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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 separated 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 **switches** as **ifs** 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 **ifs**

## 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