CS 103 Unit 1b – C++ Program/Control Flow

Java and C++

- C++ uses the same control structures and syntax as Java
  - `if`, `while`, `for`, (`switch`)*
- We expect you know each of the above structures AND **when and how to employ them to implement computational approaches**
- You should also be familiar with:
  - `break`, `continue`
  - The operation of nested loops (the inner loop performs ALL of its iterations for each one iteration of the outer loop)

When Do I Use a While Loop (1)

- When you **DON'T know** in advance how many times something should repeat?
  - How many guesses will the user need before they get it right?

```
#include <iostream>
using namespace std;
int main()
{
  int guess;

  int secretNum = /* some code */
  cin >> guess;
  while(guess != secretNum)
  {
    cout << "Enter guess: " << endl;
    cin >> guess;
  }

  cout << "You got it!" << endl;
  return 0;
}
```

When Do I Use a While Loop (2)

- Whenever you see, hear, or use the word '**until**' in a description
- Important Tip:
  - "until x" = "while not x"
    - `until(x)⇔while(!x)`
  - Ex: "Keep guessing **until** you are correct" is the same as "keep guessing **while** you are **NOT** correct"

```
#include <iostream>
using namespace std;
int main()
{
  int guess;
  int secretNum = /* some code */
  cin >> guess;
  while(guess != secretNum)
  {
    cout << "Enter guess: " << endl;
    cin >> guess;
  }

  cout << "You got it!" << endl;
  return 0;
}
```

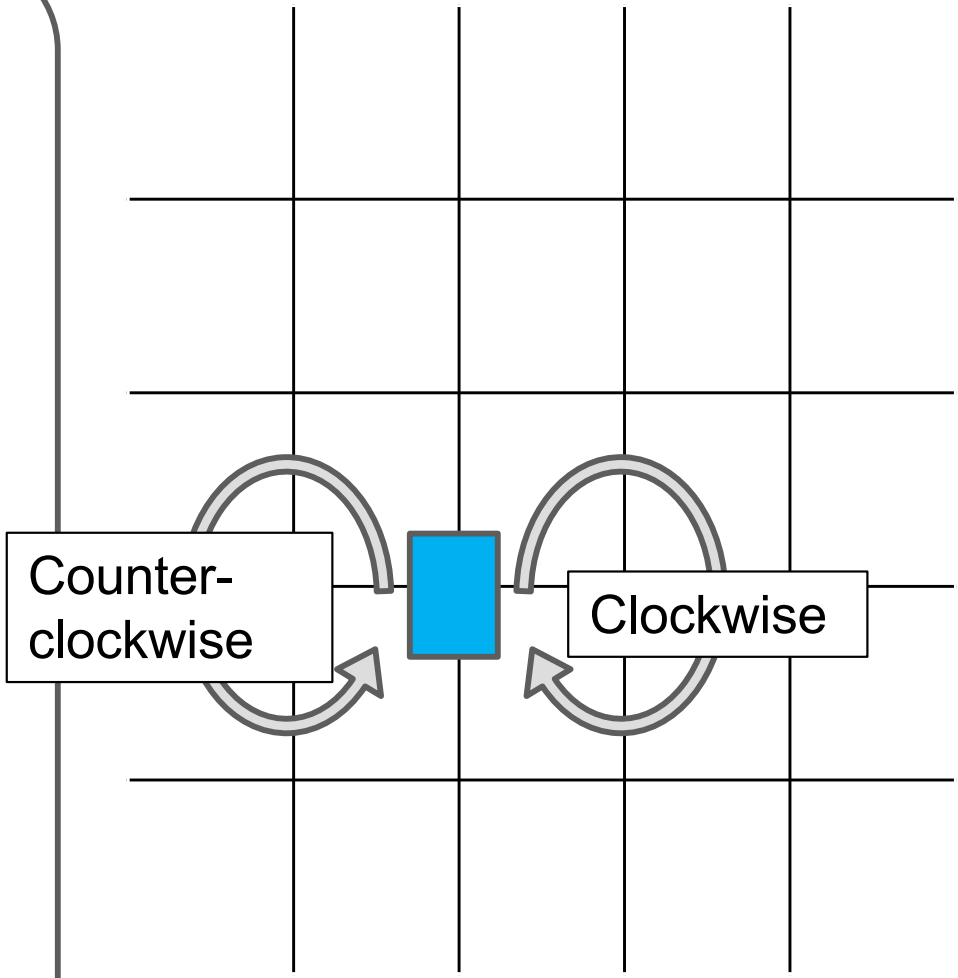
When Do I Use a For Loop (1)

- When you **DO KNOW in advance** (before the loop starts) how many times to iterate
  - Usually, a constant or variable that has been calculated or input from the user

```
// Program to output numbers
// 1 through n

#include <iostream>
using namespace std;
int main()
{
  int n;

  cin >> n;
  for(int i=1; i < n; i++)
  {
    cout << i << endl;
  }

  return 0;
}
```

Turn 360

```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
    // Write your code here!




    return 0;
}
```



Exercise

- Which of the following is NOT a condition to check if the integer x is in the range [-1 to 5]

a. `x >= -1 && x <= 5`

b. `-1 <= x <= 5`

c. `!( x < -1 || x > 5)`

d. `x > -2 && x < 6`

See solutions at end of slides

Conditions and DeMorgan's

- DeMorgan's theorem says there are always two ways to express a logic condition
- Write a condition that eats a sandwich if it has neither tomato nor lettuce
  - `if ( !tomato && !lettuce)  { eat_sandwich(); }`
  - `if ( !(tomato || lettuce) ) { eat_sandwich(); }`
- DeMorgan's theorem:
  - `!a && !b` ⇔ `!(a || b)`
  - `!a || !b` ⇔ `!(a && b)`
- More details in EE 109 and CS 170

Recall: Scope

- Scope refers to the **lifetime** and **visibility** of a variable
  - Recall variables are just memory slots in the computer…eventually the program will reclaim those slots and the variables will "die".
  - How long are those slots allocated and reserved for your use (i.e. what is their lifetime)?
  - What parts of your program can access the variables
- In C/C++, a variable's scope is the curly braces { } it is declared within
- **Main Point**: A variable dies at the end of the {…} it was declared in

```
#include <iostream>
using namespace std;
int main()
{
  int i;
  cin >> i;

  if(i > 0){
     int temp = 2*i;
     cout << temp << endl;
  }  // temp died here

  cout << temp << endl; // ERROR!
  f1();
  return 0;
} // i dies here

void f1()
{
  // is i visible here?
  cout << i << endl;
}
```

