The Absolute Beginner's Guide To Coding Using Scratch

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Why Learn To Code?

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All About MLogo

Have you ever wondered how websites are built, how video games are created, or how apps for smartphones are designed?

They were all made with a programming language, which is a special language that allows people to communicate with computers.

What is Scratch?
One of the many programming languages available is Scratch. People like to program with Scratch because it is easy to get started. Scratch is a visual programming langague, which means you will be able to quickly figure out how make the computer perform complex tasks.

When you write a program in Scratch, you are making a list of instructions for the computer to follow. A computer's job is to follow instructions. In fact, a computer follows millions of instructions every second.

Your job is to learn how to communicate with the computer so it will follow your instructions. Don't worry, learning how to code is not hard at all, and you will soon be well on your way to creating your own computer programs.

Getting Scratch

Scratch is a free programming language that runs over the internet. You can program in Scratch from your home computer by visiting the Scratch website at:

https://scratch.mit.edu

Scratch requires Adobe Flash to run on Macs, Windows, and Linux. You can get Flash at:

https://get.adobe.com/flashplayer

If Scratch does not work on your computer, you can use a very similar language called Snap!, which also runs over the internet but does not require Flash.

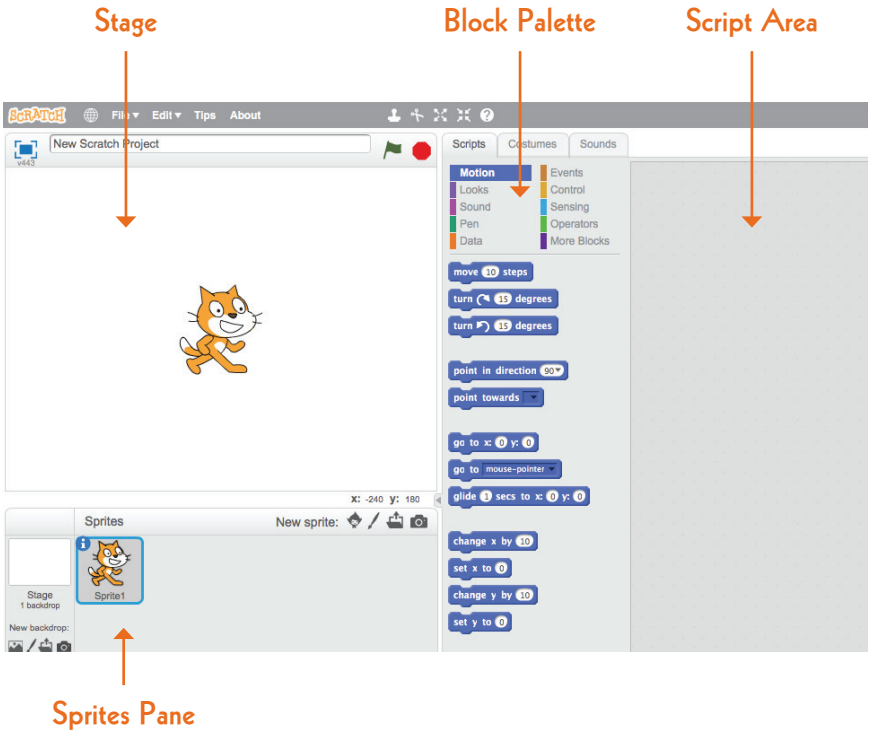
http://snap.berkeley.edu

Snap! is almost identical to Scratch and most of the programs you write in this book will work in either language.

Create Your First Program

02

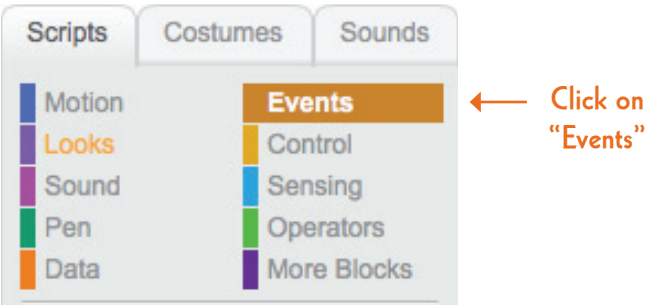
Go to the Scratch website and click the ***Create*** menu item at the top of the web page. When you first open Scratch you will see something similar to the sketch below.



One of the first thing you will notice is that there is a picture of a cat in the middle of the stage area. The cat is called a sprite. A sprite is an object that performs actions in the program. You can change your sprite's image by clicking on the ***Constumes Tab*** in the ***Block Palette***.

Making a program in Scratch is a snap because everything we want to tell the computer to do can be made by fitting together the command blocks. For our first program we will make the cat say "Hello World."

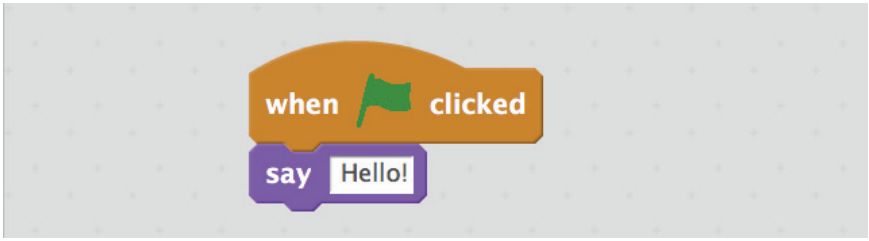
Step 1) The first thing we need is a way to start the program running. Click on ***Events*** in the block palette.



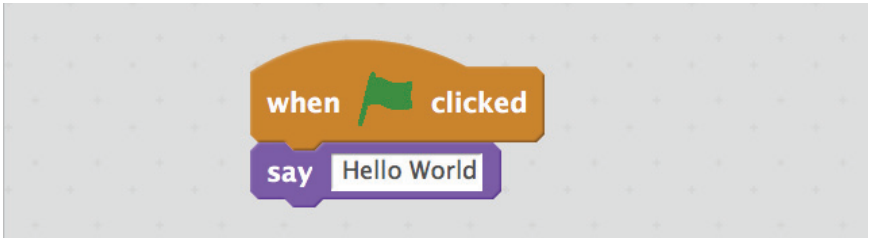
Step 2) This will reveal a the event command blocks. We would like the program to start running whenever the green flag above the stage area is clicked. Drag the when flag clicked block into the script area.

Step 3) Next, click on ***Looks*** in the block palette. Drag the say block into the script area, connecting it to the

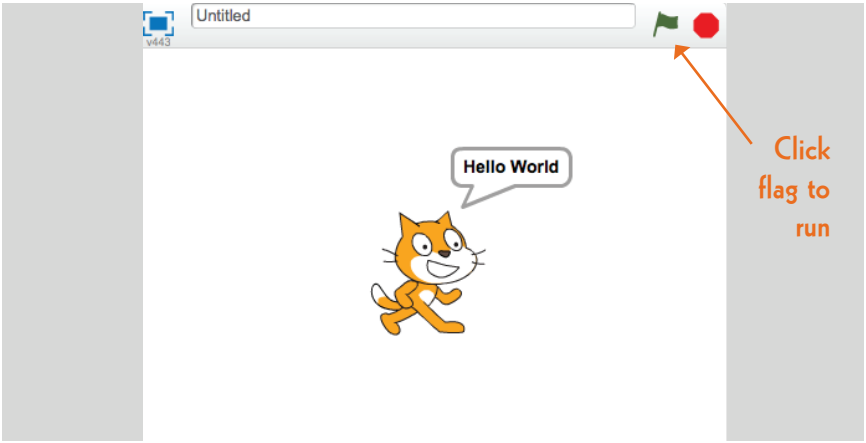
when flag clicked block.



Step 4) Double click the word "Hello!" and change it to "Hello World".



Step 5) Run your program You have written your first program in Scratch! To run your program, click on the green flag above the stage area. You should see your sprite say "Hello World."



