Impact Lab 2025: Programming Fundamentals
Lecture 2: Variables, Conditionals, and Loops, Oh My!

Summer 2025

School of Computing
and Data Science

Wentworth Institute of
Technology

p5.js

Topics for Today

- **Variables**
- Conditionals
- Bouncing Ball
- **`while`** Loops
- **`for`** Loops
- Functions(?)

Mathematical Operators

Mathematical Operators are (generally) used with numeric types.

Addition (+): `total = part1 + part2;`

Subtraction (–): `left_over = total - used;`

Multiplication (*): `force = mass * acceleration;`

Division (/): `item_wt = total / num_items;`

Predefined Variables

p5.js has many predefined variables that store specific values related to p5.js functionality.

`mouseX` and **`mouseY`** constantly update to store the pixel position of the mouse on the canvas.

```
function draw() {
  background(0);
  circle(mouseX,200,50);
}
```

What happens if this is in **`draw()`**?

Drawing Program

Let's move background(0) to setup.

What happens now and why?

Use **mouseX** and **mouseY** as the position of the circle.

```
function setup(){
  background(0);
}

function draw() {
  circle(mouseX,mouseY,50);
}

function mousePressed(){

}
```

p5.js has other special functions like setup and draw. Lets add **mousePressed()** to our program.

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Control Flow

Control flow refers to the order in which your program statements are executed.

So far, all of our programs have been executed straight-through from the first to the last.

In general, you will need more complex control flow. For example, you may need to choose between two or more possibilities.

Control Flow

Thought process:

Which greeting to give?

If I am looking at a friend:

Say "Yo"

If I am looking at an enemy:

Glare

JavaScript uses **if-else** statements to choose between alternatives

Control Flow

Example:

```
if(id == friend){
  print("Yo");
}
else {
  print("*Glare*");
}
```

Generic form:

```
if(BOOLEAN EXPRESSION){
  YES/TRUE STATEMENT(S) ABOVE
}
else {
  NO/FALSE STATEMENT(S) ABOVE
}
```


Control Flow

Each **`if-else`** statement allows your program to do one of two different things

In other words, you EITHER use one set of statements or the other, never both

The statements in-between the **`{ }`** for the **`if`** and the **`else`** can contain any code you want: printing things, using the math library, drawing things, even more **`if-else`** statements!

Boolean Expressions

Boolean expressions (like **boolean** variables) are either true or false, and are composed of comparisons

Comparison Operators

==	Equal To	`if(x == 10)`
!=	Not Equal To	`if(x != 5)`
<	Less Than	`if(hours < 40)`
<=	Less Than or Equal To	`if(dollars <= 100)`
>	Greater Than	`if(dollars > 100)`
>=	Greater Than or Equal To	`if(hours >= 40)`

Complex `Boolean` Expressions

Multiple comparisons can be combined in the same expression using the logical "and" and the logical "or" operators.

`&&` is the logical "and" operator

`(hours > 20) && (hours <= 40)`

The entire expression is true **if and only if** both comparisons are true, otherwise it is false

`||` is the logical "or" operator

`(x < 17) || (y < 22)`

The entire expression is true if **either** comparison is true and only false when **both** are false

Exercise: Odd/Even

Write an if-else statement that checks a number and determines whether it is even or odd.

Even numbers are divisible by 2

Odd numbers are not divisible by 2

Multiple Choice

What if you have/want more than two options?

The standard **`if-else`** only gives you two choices

That's where the **`else if`** comes in. You can add **`else if`** statements between the **`if`** and **`else`** (any number of them!)

The key is that each will be tested in order until one of the conditions is true. If none are true, the final **`else`** will execute.

You can actually completely omit the **`else`** if you want

Multiple Choice

```
if(EXPRESSION1){
  RUN THIS STATEMENT IF EXPRESSION1 IS TRUE
}
else if(EXPRESSION2){
  RUN THIS STATEMENT IF EXPRESSION2 IS TRUE
}
else {
  RUN THIS STATEMENT IF BOTH EXPRESSIONS ARE FALSE
}
```


Exercise: Grade

Write a set of **`if-else`** statements that take a numeric score and outputs a letter grade:

if the score is >=90, output A

if the score is >=80 and <90, output B

if the score is >=70 and <80, output C

if the score is >=60 and <70, output D

if the score is <60, output F

`if-else` Summary

Use **`if-else`** statements when you need to choose between two or more possibilities.

