Solving Problems
Flow Control in C++

CS 16: Solving Problems with Computers I
Lecture #3

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A Word About Registration for CS16

FOR THOSE OF YOU NOT YET REGISTERED:

- **There's still a waitlist to add this class!**
  - **We now have a few openings and I will go by the prioritized waitlist**

→ WAITLISTED STUDENTS MUST SEE ME AFTER CLASS ←

Lecture Outline

- Problem Solving

- Simple Flow of Control
- IF/ELSE Statements
- Loops (While ; Do-While ; For)
- Multiway Branching and the `switch` command
- Local vs. Global Variables

- Some Notes on Program Style and Errors

How Does One Solve Problems?

Understand the problem

Devise a plan

Carry out the plan

Look back and re-assess

Strategies

Ask questions!

- *What do I know about the problem?*
- *What is the information that I have to process in order the find the solution?*
- *What does the solution look like?*
- *What sort of special cases exist?*
- *How will I recognize that I have found the solution?*

Strategies

Ask questions! Don't reinvent the wheel!

Similar problems come up again and again in different guises

A good programmer recognizes a task that has been solved before and can research the solution

However, a good programmer does not plagiarize…

Strategies

Divide and Conquer!

Break up a large problem into smaller units
and solve each smaller problem

Applies the concept of abstraction

The divide-and-conquer approach can be applied over and over again until each subtask is manageable

Computer Problem-Solving

Analysis and Specification Phase
- Analyze the problem
- Specify the details

Algorithm Development Phase
- Develop an algorithm
- Test your algorithm

Implementation Phase
- Code your algorithm
- Test your code

Maintenance Phase
- Use the program
- Maintain the program

Can you see a recurring theme?

Developing Software Products

- As a business product
  - Software is “made” (developed) to meet market needs
- Needs resources and **planning**
  - Software needs to be
    programmed, documented, tested, fixed/maintained
- There is a process to everything you need to do!
  - A complex task – a problem to solve – needs a plan, an algorithm

Systems Development Life Cycle (SDLC)

A structured approach to software development:

GOAL: A software **development process** that leads to

a **high quality system** that

meets or exceeds customer expectations,

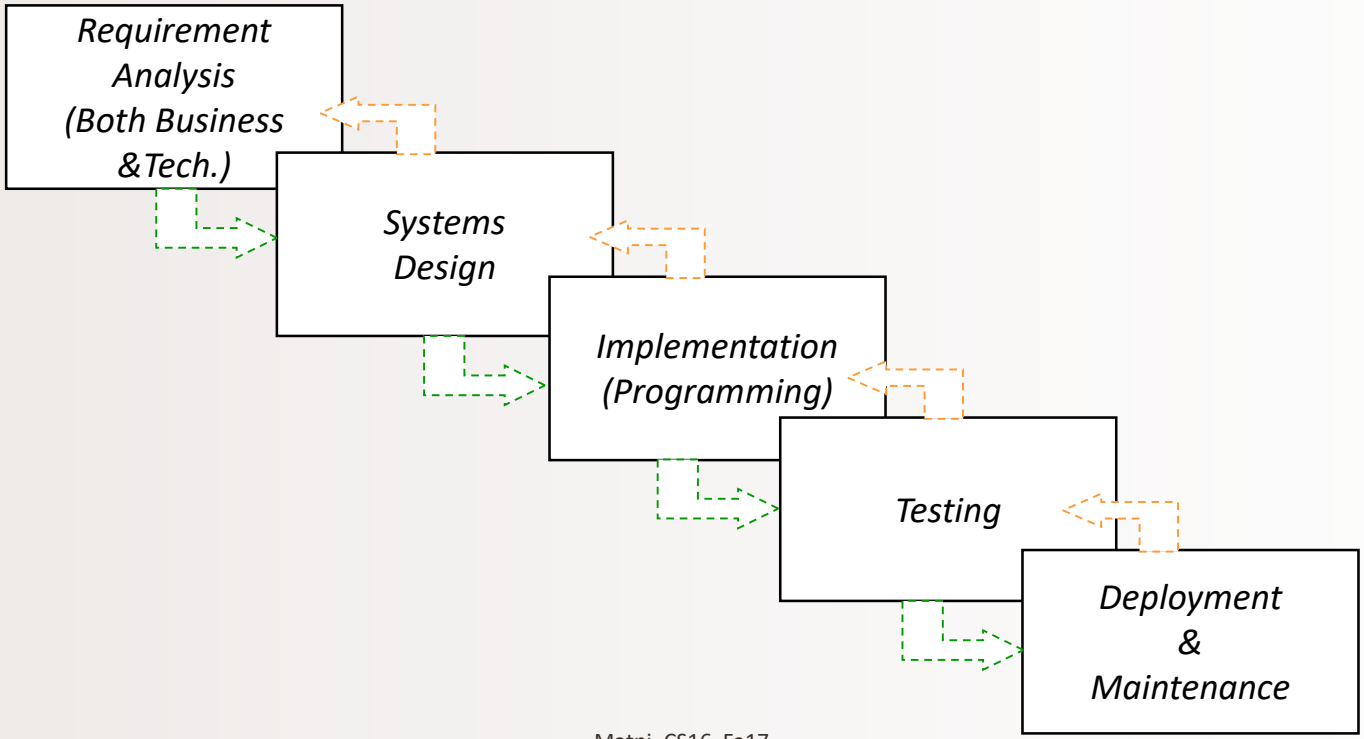
within **time and cost estimates**,

works **effectively** and **efficiently** in the current and

planned infrastructure,

and is **cheap** to maintain and **cost effective** to enhance.

Software Systems Development: Waterfall Model



Flow of Control

- Another way to say: ***The order in which statements get executed***

- Branch: *(verb)* How a program chooses between 2 alternatives
  - Usual way is by using an *if-else* statement

```
if (Boolean expression)
   true statement
else
   false statement
```

Implementing IF/ELSE Statements in C++

- As simple as:

```
if (income > 30000)
{
   taxes_owed = 0.30 * 30000;
}
else
{
   taxes_owed = 0.20 * 30000;
}
```

Where's the semicolon??!?

Curly braces are optional if they contain only 1 statement

IF/ELSE in C++

- To do additional things in a branch, use the { } brackets to keep all the statements together

```
if (income > 30000)
{
  taxes_owed = 0.30 * 30000;
  category = "RICH";
  alert_irs = true;
} // end IF part of the statement
else
{
  taxes_owed = 0.20 * 30000;
  category = "POOR";
  alert_irs = false;
} // end ELSE part of the statement
```

Groups of statements (sometimes called a **block**) kept together with **{ … }**

Examples of IF Statements

```
if ( (x >= 3) && ( x < 6) )
   y = 10;
```

- The variable **y** will be assigned 10 only if **x** is equal to 3, 4, or 5

```
if !(x > 5) y = 10;
```

- The variable **y** will be assigned 10 if **x** is NOT larger than 5 (i.e. if **x** is 4 or smaller)
  - DESIGN PRO-TIP: Unless you really have to, **avoid the NOT logic operator when designing conditional statements**

Beware: = vs ==

- ' = ' is the **assignment** operator
  - Used to assign values to variables
  - Example: **x = 3;**

'= = ' is the **equality** operator
- Used to compare values
- Example: **if (x == 3) y = 0;**

- The compiler will actually accept this logical error: **if (x = 3) y = 0;**
  - ***Why?***
  - It's an error of logic, not of syntax
  - But it stores 3 in **x** instead of comparing x and 3
  - Since the result is 3 (non-zero), the expression is true, so y becomes 0

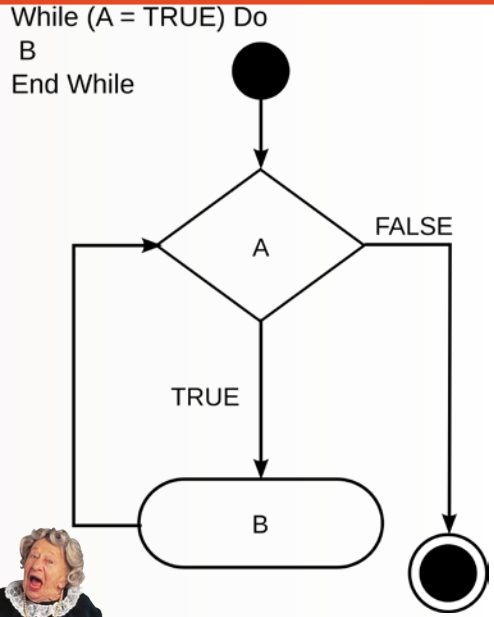
Simple Loops 1: *while*

- We use loops when an action must be repeated
- C++ includes several ways to create loops
  - while, for, do…while, etc…