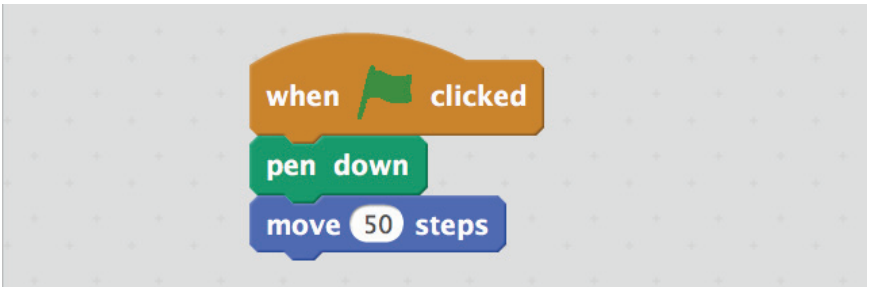
Drawing a Square

03

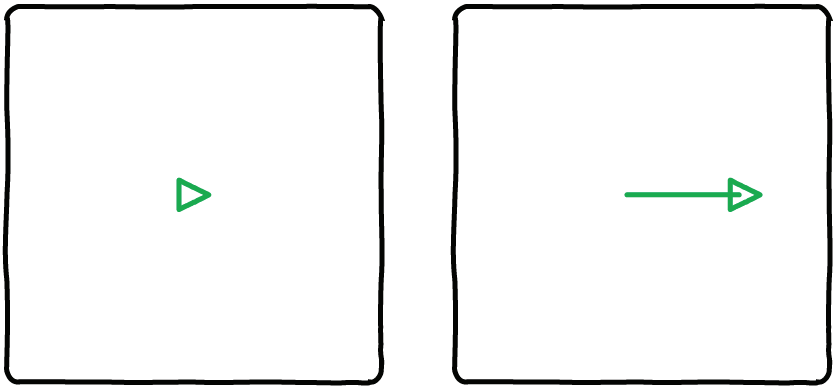
Drawing in Scratch is a lot like drawing with a pen and paper, except in order to draw something in Scratch, you have to tell the computer in which direction to draw the line and how far to draw the line.

We will use a ***sprite*** that looks like a green triangle when drawing as an aid to visibility. You can think of this triangle as a pen. Whichever direction the pen is pointing is the direction the line will be drawn. It is ok to continue using the cat sprite or you can pick your own shape.

Step 1) The first thing we need to do is draw a straight line. To do this, we will need to put the pen down. Pen down is a command block in the ***Pen*** section of the block palette. Then we will need to move the sprite. Move is a command in the ***Motion*** section. Set move to 50 steps.



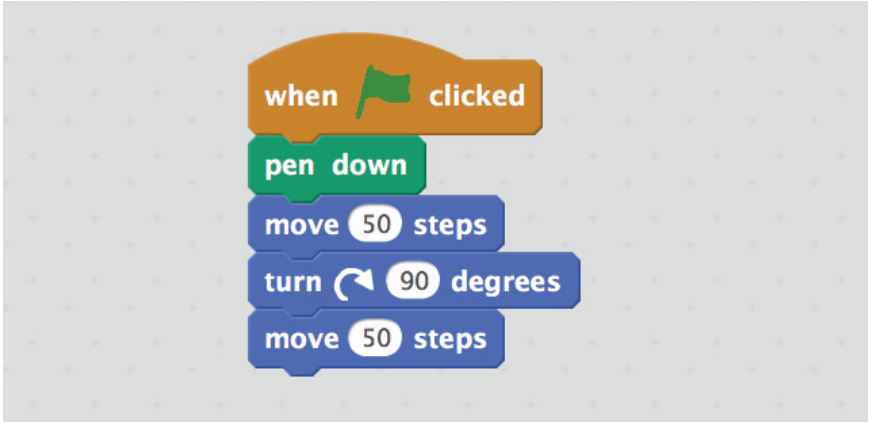
Step 2) When you click on the green flag, the pen will move across the screen, and there will be a line from where the pen started to where the pen ended.



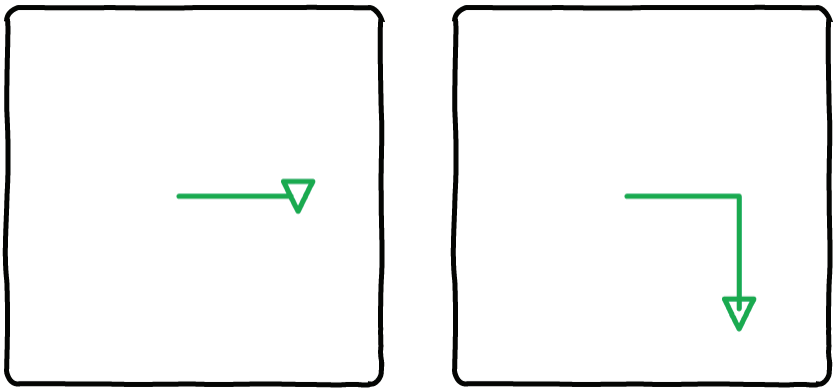
Step 3) Now we want to draw the side of the rectangle. To change the direction of pen use the turn clockwise block. Set the turn to 90 degrees.

This tells the program to rotate the pen 90 degrees to the right. The pen will change direction and will now be facing down.

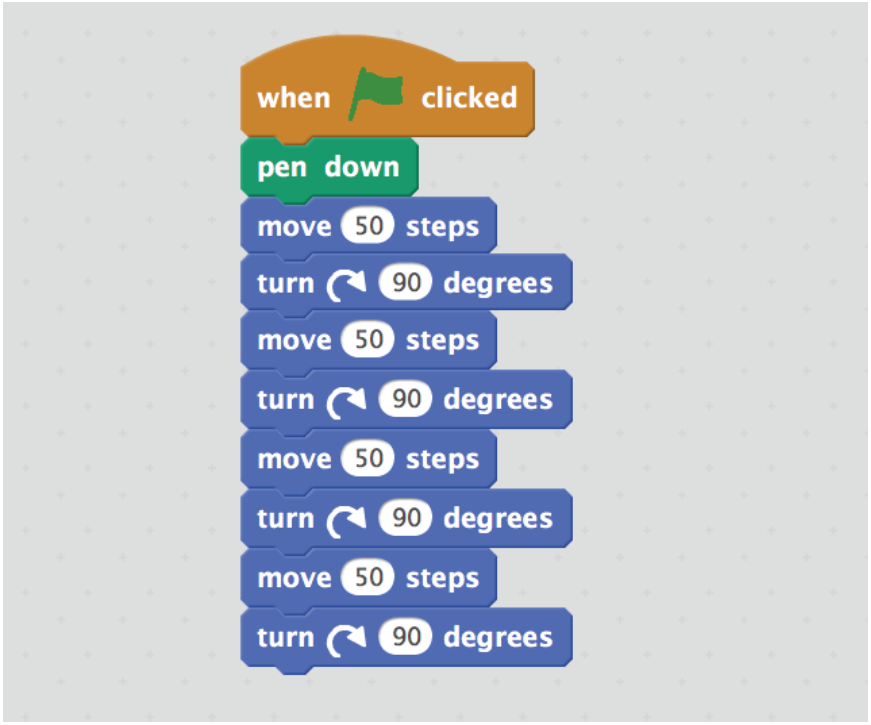
Next, draw the side if the square by connecting another move 50 steps block. Your code should look like this:

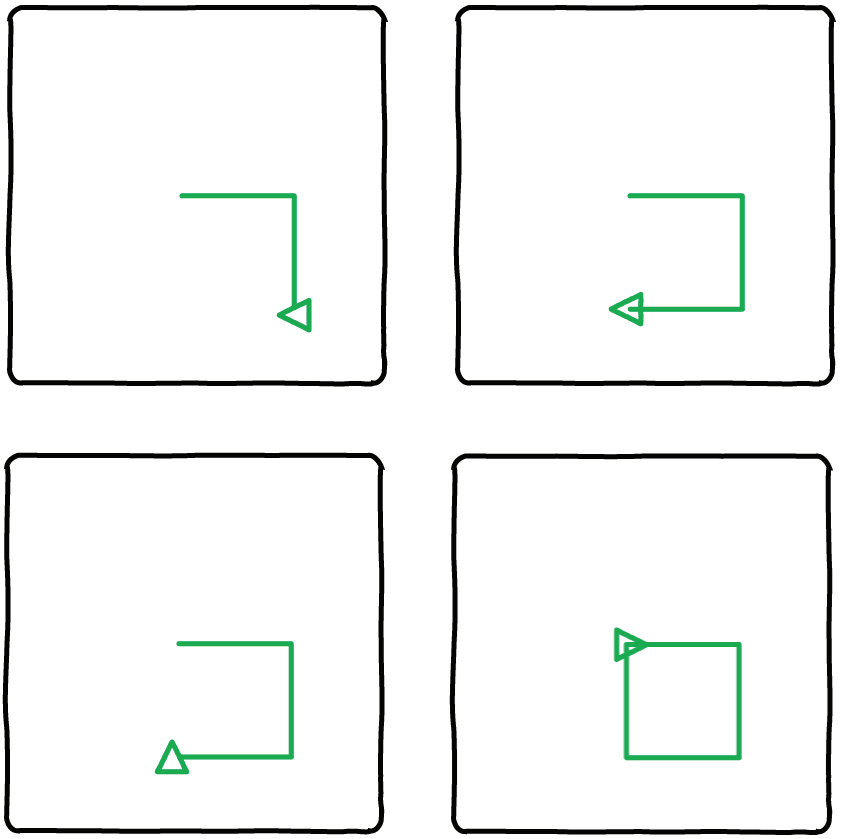


When your program runs, it should draw two sides of a square like so:



Step 4) You can see where this is going. Snap together a couple more turn and move command blocks to complete your square.