Declaring the Inductive Variable

- The initialization statement can be used to declare a control/inductive variable, but its scope is ONLY the for loop (even though it is not technically declared in the {..} of the for loop)
  - **Just realize that variable will die at the end of the loop**
- However, because it dies after the first loop you can use that same variable name in a subsequent loop

```
#include <iostream>
using namespace std;
int main()
{
  int n;
  cin >> n;
  for(int i=0; i < n; i++){
     cout << 3*i << endl;
  } // i dies here

  // won't compile
  cout << i << endl;

  // okay to reuse i
  for(int i=0; i < n; i++){
     cout << 4*i << endl;
  } // reincarnated i dies again

  return 0;
} // n dies here
```

Nested Loops Example 1

- **Key idea**: Perform all iterations of the inner loop before starting the next iteration of the outer loop
  - Said another way: The inner loop executes completely for each single iteration of the outer loop
- Trace through the execution of this code and show what will be printed

```
int main()
{
  for(int i=0; i < 2; i++){
    for(int j=0; j < 3; j++){
      cout << i << " " << j << endl;
    }
  }
}
```

i	j
0	0
0	1
0	2
0	3
1	0
1	1
1	2
1	3

Understand Your Bodies

- When you write loops write a comment as to what the body of each loop means in an abstract sense
  - The body of the outer loop represents 1 game (and we repeat that over and over)
  - The body of the inner loop represents 1 turn (and we repeat turn after turn)

```
int main()
{
  int secret, guess;
  char again = 'y';

  while(again == 'y') {
     // A single game

     // Choose secret num. 0-19
     secret = rand() % 20;
     guess = -1;
     // inner loop
     while(guess != secret) {
       // A turn of the game
       cout << "Enter guess: ";
       cin >> guess;
     }
     cout << "Win!" << endl;
     cout << "Play again (y/n): ";
     cin >> again;
  }
  return 0;
}
```

1 game

1 turn

Computing e^x

```
#include <iostream>
using namespace std;

int main()
{
   // Starter code: modify the lines below
   double x;
   cin >> x;
   double x_to_i = 1;
   int i_fact = 1;
   double e_x = 1;
   for(int i=1; i < 10; i++){
      x_to_i *= x;
      i_fact *= i;
      e_x += x_to_i / i_fact;
   }
   cout << e_x << endl;
   return 0;
}
```

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots$$

Comparison, Logical Operators, if statements, switch statements

MODULE 4: CONDITIONAL STRUCTURES

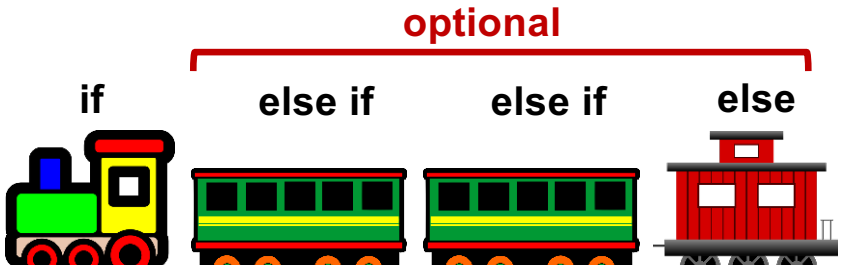
Comparison Operators

- To perform comparison of variables, constants, or expressions in C/C++ we can use the basic 6 comparison operators

Operator(s)	Meaning	Example
==	Equality	`if(x == y)`
!=	Inequality	`if(x != 7)`
<	Less-than	`if(x < 0)`
>	Greater-than	`if(y > x)`
<=	Less-than OR equal to	`if(x <= -3)`
>=	Greater-than OR equal to	`if(y >= 2)`

If…Else If…Else

- Use to execute only certain portions of code
- `else if` is ***optional***
  - Can have any number of else if statements
- `else` is ***optional***
- { … } indicate code associated with the if, else if, else block




```
if (condition1)
{
  // executed if condition1 is true
}
else if (condition2)
{
  // executed if condition2 is true
  //  but condition1 was false
}
else if (condition3)
{
  // executed if condition3 is true
  //  but condition1 and condition2
  //  were false
}
else
{
  // executed if neither condition
  // above is true
}
```

Mutually Exclusive Conditions

- What will each implementation print if 'grade' is 95?

```
if (grade >= 90)
{
  cout << "A range" << endl;
}
else if (grade >= 80)
{
  cout << "B range" << endl;
}
else if (grade >= 70)
{
  cout << "C range" << endl;
}
else if (grade >= 60)
{
  cout << "D range" << endl;
}
else
{
  cout << "Not gonna happen!" << endl;
}
```

```
if (grade >= 90)
{
  cout << "A range" << endl;
}
if (grade >= 80)
{
  cout << "B range" << endl;
}
if (grade >= 70)
{
  cout << "C range" << endl;
}
if (grade >= 60)
{
  cout << "D range" << endl;
}
else
{
  cout << "Not gonna happen!" << endl;
}
```

If…Else If…Else

- Guideline:
  - If various blocks of code are **mutually exclusive** then put them in an
    `if..`
    `else if..`
    `else`
    structure and not many individual
    `if..`
    `if..`
    `if..`
    statements

```
// BAD!
if (x < 0) {
  cout << "negative" << endl;
}
if (x >= 0) {
  cout << "positive" << endl;
}

// GOOD!
if (x < 0) {
  cout << "negative" << endl;
}
else {
  cout << "positive" << endl;
}
```

Logical Operators

- We can create compound conditions by using the logical AND, OR, and NOT operator

Operator(s)	Meaning	Example
&&	AND	`if( (x==0) && (y==0) )`
||	OR	`if( (x < 0) || (y < 0) )`
!	NOT	`if( !x )`

Logical AND, OR, NOT

- The following tables show how the logical operations are evaluated under any set of values
- AND:
  - All inputs must be true for resulting expression to be true
  - If even one is false, the condition is fails (false)
- OR:
  - If any input is true the condition evaluates to true

