

CISC 1600/1610 Computer Science I

Flow of control

Professor Daniel Leeds
dleeds@fordham.edu
JMH 328A

Linear execution of statements

- Each action performed in written order

What is the result of this set of statements?

```
int a=1, b=2, c;
c = a+b;
a=5;
cout << c;
```

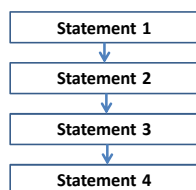
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Linear execution of statements

- Each action performed in written order

What is the result of this set of statements?

```
int a=1, b=2, c;
a=5;
c = a+b;
cout << c;
```



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Alternatives to “linear execution”

Conditional actions

```
> ./myProgram
```

What is your name? **Joe**

What time is it? **0900**

Good morning, Joe.

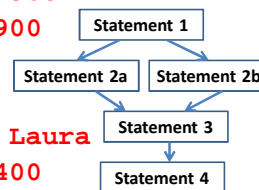
```
> ./myProgram
```

What is your name? **Laura**

What time is it? **1400**

Good afternoon, Laura.

```
>
```



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Alternatives to “linear execution”

Repeated actions

```
> ./myProgram
```

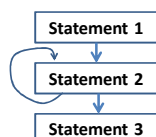
Infinite bottles of beer. Take one down.

Infinite bottles of beer. Take one down.

Infinite bottles of beer. Take one down.

Infinite bottles of beer. Take one down.

```
>
```



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The if-else statement

- if-else is used to perform a two way branch

```
if ( condition )
    statement1;
else
    statement2;
```

- statement1 is performed if condition is true
- statement2 is performed if condition is false
- Only one of the two statements is performed!

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condition – a Boolean expression

- Boolean expressions are either true or false
- Conditions often consist of **comparisons**
 - `age ≥ 21 // can buy drinks`
 - `age < 4 // can ride subway for free`
 - `year = 2 // you are a sophomore`

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Comparisons in C++

<code>=</code>	equal to	<code>==</code>	<code>a == b</code>
<code>≠</code>	not equal to	<code>!=</code>	<code>a != b</code>
<code><</code>	less than	<code><</code>	<code>a < b</code>
<code>≤</code>	less than or equal to	<code><=</code>	<code>a <= b</code>
<code>></code>	greater than	<code>></code>	<code>a > b</code>
<code>≥</code>	greater than or equal to	<code>>=</code>	<code>a >= b</code>

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Be careful with =

= is the assignment operator

- `a=b;` assigns the value of b to a

== tests equivalence

- `a==b` determines if a and b have the same value

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Multi-character comparisons

Where spaces matter:

- Correct: `a>=b` `a<=b` `a!=b`
 - Incorrect: `a> =b` `a< =b` `a! =b`
- No space between > and =, < and =, ! and =

Where spaces don't matter:

- Correct: `a>=b` `a <=b` `a !=b`

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if statement

Can write if statement without else

```
> ./myProgram
```

```
Enter charge: 32.00
```

```
Free delivery!
```

```
Thanks for shopping!
```

```
> ./myProgram
```

```
Enter charge: 10.00
```

```
Thanks for shopping!
```

```
>
```



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Compound statements: the use of { }

- Must group multiple statements with { } in if-else

```

if ( condition )
{
    statement1;
    statement2;
    statement3;
}
else
{
    statement4;
    statement5;
}
  
```

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What does this do?

```
int numBagels=5;

cout << "You are getting" << numBagels;
cout << " bagels!\n";

if ( numBagels>12 )
{
  numBagels++;
  cout << "You also get an extra bagel free!";
  cout << endl;
}

cout << "Have a good day.\n";
```

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What does this do?

```
int numBagels=5;

cout << "You are getting" << numBagels;
cout << " bagels!\n";

if ( numBagels>12 )
  numBagels++;
  cout << "You also get an extra bagel free!";
  cout << endl;

cout << "Have a good day.\n";
```

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Groups of statements

- White space (indents, extra blank lines) ignored by compiler ... BUT
- White space is good programming style
- Visually groups statements together
- Braces { } create groups for compiler

