Branching

I'll be in your city tomorrow if you want to hang out.

But where will you be if I don't want to hang out?!

You know, I just remembered I'm busy.

Why I try not to be pedantic about conditionals.
Homework 0: using cin with 10/3 is NOT the same as 3.3333 (directly)

With cin, it will stop as soon as it reaches a type that does not match the variable (into which it is storing)

(See: cinMismatchTypes.cpp)
Outline

if/else statements cont.
boolean expressions
bool - either true or false

C++ lets you change between fundamental types (casting) with ease

Q: 0 is false and 1 is true, right?  
A: 1.
boolean values

Sometimes this might cause an error, such as:

```java
int x = 2;
if( ! x>5 ) will be false
```

Why?
Sometimes this might cause an error, such as:

```java
int x = 2;
if( ! x>5 ) will be false
```

Why?
A: order of operations will do the unary operator first (the '!'')
if (! x>5) will become if ( (!2) > 5)
... if ( (!true) > 5) ... if ( false > 5) ... if (0 > 5)
if statement

Code inside an **if** statement is only run if the condition is true.

```cpp
if(guess == random0to9) {
    cout << "Correct, here is a cookie!\n";
}
```

Need parenthesis (no semi-colon)

Indent

(See last week: numberGuessing.cpp)
if/else statement

Immediately after an if statement, you can make an else statement.

If the “if statement” does not run, then the else statement will.

If you do not surround your code with braces, only one line will be in the if (and/or else) statement.
if/else statement

(See: ATM.cpp)
Logical operators

These are all the operators that result in a `bool`:

> (greater than), e.g. 7 > 2.5 is `true`

== (equals), e.g. 5 == 4 is `false`

< (less than), e.g. 1 < 1 is `false`

>= (greater than or equal to), e.g. 1 <= 1 is `true`

!= (not equal to), e.g. 8 != 7 is `true`

<= (less than or equal to), e.g. 6 <= 2 is `false`

! (not, negation), e.g. !true is `false`
Complex expressions

Two boolean operators:

&& is the AND operations

|| is the OR operations
Complex expressions

AND operation removes Ts from the result
The OR operation adds Ts to the result

Evaluate (!p OR q) AND (p)

<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>!p</th>
<th>!p OR q</th>
<th>(!p OR q) AND (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
<td>F</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
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<td>F</td>
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<td>T</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>T</td>
<td>T</td>
<td>F</td>
</tr>
</tbody>
</table>
Write an if statement for checking if a variable (int) \( x \) is a positive odd number.

Hint: You may want to use the remainder (also called modulus) operator (the \%\ sign).

For example, \( 5 \% 3 = 2 \)
Complex expressions

Humans tend to use the English word OR to describe XOR (exclusive or).

“We can have our final exam on the scheduled day (May 13) or the last day of class (May 6).”

Did you think the statement above meant final exams on both days was a possibility?
Complex expressions

Write boolean expressions for each of the following truth tables:

1. 

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

2. 

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

XOR

3. 

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

4. 

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>0</td>
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</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Complex expressions

```c
int x = 9, y = 7;
```

\[
\begin{align*}
x < 12 \land \land y > 10 \\
9 < 12 \land \land 7 > 10 \\
T \land \land F \\
F
\end{align*}
\]
Complex expressions

If statements for when $x$...

... is between 10 and 20 (inclusive)

```java
if(10 <= x && x <= 20)
```

Cannot say: $10 \leq x \leq 20$ (why?)

... is a vowel ($x$ is type `char`)

```java
if( x == 'a' || x == 'e' || x == 'i' || x == 'o' || x == 'u')
```
Short-circuit evaluation is when you have a complex bool expression (&& or ||) but you don't need to compute all parts.

```cpp
if(false && 7/0 == 2) {
    cout << "Will I crash?\n";
}
```

If this is false, then it will not check next

(See: shortCircuit.cpp)
Short-circuit evaluation

Simple cases of short-circuit:
When you have a bunch of ORs
    if( expression || exp || exp || exp )
Once it finds any true expression, if statement will be true

When you have a bunch of ANDs
    if( expression && exp && exp && exp )
Once it finds any false expression, if statement will be false
Write a single if-statement that is true on the following range of numbers:
sample) \textbf{int} i: 3

Answer: \textbf{if}( i == 3)

a) \textbf{int} i: ... -2, -1, 0
b) \textbf{int} i: 5, 6, 7, 8, ...
c) \textbf{int} i: 1, 2, 3, 4, 5
d) \textbf{int} i: ... -2, -1, 1, 2, 3, ...
e) \textbf{int} i: ... -2, -1, 5, 6, 7, ...
Complex expressions

Be careful when negating, that you follow De Morgan's Law:

```cpp
bool a, b;
!(a OR b) is equivalent to (!a) AND (!b)
!(a AND b) is equivalent to (!a) OR (!b)
```

“Neither rainy or sunny” means
“Both not rain and not sunny”
BOOLEAN HAIR LOGIC

A

B

AND

OR

XOR
Nested if statements

You can have as many if statements inside each other as you want.

```java
if (teacherAwake)
{
    if (studentAwake)
    {
        if (classWellPrepared)
        {
            learning = true;
        }
    }
}
```
Nested if statements

From a truth table perspective, nested loops are similar to AND

The previous if code is equivalent to:

```java
if(teacherAwake && studentAwake && classWellPrepared)
{
    learning = true;
}
```

However, sometimes you want to do other code between these evaluations
Nested if statements

(See: bridgeOfDeath.cpp)
Where a variable is visible is called its **scope**

Typically variables only live inside the block (denoted with matching `{ and }`)

A variable lives until the block is closed, so inner blocks can see everything from the block it was created inside
Scope

```cpp
int main()
{
    int x;
    // can use x here
    {
        int y;
        // can use x or y here
    }
    // can use x here
    return 0;
}
```

(See: scope.cpp)
If... if... else!

