if Lesson 1 Outline

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Absolute Value

Consider the function

\[ a(y) = | y | \]

So we know that

\[
\begin{align*}
  a(-2.5) &= | -2.5 | = +2.5 \\
  a(-2) &= | -2 | = +2 \\
  a(-1) &= | -1 | = +1 \\
  a(0) &= | 0 | = 0 \\
  a(+1) &= | +1 | = +1 \\
  a(+2) &= | +2 | = +2 \\
  a(+2.5) &= | +2.5 | = +2.5 \\
\end{align*}
\]
Absolute Value Definition

How is \(|y|\) defined?

Well, you could always define it as the nonnegative square root of \(y^2\):

\[
|y| = \sqrt{y^2}
\]

But here’s another definition:

\[
|y| = \begin{cases} 
-y, & \text{if } y \text{ is negative} \\
y, & \text{otherwise}
\end{cases}
\]
Absolute Value Implementation

$$|y| = \begin{cases} -y, & \text{if } y \text{ is negative} \\ y, & \text{otherwise} \end{cases}$$

Here’s an implementation of absolute value in C:

```c
if (y < 0) {
    absolute_value_of_y = -y;
} /* if (y < 0) */
else {
    absolute_value_of_y = y;
} /* if (y < 0)...else */
```
What Does This Mean?

```java
if (y < 0) {
    absolute_value_of_y = -y;
} /* if (y < 0) */
else {
    absolute_value_of_y = y;
} /* if (y < 0)...else */
```

1. Evaluate the **condition** \((y < 0)\), which is a Boolean expression, resulting in either true (1) or false (0).
2. If the condition evaluates to true, then execute the statement inside the `if` clause.
3. Otherwise, execute the statement inside the `else` clause.
Branching with if

Branching is a way to select between possible sets of statements. In C, the most common kind of branching is the if block:

```c
if (condition) {
    statement1;
    statement2;
    ...
}
```

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Example if Blocks

if (a > b) {
    printf("Wow, a is greater than b!\n");
} /* if (a > b) */

if (my_height < your_height) {
    shortest_height = my_height;
} /* if (my_height < your_height) */

if (cloud_type_code == cirrus_code) {
    printf("The cloud type is cirrus.\n");
} /* if (cloud_type_code == cirrus_code) */
if Condition

```java
if (condition) {
    statement1;
    statement2;
    ...
}
```

The condition is a Boolean expression completely enclosed in parentheses.

The *condition* is a *Boolean expression*, so it evaluates either to true (1) or to false (0).

The Boolean expression that constitutes the condition **MUST** be *completely enclosed in parentheses*. 
if Block and Statement Terminators

\[
\text{if (condition) } \{
    \text{statement1;}
    \text{statement2;}
    \ldots
\}
\]

The \textit{if} statement is followed by a block open \{ instead of by a statement terminator (semicolon).

Statements inside the \textbf{if clause} are followed by statement terminators (semicolons) as appropriate, just as if they were not inside the \textit{if} clause.

The block close } at the end of the \textit{if} block \textbf{ISN’T} followed by a statement terminator (semicolon).
if Block Indentation

```java
if (condition) {
    statement1;
    statement2;
    ...
}
```

Statements inside the `if` clause are indented additionally, beyond the indentation of the `if` statement and its associated block close.

In CS1313, the statements inside the `if` clause are indented an additional **4 spaces** beyond the `if` statement and its associated block close.

In CS1313, you are **ABSOLUTELY FORBIDDEN** to use tabs for indenting in your source code.
if Flowchart

statement_before;
if (condition) {
    statement_inside1;
    statement_inside2;
    ...
}
statement_after;

A **diamond** indicates a branch.
The Meaning of `if` #1

In `my_number.c`, we saw something like this:

```c
if ((users_number < minimum_number) ||
    (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n",
           minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

What does this mean?
The Meaning of `if` #2

```c
if ((users_number < minimum_number) ||
    (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n",
           minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

First, the condition

```c
((users_number < minimum_number) ||
    (users_number > maximum_number))
```

is evaluated, resulting in either true (1) or false (0).

