

Lesson 1

What is a Program?



Computers can do nearly anything you could imagine. They can play video games, play songs and movies, browse the internet, let you talk to people around the world, and even send people into space!

You might think that computers are very smart, but actually they aren't. In fact, a computer on its own can't do *anything*. It needs a **program** to tell it what to do.

What does a program look like?

You can touch a computer and pick it up, but programs aren't things you can touch and hold. Instead, they are instructions that are written down and saved inside the computer as files.

Programs are made up of instructions that are written in a way the computer can understand, and are written in English. It's a weird kind of English, though... it might look a little like this:

```
ellipse(10,10,10,10);
```

This is what a **programming language** looks like. Don't worry if that makes no sense right now! We will figure out what it means very soon.

Why should we learn to program?

There are so many programs out there, so why would we want to make our own?

There are many reasons to learn programming, but the main reason is that programmers can use computers to do whatever they want. Computers are really powerful!

Let's say you have an idea for a game that you've never seen before. If you know how to write a program you can make it! Want to build a robot pet that follows you around? You will need to

write a program to make that! Programming can also help you do amazing things with art, music, math, history, science, and more.

Programming is also a really cool job. Most programmers can work anywhere in the world, and a lot of companies are looking for people that can help them make their programs.

Exercise:

Think of something you would like to make a program for. It could be a game, something to help you talk to friends, a program that helps you do your homework, a website for your favorite hobby, or anything else!

Making a peanut butter sandwich

Every program is made up of a bunch of instructions that the computer reads and follows. Computers need step-by-step instructions, and we need to be very careful with how we write them. Unlike humans, computers can't guess what we mean, so we must be very clear.

Let's pretend we want to write a program that tells the computer how to make a peanut butter sandwich.



🍏 Exercise:

Pretend your computer has hands. What instructions would you give the computer to make a peanut butter sandwich?

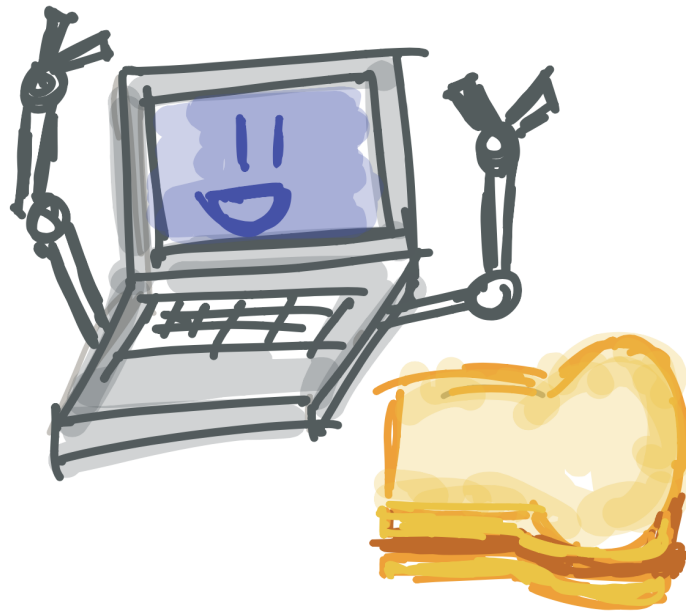
Let's say you asked your friend to make you a peanut butter sandwich but they don't know how to make one. You might tell them something like this: *"Take some bread and put peanut butter on it"*.

If your friend hears this, they could probably understand what to do, but a computer won't. Instead, it would look like this:



When we write a computer program, we need to be way more clear. Our program might look something like this:

1. Take two pieces of bread out of the bag
2. Open the peanut butter container
3. Pick up a knife, put it in the peanut butter
4. Spread the peanut butter on the bread slices
5. Put the knife away
6. Put the two pieces of bread together

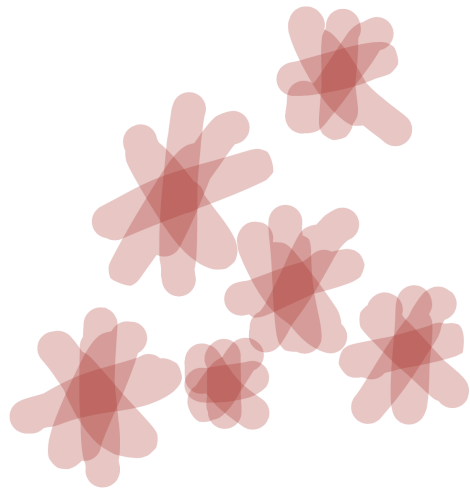


As you can see, our programming instructions need to be very clear. This can be a little hard to get used to at first, but don't worry! Our first programs will be very simple.

Enough chit-chat, let's try to write a program!

Lesson 2

Opening Processing

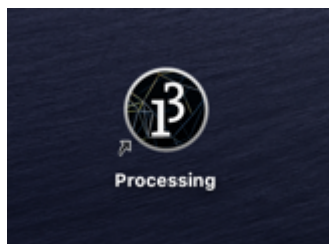


We will be using a program called **Processing** to create our programs. Before we can make anything, we need to open Processing.

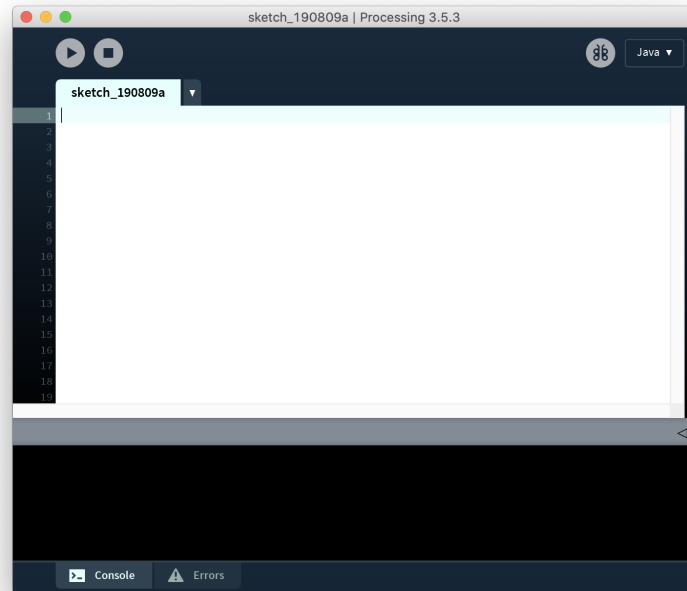
 **Tip:**

Wait, we're using a program to write our program? Believe it or not, every program is made using another program. Makes you wonder how the very first programs were made!