When in doubt, use parenthesis and blocks! (Some people like to put the first brace after the if, others on a new line)

What happens if you have an if if else?

(See: ifIfElse.cpp)
Multiway if/else

This is a special format if you put an if statement after an else.

This second “if statement” only is tested when the first “if statement” is not true

(See: grades.cpp)
Multiway if/else

(See: vending.cpp)
A **switch** statement checks to see if a variable has a specific value.

```cpp
switch( controllingVariable)
{
    case 2:
    case 4:
        cout << "controllingVariable is either 2 or 4" << endl;
        break;
    case 3:
        cout << "controllingVariable is 3\n";
        break;
    default;
        cout << "controllingVariable is not 2, 3 or 4...\n";
        break;
}
```
Switch

If the value of the controlling variable is found in a case label, all code until a break statement is ran (or the switch ends)

Switch statements only test equality with case labels (not greater or less than)

(See: switch.cpp)
Switch statements can be written as multiway if/else statements.

Could use just “if statements” but “else if” shows only one of these will run.

(See: switchToIf.cpp)
Conditional operator

We will not use in this class, but if you use other people's code you will encounter

Shorthand for an if-else statement

(boolean) ? [if true] : [if false]

Example:
max = (x>y) ? x : y;
(See: max.cpp)
Loops

Why you deriving yourself?
\[
\frac{d}{dx} \quad x^3
\]

Why you deriving yourself?
\[
\frac{d}{dx} \quad 3x^2
\]

Hey, stop that!
\[
\frac{d}{dx} \quad 6x
\]

Why you deriving yourself?
\[
\frac{d}{dx} \quad 6
\]
if/else vs loops

if/else statements makes code inside only sometimes run

Loops make code inside run more than once

Both use boolean expressions to determine if the code inside is run
while loop

A while loop tests a bool expression and will run until that expression is false.

```cpp
while (i < 10)
{
    // looped code
    // variable i should change in here
}
```

(See: whileLoop.cpp)
while loop

The `bool` expression is tested when first entering the while loop
And!
When the end of the loop code is reached (the `}` to close the loop)

```cpp
int i = 0;
while (i < 5) {
    cout << "Looping, i = " << i << "\n";
    i++;
}
cout << "Outside the loop, i = " << i << "\n";
```
while loop

It can be helpful to manually work out what loops are doing and how variables change in each loop iteration.

This will build an insight into how loops work and will be beneficial when working with more complicated loops.
while loop

https://www.youtube.com/watch?v=7-Nl4JFDLOU
while loop

3 parts to any (good) loop:

- Test variable initialized
  
  ```
  i=0;
  ```

- bool expression
  
  ```
  while (i < 10)
  ```

- Test variable updated inside loop
  
  ```
  i++;
  ```
A **for loop** is a compacted version of the **while loop** (the 3 important parts are together)

for loops are used normally when iterating over a sequence of numbers (i.e. 1, 2, 3, 4)

```c++
for (int i = 0; i < 3; i++)
```

**Initialization**  
**boolean expression**  
**Update**  
(See: forLoop.cpp)
Loops

99 bottles of beer on the wall, 99 bottles of beer!
Take one down, pass it around, 98 bottles of beer on the wall!

98 bottles of beer on the wall, 98 bottles of beer!
Take one down, pass it around, 97 bottles of beer on the wall!

97 bottles of beer on the wall, 97 bottles of beer!
Take one down, pass it around, 96 bottles of beer on the wall!
...

Write a program to output the above song
(See 99beer.cpp)
There are two commands that help control loops:

- **continue** tells the loop to start over again
- **break** stops the loop
The `continue` command can be issued to start at the next iteration of a loop.

```cpp
for (i = 0; i < 10; i++)
{
    // code will run everytime
    if (doSkip)
    {
        continue;
    }
    // code will not run
    // if doSkip is true
}
```

(See: continue.cpp)
C-C-C-COMBO BREAKER
**break**

**break** will exit the current loop

```cpp
for (i = 0; i < 10; i++)
{
    // code
    if (doSkip)
    {
        break;
    }
}
// outside loop code
```

(See: break.cpp)
Infinite loops

We talked about this last time...

(See: countingSheep.cpp)
Loops to sum

Loops allow you to decide how many times a piece of code should run on the fly (i.e. at run time, not compile time)

You can either directly prompt the user how many times or make a special value to “exit” on

(See: sumLoop.cpp)
Debugging

When your program is not working, it is often helpful to add cout commands to find out what is going on.

Normally displaying the value of your variables will help you solve the issue.

Find up until the point where it works, then show all the values and see what is different than you expected.