**AGAIN**: The condition is a Boolean expression completely enclosed in parentheses.
The Meaning of `if` #3

```c
if ((users_number < minimum_number) || (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

Second, in the event that the condition evaluates to true (1), then the sequence of statement(s) **inside** the `if` clause – that is, between the block open of the `if` statement and the associated block close – are executed in order. Otherwise, these statements are skipped.
The Meaning of `if` #4

```c
if ((users_number < minimum_number) || (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
}
/* if ((users_number < minimum_number) || ... */
```

Finally, regardless of whether the condition evaluates to true (1) or false (0), execution picks up at the next statement **immediately after** the block close of the `if` clause, and continues along from there.
The Meaning of `if` #5

```
if ((users_number < minimum_number) ||
    (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n",
            minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

In the event that the condition evaluates to true (1) – that is, **IF** it’s the case that `users_number` is less than `minimum_number` **OR** it’s the case that `users_number` is greater than `maximum_number` – then the statement

```
    printf("Hey! That's not between %d and %d!\n",
             minimum_number, maximum_number);
```

is executed, in which case the output is:

   Hey! That's not between 1 and 10!
The Meaning of if #6

```c
if ((users_number < minimum_number) || (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

On the other hand, if `users_number` lies between `minimum_number` and `maximum_number` – that is, if the condition evaluates to false (0) – then the `printf` statement is not executed, and therefore no output is produced by the `if` block.
if Example #1

#include <stdio.h>

int main ()
{ /* main */
    const int computers_number = 5;
    int users_number;

    printf("Pick an integer:\n");
    scanf("%d", &users_number);
    if (users_number < computers_number) {
        printf("That's unbelievable! Your number is\n");
        printf(" less than mine!\n");
        printf("Well, okay, maybe it’s believable.\n");
    } /* if (users_number < computers_number) */
    printf("And now I’m sick of you.\n");
    printf("Bye!\n");
} /* main */
if Example #2

% gcc -o isless isless.c
% isless
Pick an integer:
6
And now I’m sick of you.
Bye!
% isless
Pick an integer:
5
And now I’m sick of you.
Bye!
% isless
Pick an integer:
4
That's unbelievable! Your number is less than mine!
Well, okay, maybe it’s believable.
And now I’m sick of you.
Bye!
printf("Pick an integer:\n");
scanf("%d", &users_number);
if (users_number < computers_number) {
    printf("That's unbelievable! Your number is\n");
    printf("  less than mine!\n");
    printf("Well, okay, maybe it's believable.\n");
} /* if (users_number < computers_number) */
printf("And now I'm sick of you.\n");
printf("Bye!\n");
Block Open/Close Comments for `if` Block

```c
if ((users_number < minimum_number) ||
    (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

**NOTICE:**

- The **block open** of this `if` block **doesn’t** have a comment on the same line.
- The **block close** of this `if` block **does** have a comment on the same line, and that comment contains the `if` statement, or a truncated version of it, **EXCLUDING** its block close.
The condition

\[
((\text{users\_number} < \text{minimum\_number}) \lor (\text{users\_number} > \text{maximum\_number}))
\]

is a Boolean expression completely enclosed in parentheses. How do we know this?
if ((users_number < minimum_number) || (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */

First, this subexpression

( users_number < minimum_number)

is a Boolean expression, specifically a relational expression, so it evaluates to a Boolean value – true (1) or false (0).
if \((\text{users}_\text{number} < \text{minimum}_\text{number}) \lor (\text{users}_\text{number} > \text{maximum}_\text{number})\) {
    \text{printf("Hey! That's not between \%d and \%d!\n",}
    \text{minimum}_\text{number}, \text{maximum}_\text{number});
} /* if \((\text{users}_\text{number} < \text{minimum}_\text{number}) \lor (\text{users}_\text{number} > \text{maximum}_\text{number})\) */

Second, this subexpression

\((\text{users}_\text{number} > \text{maximum}_\text{number})\)

is a Boolean expression, specifically a relational expression, so it evaluates to a Boolean value – true (1) or false (0).
Boolean Expr Completely Parenthesized #4

if ((users_number < minimum_number) ||
    (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */

The condition

(users_number < minimum_number) ||
(users_number > maximum_number)

is a pair of Boolean subexpressions, specifically relational expressions, joined by a Boolean operation, OR (||). So the expression as a whole is a Boolean expression.
Boolean Expr Completely Parenthesized #5

if ((users_number < minimum_number) || (users_number > maximum_number)) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */

The condition

((users_number < minimum_number) || (users_number > maximum_number))

is a pair of Boolean subexpressions, specifically relational expressions, joined by a Boolean operation, OR (||), then enclosed in parentheses.