A	B	AND
False	False	False
False	True	False
True	False	False
True	True	True

A	B	OR
False	False	False
False	True	True
True	False	True
True	True	True

A	NOT
False	True
True	False

Exercise

- Which of the following is NOT a condition to check if the integer x is in the range [-1 to 5]

a. `x >= -1 && x <= 5`

b. `-1 <= x <= 5`

c. `!( x < -1 || x > 5)`

d. `x > -2 && x < 6`

See solutions at end of slides

Conditions and DeMorgan's

- DeMorgan's theorem says there are always two ways to express a logic condition
- Write a condition that eats a sandwich if it has neither tomato nor lettuce
  - `if ( !tomato && !lettuce)  { eat_sandwich(); }`
  - `if ( !(tomato || lettuce) ) { eat_sandwich(); }`
- DeMorgan's theorem:
  - `!a && !b` ⇔ `!(a || b)`
  - `!a || !b` ⇔ `!(a && b)`
- More details in EE 109 and CS 170

Timeout: In-Class Exercises

- nth

Common Mistakes 1

- Using assignment operator (=) rather than equality check operator (==)
  - If you accidentally use '=', it will convert the assigned value to a Boolean
  - Recall: The computer uses
    - 0 to mean **false**
    - Non-zero to mean **true**
- Using multiple `if` statements rather than `if..else` or `if..else if` statements
  - Two 'if' statements imply both could be true while 'if..else' implies only one

```
int main()
{
  int x, y;
  cin >> x >> y;

  // Wrong!
  if( x = 0 )  { /* some code */ }
  // Right!
  if( x == 0 ) { /* some code */ }

  // Wrong!
  if(x != y) { x = 5;  }
  if(x == y) { y = 7; }

  // Right
  if(x != y) { x = 5;  }
  else       { y = 7; }
  return 0;
}
```

When comparing with a constant, many companies and style guides recommend you flip the order to:

```
if( 0 == x ) { /* some code */ }
```

This, way the code won't compile if you accidentally write:

```
if( 0 = x ) // won't compile!
```

Common Mistakes 2

- All conditions must be formulated as a combination of comparisons of **two** values at a time
- Recall: The computer uses
  - 0 to mean **false**
  - Non-zero to mean **true**

```
int main()
{
  int x, y;
  cin >> x >> y;

  // Wrong!
  if( 0 <= x <= 9 )
    { /* some code */ }
  // Right!
  if( (0 <= x) && (x <= 9) )
    { /* some code */ }


  // Wrong!
  if( x == 0 || 1 )
    { /* some code */ }
  // Right!
  if( (x == 0) || (x == 1) )
    { /* some code */ }
  return 0;
}
```

Other Selection Structures

- C/C++ (and some other languages) provide alternative structures to if..else
  - `switch` (case) statement
  - Ternary operator (`cond ? x : y`)
- We will not require knowledge of these but simply recommend you briefly look over this material
  - Slides covering these structures are available at the end of the packet

while, do..while, and for Loops

MODULE 5: ITERATIVE STRUCTURES

Motivation for Loops

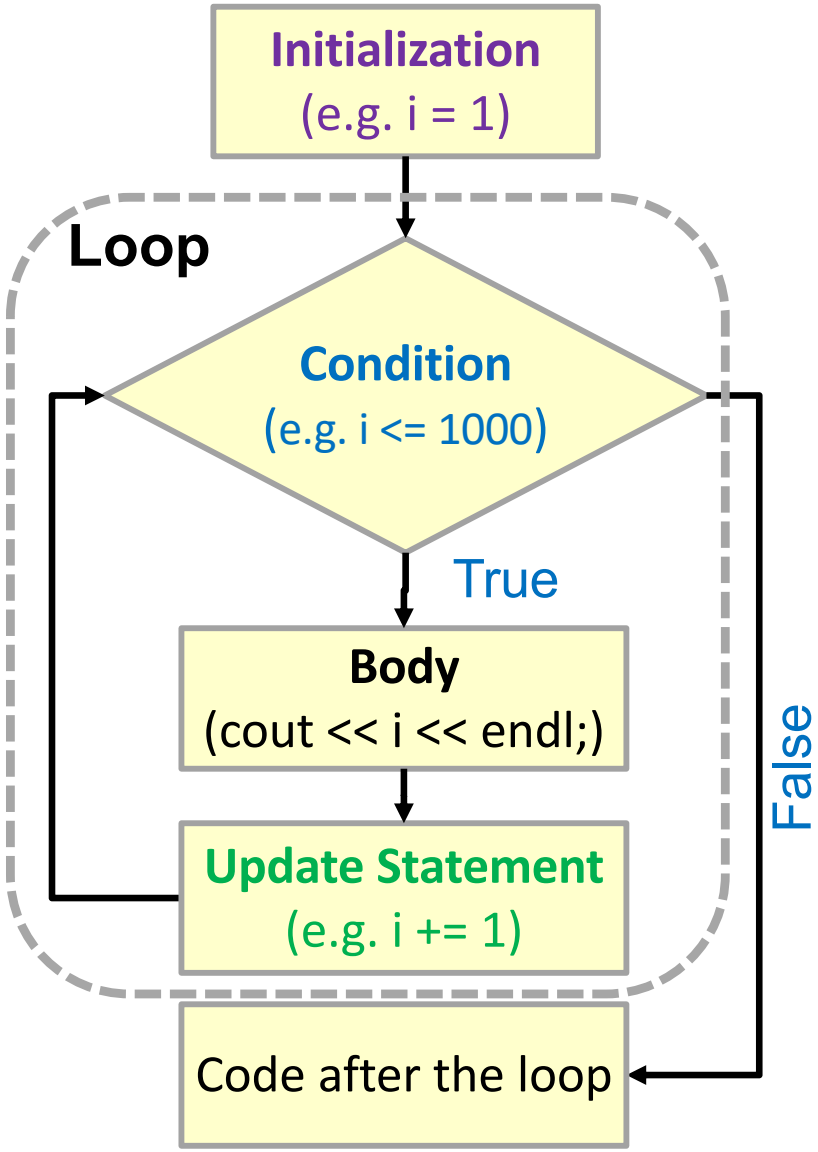
- Take a simple task such as outputting the first 1000 positive integers
  - We could write 1000 cout statements
  - Yikes! We could do it but it would be painful!
- Or we could use a loop

```
#include <iostream>
using namespace std;
int main()
{
  cout << 1 << endl;
  cout << 2 << endl;
  cout << 3 << endl;
  // hundreds more cout statements

  cout << 999 << endl;
  cout << 1000 << endl;

  return 0;
}
```

```
#include <iostream>
using namespace std;
int main()
{
  for(int i=1; i <= 1000; i+=1 )
  {
     cout << i << endl;
  }
  return 0;
}
```