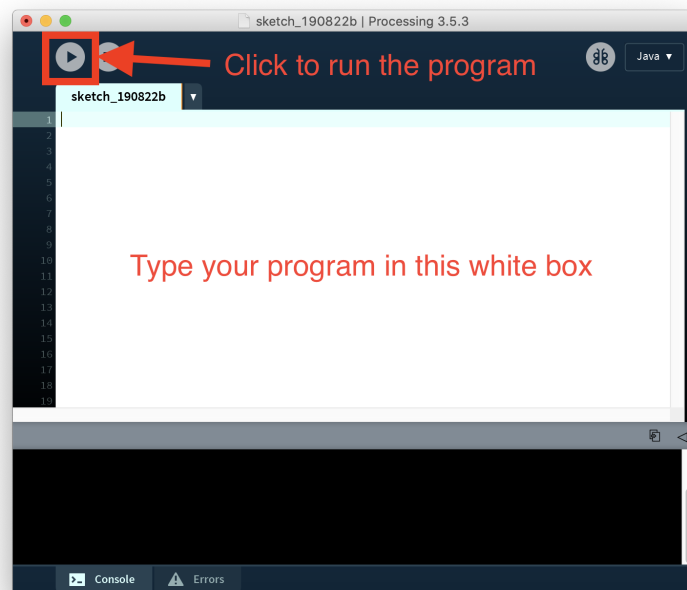
Look for the "Processing" icon on the desktop. It should look like this:



Double click on the icon to open Processing. Once it has loaded, you should see the **Processing** text editor on your screen:



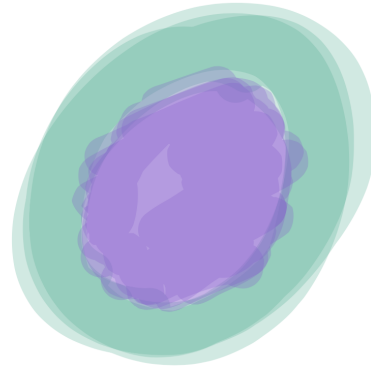
We use **Processing** to write our own programs. To write a program, we click on the white area and type our instructions. Once we have finished writing our program, we click on the ► Play button to run it:



We are now ready to start making our first program!

Lesson 3

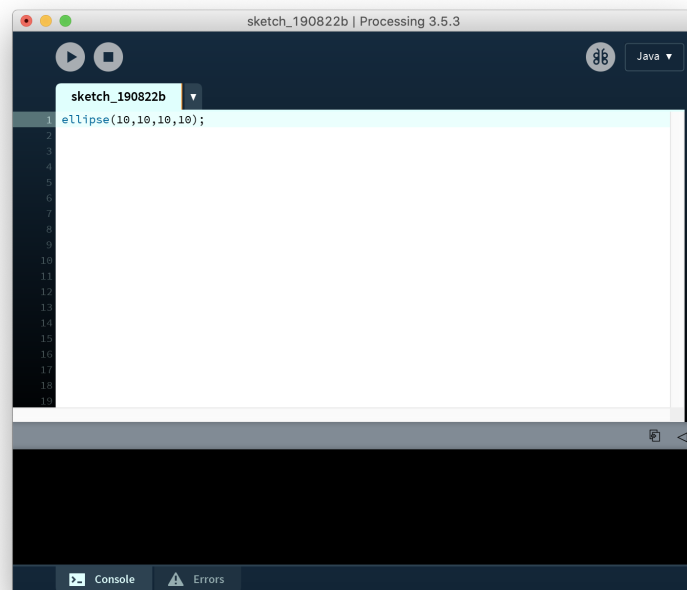
Writing our first program



Let's write our first program! Type the line below into the Processing text editor:

```
ellipse(10,10,10,10);
```

You should see this on your screen:



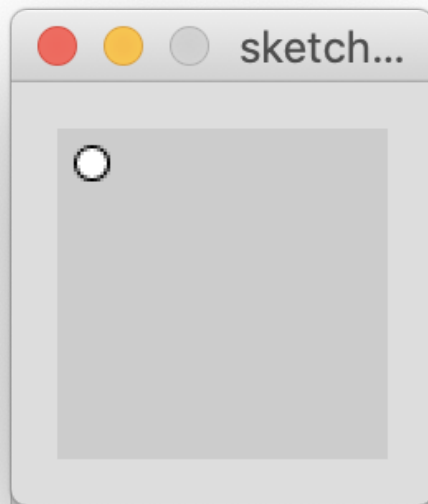
Tip:

If you are typing and nothing shows up, make sure the text editor is *focused* by clicking your cursor anywhere on the white part (this is the text editor) to select it. You should now be able to type into it.

Let's run your program! Click on the ▶ Play icon on the top of the Processing window:



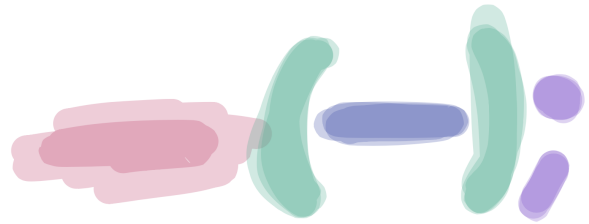
You should see a new window with a circle in it:



🎓 *Congratulations!* You just wrote your first program.

Lesson 4

Parts of an instruction



Our simple program...

```
ellipse(10,10,10,10);
```

...may not make any sense to us right now, but let's try to figure out what we just wrote.

The computer does not know what we want to do unless we give it instructions. The line we just typed is an instruction that tells it to draw an `ellipse` (ellipses are round shapes like circles or ovals).

Great! Now the computer knows we want to draw an `ellipse`, but we still need to give it more instructions! If we didn't, it wouldn't know how big to make our circle or where to put it. Computers don't like guessing!



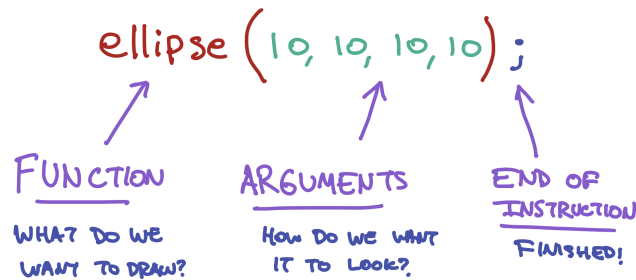
DIFFERENT TYPES OF ELLIPSIS
HOW DO WE TELL THE COMPUTER
WHICH ONE WE WANT?

That's where the second part of our instruction comes in - the numbers that look like `(10,10,10,10)`. In programming, we call these *arguments*, but they are just part of the instruction that tells the program where to put the circle and how big to make it.