Always put boolean expression in parentheses

Multiple expressions can be put together with the logical "and" (**`&&`**) and the logical "or" (**`||`**) operators.

Always put each comparison in its own set of parentheses

Don't forget to use "`==`" for equality, not "`=`"

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- **`for`** Loops
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Bouncing Ball

We're going to create a circle that bounces around the canvas region.

This in-class project will allow us to talk about a few topics:

- **Physics**, the ball needs to move
- **Boundary Checks**
- **Graphics**

Physics Lesson

$$\frac{dx}{dt} = v$$

A change in position over time is velocity

$$\frac{dv}{dt} = a$$

A change in velocity over time is acceleration

Our ball won't do any acceleration, we'll only worry about a 'kick' to change it's direction

Physics Lesson

Using the definition of the derivative:

$$\frac{df(t)}{dt} = \frac{f(t+dt) - f(t)}{dt}$$

Function at the next time

Function at the current time

So,

$$\frac{dx}{dt} = v$$

$$\frac{x(t+dt) - x(t)}{dt} = v$$

What is *dt*?

$$x(t+dt) = v \cdot dt + x(t)$$

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Physics Lesson

What is *dt*? Change in time between frames

$\mathcal{O}(16ms)$

Change in Position $x(t+dt) = v \cdot dt + x(t)$

Change in Velocity $v(t+dt) = a \cdot dt + v(t)$

Ultimately, all we need to know is the previous position/velocity!

We'll supply a value of **dt** to our code. Ideally, it should be related to our animation update time.

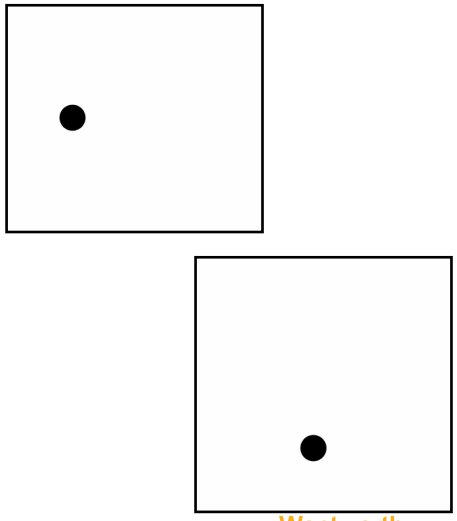
We'll also adjust the velocity values so the ball movement looks good.

cience

Bouncy Ball

We'll start with some initial code that gets some variables ready.

Declaring variables outside of setup/draw allows us to use the variables anywhere in the code.



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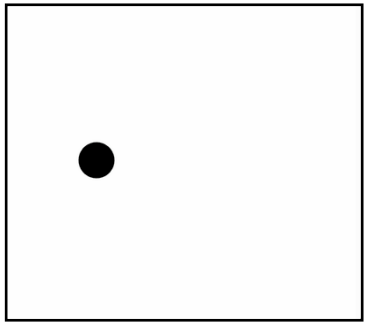
1D Ball

Let's start with a ball that only moves in 1D



```
let frameTime=60;
let dt=1/frameTime;
let xPosition=100;
let yPosition=100;
let xVelocity=0;

function setup() {
  frameRate(frameTime);
  createCanvas(400, 400);
  xVelocity=100;
}

function draw() {
  background(220,0,200);

  //bouncy code here

  fill(0);
  circle(x,y,10);
}
```

1D Ball - Bouncy Code

```
function draw() {
  background(255);

  //bouncy code here
  x=x+xvelocity*dt;
  if(x<0 || x>width){
    xvelocity*=-1;
  }

  fill(0);
  circle(x,y,diameter);
}
```

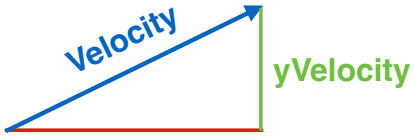
We use real physics to update the position of the ball based on the velocity!

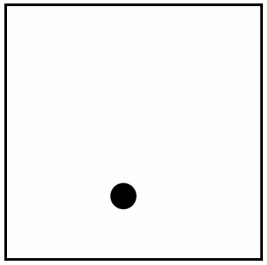
If we get near an edge, we bounce off (change the direction of the velocity, positive vs negative).

2D Ball

The 2D ball isn't much more complicated, we just need to update **x** and **y**.