4 Necessary Parts of a Loop

- Loops involve writing a task to be repeated
- Regardless of that task, there must be **4 parts** to a make a loop work
- **Initialization**
  - Initialization of the variable(s) that will control how many iterations (repetitions) the loop will executed
- **Condition**
  - Condition to decide whether to repeat the task or stop the loop
- **Body**
  - Code to repeat for each iteration
- **Update**
  - Modify the variable(s) related to the condition



Types of Loops

- There are 2 (and a half) kinds of loops
- `while` (`do..while`) loops and `for` loops
  - Let's look at the syntax of each

```
int i = 1;
while (i <= 1000)
{
  // repetitive task
  cout << i << endl;
  i++;  // update
}
// following statements
```

4 parts:
- Initialization
- Condition
- Body
- Update

T T F

```
for (int i = 1; i <= 1000; i++)
{
  cout << i << endl;
}
// following statements
```

There is a variant of the `while` loop which is the `do..while` loop which we'll cover later.

Which Kind of Loop

- Use a while loop:
  - When you **DON'T** know how many times to iterate before the loop starts.
    - How many guesses will the user need before they get it right?
  - When you use "**until**" (see next slide)
- Use a for loop:
  - When you **DO** know the number of times to iterate in BEFORE you start the loop.

```
#include <iostream>
using namespace std;
int main()
{
  int guess;

  int secretNum = /* some code */
  cin >> guess;
  while(guess != secretNum)
  {
    cout << "Enter guess: " << endl;
    cin >> guess;
  }

  cout << "You got it!" << endl;
  return 0;
}
```

"Until" and "While not"

- Whenever you see or use the word '**until**' in a description
- Important Tip:
  - "until *x*" = "while not *x*"
  - Saying "keep guessing until you are correct" is the same as "keep guessing while you are not correct"

```
#include <iostream>
using namespace std;
int main()
{
  int guess;
  int secretNum = /* some code */
  cin >> guess;
  while(guess != secretNum)
  {
    cout << "Enter guess: " << endl;
    cin >> guess;
  }

  cout << "You got it!" << endl;
  return 0;
}
```

NESTED LOOPS

Nested Loop Sequencing

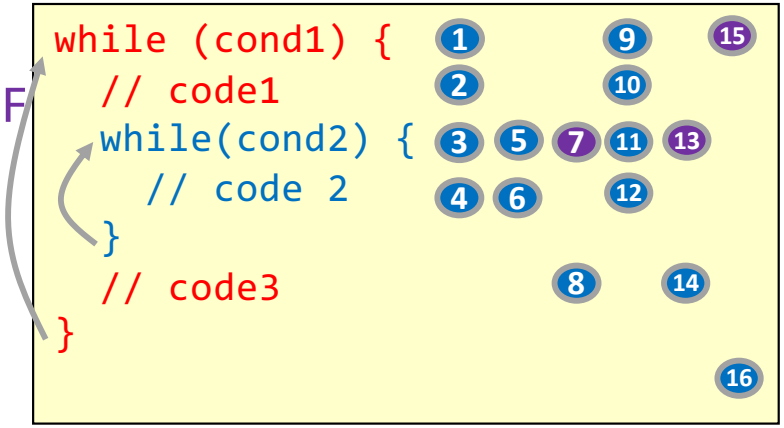
- **Key Idea**: The inner loop runs in its entirety for each iteration of the outer loop

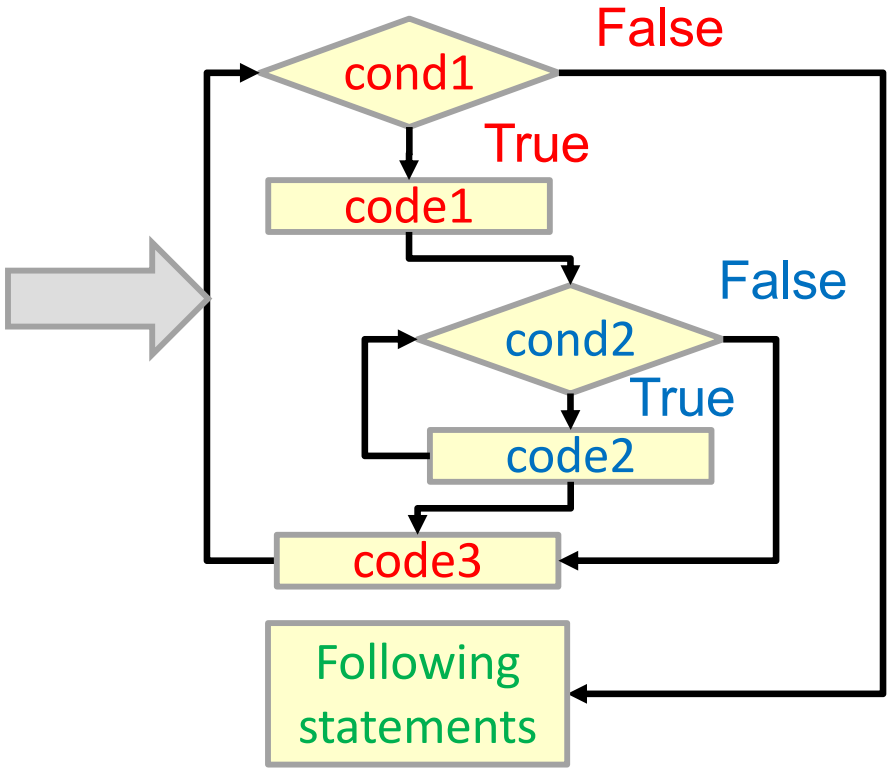
Cond1: T T F

Cond2: T T F

Cond2: T F

```
while (cond1) {
  // code1
  while(cond2) {
    // code 2
  }
  // code3
}
```