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Compound Boolean expressions

Expressions can be combined with logical operators

- The AND operator &&:
expression1 && expression2 true only if both expression1 and expression2 are true

```
if ( ( 2<x ) && ( x<7 ) )
```

- true only if x is between 2 and 7, e.g, x is 4, x is 7
- false otherwise, e.g., x is 0, x is 10
- Equivalently: `if (2<x && x<7)`
- Invalid: `if (2<x<7)`

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Compound Boolean expressions

Expressions can be combined with logical operators

- The OR operator ||:
expression1 || expression2 true only if at least one of expression1 and expression2 are true
- ```
if ((ageZoe==20) || (ageZoe==25))
```
- true only if ageZoe is 20 or 30
  - false otherwise
  - Equivalently: `if ( ageZoe==20 && ageZoe==25 )`

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### Logical operators, continued

Expressions can be altered with logical operators

- The NOT operator !:  
!expression true only if expression is false

```
if (!(ageZoe>20))
```

- true only if ageZoe is below 20
- false otherwise
- Preferably: `if ( ageZoe<=20 )`
- Preferable to avoid `!expression`

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## In summary

| a     | b     | a && b | a     | b     | a    b |
|-------|-------|--------|-------|-------|--------|
| true  | true  | true   | true  | true  | true   |
| true  | false | false  | true  | false | true   |
| false | true  | false  | false | true  | true   |
| false | false | false  | false | false | false  |

| a     | !a    |
|-------|-------|
| true  | false |
| false | true  |

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## What does this code do?

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

 cout << "What is your soup temperature? ";
 cin >> soupTemp;
 if ((soupTemp > 80) && (soupTemp<95))
 cout << "This soup is just right!\n";
 else
 cout << "This soup is no good!\n";
 return 0;
}
```

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## When do we need parentheses?

`(soupTemp > 80) && (soupTemp<95)`

is the same as

`soupTemp > 80 && soupTemp<95`

How about:

`(soupTemp > 80) && !(soupTemp>=95)`

vs.

`soupTemp > 80 && !soupTemp<95`

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## Order of operations for logic

1. Parentheses: ( )
2. Negation: !
3. Comparison: <, >, <=, >=, ==, !=
4. And: &&
5. Or: ||

Operations on same level evaluated left-to-right

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## Order of operations in action

```
int soupTemp=100;
```

```
(soupTemp > 80) && !(soupTemp>=95)
```

vs.

```
soupTemp > 80 && !soupTemp<95
```

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## Cautionary notes

- Be careful using !, better to avoid it
- Remember int-to-bool conversion
  - 0 as false
  - 1 (or any non-zero number) as true

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## Short-circuit evaluations

- If the value of the leftmost sub-expression determines the value of the full expression, the rest of the expression is not evaluated

```
float x=0, y=20;
if (x!=0 && y/x>=3) // only x!=0
 // evaluated
{ . . .
}
if (y/x >= 3 && x!=0) // error
 // divide-by-0
```

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## Different parts of the afternoon

### Conditional actions

```
> ./myProgram
What is your name? Jill
What time is it? 1400
Good afternoon, Jill.
> ./myProgam
What is your name? Leon
What time is it? 2100
Good evening, Leon.
>
```

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## Nested ifs

```
if (time > 1200)
{
 if (time < 1800)
 cout << "Good afternoon\n";
 else
 cout << "Good evening\n";
}
else
 cout << "Good morning\n";
```

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## Remembering const

Constant variables – replace numbers with meaningful names

```
const int noon=1200, startOfEve=1800;
if (time > noon)
 if (time < startOfEve)
 cout << "Good afternoon\n";
 else
 cout << "Good evening\n";
else
 cout << "Good morning\n";
```

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## What does this code do?

