

15-104 Introduction to Computing for Creative Practice

Fall 2021

37 Greatest Hits

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Basics

- Your p5.js programs consist of two basic functions:

- `function setup() {`

- ...

- }

Runs first when your program launches to set up the canvas.

- `function draw() {`

- ...

- }

Runs repeatedly, over and over, to draw on the canvas (unless you execute `noLoop()` ;)

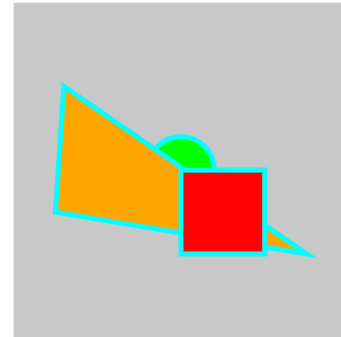
- If you draw the same thing each time `draw()` runs, then it will look like a painting.
If you draw something different each time, then it will look like an animation.

`frameRate(r);`
sets the number of times
draw repeats to r times per second.

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The Canvas

- A canvas is made up of **pixels** (picture elements).
- Screen resolution is expressed in pixels (e.g. 1920 X 1080)
- The origin (0, 0) of the canvas is at the top left.
 - x coordinates increase from left to right
 - y coordinates increase from top to bottom
- Drawing is like painting...
 - It's sequential. New paint goes on top of old paint.
 - The order you write the instructions is the order that your painting will be constructed.



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Functions / Parameters vs. Arguments

- We've used functions that are predefined. (e.g. `random`, `ellipse`, etc.)
- We pass arguments to these functions (a function call).
- Each function assigns these arguments to a set of parameters.
- When the function completes its computation, it can return a result.*
- Computation continues where we left off after the function call.
- When you call a function, you should supply the same number of arguments as it has parameters.
- We can define our own functions that can be called from `draw` (or from each other).
- General format:

```
function name ( parameterlist ) {
    function body
}
```

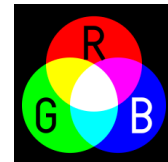
*In your own functions, you can return a value with `return` statement(s). Once a `return` statement executes, flow of control goes back to the calling function immediately.
General format: `return (expression);`

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Shapes & Fill

- `ellipse(x, y, w, h);`
- `circle(x, y, d);`
- `rect(x, y, w, h);`
- `square(x, y, s);`
- `triangle(x1, y1, x2, y2, x3, y3);`
- `quad(x1, y1, x2, y2, x3, y3, x4, y4);`
- `fill(r, g, b, [alpha]);`
- `fill(grayvalue);`
- `fill(color);`
- `noFill();`

`rectMode(CENTER);` treats `x, y` as center rather than top left for subsequent rectangles/squares.



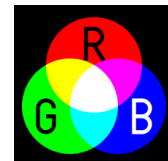
`r` red (0 to 255, inclusive).
`g` green (0 to 255, inclusive).
`b` blue (0 to 255, inclusive).
`alpha` opacity (0 = transparent, to 255 = fully opaque).

`grayvalue` black(0) to white (255)
`color` a p5.Color object

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Lines and Stroke

- `line(x1, y1, x2, y2);`
- `point(x, y);`
- `stroke(r, g, b, [alpha]);`
- `stroke(grayvalue);`
- `stroke(color);`
- `strokeWeight(weight);`
- `noStroke();`
- `dist(x1, y1, x2, y2)`
returns the distance between (x1,y1) and (x2,y2)



`r` red (0 to 255, inclusive).
`g` green (0 to 255, inclusive).
`b` blue (0 to 255, inclusive).
`alpha` opacity (0 = transparent, to 255 = fully opaque).