Nested Loops Example 1

- When you write loops consider what the body of each loop means in an abstract sense
  - The body of the outer loop represents 1 game (and we repeat that over and over)
  - The body of the inner loop represents 1 turn (and we repeat turn after turn)

```
int main()
{
  int secret, guess;
  char again = 'y';
  // outer loop
  while(again == 'y')
  {  // Choose secret num. 0-19
     secret = rand() % 20;
     guess = -1;
     // inner loop
     while(guess != secret)
     {
       cout << "Enter guess: ";
       cin >> guess;
     }
     cout << "Win!" << endl;
     cout << "Play again (y/n): ";
     cin >> again;
  }
  return 0;
}
```

1 game

1 turn

Nested Loops Example 2

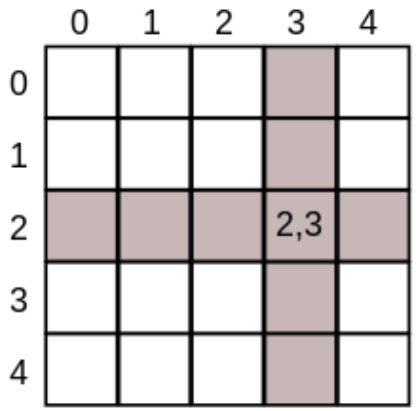
- **Key idea**: Perform all iterations of the inner loop before starting the next iteration of the outer loop
  - Said another way: The inner loop executes completely for each single iteration of the outer loop
- Trace through the execution of this code and show what will be printed

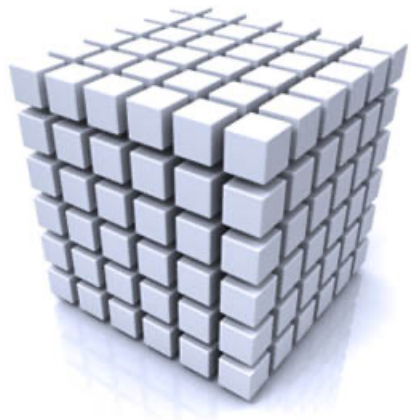
```
int main()
{
  for(int i=0; i < 2; i++){
    for(int j=0; j < 3; j++){
      cout << i << " " << j << endl;
    }
  }
}
```

i	j
0	0
0	1
0	2
0	3
1	0
1	1
1	2
1	3

Tips

- Nested loops often help us represent and process multi-dimensional data
  - 2 loops allow us to process data that corresponds to 2 dimension (i.e. rows/columns)
  - 3 loops allow us to process data that corresponds to 3 dimensions (i.e. rows/columns/planes)





I/O Manipulators

- Manipulators control HOW cout handles certain output options and how cin interprets the input data (but print nothing themselves)
  - Must `#include <iomanip>`
- Common examples
  - **`setw(n)`**: Separate consecutive outputs by n spaces
  - **`setprecision(n)`**: Use n digits to display doubles (both the integral + decimal parts)
  - **`fixed`**: Uses the precision for only the digits after the decimal point
  - `boolalpha`: Show Booleans as `true` and `false` rather than 1 and 0, respectively
- Separated by << or >> and used inline with actual data
- Other than `setw`, manipulators continue to apply to other output until changed

```
#include <iostream>
#include <iomanip>
using namespace std;

int main()
{
  double pi = 3.14159;

  cout << pi << endl;
  // Prints: 3.14159

  cout << setprecision(2) << fixed << pi << endl;
  // Prints: 3.14

  return 0;
}
```

http://en.cppreference.com/w/cpp/io/manip

See "iomanip" in-class exercise to explore various options

break statement

- `break`
  - Ends the current **loop** immediately and continues execution after its last statement
  - Only stops the INNER-MOST containing loop, not ALL nested loops.
- Consider two alternatives for stopping a loop if an invalid (negative) guess is entered

```
bool done = false;
while ( done == false ) {
  cout << "Enter guess: " << endl;
  cin >> guess;
  if( guess < 0 )
    done = true;
  }
  else {
     // Process guess
  }
}
```

```
bool done = false;
while ( done == false ) {
  cout << "Enter guess: " << endl;
  cin >> guess;
  if( guess < 0 )
    break;
  }
  // Process guess
  // If guess < 0 we would skip this
}
```

continue statement

- `continue`
  - Ends the current **loop** [not **if** statement] immediately and continues execution after its last statement
- Consider two alternatives for repeating a loop to get a new guess if an invalid (negative) guess is entered
  - **Often `continue` can be eliminated by changing the if condition**

```
bool done = false;
while( done == false) {
  cout << "Enter guess: " << endl;
  cin >> guess;
  if(guess < 0){
    continue;
  }
  // Process guess (only here if guess>=0)
}
```

```
bool done = false;
while ( done == false ) {
  cout << "Enter guess: " << endl;
  cin >> guess;
  if( guess >= 0 ) {
    // Process Guess
  }
}
```

ODDS AND ENDS REGARDING C/C++ LOOPS

Recall: Scope

- Scope refers to the **lifetime** and **visibility** of a variable
  - Recall variables are just memory slots in the computer…eventually the program will reclaim those slots and the variables will "die".
  - How long are those slots allocated and reserved for your use (i.e. what is their lifetime)?
  - What parts of your program can access the variables
- In C/C++, a variable's scope is the curly braces { } it is declared within
- **Main Point**: A variable dies at the end of the {…} it was declared in

```
#include <iostream>
using namespace std;
int main()
{
  int i;
  cin >> i;

  if(i > 0){
     int temp = 2*i;
     cout << temp << endl;
  }  // temp died here

  cout << temp << endl; // ERROR!
  f1();
  return 0;
} // i dies here

void f1()
{
  // is i visible here?
  cout << i << endl;
}
```

Declaring the Inductive Variable

- The initialization statement can be used to declare a control/inductive variable, but its scope is ONLY the for loop (even though it is not technically declared in the {..} of the for loop)
  - **Just realize that variable will die at the end of the loop**
- However, because it dies after the first loop you can use that same variable name in a subsequent loop

```
#include <iostream>
using namespace std;
int main()
{
  int n;
  cin >> n;
  for(int i=0; i < n; i++){
     cout << 3*i << endl;
  } // i dies here

  // won't compile
  cout << i << endl;

  // okay to reuse i
  for(int i=0; i < n; i++){
     cout << 4*i << endl;
  } // reincarnated i dies again

  return 0;
} // n dies here
```