To move diagonally, we move a little bit in the **x** and a little bit in the **y**.





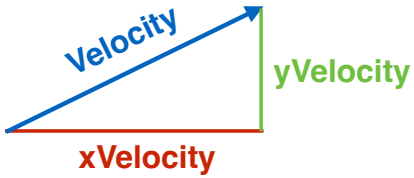
We'll also have to think a bit more about howe we bounce off of the boundaries

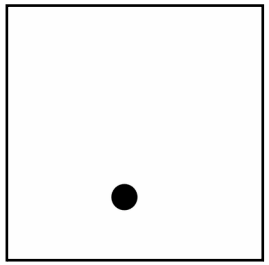
2D Ball

The 2D ball isn't much more complicated, we just need to update **x** and **y**.

To move diagonally, we move a little bit in the **x** and a little bit in the **y**.

Let's try to code it up.





We'll also have to think a bit more about howe we bounce off of the boundaries

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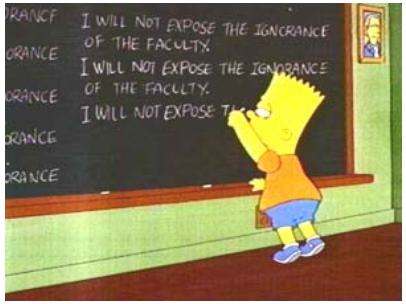
Loops

Often, you need to repeat the same computation, action, or sequence of steps many times.



Like writing "I will not expose the ignorance of the faculty." 100 times

Loops

Of course, you could use 100 **`print()`** statements to do this, but that's a lot of copy and paste work.

Instead, programming languages have control flow mechanisms called **loops** that allow you to loop over (repeat) the same section of code as many times as you need.

Two of the most common types of loops are **`while`** loops and **`for`** loops

`while` Loops

The **`while`** loop is used to repeat a set of statements **`while`** some condition is **`true`**.

```
let iteration = 1;
while (iteration <= 100) {
  print("Repeat this line\n");
  iteration = iteration + 1;
}
```

Notice how there is a boolean expression after the **`while`**. Also, Within the loop the iteration variable is incremented.

`while` Loops

```
while (BOOLEAN EXPRESSION) {
  STATEMENT1;
  STATEMENT2;
  ...
}
```

The loop body is between the { and }

The loop body executes over and over as long as the expression is true.

These boolean expressions are the same as the **`if/else if`** statements

Each repetition of the loop is called an **`iteration`**.

while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

Current Value of i: 7

while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

7

Current Value of i: 7

while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

7

Current Value of i: 3.5

while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

7

Current Value of i: 3.5

while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
```

Current Value of i: 3.5

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while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
```

Current Value of i: 1.75

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while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
```

Current Value of i: 1.75

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while Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
1.75
```

Current Value of i: 1.75

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`while` Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
1.75
```

Current Value of `i`: `0.875`

`while` Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
1.75
```

Current Value of `i`: `0.875`

`while` Loop Behavior

```
let i=7;

while (i > 1) {
  print(i);
  i = i / 2;
}

print("Done.");
```

Console Output

```
7
3.5
1.75
Done.
```

Current Value of `i`: `0.875`

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- Variables
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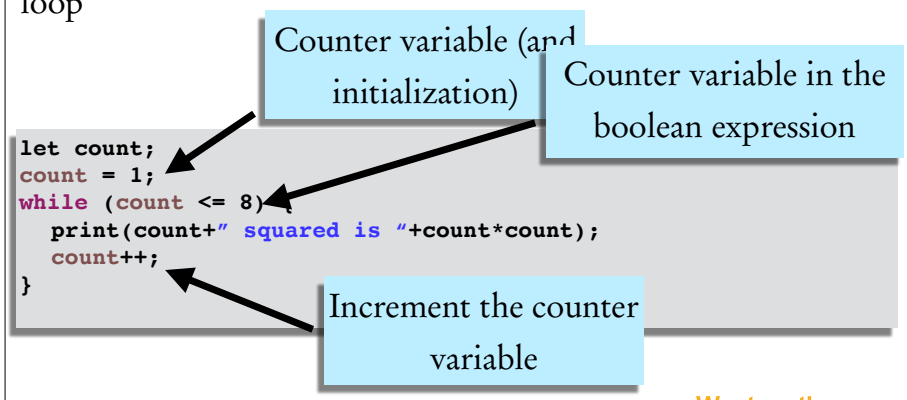
- **`for`** Loops
- Functions(?)

