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Lecture Objectives

1 Functions

- What is a function?
  - In programming, a function is a reusable block of code
  - It (optionally) takes input and (optionally) returns an output
- Why use functions?
  - We often want to repeat the same behavior on different pieces of data
  - Rather than pasting the same code many times, we use a function
    - Functions help to keep code maintainable and readable
  - There is a balance to strike when extracting code into functions
    - Too few functions results in long and repetitive code
    - Too many functions will result in sub-optimal performance and a code base that is very hard to read
      - Every time a function is called a new frame needs to be pushed to the stack and we jump around the executable
- How to define a function: **type name(arguments)**
  - **type**: The return type of the function (can be `void`)
  - **name**: The function's name
  - **arguments**: The input arguments to a function
    - Specified as **type name** in a comma seperated list
    - **Example**: `int add(int a, int b, int c) {...}`
  - Together, the function's name and arguments make up the signature
- How to call a function: `name(arguments)`
  - **Example**: `int sum = add(1, 2, 3); // sum = 6`

2 Scope

In C++, **scope** refers to the region of a program, where a variable or function is accessible and valid. It defines the part of the code where the name of an identifier is recognized.

- How is scope defined?
  - A scope is defined by curly braces: {...}
  - ... is said to be "within the scope" and everything else is outside

- Types of scope:
  - Global scope: Accessible from any part of the program
    - Variables declared outside any function
  - Local scope: Accessible only within the same block ({...})
    - Variables declared within functions

3 Conditions and Branches

3.1 Boolean Statements

- What is a Boolean statement?
  - A `bool` type in C++ can either hold `true` or `false`
  - Therefore, a Boolean statement evaluates to `true` or `false`
  - They are often the inputs to conditional evaluation (for clear reasons)
- How to create a Boolean statement:
  - `bool(x)`: casts `x` to a type `bool`
    - For numeric types, returns `true` if `x` $\neq 0$, `false` if `x` $= 0$
    - `bool(1) == true; bool(-1) == true; bool(0) == false`
  - Comparison operators: return a boolean based on the comparison
    - `==`, `!=`, `<`, `>`, `<=`, `>=` are all rather simple (`a == b` $\leftrightarrow a = b$)
  - Unary `!` operator: negation operator
    - `!true == false` `!false == true`
    - `!(5 == 6) == true` `!(0 == 0) == false`
  - Operator `&&`: and operator
    - The **and** operator, `&&` returns true if both sides are true
    - `(1 == 1) && (0 == 0) == true`
    - `(1 > 0) && (0 > 1) == false`
  - Operator `||`: or operator
    - The **or** operator, `||` returns true if either side is true
    - `(1 == 1) || (1 == 0) == true`
    - `(1 < 0) || (0 > 1) == false`

3.2 `if` Statements

- When to use an `if` statement:
  - Use `if` statements when you want to run a block of code conditionally
  - **Example**: You only want to log a user in **if** their password is correct
- `if` statement syntax: `if (condition) {...}`
  - Only executes the block of code (...) if the boolean expression is true
- Use of `else` to provide an alternative
  - `if (condition) {...} else {...}`
- Chaining `if` and `else` into `else if`
  - `if (cond 1) {...} else if (cond 2) {...} else {...}`
  - `else if` is not a new keyword, rather an `if` within an `else`
- The overhead of `if` statements
  - Every time an `if` statement is evaluated, the computer has to "jump" around the executable to the correct execution block
  - This entails an expensive load operation, making `if` statements relatively expensive
  - Overhead is minuscule, why even bother explaining this?
    - It's important to understand how things actually work
    - Builds an understanding for the motivation of `constexpr`
    - Sometimes you do actually care about nanoseconds-microseconds
  - For these reasons, programmers often use ternary operator
    - `(condition) ? (if true) : (if false)`
    - "returns" second argument if first argument (boolean) is true, else "returns" third argument
  - There are also often mathematical ways to get around using `if`

3.3 `switch` Statements

- Think of `switch`es as `if`s where you have an `int` condition, not a `bool`
- `switch` statement syntax: `switch(var) { cases... }`
  - The case corresponding to the `int` expression will be executed
  - If no case matches, `default` is executed
- The `break` statements are needed, else every case below will also execute
  - Sometimes this is desired behavior, but rarely
- Switches are often preferred to chained `if-else` statements when possible
  - They do not have the same overhead as many `if`s

4 Loops

Often times, we need a certain block of code to run multiple times. Rather than copying and pasting said block, we can use a loop. A loop is a structure that allows a block of code to be run a specified amount of times.

4.1 `while` Loops

- When to use a `while` loop?
  - You have a block that you need to run **while** a condition is true
  - **Example**: **while** the player is playing the game, render the screen
- `while` loop syntax: `while (condition) {...}`
  - `...` will run `while` condition is true
- When to use a `do while` loop?
  - You need the block of code to run at least one time
  - `do {...} while (condition)`
    - The `do` keyword's only purpose is to pair the `while` loop to a scope written before it, rather than after
  - A `do while` loop runs the block first, and checks the condition second

4.2 `for` Loops

- When to use a `for` loop?
  - You need a block of code to run a set number of times
    - `for` loops are much more flexible than `while` loops
    - Any `while` loop can be a `for` loop
- `for` loop syntax: `for (init; condition; update) {...}`
  - **init** is a piece of code that will run once before the loop runs
  - **condition** works just like a `while` loop
  - **update** runs at the end of every loop iteration
  - You can leave any or all fields empty
    - The default behavior for an empty condition is "`true`"

4.3 Control Flow Statements

4.3.1 `break`

- `break` is used to "break out" of loops and switches early
- Can only be used within a loop or a switch, not any scope

4.3.2 `continue`

- `continue` is used to "continue" to the next iteration of a loop
- Can only be used within a loop structure

4.3.3 `return`

- `return` is used to "return" a value from a function