The Loops That Keep On Giving

- There's a problem with the loops below
- We all write "**infinite**" loops at one time or another
- Infinite loops never quit
- When you do write such a program, just type "Ctrl-C" at the terminal to halt the program

```
#include <iostream>
using namespace std;
int main()
{ int val;
  bool again = true;
  while(again = true){
    cout << "Enter an int or -1 to quit";
    cin >> val;
    if( val == -1 ) {
       again = false;
    }
  }
  return 0;
}
```

```
#include <iostream>
using namespace std;
int main()
{
  int i=0;
  while( i < 10 ) {
     cout << i << endl;
     i + 1;
  }
  return 0;
}
```

http://blog.codinghorror.com/rubber-duck-problem-solving/

The Loops That Keep On Giving

- There's a problem with the loop below
- We all write "infinite" loops at one time or another
- Infinite loops never quit
- When you do write such a program, just type "Ctrl-C" at the terminal to halt the program

```
#include <iostream>
using namespace std;
int main()
{ int val;
  bool again = true;
  while(again == true){
    cout << "Enter an int or -1 to quit";
    cin >> val;
    if( val == -1 ) {
       again = false;
    }
  }
  return 0;
}
```

```
#include <iostream>
using namespace std;
int main()
{
  int i=0;
  while( i < 10 ) {
     cout << i << endl;
     i = i + 1;
  }
  return 0;
}
```

http://blog.codinghorror.com/rubber-duck-problem-solving/

SOLUTIONS

Exercise

- Which of the following is NOT a condition to check if the integer x is in the range [-1 to 5]

a. `x >= -1 && x <= 5`

b. `-1 <= x <= 5`

c. `!( x < -1 || x > 5)`

d. `x > -2 && x < 6`

See solutions at end of slides

OTHER SELECTION STRUCTURES

Switch (Study on own)

- Again used to execute only certain blocks of code
- *Cases must be a constant*
- Best used to select an action when an expression could be 1 of a set of constant values
- { … } around entire set of cases and not individual case
- Computer will execute code until a break statement is encountered
  - Allows multiple cases to be combined
- Default statement is like an else statement

```
switch(expr) // expr must eval to an int
{
 case 0:
   // code executed when expr == 0
   break;
 case 1:
   // code executed when expr == 1
   break;
 case 2:
 case 3:
 case 4:
   // code executed when expr is
   // 2, 3, or 4
   break;
 default:
   // code executed when no other
   // case is executed
   break;
}
```

Switch (Study on own)

- What if a break is forgotten?
  - All code underneath will be executed until another break is encountered

```
switch(expr) // expr must eval to an int
{
 case 0:
   // code executed when expr == 0
   break;
 case 1:
   // code executed when expr == 1
   // what if break was commented
   // break;
 case 2:
 case 3:
 case 4:
   // code executed when expr is
   // 3, 4 or 5
   break;
 default:
   // code executed when no other
   // case is executed
   break;
}
```

? Operator (Study on own)

- A simple if..else statement can be expressed with the ? operator
  - `int x = (y > z) ? 2 : 1;`
  - Same as:

```
if(y > z)  x = 2;
else x = 1;
```

- Syntax: (*condition*) ? *expr_if_true* : *expr_if_false*;
- Meaning: the expression will result/return *expr_if_true* if *condition* evaluates to true or *expr_if_false* if *condition* evaluates to false

LOOP STRUCTURES

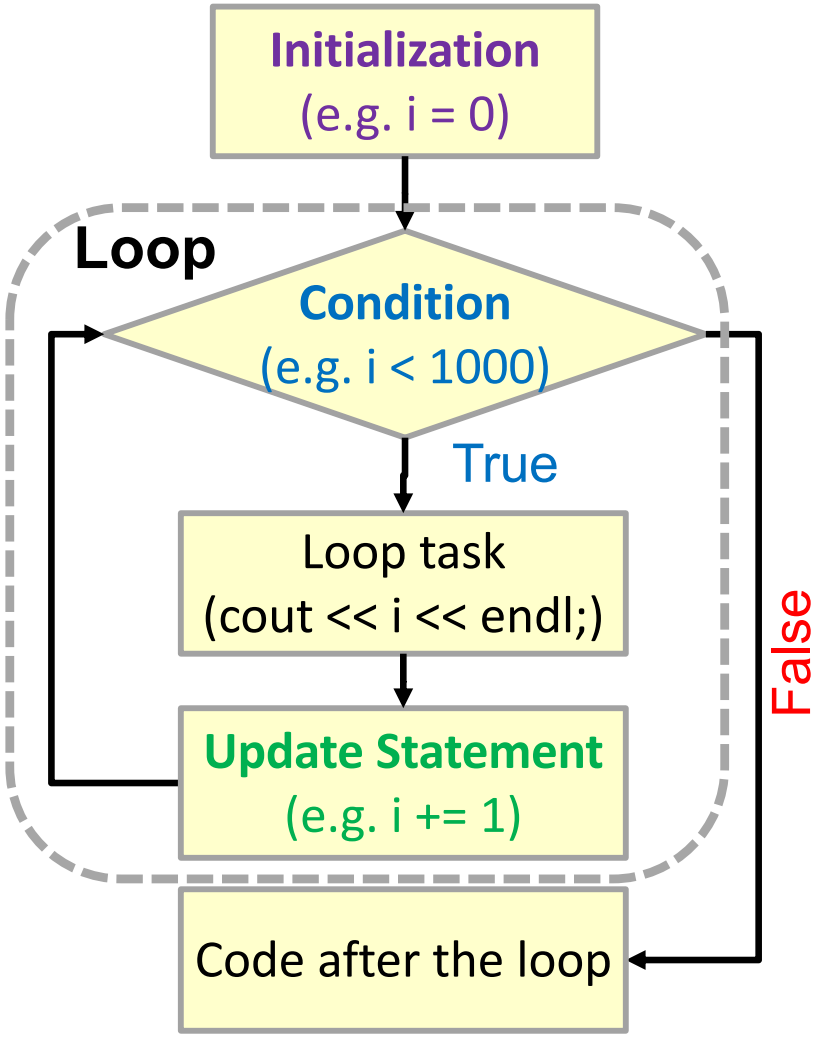
Type 1: while Loops

- A while loop is essentially a repeating 'if' statement

```
initialization                    (1)
while (condition1)                (2) (5) (8)
{                                  T   T   F
                                  (3) (6)
  // Body: if condition1 is true
                                  (4) (7)
} // go to top, eval cond1 again
                                      (9)
// following statements
// only gets here when cond1 is false
```

```
int i=0;
while (i < 1000)
{
  cout << i << endl;
  i++;
}

// following statements
```