`grayvalue` black(0) to white (255)
`color` a p5.Color object

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Variables

- A variable is a container that holds some data value.
 - Global variables – defined before the setup function (i.e. not inside any specific function)
 - Local variables – defined within a function
- We store a value in a variable using assignment (=).
 - An assignment statement is of the form: `variable = expression ;`
 - Assignment overrides the previous value stored in the variable.
- p5.js has some variables that are predefined in the language to mean something: `mouseX`, `mouseY`, `width`, `height`, `mouseIsPressed`
- Variables in p5.js have implicit data types. (e.g. Number, Boolean)

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Using Arithmetic

- In general, at any place you can write a number, you can write an arithmetic expression or a function call that evaluates to a number.
- Order of operations:
 - * / % first (as they occur, left to right)
 - + - next (as they occur, left to right)
- Parentheses can override order of operations. (e.g. `(2 + 3) * 4 = 20`)
- Modulo operator:
 - `x % y` (for integers $x > 0$, $y > 0$): Divide x by y and keep the remainder.
 - Examples: `45 % 10 = 5` `8 % 12 = 8`
- Exponentiation:
 - `Math.pow(a,b)` returns a^b

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Mouse and key processing

`mouseX` – contains the current horizontal position of the mouse, relative to (0, 0)

`mouseY` – contains the current vertical position of the mouse, relative to (0, 0)

`mouseIsPressed` – Boolean that is true while the mouse button is pressed down

`mousePressed()` – function that is called when the mouse button is pressed down

`mouseReleased()` – function that is called when the mouse button is released

`key` – contains the current key pressed as a string

`keyIsPressed` – Boolean that is true while a key is pressed down

`keyPressed()` – function that is called when a key is pressed down

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Conditionals (the if/else statement)

- An if statement allows to test a logical condition to determine whether to run some code or not.
- An if-else statement allows to test a logical condition to determine whether to run some code or some other code.
- Logical conditions are expressions that evaluate to true or false.
- General forms for if and if-else:

```
if ( condition ) {
    instruction(s) if true
}
```

```
if ( condition ) {
    instruction(s) if true
} else {
    instruction(s) if false
}
```

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Boolean expressions

- Expressions with the relational operators lead to true or false:

```
x < y    less than
x > y    greater than
x <= y   less than or equal to
x >= y   greater than or equal to
x == y   equal to    (also ===)
x != y   not equal to
```

- Expressions with logical operators lead to true or false:

```
a && b    logical and (true if both a and b are true)
a || b    logical or  (true if either a or b are true)
!a        logical not (true if a is false, and vice-versa)
```

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Boolean shortcuts

```
if (on == true) { ...           if (on) { ...
```

```
if (on == false) { ...         if (!on) { ...
```

```
if (on) {                       on = !on;
    on = false;
} else {
    on = true;
}
```

```
return (on == true);           return (on);
```

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Bounds & Mapping

- `min(num1, num2)`
- `max(num1, num2)`
- `constrain(num, low, high)`
- `map(value, start1, stop1, start2, stop2)`
 - Re-maps a number from one range [start1,stop1] to another [start2, stop2].
- `floor(x)` — returns the greatest integer less than or equal to `x`
- `round(x)` — returns the nearest integer to `x` (a number with .5 rounds up)

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Random values

`random(x, y)`

- Returns a random number between `x` (inclusive) and `y` (exclusive), uniformly.

`random(y)`

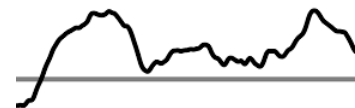
- Returns a random number between 0 (inclusive) and `y` (exclusive), uniformly.

`noise(xoff)`

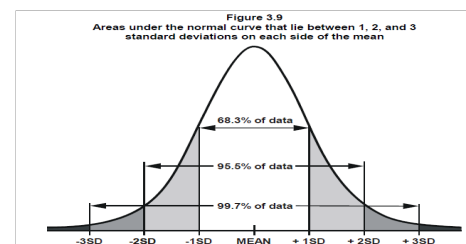
- Returns a random value between 0 and 1 from a Perlin noise function at offset `xoff`.

`randomGaussian(m, sd)`

- Returns a random value so that, over time, the mean is `m` and the standard deviation is `sd`.



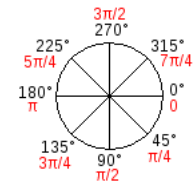
Perlin noise is a random sequence generator producing a more naturally ordered, harmonic succession of numbers compared to the standard `random()` function.