So: The condition is a Boolean expression completely enclosed in parentheses.
BAD Condition #1

```c
if (users_number < minimum_number) || (users_number > maximum_number) {
    printf("Hey! That's not between %d and %d!\n", minimum_number, maximum_number);
} /* if ((users_number < minimum_number) || ... */
```

What if the condition

```c
(users_number < minimum_number) || (users_number > maximum_number)
```

were a Boolean expression but were not completely enclosed in parentheses?

The compiler would treat this as an error!

It would be **WRONG WRONG WRONG.**
BAD BAD BAD Condition Example

```c
#include <stdio.h>

int main ()
{ /* main */
    const int minimum_number = 1;
    const int maximum_number = 10;
    int users_number = 0;

    if  (users_number < minimum_number) ||
        (users_number > maximum_number) {
        printf("Hey! That's not between %d and %d!\n",
               minimum_number, maximum_number);
    } /* if  (users_number < minimum_number) || ... */
} /* main */
```

```
% gcc -o condnotenclosed condnotenclosed.c
condnotenclosed.c: In function main:
condnotenclosed.c:9: error: expected expression
before || token
```

Notice that the compiler is **VERY UNHAPPY**.
GOOD Condition Example

```c
#include <stdio.h>

int main ()
{ /* main */
    const int minimum_number = 1;
    const int maximum_number = 10;
    int users_number = 0;

    if ((users_number < minimum_number) ||
        (users_number > maximum_number))  {
        printf("Hey! That's not between %d and %d!\n",
            minimum_number, maximum_number);
    } /* if ((users_number < minimum_number) || ... */
} /* main */
```

```
% cat condenclosed.c
#include <stdio.h>

int main ()
{ /* main */
    const int minimum_number = 1;
    const int maximum_number = 10;
    int users_number = 0;

    if ((users_number < minimum_number) ||
        (users_number > maximum_number))  {
        printf("Hey! That's not between %d and %d!\n",
            minimum_number, maximum_number);
    } /* if ((users_number < minimum_number) || ... */
} /* main */
```

```
% gcc -o condenclosed condenclosed.c
% condenclosed
Hey! That's not between 1 and 10!
```

Notice that the compiler is now **HAPPY!**
Kinds of Statements Inside if Block

Between the if statement’s block open and the associated block close, there can be any kind of executable statements, and any number of them.

For example:
- `printf` statements;
- `scanf` statements;
- assignment statements;
- if blocks.

There are several other kinds of executable statements that can occur inside an if block, some of which we’ll learn later in the semester.
Statements Inside if Block

In the event that the if condition evaluates to true (1), then the statements inside the if block will be executed one by one, in the order in which they appear in the if block.
No Declarations Inside if Block

Notice that an if block **SHOULDN’T** contain declaration statements, because the if statement is an executable statement, and **ALL** declarations **MUST** come before **ANY** executable statements.
Absolute Value Example #1

% cat absval.c
#include <stdio.h>

int main ()
{ /* main */
  float input_value, output_value;

  printf("I'm going to calculate the absolute\n");
  printf(" value of a value that you input.\n");
  printf("Please input the value.\n");
  scanf("%f", &input_value);
  if (input_value < 0) {
    output_value = -input_value;
  } /* if (input_value < 0) */
  else {
    output_value = input_value;
  } /* if (input_value < 0)...else */
  printf("The absolute value of \%f is \%f.\n",
    input_value, output_value);
} /* main */
Absolute Value Example #2

% gcc -o absval absval.c
% absval
I'm going to calculate the absolute value of a value that you input.
Please input the value.
5
The absolute value of 5.000000 is 5.000000.
% absval
I'm going to calculate the absolute value of a value that you input.
Please input the value.
-5
The absolute value of -5.000000 is 5.000000.
A More Complicated if Example #1

