{
  Person p1{"a", "a"};
  Person p2{"b", "b"};
  Person p3{"a", "b"};
  REQUIRE(p1 == p3);
  REQUIRE_FALSE(p1 == p2);
  REQUIRE(p1 < p2);
  REQURE_FALSE(p2 < p1);
}
```

Testing

`catch.hpp`

- `catch.hpp` is a testing framework (a module) that we will use in this course.
- It makes it a lot easier for us to test our modules.
- The framework will create a good main-function for you with tests and nice output messages.
- All you have to do is create the test cases.

Testing

`catch.hpp`

- To start using `catch.hpp` you have to download the header file `catch.hpp` from here: https://github.com/catchorg/Catch2
- Place the file in the same directory as your program.
- Define the symbol `CATCH_CONFIG_MAIN` and then include `catch.hpp`.

Testing

`catch.hpp`

- To create a test case you use the command `TEST_CASE` which takes a string that is supposed to contain a short description of what this test case is testing.
- Then you open a block and everything inside this block will be bundled together as one testcase.
- Then you add conditional statements which you surround with either the keyword `CHECK` or `REQUIRE`.

Testing

`catch.hpp`

- `CHECK` simply tests whether the statement inside is `true` (there is a `CHECK_FALSE` version that tests if it is `false`). Either way, once it has been tested it will move on to the next test.
- `REQUIRE` works the same way, except that it will stop all tests if this one fails.
- That is all the basic tools you need to use `catch.hpp`.

1 Functions
2 More on variables
3 More on functions
4 Operator Overloading
5 Stream flags
6 File separation
7 Testing
8 Time lab

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Time lab

Lab 2

- The Time lab (lab2) covers everything we have discussed in these lectures: `struct`, functions, operator overloading, testing etc.
- It is a lot harder than lab 1 so plan your time accordingly.
- The goal of the lab is to create your own module.
- That means you are not creating a program but instead a smaller part of a program that can be used for many different programs.
- Testing is a part of the lab so we expect you to write good testcases.

Time lab

Labs

- Lab1 Deadline: September 6th
- Lab2 Deadline: September 20th
- Complementary work

Time lab

Teaching session

- First teaching session: September 8th at 08:15-10:00
- There will be one session in English (always given in the highest numbered room in TimeEdit)
- Content will be about lab 2

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