```
// buying a laptop
int price=500; // $500
float weight=50.5; // 50.5 pounds
if (weight<5.5)
 if (price<1000)
 cout << "Buy this!" << endl;
else
 cout << "Too heavy!" << endl;
```

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## Grouping of if and else

- else statement is connected with closest if
- Indentation ignored by compiler!
- { } braces instruct the compiler for grouping

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## Multiway if-else statement

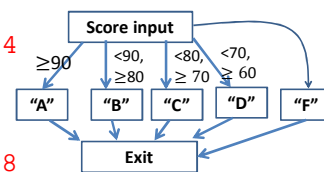
Actions for multiple mutually-exclusive conditions

```
if (expression1)
 statement1;
else if (expression2)
 statement2;
. . . .
else if (expressionN)
 statementN;
else // all above expressions false
 statementLast;
```

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## Branching on grade

```
> ./myProgram
Enter score: 94
You get an A.
> ./myProgram
Enter score: 78
Your get a C
```



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## Scope

- Variables declared inside a block are not “visible” outside the block
- Variables declared in an outer block are visible to inner blocks
- Blocks are enclosed by braces { }

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## What does this code do?

```
int main () {
 int a=5, b=10;
 if (a >= 3) {
 int a=8;
 cout << a << " " << b << endl;
 }
 cout << a << " " << b << endl;
 return 0;
}
```

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## What does this code do?

```
int main () {
 int a=5, b=10;
 if (a >= 3) {
 int a=8, c=5;
 cout << a << " " << b << endl;
 }
 cout << a << " " << c << endl;
 return 0;
}
```

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## What does this code do?

```
int main () {
 int a=5, b=10;
 if (a >= 3) {
 int a=8, c=5;
 b=12;
 cout << a << " " << b << endl;
 }
 cout << b << " " << c << endl;
 return 0;
}
```

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## Multiway switch statement

switch picks which statements to perform based on value of controlStatement

```
switch (controlStatement)
{
 . . .
 case constantX :
 statementSequenceX
 break;
 . . .
}
```

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## Full switch syntax

```
switch (controlStatement)
{
 case constant1 :
 statementSequence1
 break;
 . . .
 case constantN :
 statementSequence3
 break;
 default :
 statementSequence
}
```

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## controlStatement

Must return a value of type:

- bool
- integer (int, and related types)
- char

## case statement

case constantX : tells program to start running following code if controlStatement has given value

## break statement

break; exits the current block of code

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## switch example

```
switch (letter) {
 case 'A':
 cout << "A is for apple\n";
 break;
 case 'B':
 cout << "B is for banana\n";
 break;
 case 'C' :
 cout << "C is for cherry\n";
 break;
 default :
 cout << "No fruit for you\n";
 break;
}
```

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## switch example

```
switch (letter) {
 case 'A':
 cout << "A is for apple\n";
 break;
 case 'B':
 cout << "B is for banana\n";
 break;
 case 'C' :
 cout << "C is for cherry\n";
 break;
 default :
 cout << "No fruit for you\n";
 break;
}
```

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## switch example

```
switch (letter) {
 case 'A':
 cout << "A is for apple\n";
 break;
 case 'B':
 cout << "B is for banana\n";
 break;
 case 'C' :
 cout << "C is for cherry\n";
 break;
 default :
 cout << "No fruit for you\n";
 break;
}
```

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## Can omit break statements to group conditions

```
switch (letter) {
 case 'A':
 case 'a':
 cout << "A is for apple\n";
 break;
 case 'B':
 case 'b':
 cout << "B is for banana\n";
 break;
 case 'C' :
 case 'c' :
 cout << "C is for cherry\n";
 break;
 default :
 cout << "No fruit for you\n";
 break;
}
```

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Write a program that takes in the month as a number between 1 and 12 (1 is January, 2 is February...). Print a different message for each season. For example, for Winter (January-March), print "It is cold!"; for summer, "It is hot"

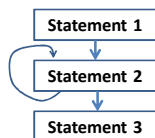
Extra: Ask the user what the temperature is. Say if it is too hot or cold for the season.

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## Alternatives to "linear execution"

## Repeated actions

```
> ./myProgram
Hello world.
Hello world.
Hello world.
Hello world.
>
```



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## The while loop

```
while (condition)
 statement_to_repeat;
```

OR

```
while (condition)
{
 statement_to_repeat1;
 . . .
 statement_to_repeatN;
}
| block of
| statements
```

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## condition – a Boolean expression

*Just a reminder from our earlier if-else slides*

- Boolean expressions are either true or false
- Conditions often consist of **comparisons**
  - age  $\geq$  21 // can buy drinks
  - age < 4 // can ride subway for free
  - year = 2 // you are a sophomore

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## How can we output "Hello world" 4 times?