Finally, we need to tell the program that we are finished giving it an instruction. You might use a period when you are writing a sentence, but computers use a different letter - the semicolon:

`;`. It's a weird letter, but that's what we use to tell programs we are finished with our instructions.

So, what did we do when we wrote this line? We gave the program a *function* (draw an `ellipse`), a bunch of *arguments* `(10,10,10,10)`, and then told it we are finished with our instruction `;`



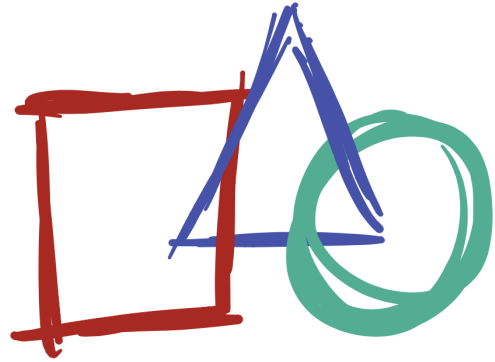
We don't know what the numbers do yet, but let's try changing them! Change the numbers to something different (but keep each number under 100 for now), then click the Play button. What happens to your circle?

Exercise:

Try changing the numbers to something else like (30,25,32,48), then click Play. What happens to your circle? Try changing the number a few times!

Lesson 5

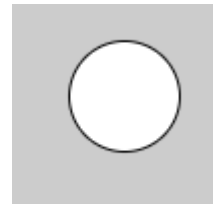
Drawing more shapes



We just drew a circle with the `ellipse` function, but there are so many other types of shapes we can draw.

`ellipse()`

Draws an ellipse (oval) to the screen

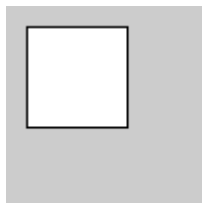


Rectangles and Squares

Let's make a square! Press the 'Backspace' key until all of your code is removed, and then type the line below:

```
rect(10,10,50,50);
```

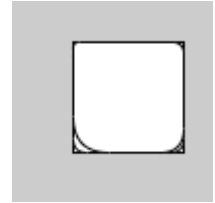
Now press the **▶ Play** button. You should see this on your screen:



This program looks a lot like our first program, but we replaced the `ellipse` function with the `rect` function. We have now told the computer we want to draw a rectangle instead of a circle.

rect()

Draws a rectangle to the screen



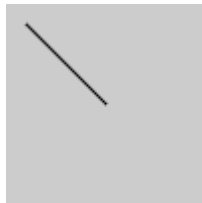
Lines

Let's try a different function. Replace the `rect` function with `line`.

Your program should look like this:

```
line(10,10,50,50);
```

Now press the **▶ Play** button. You should see this on your screen:



line()

Draws a line (a direct path between two points) to the screen



Triangles

Let's try drawing a triangle! Press the 'Enter' key, then type the line below:

```
triangle(50,50,20,90,80,90);
```

Your program should look like this:

```
line(10,10,50,50);  
triangle(50,50,20,90,80,90);
```

Now press the **▶ Play** button. You should see this on your screen:



We just did a couple of interesting new things! All of the *functions* we have written until now have four numbers, but the *triangle function* has six! Some functions - like *triangle* - need more information than others.

triangle()

A triangle is a plane created by connecting three points



The other thing we just did is we wrote a program that has two instructions. When we run the program, the computer will first create a *line* and then create a *triangle*. This is why we need to type the `;` semicolon at the end of each instruction, so the computer knows when to start the next instruction. You would think it could figure this out every time you type a new line, but computers aren't very smart.

We've tried a bunch of functions, but each one of them has these weird numbers like `(10, 10, 10, 10)` next to it. What do those mean? Let's look at that next.

Lesson 6

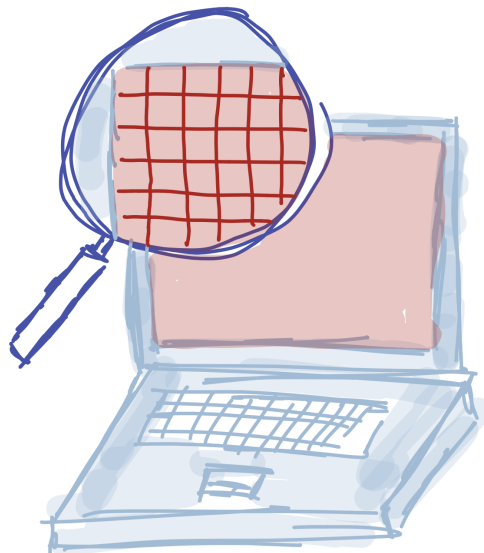
Placing things on the screen



So far, we've written a number of *functions* - like `ellipse` - with a bunch of numeric *arguments* - such as `(10,10,10,10)` - that tell the program where to put the shapes and how big to make them. But what do these numbers mean?

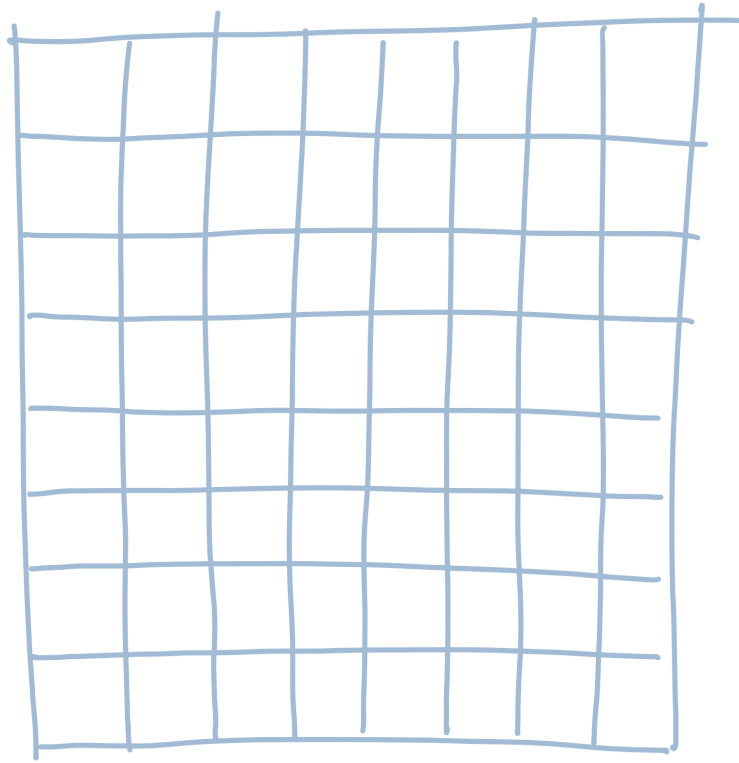
The screen you see in front of you is made up of millions of teeny, tiny lights. When we write a program, we tell the computer what to do with these lights. But in order to do this, we need a way to tell the computer *which* lights we want to control.