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Transformations

- In p5.js, you can perform a transformation on the canvas to create interesting effects.
- Types of transformations:
 - `translate(x, y)` – Translation (shift horizontally and/or vertically)
 - `rotate(angle)` – Rotation (rotate a certain angle around the origin)
 - `angle` is in radians. Call `radians(d)` to convert degree value `d` to radians.
 - `scale(s)` – Scaling (expand or contract) by factor `s`
- Transformations occur by moving the coordinate system of the canvas, not the object itself.
- `push()` saves the current coordinate system and drawing properties.
- `pop()` returns you back to your previously saved coordinate system and drawing properties.



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for Loop

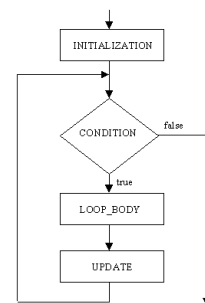
```
for ( loop_initialization ; loop_condition ; loop_update ) {
    code to repeat
}
```

Example:

```
for (var i = 0 ; i < n ; i += 1) {
    // loop body goes here
}
```

This is how programmers typically write a loop that runs `n` times where `i` is the loop counter. (`n > 0`)
 The variable `i` cannot be used outside of the loop since it is defined locally (within the loop structure).
 Loops can be nested:

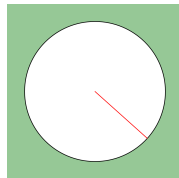
```
for (var row = 0; row < 5; row += 1) {
    for (var col = 0; col < 4; col += 1) {
        ...
    }
}
```



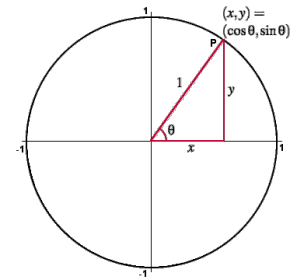
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Polar Coordinates

- You can describe locations in terms of angle and radius (polar coordinates).
- `cos` and `sin` functions tell you X and Y coordinates of a point on a circle of radius 1. The input parameter for `cos` and `sin` is the *angle* (in radians): how far to rotate around the circle. The output is where you land in terms of X (using `cos`) and Y (using `sin`).



```
translate(width/2, height/2);
circle(0, 0, 2*r);
x = r * cos(radians(theta));
y = r * sin(radians(theta));
line(0, 0, x, y);
```



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Arrays

- An array with n elements ($n > 0$) is an ordered collection of values of the same type, indexed from 0 to $n-1$. (ordered does not necessarily mean sorted here)

```
temps = [79, 81, 57, 64, 63, 57, 57]
```

- To access an array, we use “subscript” (index) notation:

```
average = sum / temps.length;
min = temps[0];
for (var j = 1; j < temps.length; j++) {
  if (temps[j] < min) { min = temps[j]; }
}
```

- Methods:
 - `push(element)` — appends element to an array (e.g. `temps.push(73);`)
 - `pop()` — deletes the last element, and returns it
 - `shift()` — returns the first element and shifts the rest down

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Objects

- An object can be defined literally

```
var sqr = {x: 100, y: 100, w: 50, dx: 5,
          r: 255, g: 255, b: 0};
```

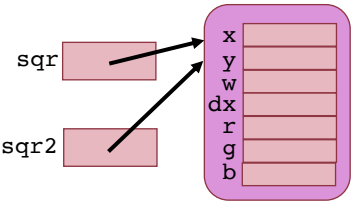
- We can also create objects by construction within our program code.

```
var sqr = new Object();
sqr.x = 100; sqr.y = 100; sqr.w = 50; sqr.dx = 5;
sqr.r = 255; sqr.g = 255; sqr.b = 0;
```

- To access any properties of the object, we use dot notation, listing the object variable name followed by a dot followed by the property (field) of the object.

```
fill(sqr.r, sqr.g, sqr.b);
```

- An object variable points to ("references") its own object.



`sqr2 = sqr;`
sqr2 is an alias.