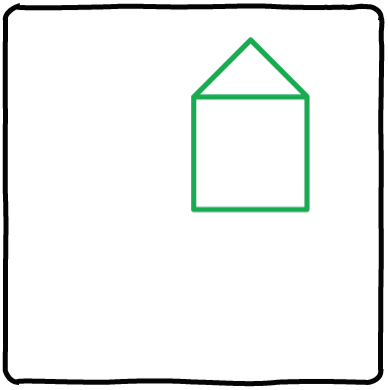




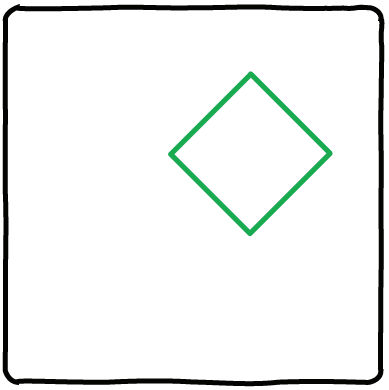
We manage to create a square! In future chapters we will learn how to draw triangles and circles.

Ch 3: Practice Problems

1) Can you draw a house by adding a triangle on top of the rectangle we drew in this chapter?



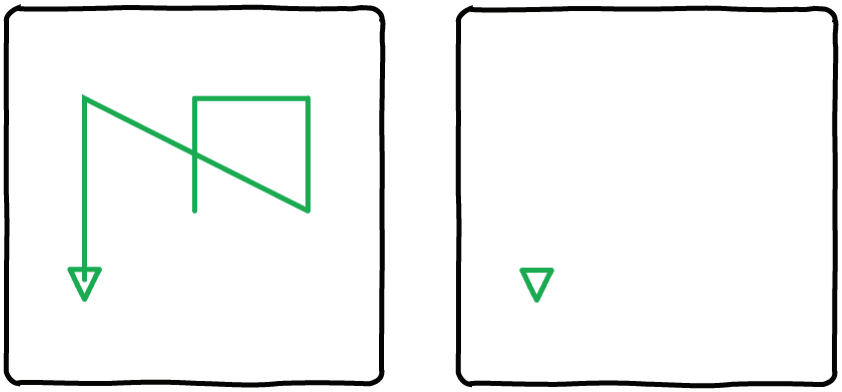
2) Try drawing a square that has been rotated 45 degrees. It is very similar to the rectangle that we drew in this chapter except the intial angle of the pen is 45 degrees instead of 90 degrees.



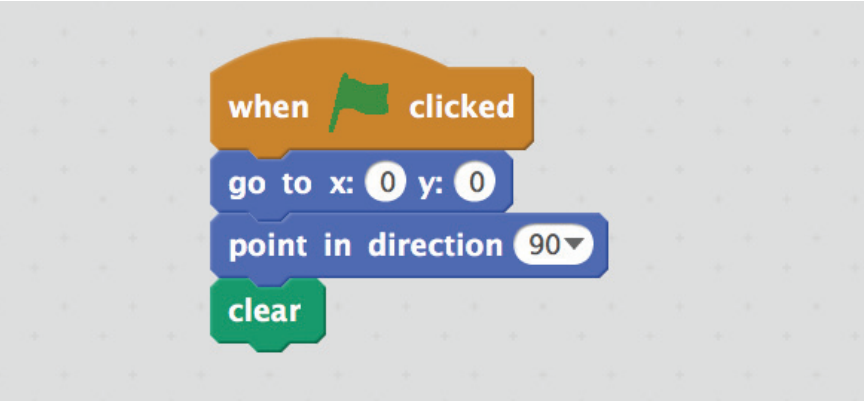
Deleting Your Drawing

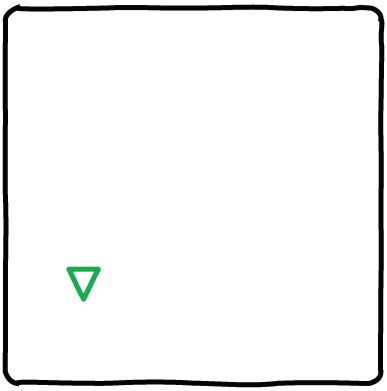
04

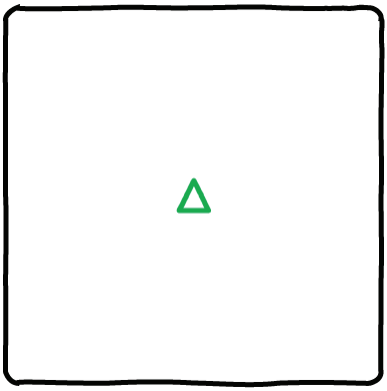
Clearing Your Drawing After you have experimented with drawing, you may want to clear your stage so you can start anew. The fastest way to clear the stage is to use the clear command from the ***Pen*** section of the block palette. Drag the clear command to the script area and double click on the button.



Return Home If you want to return your triangle to the middle of the screen, you can use the commands:

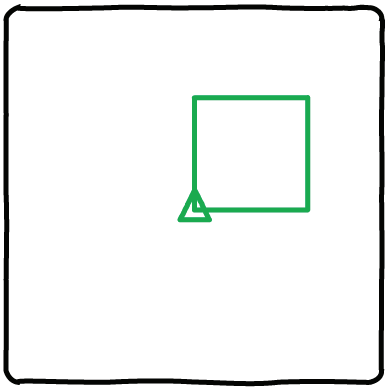




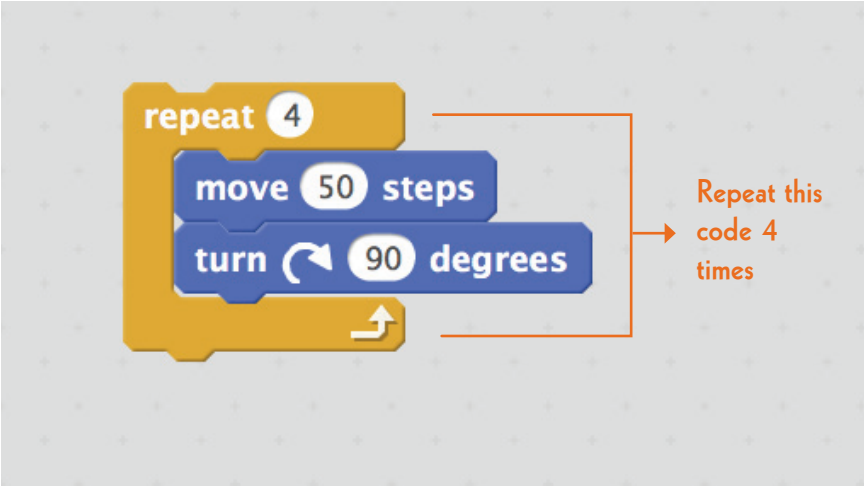


Repeat Command

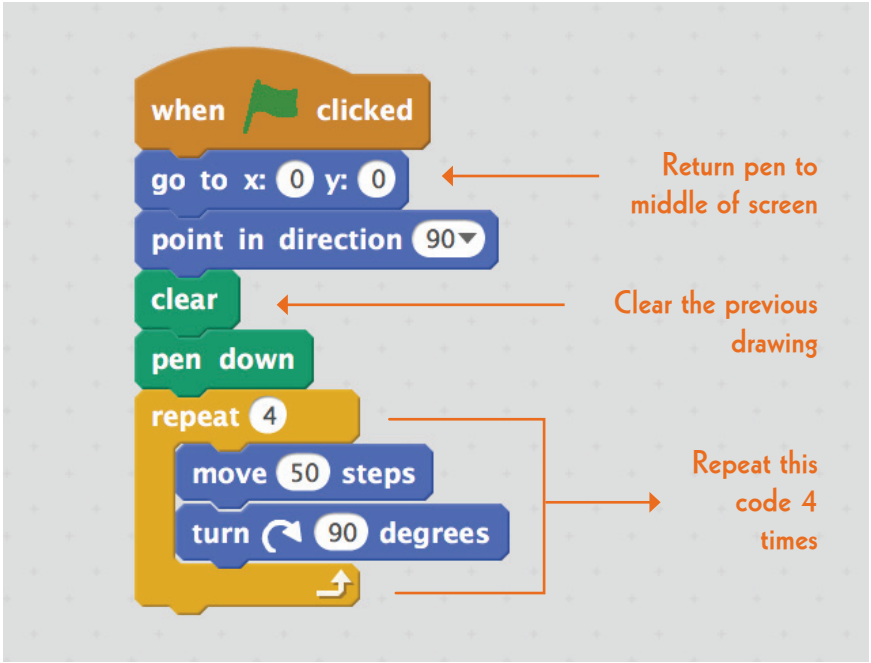
05



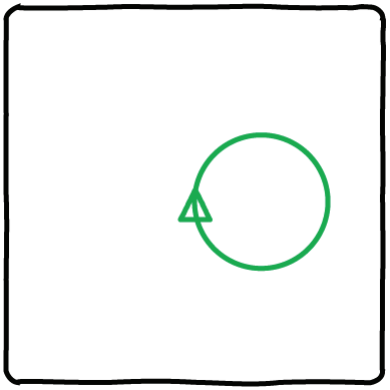
You may have noticed that in the last program we used the two commands move and turn clockwise four times each. There is a way to shorten this task so we only have to type each command once. We can do this by using the repeat command.