- The **while loop** example:

```
int count_down = 3;
while (count_down > 0)
{
    cout << "Hello ";
    count_down -= 1;
}
```

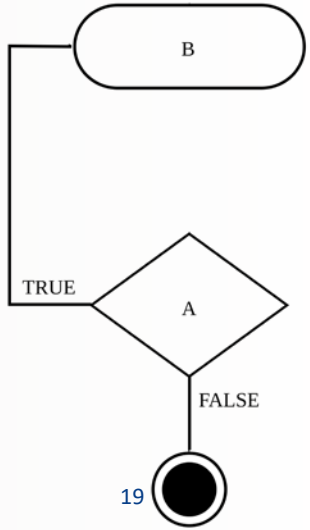
Output is:
Hello Hello Hello



Simple Loops 2: *do-while*

- Executes a block of code ***at least once***, and then repeatedly executes the block depending on a given Boolean condition at the end of the block.
  - So, unlike the while loop, the Boolean expression is checked ***after*** the statements have been executed

Do B
While (A = TRUE)
End While




```
int flag = 1;
do
{
   cout << "Hello ";
   flag -= 1;
}
while (flag > 0);
```

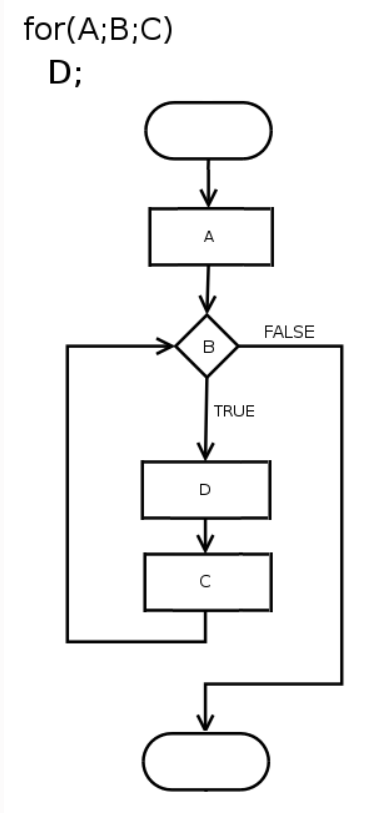
Why **is there** a semicolon here??!?

Output is:
Hello

Simple Loops 3: *for*

- Similar to a while loop, but presents parameters differently.
- Allows you to initiate a counting variable, a check condition, and a way to increment your counter all in one line.

for (counter declaration; check condition statement; increment rule) {…}



Output is:
Hello Hello Hello

```
for (int count = 2; count < 5; count++)
{
   cout << "Hello ";
}
```

Increments and Decrements by 1

In C++ you can increment-by-1 like this:

more common → `a++`

or like this:

`++a`

Similarly, you can decrement by:

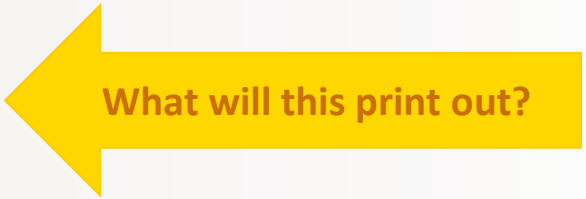
`a--` or `--a`

Some Cool Uses of **x++**

- In a while loop, you always need to increment a counter var.

Example:

```
int max = 0;
while (max < 4)
{
   cout << “hi” << endl;
   max++;
}
```



Some Cool Uses of **x++**

- You can make a slight change and save a line of code!

Example:

```
int max = 0;
while (max++ < 4)
{
   cout << “hi” << endl;
}
```

When to use **x++** vs **++x**

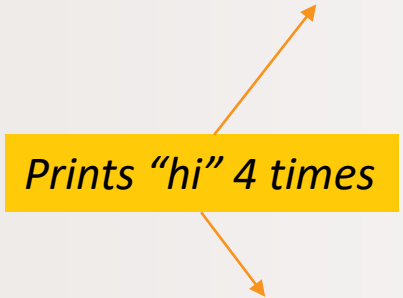
- **x++** will assess **x** *then* increment it
- **++x** will increment **x** first, *then* assess it

- 95% of the time, you will use the first one

- In *while* statements, it **makes** a difference
- In *for* statements, it **won't make** a difference

Examples

```
for (int c = 0; c < 4; c++)
   cout << “hi” << endl;
```




```
for (int c = 0; c < 4; ++c)
   cout << “hi” << endl;
```