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Object Methods

```
function tulipDraw() {
  ...
  rect(this.x, this.y - this.height, 10, this.height);
  var y = this.y - this.height;
  ellipse(this.x + 5, y, 44, 44);
  ...
};

function tulipGrow(amount) {
  this.height += amount;
};

function makeTulip(tx, ty, th) {           // constructor
  var tulip = {x: tx, y: ty, height: th,
               show: tulipDraw, grow: tulipGrow}; // new object
  return tulip; // return the new object
};
```

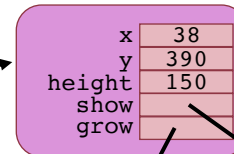
We use the reference `this` to indicate that we are writing a function and we are referencing a property of this object while performing the function.

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Using objects

```
var tulip;
function setup() {
  createCanvas(400, 400);
  tulip = makeTulip(38, 390, 150);
}
function draw() {
  background(207, 250, 255);
  tulip.show();
  text("Press mouse to grow", 10, 20);
};
function mousePressed() {
  tulip.grow(5);
}
```

tulip



```
function tulipDraw() {
  ...
}
```

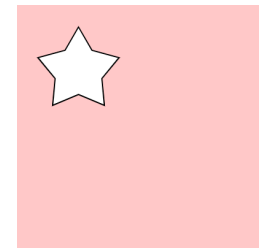
```
function tulipGrow(amount) {
  ...
}
```

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Uses of arrays

Custom Shape

```
var x = [50, 61, 83, 69, 71, 50, 29, 31, 17, 39];
var y = [18, 37, 43, 60, 82, 73, 82, 60, 43, 37];
beginShape();
for (var i = 0; i < nPoints; i++) {
  vertex(x[i], y[i]);
}
endShape(CLOSE);
```



Array of Objects

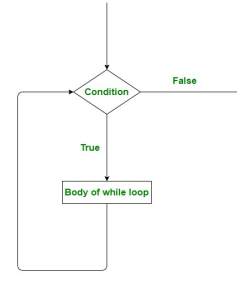
```
var sqr_array = [];
sqr_array[0] = {x: 100, y: 100, w: 50, dx: 5, r: 255, g: 255, b:0};
sqr_array[1] = {x: 50, y: 50, w: 50, dx: 10, r: 0, g: 255, b:255};
fill(sqr_array[0].r, sqr_array[0].g, sqr_array[0].b);
square(sqr_array[0].x, sqr_array[0].y, sqr_array[0].w);
```

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while Loop

```
while (condition) {
    loop body
}
```

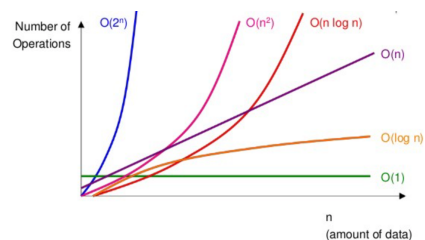
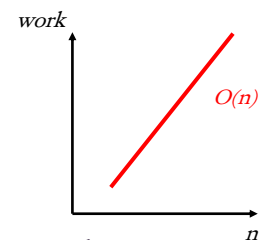
```
function linear_search(arr, element, index) {
    if (index < 0 || index >= arr.length) return -1;
    var i = index;
    while (i < arr.length) {
        if (arr[i] == element) return i;
        i++;
    }
    return -1;
}
```



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Big O

- We say linear search is $O(n)$ in the worst case.
 - All algorithms in this class do an amount of work linearly proportional to the number of data values (n).
 - If an algorithm is $O(n)$, then if we double the number of inputs/elements, then we can expect twice as much work, approximately.
- If an algorithm is $O(n^2)$ (a quadratic algorithm), then if we double the number of data values, we can expect $4 = 2^2$ times as much work.
- Comparing algorithms: When n is small, the algorithm you pick doesn't really matter. But when n is large, it matters!