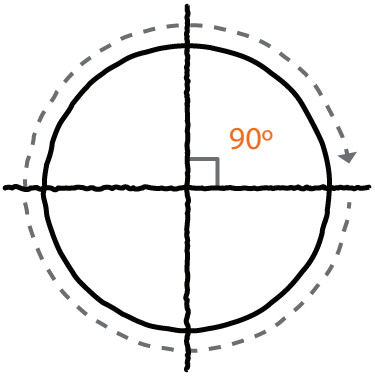
Square with Repeat



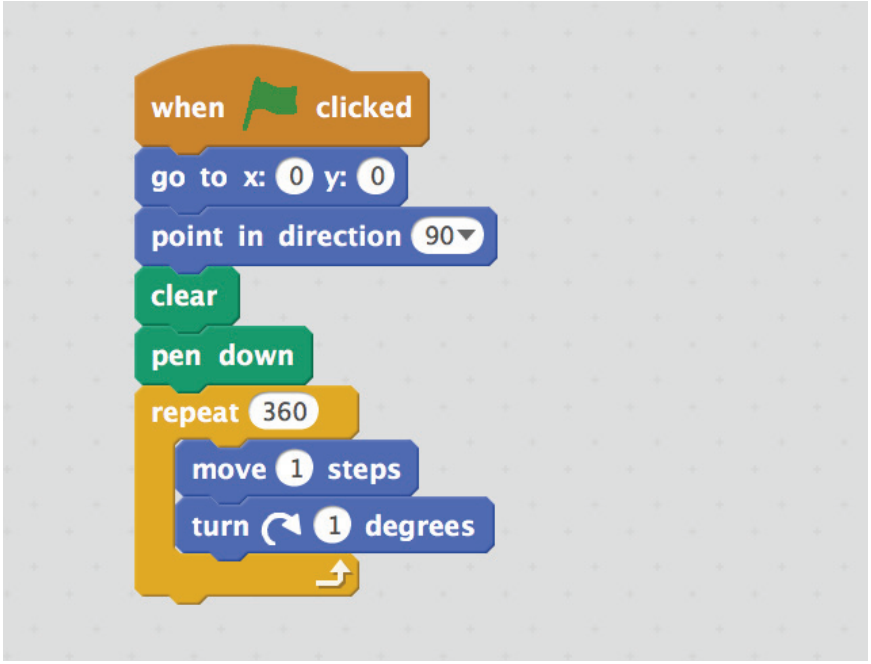
Drawing a Circle



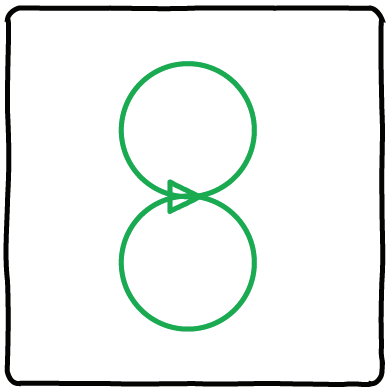
Drawing a circle on a computer is different from drawing a circle by hand. A computer can only draw straight lines, but we can create the appearance of a curved line by drawing a bunch of of tiny lines that, when connected together, look like a circle.



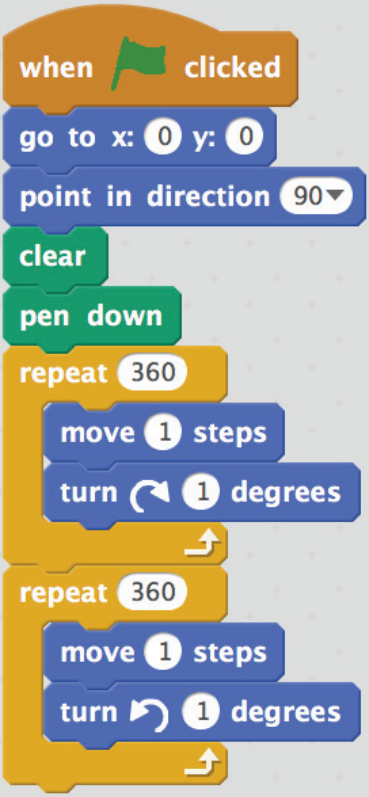
Since a circle has 360 degrees, we can create a circle by making 360 tiny lines, each one pixel long. After each line is drawn, we turn the pen 1 degree to the right. Together, all the tiny little lines will look like a circle!



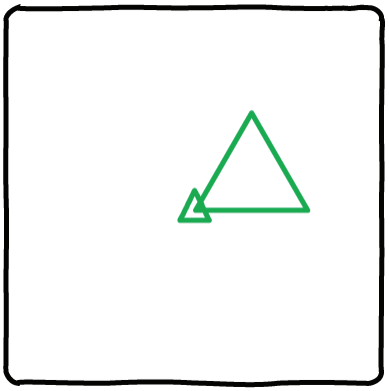
Drawing Two Circles



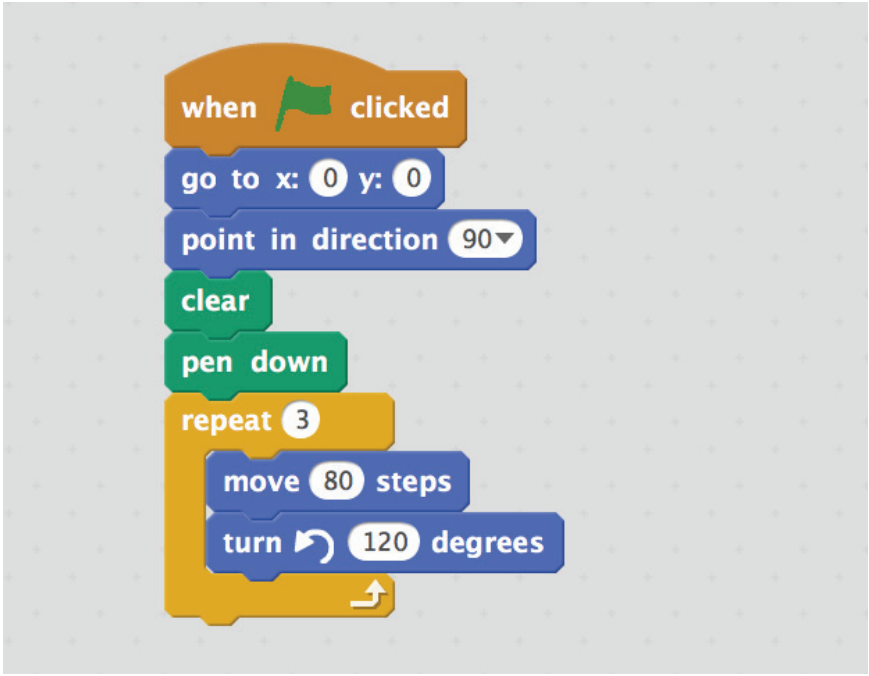
What if you wanted to draw a circle to the left? You could repeat the same commands except change the command from turn clockwise to the opposite command turn counter-clockwise



Drawing a Triangle

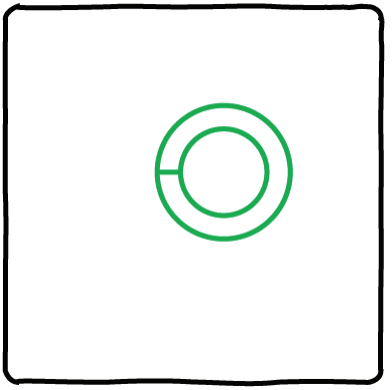


We can also use the repeat command to easily make an equilateral triangle (a triangle in which the length of all three sides are equal). Since each of the internal angles must also be equal we can create a triangle by rotating the pen 120 degrees after each line is drawn.

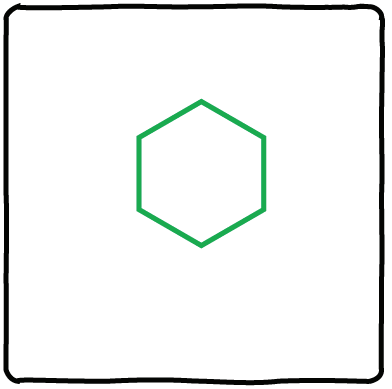


Ch 5: Practice Problems

1) Can you draw a small circle nested inside a big circle?