Prints “hi” 4 times

```
int max = 0;
while (max++ < 4)
{
   cout << “hi” << endl;
}
```

Prints “hi” 3 times

```
int max = 0;
while (++max < 4)
{
   cout << “hi” << endl;
}
```

Infinite Loops

- Loops that never stop – to be avoided!
  - Your program will either "hang" or just keep spewing outputs for ever

- The loop body should contain a line that will eventually cause the Boolean expression to become false (to make the loop to end)

- **Example**: Goal: Print all positive odd numbers less than 6

```
x = 1;
while (x != 6)
{
  cout << x << endl;
  x = x + 2;
}
```

What is the problem with this code?

`x will never be 6! Infinite Loop!`

What simple fix can undo this bad design?

`while ( x < 6 )`

Using **for-loops** For Sums

- A common task is reading a list of numbers and computing the sum
  - Pseudocode for this task might be:

```
sum = 0;
   repeat the following this_many times
        get input for “next”
        sum = sum + next
   end of loop
```

- Let’s look at it as a for-loop in C++ …

Using **for-loops** For Sums

- The pseudocode from the previous slide can be implemented as

```
int sum = 0;
for(int count = 0; count < 10; count++)
    {
        cin >> next;
        sum = sum + next;
    }
```

- Note that “sum” must be initialized prior to the loop body!
  - **Why?**

Using **for-loops** For Products

- Forming a **product** is very similar to the sum example seen earlier

```
int product = 1;
for(int count = 0; count < 10; count++)
{
     cin >> next;
     product = product * next;
 }
```

- Note that “product” must be initialized prior to the loop body
  - Product is initialized to **1**, not 0!

Ending a While Loop

- A for-loop is generally the choice when there is **a predetermined** number of iterations
- When you DON'T have a predetermined number of iterations,
  you will want to use **while loops**

The are 3 common methods to END a while loop:

- *List ended with a sentinel value:* Using a particular value or calculation to signal the end
- *Ask before iterating:* Ask if the user wants to continue before each iteration
- *Running out of input:* Using the *eof* function to indicate the end of a file (more on this when we discuss file I/Os)

List Ended With a Sentinel Value

```
cout  << "Enter a list of positive integers.\n"
      << "Place a negative integer after the list to quit.\n";
sum = 0;
cin >> number;
while (number > 0)
{
   cout << “The double of that is: ” << 2*number << endl;
   cin >> number;
}
```

– Notice that the sentinel value is read, but not processed at the end

Ask Before Iterating

```
sum = 0;
char ans;


cout << "Are there numbers in the list (Y/N)?";
cin >> ans;

while (( ans == 'Y')  || (ans == 'y'))
{
      //statements to read and process the number


      cout << "Are there more numbers(Y/N)? ";
   cin >> ans;
 }
```

Nested Loops

- The body of a loop may contain any kind of statement,
  including another loop

- When loops are nested, **all iterations of the inner loop**
  are **executed for each iteration of the outer loop**

- *ProTip:* Give serious consideration to making the inner loop a function call to make it easier to read your program
  - More on functions later…

Example of a Nested Loop

- You want to collect the total grades of 100 students in a class
- Each student has multiple scores
  - Example: multiple homeworks, multiple quizzes, etc…
- You go through each student – one at a time – and get their scores
  - You calculate a sub-total grade for each student
- Then after collecting every student score, you calculate a grand total grade of the whole class and a class average (grand total / no. of students)

Example of a Nested Loop

```
int students(100);
double grade(0), subtotal(0), grand_total(0);
for (int count = 0; count < students; count++) {
    cout << "Starting with student number: " << count << endl;
    cout <<
    "Enter grades. To move to the next student, enter a negative number.\n"
    cin >> grade;
    while (grade >= 0)          {
        subtotal = subtotal + grade;
        cin >> grade;
    } // end while loop
    cout <<
    "Total grade count for student " << count << "is " << subtotal << endl;
    grand_total = grand_total + subtotal;
    subtotal = 0;
} // end for loop

 cout << "Average grades for all students= " << grand_total / students <<
endl;
```

YOUR TO-DOs

- ❑ Finish reading up to (& including) Chapter 3
- ❑ Finish Lab1 by TOMORROW AT NOON (Fri, 10/6)

- ❑ HW2 is now ready
- ❑ Visit Prof's and TAs' office hours if you need help!

- ❑ Eat all your vegetables


</LECTURE>