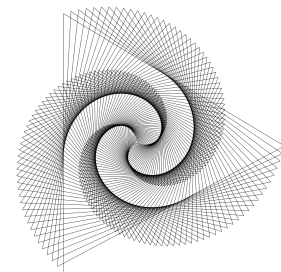


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Turtle Graphics API

- `makeTurtle(x, y)` -- make a turtle at x, y, facing right, pen down
- `left(d)` -- turn left by d degrees
- `right(d)` -- turn right by d degrees
- `forward(p)` -- move forward by p pixels
- `back(p)` -- move back by p pixels
- `lowerPen()` -- set pen down
- `raisePen()` -- pick pen up
- `goto(x, y)` -- go straight to this location
- `setColor(color)` -- set the drawing color
- `setWidth(w)` -- set line width to w
- `face(d)` -- turn to this absolute direction in degrees
- `angleTo(x, y)` -- what is the angle from my heading to location x, y?
- `turnToward(x, y, d)` -- turn by d degrees toward location x, y
- `distanceTo(x, y)` -- how far is it to location x, y?

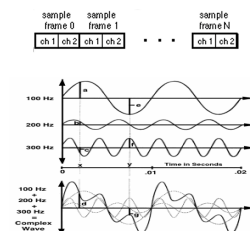
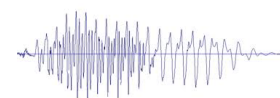
An Application Programmer's Interface (API) is a view of the methods (functions) of the object without seeing the details. The programmer can use the object just by knowing how to call the methods and what they return.



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Sound

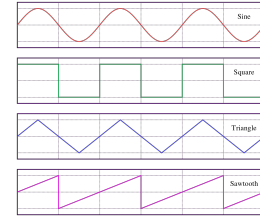
- Audio signals are essentially vibrations that travel through the air (and other materials) creating changes in pressure.
- The accuracy of the digital audio sequence compared to the original analog audio signal increases with increased sampling rate, and increased bits per sample.
 - e.g. CD audio: 44,100 Hz, 16 bits/sample (2^{16} sound levels), 2-channel audio
- Multichannel sound interleaves samples in a sound data file.
- To capture a frequency of X, you must sample the signal at a sample rate of $2X$. (sampling theorem)
- A sound made up of a set of harmonic sinusoids at varying amplitudes and phases, summed together.



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p5.Oscillator

- Creates a signal that oscillates between -1.0 and 1.0.
 - By default, the oscillation takes the form of a sinusoidal shape ('sine').
 - The frequency defaults to 440 oscillations per second (440Hz).
 - `start()` Start an oscillator.
 - `stop()` Stop an oscillator.
 - `amp()` Set the amplitude between 0 and 1.0.
 - `freq()` Set frequency of an oscillator to a value.
 - `setType()` Set type to 'sine', 'square', 'triangle', or 'sawtooth'.



```
function soundSetup() {
  myTone = new p5.Oscillator();
  myTone.setType('sine');
  myTone.freq(880);
  myTone.start();
}
```

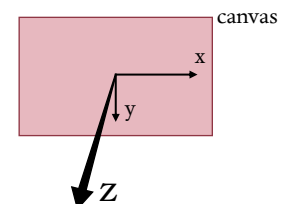
```
function draw() {
  myTone.amp(mouseX / width);
  myTone.freq(200 + 1000*(mouseY / height));
}
```

↔ Volume Pitch ↑↓

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Drawing in 3D

- The origin in WebGL is in the center of the canvas by default.
 - x increases left to right (as before)
 - y increases top to bottom (as before)
 - z increases toward us. (by default, the canvas is the z=0 plane)
- `createCanvas(400, 250, WebGL);`
- Camera views: perspective, orthographic
- 3D Shape Primitives (center is at origin):
 - `box(width, height, depth);`
 - `sphere(radius);`
 Use transformations to place shapes in scene.
- Lighting: ambient, directional, point
- Materials: basic, normal, ambient, specular



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Code Style

- Comments help explain parts of your code to the reader

```
fill (255, 255, 255); // this is a comment (to the end of the line)
/* this is a comment
   over several lines */
```

- Indentation shows code that is “inside” other code.
 - Examples: the body of a function, the body of a loop, nested code.
 - Typically a left bracket { increases indentation and a right bracket } decreases it.
- Functions compartmentalize the code into individually managed units which can be debugged/managed separately.
 - Functions manage complexity of your code by “hiding” finer details to help the programmer focus on the overall design task.