While loop printing 0 to 999

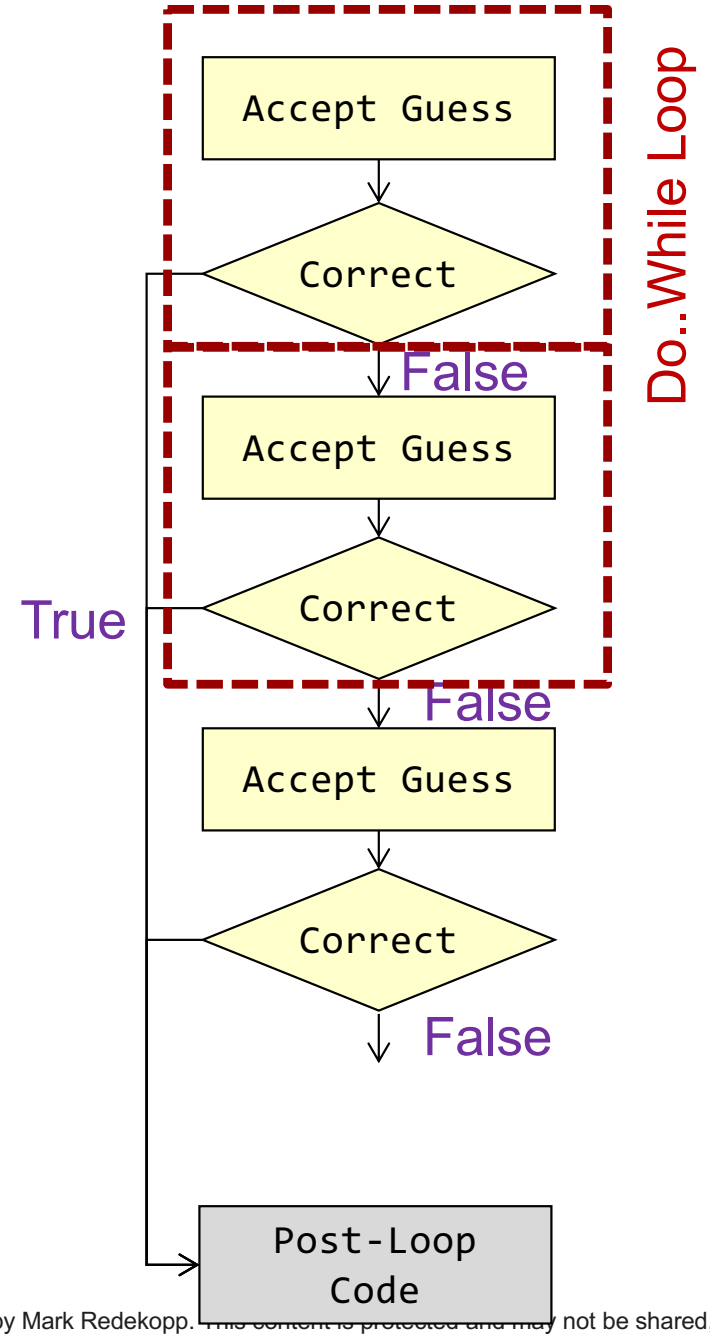


while vs. do..while Loops

- while loops have two variations: while and do..while
- `while`
  - Cond is evaluated first
  - Body only executed if condition is true (**maybe 0 times**)
- `do..while`
  - Body is executed **at least once**
  - Cond is evaluated
  - Body is repeated if cond is true

```
// While:
while(condition)
{
  // code to be repeated
  // (should update condition)
}



// Do while:
do {
  // code to be repeated
  // (should update condition)
} while(condition);
```

Using Flow Charts to Find Loops

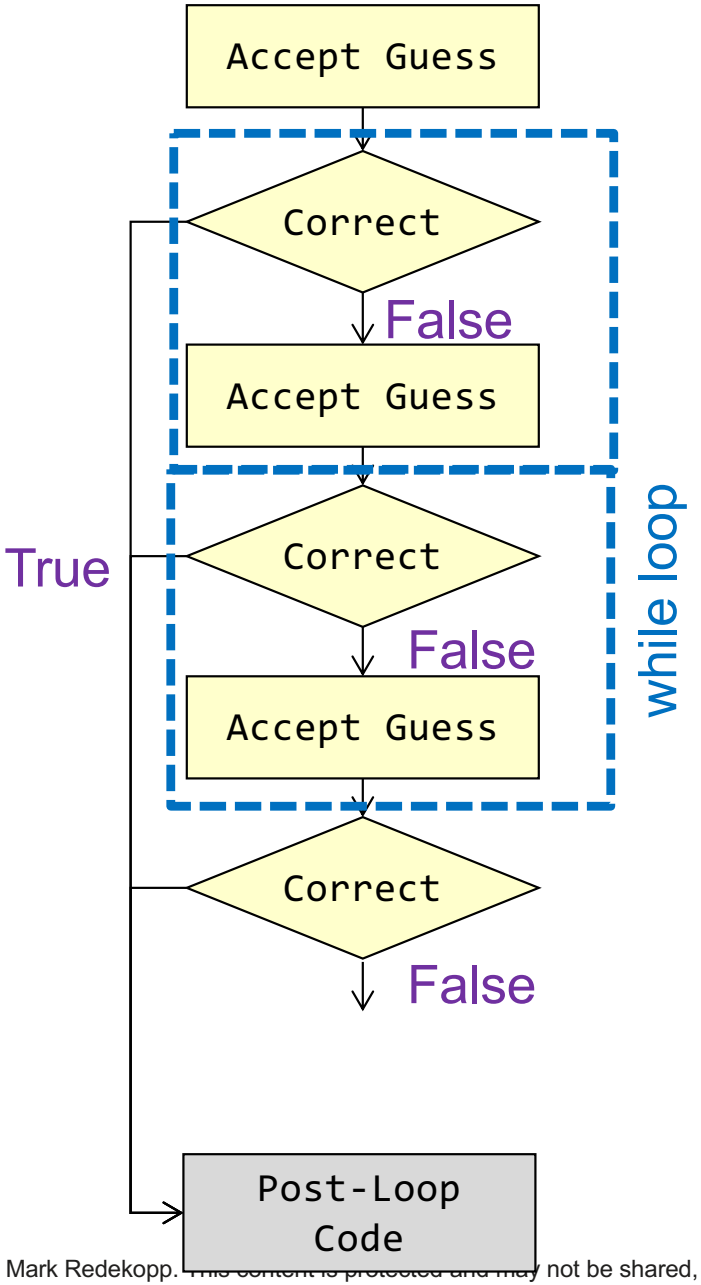


Draw out a flow chart of the desired sequence and look for the repetitive sequence