2) Try drawing a hexagon (a shape with 6 sides). To figure out the angles between the lines, divide 360 degrees by the number of sides.

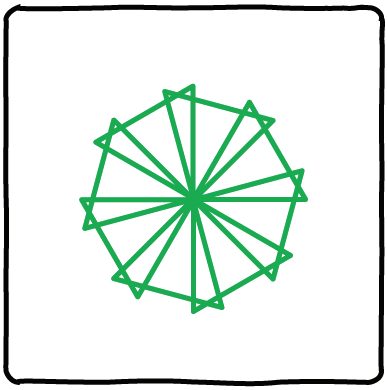


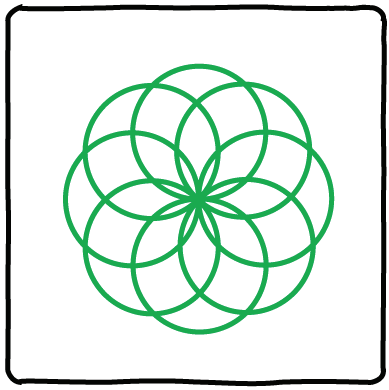
Nested Repeats

06

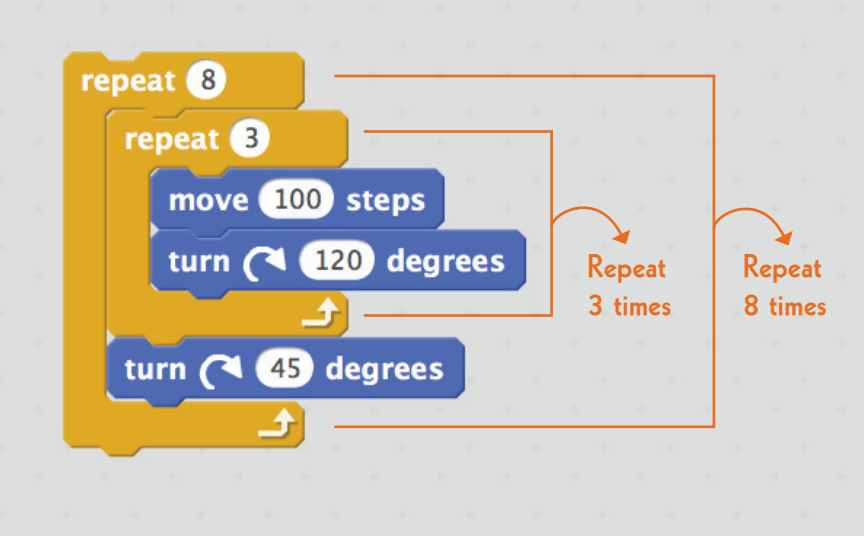
The really cool thing about repeat is that it allows us to draw the same shape as many times as we want with only a few lines of code.

In the last chapter we learned about using the repeat command. We can also nest a repeat command inside another repeat command. This allows us to build more complex shapes.



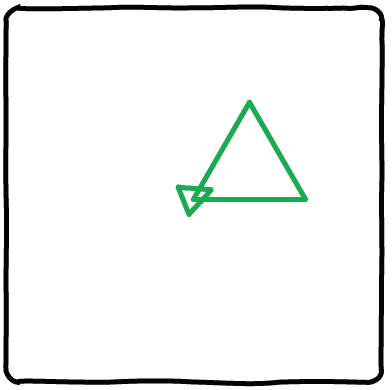


Nested loops can look a little complicated the first time you see them, so lets go through the code line by line for the drawing on the left.



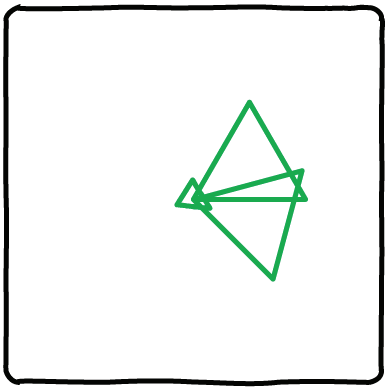
Step 1) First, Scratch does the inner repeat command repeat 3[move 100 steps, turn right 120 degrees]. This creates a triangle.

Step 2) Scratch then does the turn right 45 degrees. This turns the pen right by 45 degrees.

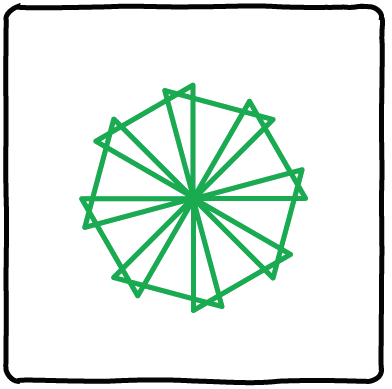


Step 3) After these two steps, Scratch has drawn a triangle. Scratch is now also ready to draw the next triangle.

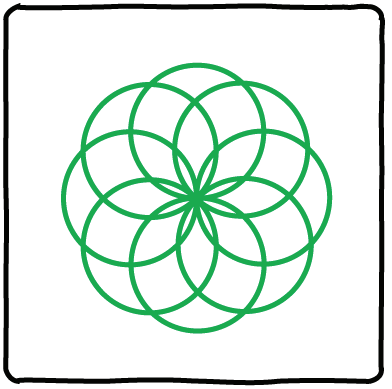
Step 4) Scratch then does steps 1 and 2 again. The screen now looks like this:



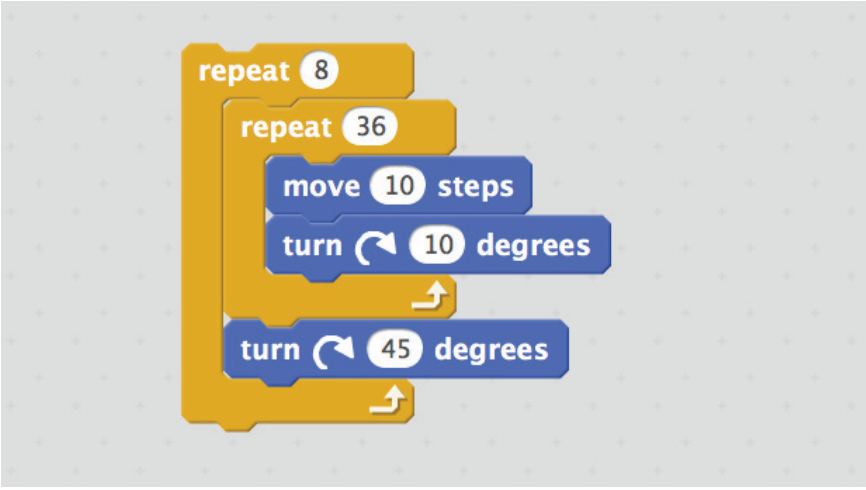
Step 5) Scratch continues to do steps 1 and 2 until it has done them 8 times. After the 8th time, Scratch stops. The final screen now looks like this:



Nested Repeats with Different Shapes



We can make lots of interesting shapes by repeating a simple shape over and over again. Other shapes that we could use as a base are circles, pentagons (shapes with 5 sides), and octogons (shapes with 8 sides).

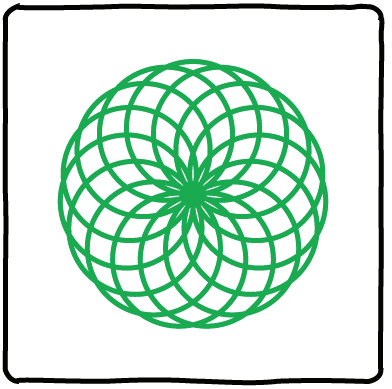


What would happen if you repeated the outer loop 36 times? Or if you changed the angle the pen rotates from 45 degrees to 10 degrees?

Ch 6: Practice Problems

1) Try to draw the shape below, which is just a repeat of a hexagon shape (a shape with 6 sides).

2) Edit the nested code for the circle shape in this chapter so there are more circles in the shape.



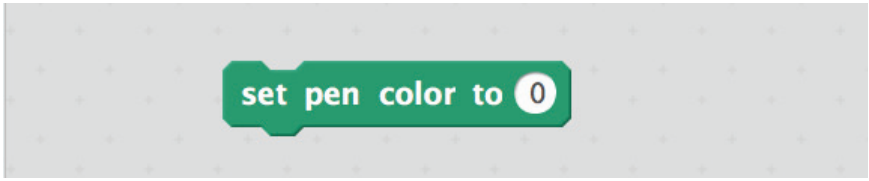
Making Colors

07

So far we have only been able to draw with the color black, but we can change the color of the pen to any color that we want.