If you hold a magnifying glass in front of a screen, you will see that it looks a little bit like this:

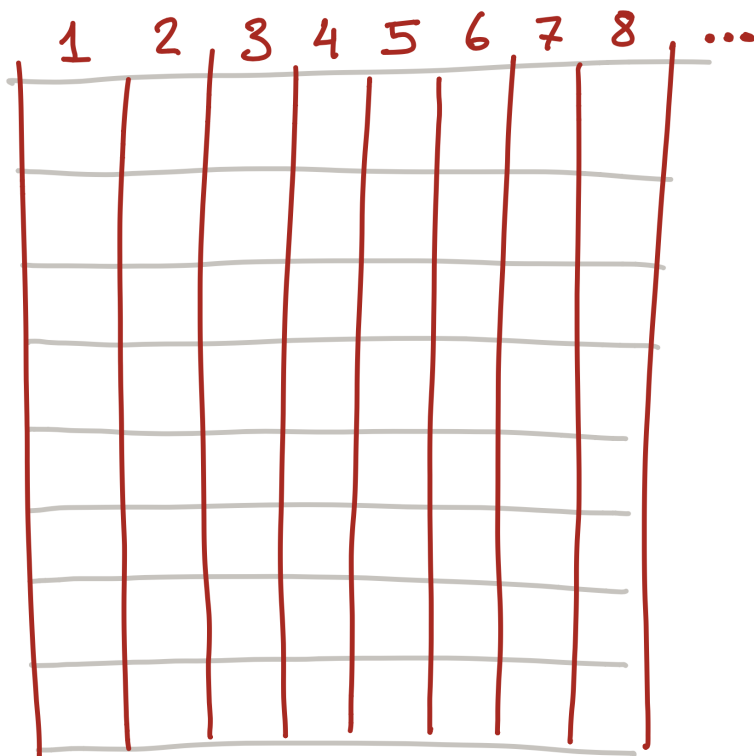


A COMPUTER SCREEN HAS
MILLION OF LIGHTS, CALLED PIXELS

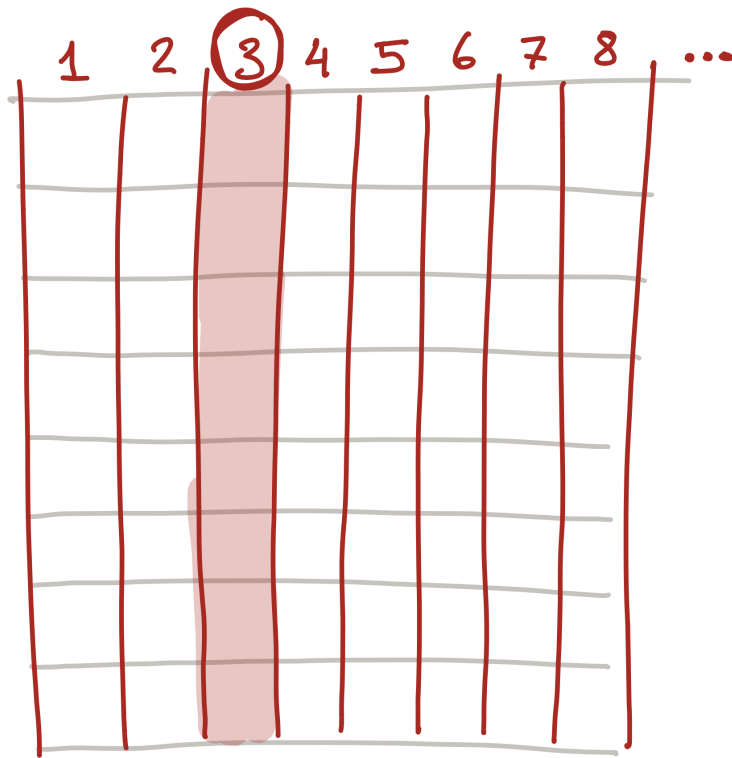
One way to think of a screen is like a graph paper:



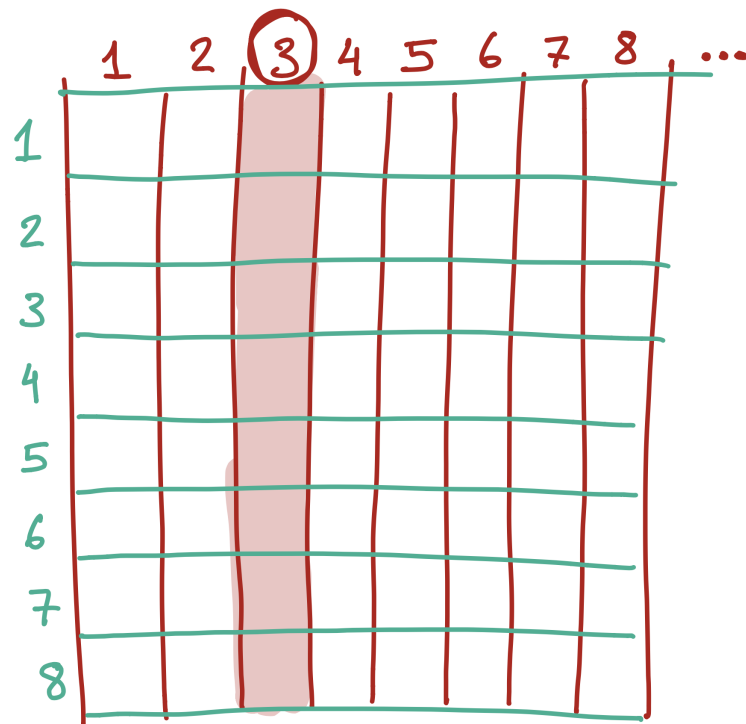
We need to pick a number for each light. The easiest way to do this (and the way programs do it) is by starting from the left side of the screen and giving the first column the number 1. We give the second column the number 2. The third is 3, and so on. So it looks a bit like this:



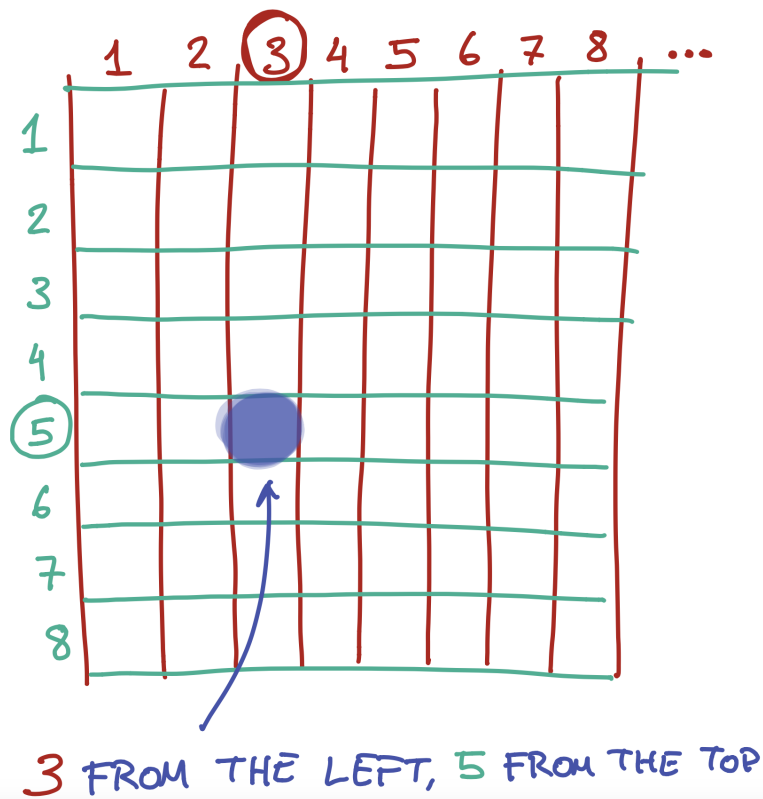
But this isn't quite good enough! We can pick the column we want to control, such as column 3:



But what if we want to control a specific light? To do this, we also number each row starting from the top:



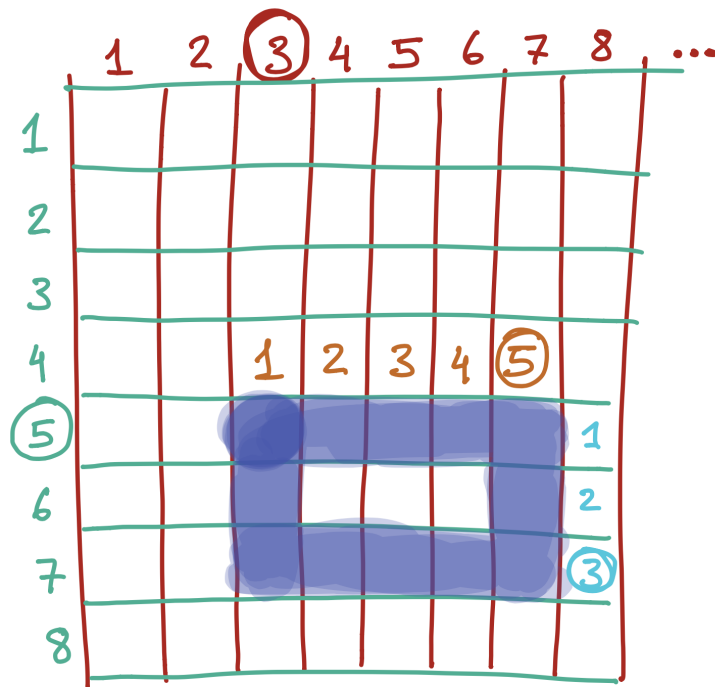
So each light actually has two numbers - the column and the row. So, the number in black below...



..is in the 3rd column from the left, and the 2nd column from the top.

To do this, we give each light a number. Actually, we give it two - a number from the left, and a number from the top. To figure out the number for each light, we start from the top left side of the screen. The light at the top left

We can also use the same numbers to tell the computer how wide or tall to make something. So, for example, you could say **"draw a rectangle that starts from the 3rd light on the left and the 5th light on the top, and make it 5 lights wide and 3 lights tall"**.



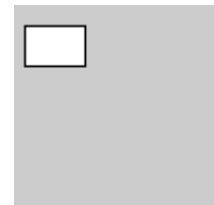
3 FROM THE LEFT, 5 FROM THE TOP,
5 WIDE, 3 TALL

This is exactly what we do when we write the following instruction:

Code:

```
rect(5, 10, 30, 20);
```

Preview:

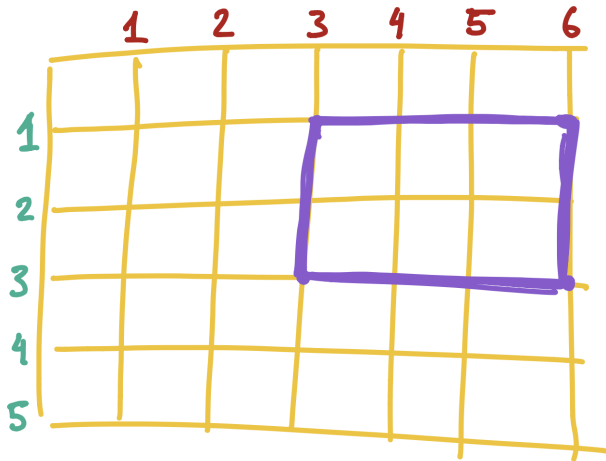


The four *arguments* we give the `rect` function are instructions on where to start the rectangle on the left and top, and how wide and tall to make it:

`rect(left, top, width, height);`

🍏 Exercise:

What would the four (left, top, width, height) arguments for this rectangle be?

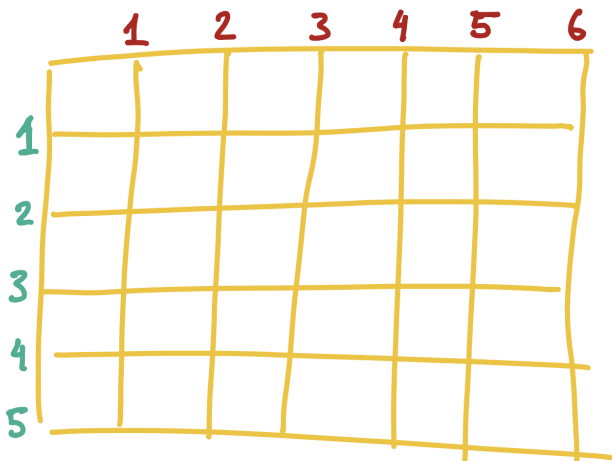


rect (, , ,);
HINT: LEFT, TOP, WIDTH, HEIGHT

🍏 Exercise:

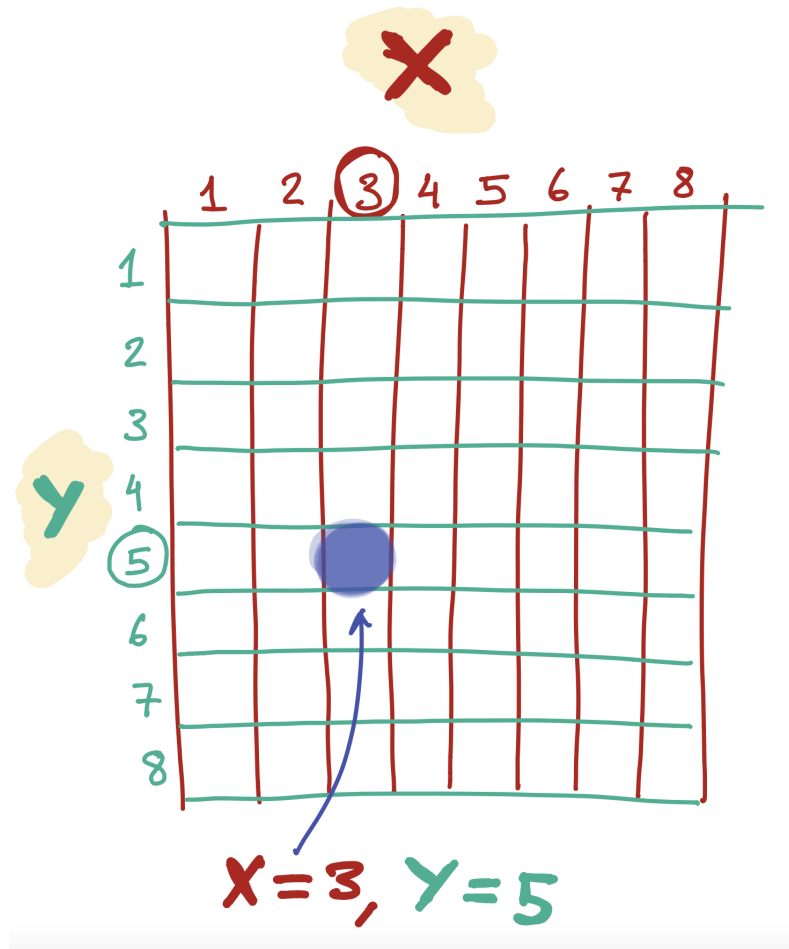
Draw your own rectangle on the graph paper below, then write the *rect* function that would

create it.



rect (, , ,);
HINT: LEFT, TOP, WIDTH, HEIGHT

We generally don't use the words *left* and *top* when we are talking about where something is on the screen. Instead, we normally use the letter **x** to talk about the left-to-right part and **y** to talk about the top-to-bottom part:



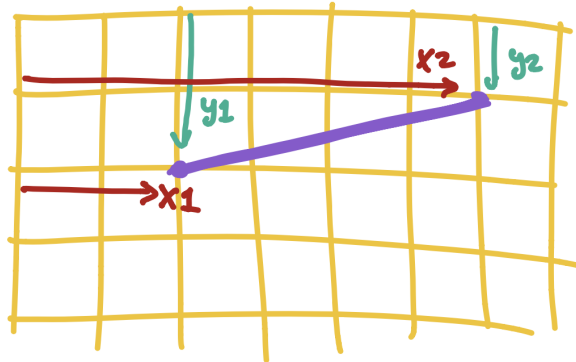
If you've done any math homework with shapes, you may have seen these letters before!

Placing a line on the screen

The *line* function is a little different from the *rect* function. To draw a line, we pick two points on the screen and tell the computer to make a line from one to the other.

The first two arguments are the left & top values for the first point - we generally call this **x1** and **y1**. The next two arguments are the left & top values for the second point - we generally call this **x2** and **y2**:

```
line ( x1, y1, x2, y2 );
```

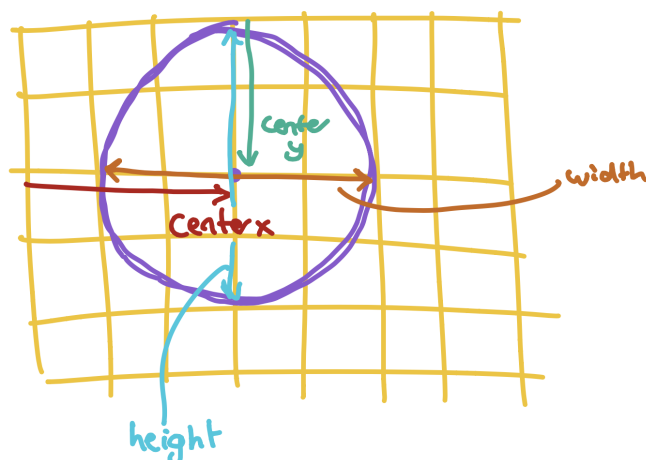


Placing an ellipse/circle on the screen

The *ellipse* function is a little different, because it doesn't have a top and left point - circles don't really have an edge we can use for this!

Instead, we tell the program where to put the middle of the circle from the left and top of the screen (we call this **center x** and **center y**), as well as how wide and tall to make it:

```
ellipse ( center x, center y, width, height );
```

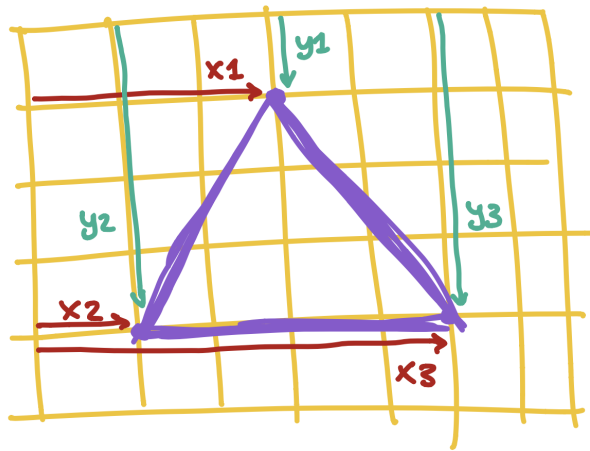


Placing a triangle on the screen

The *triangle* function is the weirdest! Triangles have three points, and so we need to tell the program where to put each of them.