Here we check at the end to see if we should repeat…perfect for a do..while loop

```
do
  { accept_guess }
while ( ! correct )
```

Finding the 'while' Structure



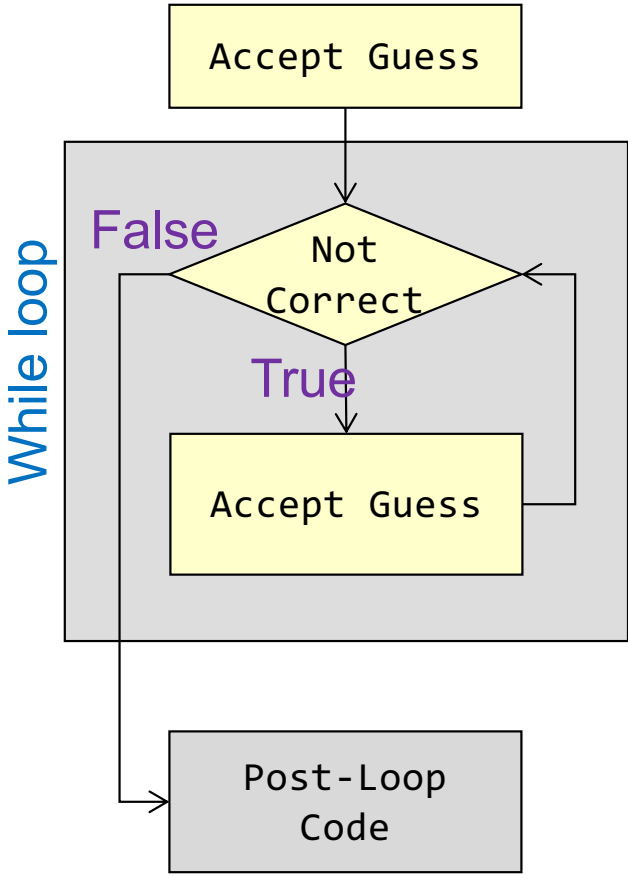
Draw out a flow chart of the desired sequence and look for the repetitive sequence

Here we check at the end to see if we should repeat…perfect for a do..while loop

```
do
  { accept_guess }
while ( ! correct )
```

But a while loop checks at the beginning of the loop, so we must accept one guess before starting:

```
accept_guess
while( ! correct )
  { accept_guess }
```



Hand Tracing (1)

- For the first program, trace through the code and show all changes to i for:
  - n = 2;
- For the second program, trace through the code and show the output for:
  - t = PI/2, T = 2*PI

```
int main()
{
  int n;
  cin >> n;
  for(int i = -n; i <= n; i++)
  {
     cout << i << endl;
  }
  return 0;
}
```

```
int main()
{
  double t, T;
  cin >> t >> T;
  for( double th = 0 ; th < T; th += t)
  {
     cout << sin(th) << endl;
  }
  return 0;
}
```

Hand Tracing (2)

- For the first program, trace through the code and show all changes to i and y for:
  - x = 10
  - y = 2
- For the second program, trace through the code and show all changes to i and y for:
  - x = 4
  - y = 11

```
int main()
{
  int x, y;
  cin >> x >> y;
  for(int i=1; i <= x; i=i+y)
  {
     cout << i << endl;
     y++;
  }
  return 0;
}
```

```
int main()
{
  int x, y;
  cin >> x >> y;
  for(  ; x < y; x++)
  {
     cout << x << " " << y << endl;
     y--;
  }
  return 0;
}
```

bools, ints, and Conditions

- Loops & conditional statements require a **condition** to be evaluated resulting in a `true` or `false` result.
- In C/C++…
  - 0 means `false` / Non-Zero means `true`
  - **`bool`** type available in C++ => '`true`' and '`false`' keywords can be used but internally
    - `true` = non-zero (usually 1) and
    - `false` = 0
- Any place a condition would be used, a bool or int type can be used and will be interpreted as bool

```
int x = 100;
while(x)
  { x--; }
```

```
bool done = false;
while( ! done )
  { cin >> done; }
```

```
int x=100, y=3, z=0;
if( !x || (y && !z) )
  { /* code */ }
```

Single Statement Bodies

- The Rule: Place code for an if, else if, or else construct in curly braces { … }
- The Exception:
  - An if or else construct with a **single statement body** does not require { … }
  - Another if counts as a single statement
- However, you should ALWAYS prefer { … } even in single statement bodies so that editing later does not introduce bugs

```
if (x == 5)
  y += 2;
else
  y -= 3;
cout << "done1" << endl;


while (x != 0)
  x--;
cout << "done2" << endl;

for(int i=0; i < 10; i++)
  if( i % 2 == 0)
    cout << i << endl;
cout << "done3" << endl;
```

Solutions 1

```
int main()
{
  int n;
  cin >> n;
  for(int i = -n; i <= n; i++)
  {
     cout << i << endl;
  }
  return 0;
}
```

Program Output for input of **2**:

```
-2
-1
0
1
2
```

```
int main()
{
  double t, T;
  cin >> t >> T;
  for( double th = 0 ; th < T; th += t)
  {
     cout << sin(th) << endl;
  }
  return 0;
}
```

Program Output for input π /2 and 2π:

```
0
1
0
-1
```

Solutions 2

```
int main()
{
  int x, y;
  cin >> x >> y;
  for(int i=1; i <= x; i=i+y)
  {
     cout << i << endl;
     y++;
  }
  return 0;
}
```

```
int main()
{
  int x, y;
  cin >> x >> y;
  for(  ; x < y; x++)
  {
     cout << x << " " << y << endl;
     y--;
  }
  return 0;
}
```

Program Output for input of **10 2**:

```
1
4
8
```

Program Output for input **4 11**:

```
4 11
5 10
6 9
7 8
```