Control Statements and Functions

EECS 230

Winter 2017
Agenda

- Computation
  - What is computable? How best to compute it?
  - Abstractions, algorithms, heuristics, data structures

- Language constructs and ideas
  - Sequential order of execution
  - Expressions and statements
  - Selection
  - Iteration
  - Functional abstraction
You already know most of this

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  - $d = a + b \times c$
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- You know how to iterate:
  - “Do 20 reps.”
  - “Stir until no lumps remain.”
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  - “Go ask Alice and report back to me.”
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So what I’ll be showing you is mainly syntax for things you already know.
Computation: the big picture

- Input: from keyboard, files, mouse, other input devices, the network, other programs
- Code: consumes the input and does something to produce the output
- Output: to the screen, files, printer, other output devices, the network, other programs
Expressing computation

Our job is to express computations

• simply,
• correctly, and
• efficiently.
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  - Use a higher-level concept that hides detail
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- **Divide and conquer**
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- **Data organization** (often key to good code)
  - Input/output formats
  - Communication protocols
  - Data structures
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  ▶ Break a big computation into several smaller ones

• Abstraction
  ▶ Use a higher-level concept that hides detail

• Data organization (often key to good code)
  ▶ Input/output formats
  ▶ Communication protocols
  ▶ Data structures

Note the emphasis is on structure and organization
Each language feature exists to express a fundamental idea:

- `+` addition
- `*` multiplication
- `{ stm stm ... }` sequencing
- `if (expr) stm else stm` selection
- `while (expr) stm` iteration
- `f(x);` function call
Programming language features

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- `*` multiplication
- `{ stm stm ... }` sequencing
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- `while (expr) stm` iteration
- `f(x);` function call

The meaning of each feature is simple, but we combine them into programs of arbitrary complexity.
Expressions

An expression computes a value:

```c
int length = 20;                     // simplest expression is a literal
int width = 40;
```
Expressions

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```c
int length  = 20; // simplest expression is a literal
int width   = 40;
int area    = length * width; // multiplication
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// as in algebra, you can compose operations
int average = (length + width) / 2;
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When in doubt, parenthesize (but don’t overdo it)
What expressions are made of

Operators and operands

- operators specify what to do
- operands specify the data to do it to
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Operators and operands

- operators specify what to do
- operands specify the data to do it to

Some common operators:

<table>
<thead>
<tr>
<th>Operator(s)</th>
<th>Meaning</th>
<th>bool</th>
<th>int</th>
<th>double</th>
</tr>
</thead>
<tbody>
<tr>
<td>+, −, *, /</td>
<td>arithmetic</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>%</td>
<td>remainder</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>==</td>
<td>equal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>!=</td>
<td>not equal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>&lt;, &lt;=, &gt;, &gt;=</td>
<td>comparisons</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>&amp;&amp;,</td>
<td></td>
<td></td>
<td>and, or</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Concise operators

For many binary operators, there are (roughly) equivalent more concise versions:

\[
\begin{align*}
  a &\quad += c \quad \text{means} \quad a = a + c \\
  a &\quad *= \text{scale} \quad \text{means} \quad a = a * \text{scale} \\
  a &\quad ++a \quad \text{means} \quad a += 1 \\
      &\quad \quad \quad \quad \text{or} \quad a = a + 1
\end{align*}
\]

Use them when they make your code clearer.
Statements

A statement is one of:

- an expression followed by a semicolon,
- a declaration, or
- a *control* statement that determines control flow.
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Examples:

- \( a = b; \)
- \( \text{double } d2 = 2.5; \)
- \( \text{if } (x == 2) y = 4; \)
- \( \text{while } (\text{cin } >> \text{number}) \text{ numbers.push_back(number);} \)
- \( \text{int } \text{average} = (\text{length } + \text{width}) / 2; \)
- \( \text{return } x; \)
Statements

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Examples:

- `a = b;`
- `double d2 = 2.5;`
- `if (x == 2) y = 4;`
- `while (cin >> number) numbers.push_back(number);`
- `int average = (length + width) / 2;`
- `return x;`

I don’t expect you to recognize all of these…yet.
Selection

Sometimes we must choose between alternatives.