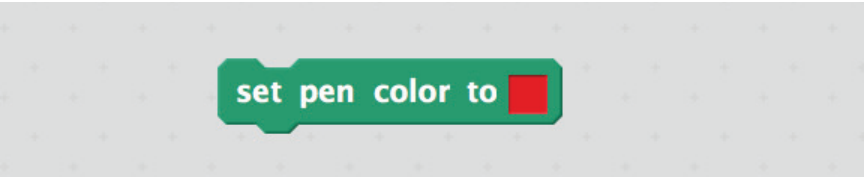
You can think of pen colors as a rainbow that ranges from red to yellow to green to blue and back to red.

The set pen color to block is a ***Pen*** block. The block takes a number between 0 and 199. A value of 200 is the same color as a 0 value. This means that whenever you change the pen color by adding 200 to the current pen value, the color still looks the same.

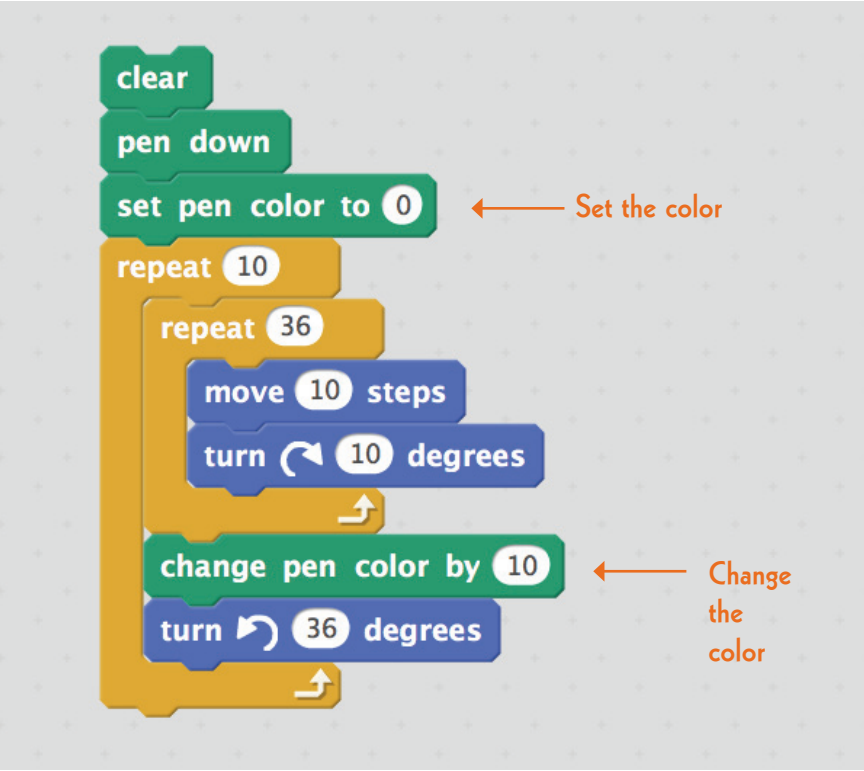


The easiest way to create a color is to use the color picker version of the set pen color to block. When you click in the color area, then click on a color anywhere else in the

Scratch environment to use that color.



How To Use the Color Codes In the code example below, the color is set to red before the rectangle is drawn. Notice that the values in change pen color to are the same as the color values in the table to the right.

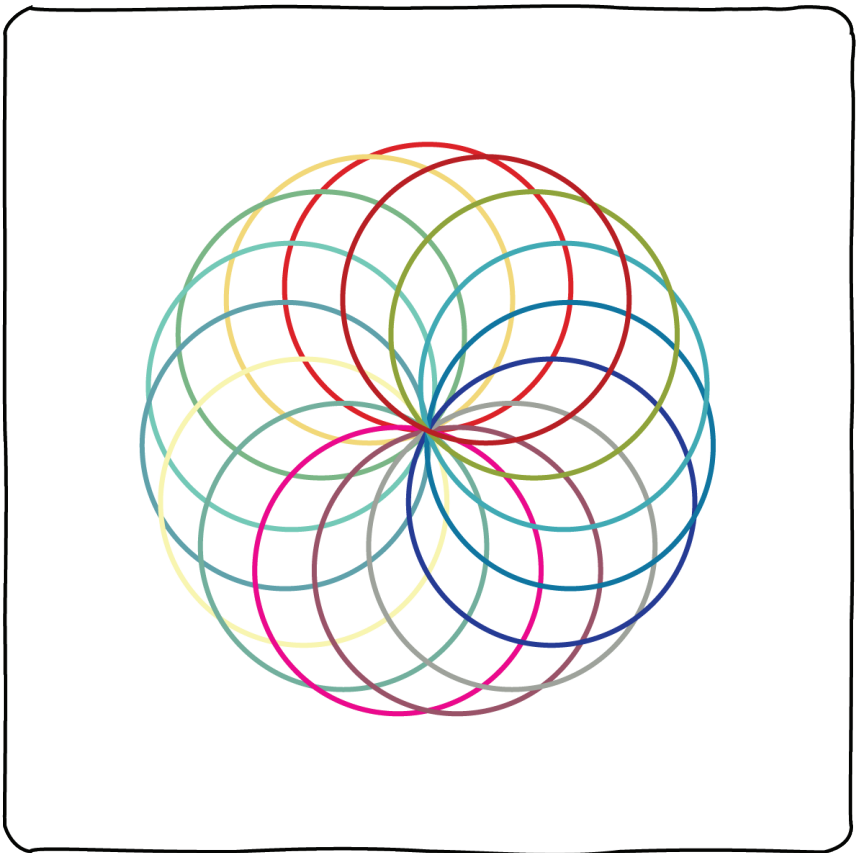


Common Colors			
Color	RGB Value	Color	RGB Value
Red	0	Yellow	33
Green	66	Cyan	99
Blue	132	Magenta	165

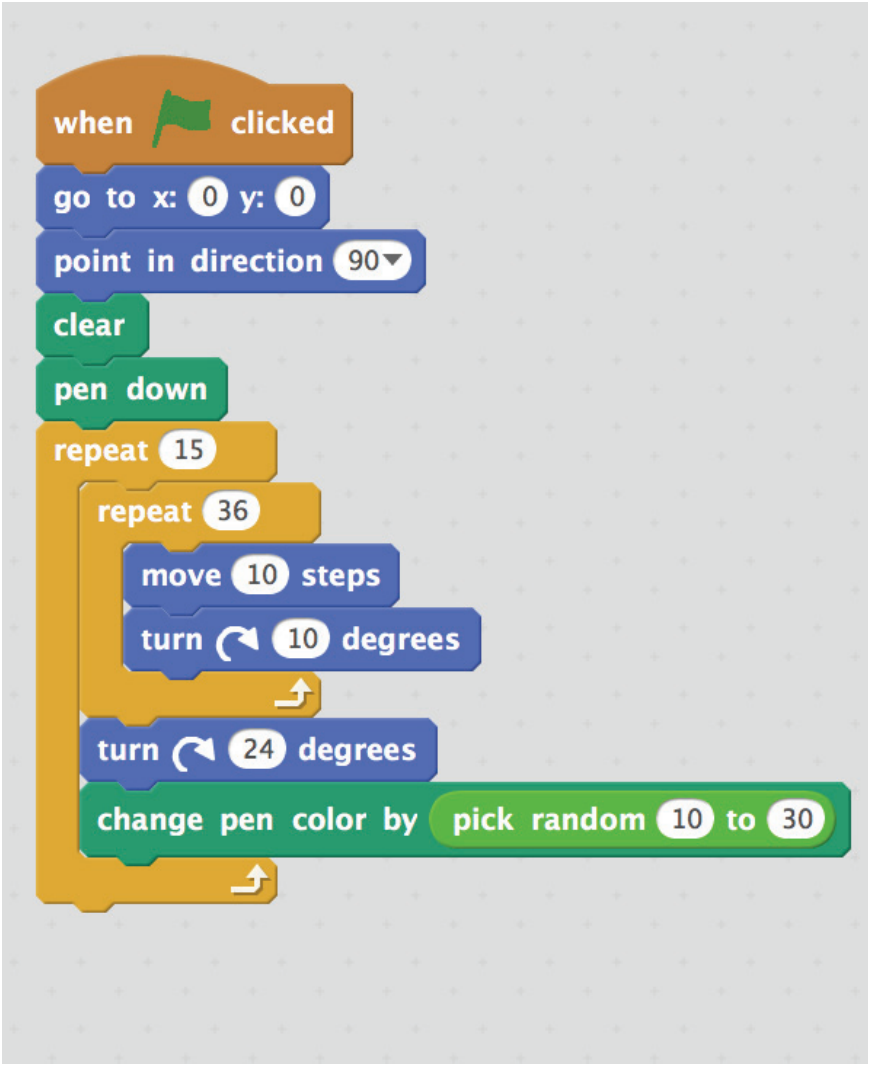
Random Colors To create random colors, we need to generate random values. There is an Operator Block called pick random that allows us to pick a random number between two values.