#include <stdio.h>
#include <stdlib.h>

int main()
{
    /* main */

    const int int_code = 1, float_code = 2;
    const int program_failure_code = -1;
    const int program_success_code = 0;
    float float_input_value, float_output_value;
    int int_input_value, int_output_value;
    int data_type_code;

    printf("I'm going to calculate the absolute value\n");
    printf(" of a number that you input.\n");
A More Complicated if Example #2

printf("Would you like to input an int or a float?\n");
printf(" (Enter %d for an int or %d for a float.)\n",
        int_code, float_code);
scanf("%d", &data_type_code);
if ((data_type_code != int_code) &&
       (data_type_code != float_code)) {
    printf("ERROR: I don't recognize data type code %d.\n",
           data_type_code);
    exit(program_failure_code);
} /* if ((data_type_code != int_code) ... */
if (data_type_code == int_code) {
    printf("What is the int value?\n");
    scanf("%d", &int_input_value);
} /* if (data_type_code == int_code) */
else if (data_type_code == float_code) {
    printf("What is the float value?\n");
    scanf("%f", &float_input_value);
} /* if (data_type_code == float_code) */

Idiotproofing
A More Complicated `if` Example #3

```c
if (data_type_code == int_code) {
    if (int_input_value < 0) {
        int_output_value = -int_input_value;
    } /* if (int_input_value < 0) */
    else {
        int_output_value = +int_input_value;
    } /* if (int_input_value < 0)...else */
} /* if (data_type_code == int_code) */
else if (data_type_code == float_code) {
    if (float_input_value < 0) {
        float_output_value = -float_input_value;
    } /* if (float_input_value < 0) */
    else {
        float_output_value = +float_input_value;
    } /* if (float_input_value < 0)...else */
} /* if (data_type_code == float_code) */
```
A More Complicated if Example #4

```c
if (data_type_code == int_code) {
    printf("The absolute value of %d is %d.\n", 
            int_input_value, int_output_value);
} /* if (data_type_code == int_code) */
else if (data_type_code == float_code) {
    printf("The absolute value of %f is %f.\n", 
            float_input_value, float_output_value);
} /* if (data_type_code == float_code) */

return program_success_code;

} /* main */
```
A More Complicated if Example Runs #1

```bash
% gcc -o absvalbytype absvalbytype.c
% absvalbytype
I'm going to calculate the absolute value of a number that you input.
Would you like to input an int or a float?
   (Enter 1 for an int or 2 for a float.)
0
ERROR: I don't recognize data type code 0.
```
A More Complicated if Example Runs #2

```matlab
absvalbytype
I'm going to calculate the absolute value of a number that you input. Would you like to input an int or a float? (Enter 1 for an int or 2 for a float.)
```

```matlab
1
What is the int value?
```

```matlab
5
The absolute value of 5 is 5.
```

```matlab
absvalbytype
I'm going to calculate the absolute value of a number that you input. Would you like to input an int or a float? (Enter 1 for an int or 2 for a float.)
```

```matlab
1
What is the int value?
```

```matlab
-5
The absolute value of -5 is 5.
```
A More Complicated if Example Runs #3

% absvalbytype
I'm going to calculate the absolute value of a number that you input. Would you like to input an int or a float? (Enter 1 for an int or 2 for a float.)
2
What is the float value?
5.5
The absolute value of 5.500000 is 5.500000.

% absvalbytype
I'm going to calculate the absolute value of a number that you input. Would you like to input an int or a float? (Enter 1 for an int or 2 for a float.)
2
What is the float value?
-5.5
The absolute value of -5.500000 is 5.500000.
Compound Statement a.k.a. Block #1

A **compound statement** is a sequence of statements, with a well-defined beginning and a well-defined end, to be executed, in order, under certain circumstances.

An `if` block is a compound statement. We’ll see others later.

Although an `if` block is actually a sequence of statements, we can think of it as a single “super” statement in some contexts.

Compound statements are also known as **blocks**. Thus, we speak of an `if` block.
Compound Statement a.k.a. Block #2

In C, a compound statement, also known as a block, is delimited by curly braces.

That is, a compound statement (block):

- begins with a **block open**

  ```
  {
  }
  ```

- ends with a **block close**

  ```
  }
  ```