For example, suppose we want to identify the larger of two numbers. We can use an if statement:

```
if (a < b)
    max = b;
else
    max = a;
```
Selection

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For example, suppose we want to identify the larger of two numbers. We can use an if statement:

```java
if (a < b)
    max = b;
else
    max = a;
```

The syntax is

```java
if (condition)
    statement-if-true
else
    statement-if-false
```
Sequencing

What if you want to do more than one thing in an if?

Use a compound statement:

```plaintext
if (a < b) f_{max} = b; min = a; g
else f_{max} = a; min = b; g
```

The syntax is
```plaintext
first-statement second-statement // etc.
```
Sequencing

What if you want to do more than one thing in an if?

Use a compound statement:

```java
if (a < b) {
    max = b;
    min = a;
} else {
    max = a;
    min = b;
}
```
Sequencing

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Use a compound statement:

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if (a < b) {
    max = b;
    min = a;
} else {
    max = a;
    min = b;
}
```

The syntax is

```java
{
    first-statement
    second-statement
    // etc.
}
```
int i = 0;
while (i < 100) {
    cout << i << 't' << square(i) << '
;
    ++i;
}
Iteration (while)

```cpp
int i = 0;
while (i < 100) {
    cout << i << ' ' << square(i) << '
';
    ++i;
}
```

The syntax is

```
while (condition) statement
```
Iteration (for)

```cpp
int i = 0;  // initialization

while (i < 100) {
    cout << i << 't' << square(i) << 'n';
    ++i;  // step
}
```

This pattern—a loop with initialization and step—is so common that there’s special syntax for it:

```cpp
for (int i = 0; i < 100; ++i)
    cout << i << 't' << square(i) << 'n';
```
Iteration (for)

```cpp
int i = 0; // initialization

while (i < 100) {
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This pattern—a loop with initialization and step—is so common that there’s special syntax for it:

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for loops are the idiomatic way to count in C++
Syntax of for

\[
\text{for } (\text{init-expr}; \text{cond-expr}; \text{step-expr}) \newline
\text{body-stm}
\]
Syntax of for

\[
\text{for (init-expr; cond-expr; step-expr) }
\begin{align*}
\text{body-stm} \\
\text{means} \\
\text{init-expr;} \\
\text{while (cond-expr) } \\
\text{body-stm} \\
\text{step-expr;}
\end{align*}
\]

Functions

But what did square(i) mean?
Functions

But what did \texttt{square(i)} mean?

A call to the function \texttt{square(int)}, which might be defined like

\begin{verbatim}
int square(int x)
{
    return x * x;
}
\end{verbatim}
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Why define a function?
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Why define a function? We want to separate and name a computation because it…

- …is logically separate.
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- …can be reused.
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Why define a function? We want to separate and name a computation because it…

- …is logically separate.
- …make the program clearer.
- …can be reused.
- …eases testing, distribution of labor, and maintenance.
int square(int n) {
    return n * n;
}

int main () {
    cout << sqrt(square(3) + square(4)) << '
';
}
A function example

```c++
int square(int n) {
    return n * n;
}

int main () {
    double a2 = square(3);
    double b2 = square(4);
    double c2 = a2 + b2;
    double c  = sqrt(c2);
    cout << c << '
';
}
```
int main () {
    double a2 = square(3);
    double b2 = square(4);
    double c2 = a2 + b2;
    double c  = sqrt(c2);
    cout <<= c <<= ' \n';
}

int square(int n) {
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}
A function example

```cpp
int main () {
    double a2 = square(3);
    double b2 = square(4);
    double c2 = a2 + b2;
    double c = sqrt(c2);
    cout << c << 'n';
}

int square(int n) {
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}

double sqrt(double);
```
Function definition syntax

Our function

```c
int square(int x)
{
    return x * x;
}
```

is an example of

```c
return-type function-name(param-type param-name, …)
{
    // code, which can use parameter(s) param-name, etc.
    return some-value;
}
```