The first two arguments tell the program where to put the first point from the left and top of the screen (we call this **x1** and **y1**), the second two arguments tell us where to put the second point from the left and top of the screen (we call this **x2** and **y2**), and the last two arguments tell us where to put the third point from the left and top of the screen (we call this **x3** and **y3**):

```
triangle (x1, y1, x2, y2, x3, y3);
```



Tip:

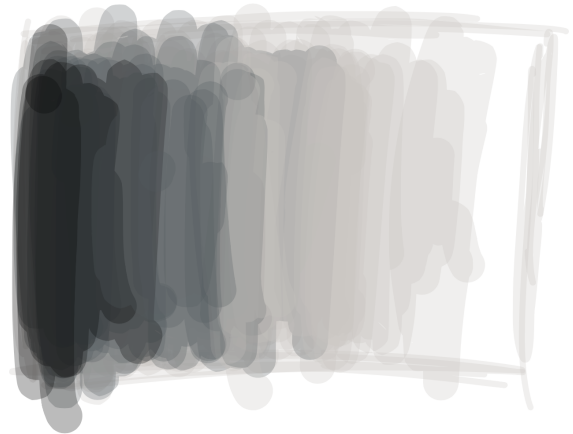
Don't worry if you are having a hard time figuring out which numbers to write down! A lot of programmers don't know what they are doing when they type in the numbers. You can always try random numbers until you find something that looks like what you want. The more you play around, the more your brain will be able to guess what the numbers should be..

Exercise:

Create a program that draws a face on the screen. You will need to draw two circles - one for each eye - and a rectangle for the mouth. If you want, you can also draw a triangle for the nose!

Lesson 7

Black, White, and In Between



So far, all of our shapes have looked pretty boring. Let's learn how we can add some color to them!

When we talk about colors, we use words like 'red' and 'pink', but computers don't know what these words mean. Instead, we have to use numbers to tell the computer what color to use. We pass these numbers as *attributes* to the a new *function* called `fill()`, which fills the middle of the shape with the color we give it.

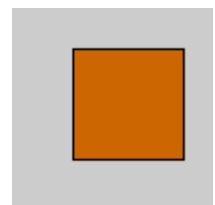
Let's take a look at how we do this. Type the following line at the top of your program:

```
fill(0);
```

We are telling the program to run the *function* `fill` with an *attribute* of `0`.

fill()

Sets the color used to fill shapes



If you just drew a face at the end of the previous lesson, your code might look a little bit like this:

Code:

```
fill(0);  
ellipse(25,30,30,30);  
ellipse(75,30,30,30);  
rect(20,60,60,20);
```

Preview:








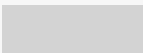

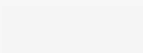

When we typed `fill(0);` at the top of the program, we told the computer to `fill` all of the shapes after it with a color of `0`. The color `0` is black, so the eyes and mouth will now look black.

Tip:

We have to tell the program which color to pick *before* we draw any shapes, kind of like how you need to pick a color before you draw something on a piece of paper. If your face's color is still white, make sure that you put the *fill* function at the top of the program.

Colors are expressed as numbers from 0 to 255. The number 255 might sound like a strange one to pick (why not 100?), but it's a quirk with how computers store numbers. You will see the number 255 quite a lot when you write programs!

The color 0 is black, and the color 255 is white. Every color between white and black has a number between 0 and 255. Here is what some of these numbers look like:

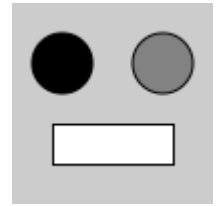
Color	Number	Code
 Black	0	<code>fill(0);</code>
 Dim Gray	105	<code>fill(105);</code>
 Gray	128	<code>fill(128);</code>
 Dark Gray	169	<code>fill(169);</code>
 Silver	192	<code>fill(192);</code>
 Light Gray	211	<code>fill(211);</code>
 Gainsboro	220	<code>fill(220);</code>
 White Smoke	245	<code>fill(245);</code>
 White	255	<code>fill(255);</code>

Let's try changing the program so that we have different colors for each part of the face:

Code:

```
fill(0);  
ellipse(25,30,30,30);  
fill(130);  
ellipse(75,30,30,30);  
fill(255);  
rect(20,60,60,20);
```

Preview:



Exercise:

Change the color of the face you made in your last program. You can make it black, white, or anything in between.

Lesson 8

Color



We've looked at making things black and white, but that's pretty boring. How do we make things actually look colorful?!

So far, we've been using the `fill` function with one attribute:

```
fill( grayscale );
```

But `fill` can also take three attributes, with numbers between 0-255 for red, green, and blue:

```
fill( red, green, blue );
```



The way we make colors is by mixing red, green, and blue values.


If we wanted to make red, we would give it a `(red, green, blue)` value of `(255, 0, 0)`. This tells the program to make the color as red as possible (255), and no green (0) and no blue (0).

To make green, we would give it a `(red, green, blue)` value of `(0, 255, 0)`: no red, as much green as possible, and no blue.

To make blue, we would give it a `(red, green, blue)` value of `(0, 0, 255)`: no red, no green, and as much blue as possible.

So to make red, green, and blue, we would type these lines:

Color	Red	Green	Blue	Code
 Red	255	0	0	<code>fill(255, 0, 0);</code>
 Green	0	255	0	<code>fill(0, 255, 0);</code>

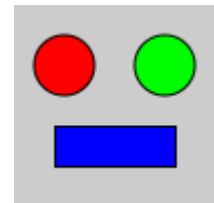
Color	Red	Green	Blue	Code
 Blue	0	0	255	<code>fill(0,0,255);</code>

Here's what this might look like in a program

Code:

```
fill(255,0,0);
ellipse(25,30,30,30);
fill(0,255,0);
ellipse(75,30,30,30);
fill(0,0,255);
rect(20,60,60,20);
```







Preview:








Tip:

Don't worry if its hard to guess which *attributes* to type to get the color you want. Most programmers don't know what numbers to type, and use a reference guide to tell them what to type in. You can also experiment by typing different numbers for each attribute until you get a color you like!

When you are painting, you can mix red, green, and blue together to make different colors. The same thing happens in programs too. Here are some common color mixtures:

Color	Red	Green	Blue	Code
 Yellow	255	255	0	<code>fill(255,255,0);</code>
 Cyan	0	255	255	<code>fill(0,255,255);</code>
 Fuchsia	255	0	255	<code>fill(255,0,255);</code>
 Purple	128	0	128	<code>fill(128,0,128);</code>
 Navy	0	0	128	<code>fill(0,0,128);</code>
 Crimson	220	20	60	<code>fill(220,20,60);</code>

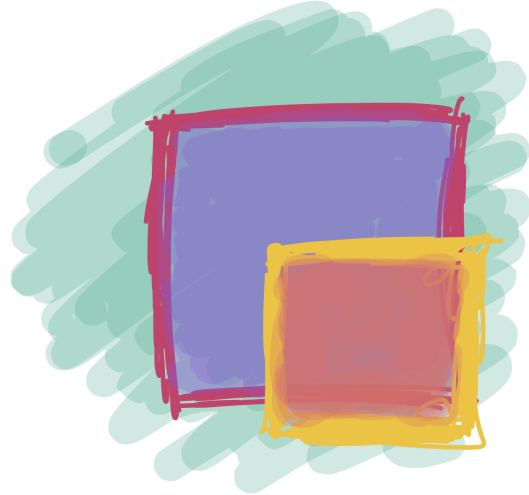
Color	Red	Green	Blue	Code
 Gold	255	215	0	<code>fill(255,215,0);</code>
 Deep Pink	255	20	147	<code>fill(255,20,147);</code>
 Wheat	245	222	179	<code>fill(245,222,179);</code>
 Steel Blue	119	196	222	<code>fill(119,196,222);</code>
 Sea Green	46	139	87	<code>fill(46,139,87);</code>

 **Exercise:**

Change the color of your face so that it is your favorite color. You can use one of the colors from the table above, or try typing in different numbers until you find a brand new color you like!

