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;
    ...
}
...
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 (entree_item_code == lasagna_code) {
    entree_price = lasagna_price;
} /* if (entree_item_code == lasagna_code) */
if Condition

```
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

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

The `if` statement is followed by a block open `{` rather than by a statement terminator (semicolon).

Statements inside the `if` clause are followed by statement terminators (semicolons) as appropriate, just as if they were not inside the `if` clause.

The block close `}` at the end of the `if` block **ISN’T** followed by a statement terminator (semicolon).
if Block Indentation

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

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

```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) || ... */
```

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

```c
    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.
#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 */
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!
Example Flowchart

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

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.
Boolean Expr Completely Parenthesized #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) || ... */
```

The condition

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

is a Boolean expression completely enclosed in parentheses. How do we know this?
Boolean Expr Completely Parenthesized #2

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).
Boolean Expr Completely Parenthesized #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, this subexpression

```
(users_number > maximum_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

```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) || ... */
```

The condition

```c
(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

```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) || ...

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

```
(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

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

int 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) || ... */

% 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

% 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

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

int main ()
{ /* main */
    const int int_code = 1;
    const int float_code = 2;
    const int program_failure_code = -1;
    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");
printf(" absolute value\n");
printf(" of a number that you input.\n");
printf("Would you like to input ");
printf("an int or a float?\n");
printf(" (Enter %d for an int ", int_code);
printf("or %d for a float.)\n", float_code);
scanf("%d", &data_type_code);
if ((data_type_code != int_code) &&
    (data_type_code != float_code)) {
    printf("ERROR: I don’t recognize the ");
    printf("data type code %d.\n",
           data_type_code);
    exit(program_failure_code);
} /* if ((data_type_code != int_code) ... */
A More Complicated \textit{if} Example \#3

\begin{verbatim}
if (data_type_code == int_code) {
    printf("Please input the int.\n");
    scanf("%d", &int_input_value);
    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 */
    printf("The absolute value of ");
    printf("%d is %d.\n", int_input_value, int_output_value);
} /* if (data_type_code == int_code) */
\end{verbatim}
if (data_type_code == float_code) {
    printf("Please input the float.\n");
    scanf("%f", &float_input_value);
    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 */
    printf("The absolute value of ");
    printf("%f is %f.\n", 
        float_input_value, float_output_value);
} /* if (data_type_code == float_code) */
} /* main */
A More Complicated if Example Runs #1

% 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 the data type code 0.
A More Complicated if Example Runs #2

```python
% 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.)
1
Please input the int.
5
The absolute value of 5 is 5.
```

```python
% 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.)
1
Please input the int.
-5
The absolute value of -5 is 5.
```
A More Complicated if Example Runs #3

```plaintext
% 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
Please input the float.
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
Please input the float.
-5.5
The absolute value of -5.500000 is 5.500000.
```
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**.
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**
  ```
  }
  ```