UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING
Department of Electrical & Computer Engineering

ECE 150 *Fundamentals of Programming*

Anatomy of a program

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Outline

- In this presentation, we will:
  - Define the components of a program
    - Pre-processor directives
    - Statements
    - Blocks of statements
    - Function declarations and definitions

Pre-processor directives

```
#include <iostream>

int main();

int main() {
	std::cout << "Hello world!";
	std::cout << std::endl;

	return 0;
}
```

Pre-processor directives

- Indicates that a particular standard library or file should be included in the compilation
  - C++ Standard libraries contain functionality available to all programmers except perhaps in embedded systems
  - Possible to include other source code you or others have written

```
#include <iostream>
```

  - All pre-processor directives start with a "#"
  - Pre-processor directives are not part of the C++ programming language

Statements

```
#include <iostream>

int main();

int main() {
        std::cout << "Hello world!";
        std::cout << std::endl;

        return 0;
}
```

Statements

- A statement may always be described a
  - the introduction (or "*declaration*") of a name (or "*identifier*")
  - an action that is being performed on data

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

- A statement is always terminated by a semi-colon

Statements

- Some sample statements from the NASA core Flight System Memory Manager Application:

```
Valid = FALSE;
BytesRemaining = 0;
MM_AppData.ErrCounter++;
CFE_EVS_SendEvent(MM_PSP_READ_ERR_EID, CFE_EVS_ERROR,
                  "PSP read memory error: RC=0x%08X, "
                  "Src=0x%08X, Tgt=0x%08X, Type=MEM16",
                   (unsigned int)PSP_Status,
                   (unsigned int)DataPointer16,
                   (unsigned int)&ioBuffer16[i] );
break;
```

A block of statements

- A *block of statements* is zero or more statements surrounded by braces
  - Statements are executed one at a time in the order they appear
  - One statement must finish executing before the next starts

```
{
        std::cout << "Hello world!";
        std::cout << std::endl;

        return 0;
}
```

A block of statements

- A sample block of statements from the NASA core Flight System Memory Manager Application:

```
{
    Valid = TRUE;
    MM_AppData.LastAction     = MM_LOAD_FROM_FILE;
    MM_AppData.MemType        = FileHeader->MemType;
    MM_AppData.Address        = DestAddress;
    MM_AppData.BytesProcessed = BytesProcessed;
    strncpy( MM_AppData.FileName,
             FileName, OS_MAX_PATH_LEN );
}
```

Function declarations and definitions

```
#include <iostream>

int main();

int main() {
    std::cout << "Hello world!";
    std::cout << std::endl;

    return 0;
}
```

Function declaration

Function definition

The statements executed when the function is called is also referred to as the *function body*.

Function declarations

- From your secondary school mathematics courses, you have seen:

$$\sin\left(\frac{\pi}{6}\right) \qquad \gcd(91,119)$$

- The names of these functions are sin and gcd:
  - sin has one real parameter and evaluates to a real
  - gcd has two integer parameters and evaluates to an integer

Function declarations

- A *function declaration* indicates to the compiler:
  - That a function with a specific name exists
    - The name is called the *identifier* of the function
  - The function's parameters
  - What it returns

- The declaration:
  `int main();`
  indicates:
  - The name of the function is `main`
  - It has no parameters
  - It returns an `int`
    - An integer

Function declarations

- The function declarations for sin and gcd would be:

```
double sin( double x );
int gcd( int m, int n );
```

  indicates:
  - The names of the functions are `sin` and `gcd`
  - The first has one parameter, the second has two
  - The first returns a `double`, the second an `int`

Function definition

- A *function definition* is the function declaration immediately followed by a block of statements
  - This block of statements is also called the *body of the function*
  - These statements are executed when the function is run
  - The three statements executed when `main()` is called include:
    - Printing “Hello world!” to the console output,
    - Printing an end-of-line character to the console output, and
    - Returning the integer `0`

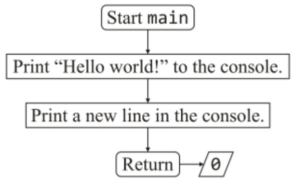
```
int main() {
        std::cout << "Hello world!";
        std::cout << std::endl;

        return 0;
}
```

Function definition

- The *main* function is especially important in C++
  - There can by many functions, but if source code is compiled into an executable, when that executable is run, it is the `main()` function that is first called

Flow charts

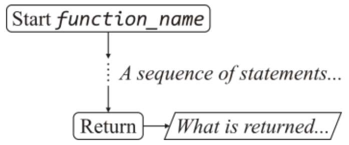
- A *flow chart* is a diagrammatic means of documenting what a function does


Start main
Print “Hello world!” to the console.
Print a new line in the console.
Return
0

```
int main() {
        std::cout << "Hello world!";
        std::cout << std::endl;

        return 0;
}
```

Flow charts

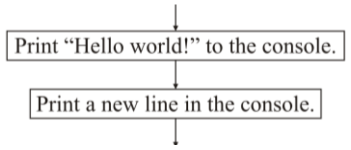
- The start and end of functions are indicated with rounded boxes
- Any internal output is marked with a parallelogram



- Often, the descriptions are point form or English prose

Flow charts

- Statements are shown in rectangular boxes
  - The order of the execution of the statements is indicated by the arrows


Print "Hello world!" to the console.
Print a new line in the console.

- Again, the descriptions are in point form or English prose
  - They tell the reader what is meant to happen
  - These are programming language independent

Matching delimiters

- As in your mathematics courses, `( )`, `[ ]`, and `{ }` are used to group mathematical expressions
  - We will call these parentheses, brackets and braces
    - For clarity, we may use the terms *round parentheses*, *square brackets*, and *curly braces*
  - `(`, `[`, and `{` are referred to as opening delimiters
    while `)`, `]`, and `}` are referred to as closing delimiters

- Given an opening delimiter, its *matching* closing delimiter is next closing delimiter that does not have a closer matching opening delimiter
  - Each opening delimiter must have a matching closing delimiter

```
{ ( [ ( ( ) [ ( ) ] ) { } ] { } [ ] ) } [ ( ) { [ ] } ]
```

Summary

- In this presentation, you now
  - Described the include pre-processor directive
  - Defined a statement
    - Operators and function calls terminated by a semi-colon
  - Defined a block of statements
    - Zero or more statements surrounded by braces
  - Defined function declarations and definitions
  - Described and introduced flow charts

References

[1] Wikipedia
https://en.wikipedia.org/wiki/Statement_(computer_science)

Acknowledgments

Proof read by Dr. Thomas McConkey and Charlie Liu.

Colophon

These slides were prepared using the Georgia typeface. Mathematical equations use Times New Roman, and source code is presented using `Consolas`.

The photographs of lilacs in bloom appearing on the title slide and accenting the top of each other slide were taken at the Royal Botanical Gardens on May 27, 2018 by Douglas Wilhelm Harder. Please see

https://www.rbg.ca/

for more information.

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