The example above tells Scratch to pick a number between 1 and 200. In the next project we will learn how to generate random colors while drawing.

Project: Nested Circles with Random Colors



In this example, we changed the color inside the repeat 15 block. This ensures that each separate circle is drawn with a different color. Try seeing what will happen if you move the change pen color block to inside the repeat 36 block.

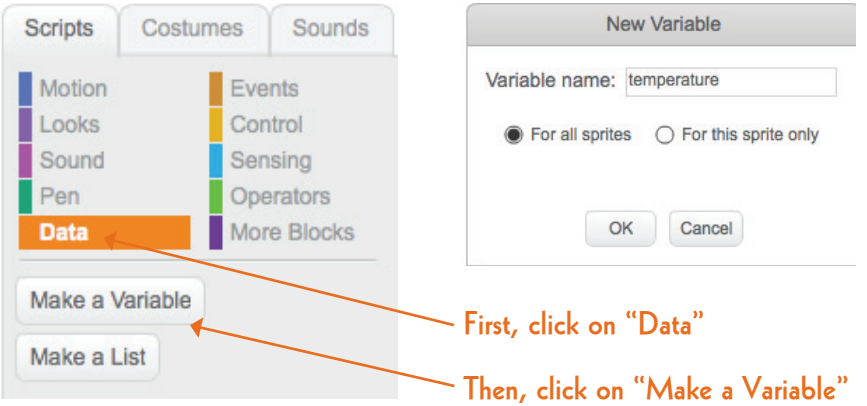

when clicked
go to x: 0 y: 0
point in direction 90
clear
pen down
repeat 15
repeat 36
move 10 steps
turn 10 degrees
turn 24 degrees
change pen color by pick random 10 to 30

All About Variables

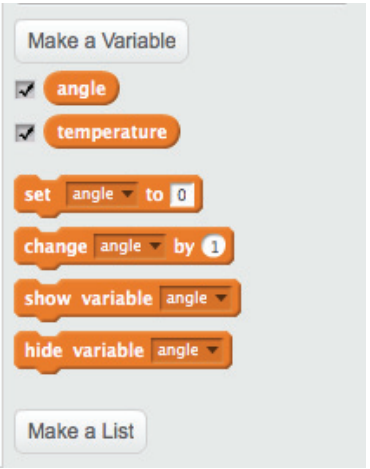
08

What is a Variable? Sometimes we want to be able to keep track of a value that might change as the code executes. In order to keep track of that value, we need to store it memory so we can access it again. Variables are a way for programmers to store values. It is helpful to think of a variable as a box that can only store one value. When a new value is put in the box, the old value is destroyed forever.

How to Create a Variable Go to the Data Section in the ***Block Palette*** and click the "***Make A Variable***" button. Then enter the name of the variable and click "***Ok***."



You will then see some new command blocks in the Data Section that can be used to set the value of your variable.



Changing the Value of a Variable At some point we will want to change the value stored in a variable. We can set the value to a specific number or we can perform some math on the variable already being stored. Math can be done using the blocks in the Operator Section.

Math Commands

Command	Math	Command In Scratch
add	2 + 4	2 + 4
subtract	5 + 9	5 - 9
multiply	2 * 2	2 * 2
divide	8 / 4	8 / 4

Project: Make a Spiral

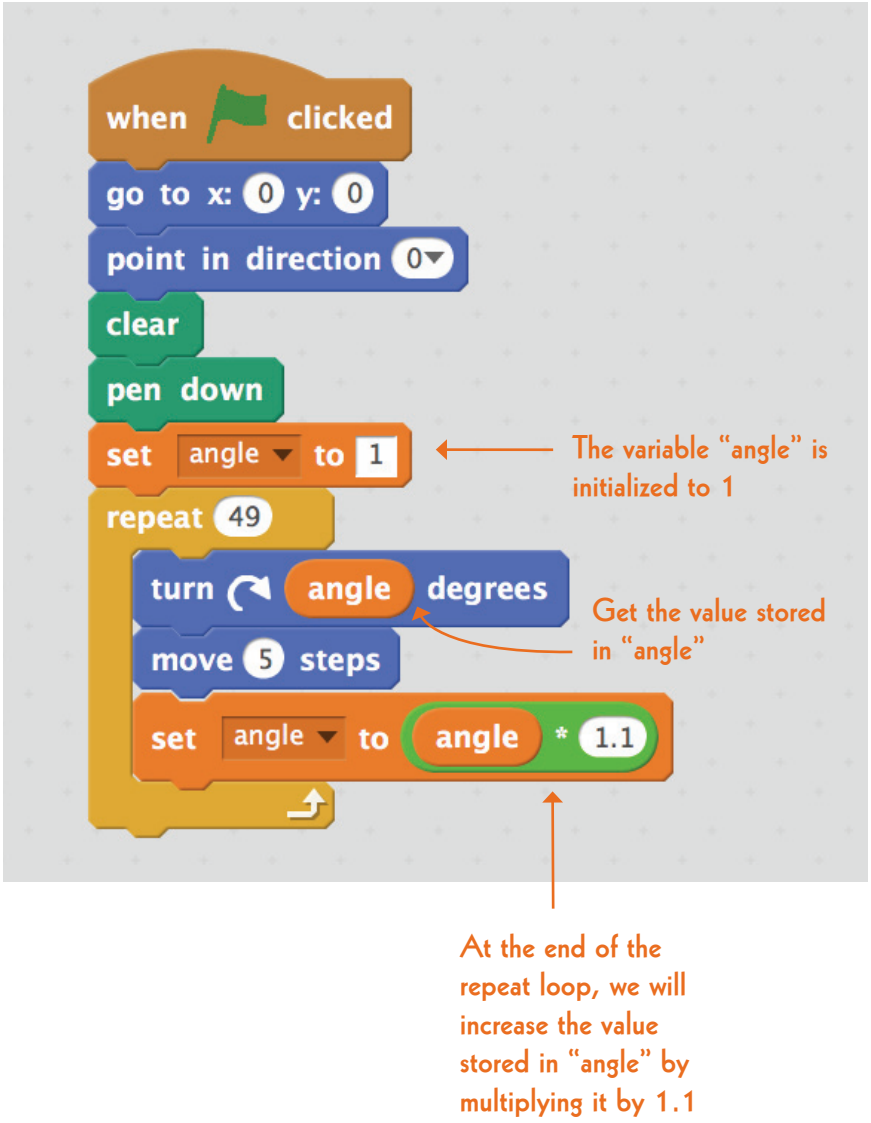
When we draw a spiral, we need to adjust the angle of pen after each line segment is drawn. Now that we have learned about variables, it will be easy for us to draw a spiral because we can store the angle value in a variable.

How variables work When we first start the program, the value stored in angle is 0. As the program progresses, the we may want to change the value stored in the variable. To do this, we can use the set block to change the value of the variable.

Getting the value of a variable After we make a new variable, there is a new oval block with the variable name in the Data Block section. This variable block can be dragged onto any other block that takes a number as an argument.

When we draw a spiral, we need to adjust the angle of the

pen after each line segment is drawn. Now that we have learned about variables, it will be easy for us to draw a spiral because we can store the angle value in a variable.



Ch 8: Practice Problems

1) True or False. Are these two variable names the same: ‘myFirstVariable and ‘MYFIRSTVARIABLE?

2) What is the final value stored in w after the program executes?

The final value of w is: _____

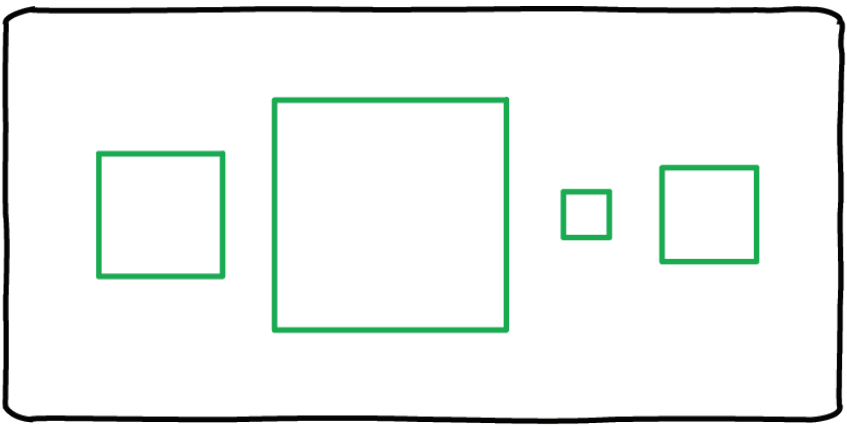
3) What is the final value stored in w after the program executes?

The final value of w is: _____

Awesome Functions

09

Why Use Functions? When we used the repeat command, it made drawing complex shapes really easy. Now we will learn about functions, which allow us to repeat the same code over and over again without having to rewrite the code. A function may sound an awful lot like the repeat command, but functions are one of the most useful tools a programmer can have because it allows us to adjust certain parts of the code based on our needs.