```
int x=4;
while (x>0)
{
 cout << "Hello world.\n";
 x--;
}
```

Remember `x--;` same as `x=x-1;`

Repeats until `x ≤ 0`

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## Execution of while loop

- If condition is true, enter while loop
  - Complete all statements in block
  - Return to top (re-evaluate condition)
- Otherwise, continue to statements beyond loop

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## Execution of while loop

- If condition is **true**, enter while loop
  - Complete all statements in block
  - Return to top (re-evaluate condition)
- Otherwise, continue to statements beyond loop

```
int x=2;
while (x>0)
{
 x--;
 cout << "Hello world.\n";
}
```

How many  
"Hello world"s  
are output?

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## What code will do this for us?

```
> ./myProgram
1 mississippi
2 mississippi
3 mississippi
4 mississippi
5 mississippi
>
```

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Ask the user for a minimum and maximum number (integer)

Use a loop to calculate the sum of the numbers between minimum and maximum

E.g., if min is 3 and max is 6, sum is 3+4+5+6=18

Extra: Ask the user for two numbers (don't specify the order) and have the computer figure out the min and max

Extra 2: Compute the **product** of the numbers between min and max (E.g., 3x4x5x6=360)

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## a++ vs. ++a

- a++ returns value of a, then adds 1 to a
- ++a adds 1 to a, then returns value of a

Different results for:

```
int a=0; int a=0;
while (a++ < 3) while (++a < 3)
 cout << "Hi!\n"; cout << "Hi!\n";
```

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## do-while loop

- while evaluates condition, then performs statements if condition is **true**
- do-while performs statements, then evaluates condition to determine whether to perform statements again

```
do
{
 statement1;
 . . .
 statement N;
}
while (condition);
```

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### What does this code do?

```
int main () {
 int a=5;
 do {
 cout << "one ";
 a-=2;
 cout << "two\n";
 } while (a > 0);
 return 0;
}
```

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### What does this code do?

```
int main () {
 int a=5;
 do {
 cout << "one ";
 a-=2;
 cout << "two\n";
 } while (a != 0);
 return 0;
}
```

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### Beware infinite loops!

- Loops that never stop are called infinite loops
- Typically, write code so each loop will stop

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### for loop a while loop alternative

```
for (init; condition; update)
{
 statement1;
 . . .
 statement N;
}
```

typical example:

```
int i, product=1;
for (i=1; i<=5; i++)
{
 product = product*i;
}
```

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`init` – initializes variable

`condition` – statement about variable,  
must stay true for loop to keep running

`update` – updates the variable after each  
loop execution

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### Reviewing scope

Counter `i` exists outside of loop

```
int i, product=1;
for (i=1; i<=5; i++)
{
 product = product*i;
}
```

Counter `i` exists **only** inside of loop

```
int product=1;
for (int i=1; i<=5; i++)
{
 product = product*i;
}
```

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### What does this code do?

```
int main () {
 int i, product=1;
 for (i=1; i<=5; i++);
 product = product*i;
 cout << i << "! = " << product << endl;

 return 0;
}
```

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### Beware the misplaced ;

Placing a semicolon after the parentheses of a for loop causes an empty statement as the body of the loop

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### Picking a loop

- `do-while` if you need to perform the action at least once
- `for` if there is a standard repeated mathematical update to your loop variable (e.g., `count++`)
- `while` loop for less-standard loop variable updates

“loop variable” is the variable tested by the condition in your given loop

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