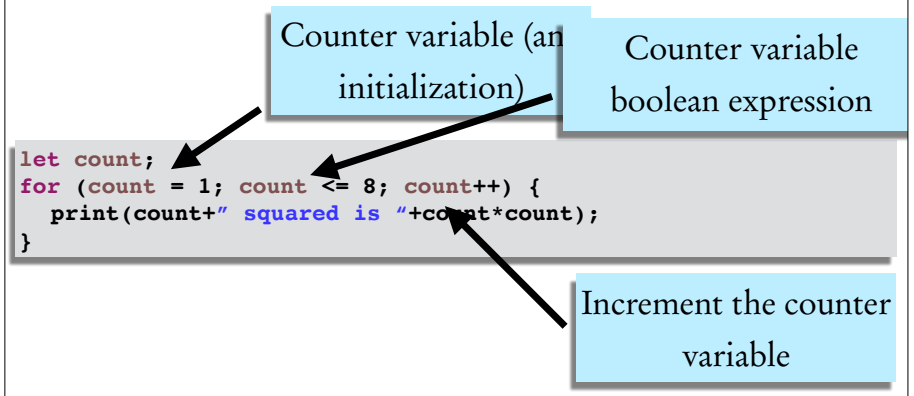
`while` Loops...Again...

`while` loops are often used to repeat a task a fixed number of times, which often leads to similar structure in the body of the loop



`for` Loops

`for` loops are specialized loops that have these features built in (and you'll probably use them for most loops that you write)



Generic Form

```
for (INITIALIZATION; BOOLEAN_EXPRESSION; UPDATE) {
  STATEMENT1;
  STATEMENT2;
  …
}
```

Again, the loop body is between the { }

`INITIALIZATION` is done one time before the first loop iteration.

`UPDATE` is done every loop iteration after the end of the loop body.

`BOOLEAN_EXPRESSION` is checked every loop iteration after **`UPDATE`** (and once after **`INITIALIZATION`**)

Example: Summing Values

Say we have a math equation:

$$\sum_{i=0}^{10} i$$

```
let sum=0;
for (let i = 0; i <= 10; i++) {
  sum+=i;
}
print(sum);
```

Gotchas

There are only two semicolons!

- Between the initialization and the boolean
- Between the boolean and the update

No semicolon after the update

No semicolon after the parentheses

If you are doing and increment, be sure you use **`i++`** or **`i=i+1`**, not just **`i+1`** (it doesn't do anything)

`for` and `while`

Both loops work basically the same way

The main difference is the **initialization** and **update** process that is defined within the syntax of the **for** loop.

Which one is better?

Topics for Today

- Variables
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- **`while`** Loops
- **`for`** Loops
- **Functions(?)**

Predefined Functions

JavaScript and p5.js includes many predefined functions for common tasks

We've already been using functio

Function call

```
Function setup(){
  createCanvas(400,400);
}
```

Arguments

If the function has a return value, we "capture" it using an =

Terminology Notes

We use **parameters** to refer to the list of variables that a method requires (in parentheses)

They are place holders for the values that will be used when the method is called (or dummy variables)

We use **arguments** to refer to the specific values and/or variables that are passed to the method when you invoke the method

Also, other languages refer to methods as **functions**, **procedures**, **methods**, or **subroutines**

Example

```
function setup(){
  let number=15;
  let cube=0;
  let log2=0;

  cube=Math.pow(number,3);
  print(number+" cubed = "+cube);

  print("square root of "+number+" = "+Math.sqrt(number));

  log2=Math.log2(number);
  print("log2 of "+number+" = "+log2);
}
```


Pogrammer Defined Functions

JavaScript allows you to define your own functions to meet the needs of your specific program

All of the functions that you create will have a **signature** and a **body** that you define

The signature includes the method name and parameter list.

The body is the set of JavaScript statements that will be executed when the method is invoked

Generic Form

```
function METHOD(PARAMETER_1, PARAMETER_2, …, PARAMETER_N)
```

A method can have any number of parameters, even zero.

A method has either zero or one return value(s)

The return value is commonly the result of a function.

The return value can be assigned to a variable when calling the function.

Alternatively, the method call can be placed directly in another JavaScript expression.

Example

```
function computeSquare(value){
  return value*value;
}
```

Our function is named "**computeSquare**" and takes one argument.

It returns **value*value**;