Lesson 9

Fill, Stroke, and Background



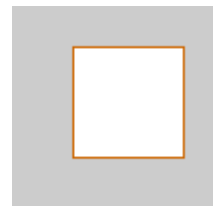
We've been able to change the color of our shapes, but did you notice that they always have a black border around them? What if we want to change that?

Luckily, there's another *function* that can help us with this. It's called `stroke`, and it works a lot like `fill`; the only difference is that it changes the color of the border instead of the center:

```
stroke(red, green, blue);
```

`stroke()`

Sets the color used to draw lines and borders around shapes

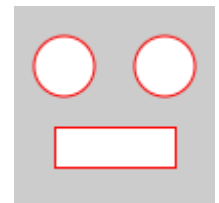


So, if we wanted to make a face with red lines we might type something like this:

Code:

```
stroke(255,0,0);  
ellipse(25,30,30,30);  
ellipse(75,30,30,30);  
rect(20,60,60,20);
```

Preview:



What if we want to change the background? Turns out there is another *function* for that as well, called `background`. It also works just like `fill` and `stroke`, but it changes the color of the entire background.

background()

The background() function sets the color used for the background of the Processing window



So, if we wanted to make a face with a purple background, we might type something like this:

Code:

```
background(255,0,255);  
ellipse(25,30,30,30);  
ellipse(75,30,30,30);  
rect(20,60,60,20);
```

Preview:



Lesson 10

Variables



Until now, we have always typed the numbers for our *attributes* directly, like this:

```
fill(255);
```

But in most programs, we don't do this. Instead, we usually use something called a *variable*. When you write a *variable*, you can think of it as the computer remembering a number for you. When you want, you can ask the program to write the number back. Here's how the same program looks with a *variable*:

```
int color = 255;  
fill(color);
```

When we create a variable, we pick a name. We can give a variable any name we want, but it should only have letters - no numbers or spaces. Names are normally uncapitalized (e.g. `age` instead of `Age`), which might make your English teacher upset but makes programmers happy.

Not being able to use spaces is annoying, but there are a few ways we can deal with this. If we want to use a name with multiple words, such as `My Favorite Color`, we either use Capital Letters to indicate the words: `myShoeSize`, or we use the underscore (`_`) letter: `my_shoe_size`. Either option works, so it comes down to which one you find prettier.

Here's what some variables might look like:

```
int color = 255;  
int myFavoriteColor = 255;  
int age = 15;  
int shoe_size = 8;
```

Why do we need variables?

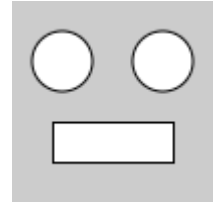
Variables are incredibly useful for a whole bunch of reasons, but for now we are going to focus on just one of them. Putting a number into a variable makes it really easy to change parts of your program quickly.

For example, let's take a look at the face we drew before:

Code:

```
ellipse(25,30,30,30);  
ellipse(75,30,30,30);  
rect(20,60,60,20);
```

Preview:

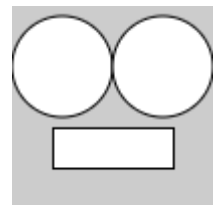


If we wanted to make the eyes bigger - say from size 30 to 50 - we would need to change every spot where we typed 30:

Code:

```
ellipse(25,30,50,50);  
ellipse(75,30,50,50);  
rect(20,60,60,20);
```

Preview:

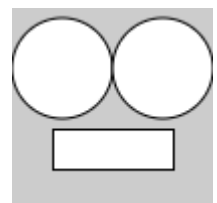


That's a lot of typing! But if we create a *variable* to store our eye size, we only need to type the number once:

Code:

```
int eyeSize = 50;  
ellipse(25,30,eyeSize,eyeSize);  
ellipse(75,30,eyeSize,eyeSize);  
rect(20,60,60,20);
```

Preview:

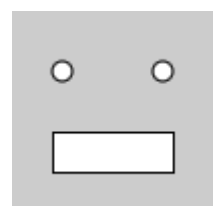


Now that we've done it this way, we only need to change one number and both eyes will look different. Let's try changing the size from 50 to 10:

Code:

```
int eyeSize = 10;  
ellipse(25,30,eyeSize,eyeSize);  
ellipse(75,30,eyeSize,eyeSize);  
rect(20,60,60,20);
```

Preview:



Calculating different numbers from our variables

We can also do math with our variables (eww, math!!) This means that we can write one number as a variable, and calculate a few numbers from it.

Let's say we're not sure how far our face should be from the left side of the screen. Rather than having to figure out where each eye and the mouth should be every time we want to make a change, we can create one variable called

```
int left = 20;
```

...and calculate the left side of each eye and the mouth from it. So, the left-most eye would change from..

```
ellipse(25,30,eyeSize,eyeSize);
```

... to ...

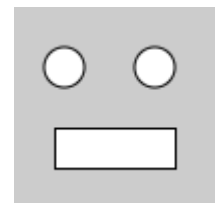
```
ellipse(left + 5,30,eyeSize,eyeSize);
```

If we do the same thing for the other eye and the mouth, we get something that looks like this:

Code:

```
int eyeSize = 20;
int left = 20;
ellipse(left + 5,30,eyeSize,eyeSize);
ellipse(left + 50,30,eyeSize,eyeSize);
rect(left,60,60,20);
```

Preview:

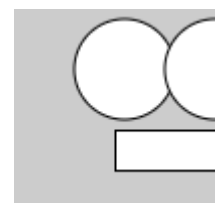


Now let's say we want to change the size of the eyes and the location of the face. We can do this by just changing the value of the two variables

Code:

```
int eyeSize = 50;
int left = 50;
ellipse(left + 5,30,eyeSize,eyeSize);
ellipse(left + 50,30,eyeSize,eyeSize);
rect(left,60,60,20);
```

Preview:



 **Exercise:**

Create a new variable called *top*, which determines where the top of the face will start. Update each eye and the mouth so their *top attribute* uses a calculation based on the *top* variable.