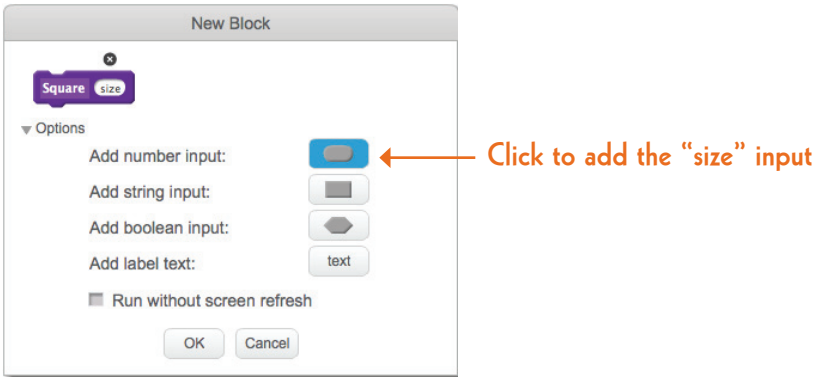
The limitation of the repeat command is that if we want to draw a bunch of squares, each with a different side length, each square will be coded with virtually identical code

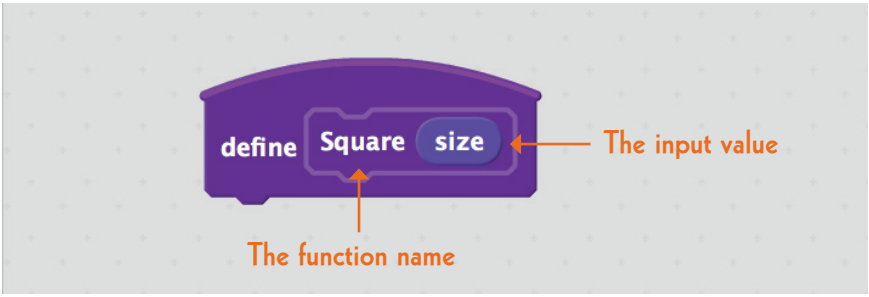
except for the length of the sides. With a function, we can use one block of code to draw different size squares!

Formatting Functions Functions have to be written in a particular way. A function must have a name and it may have zero or it may have multiple inputs.

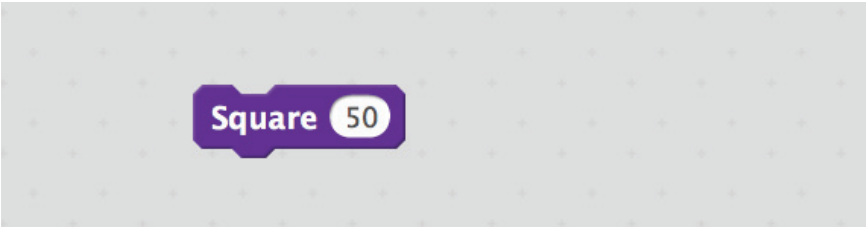
Inputs Scratch offers three different types of inputs: number, string, and boolean. Strings are words like "hello" or "program." Booleans can have only two values: true or false. Finally, numbers are values like 23.56 or 200.

Create a Function To create a function, go to the More Blocks section and click on the "***Make a Block***" button. Then, enter a name for your function. If your function needs to use input values, click on one of the options and enter a name for the input.

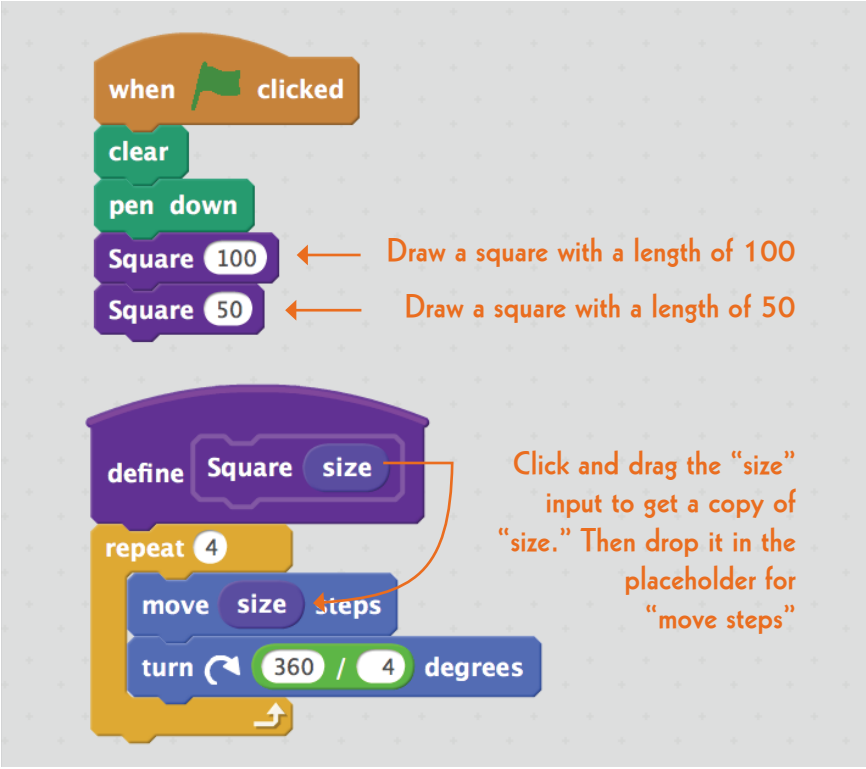




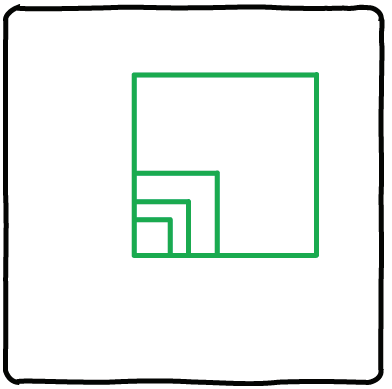
Calling A Function You can make a script attached to a define block and click "run", but nothing will happen. That is because we have to tell the computer to call the function. The way we call the "Square" function that we defined above is by using the following command block, which is created when we make the function.



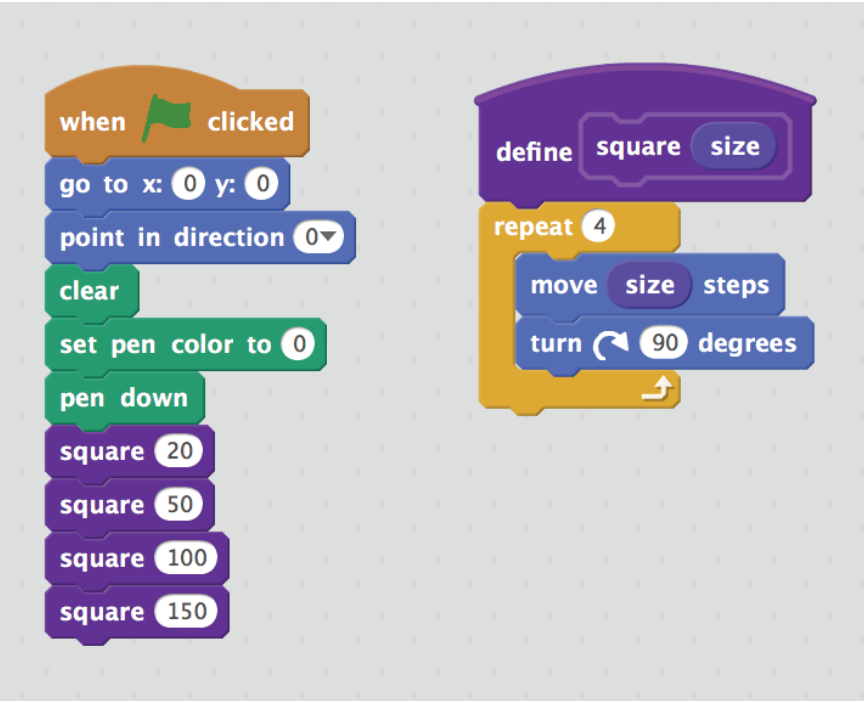
In the example above, the input value is 50, but it could be set to any positive number.



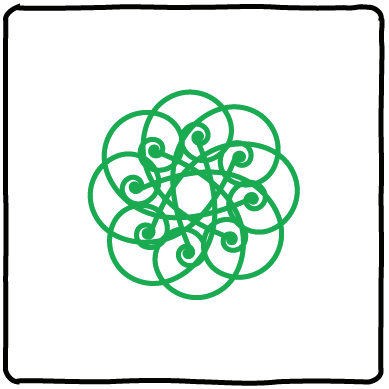
Project: Drawing Squares



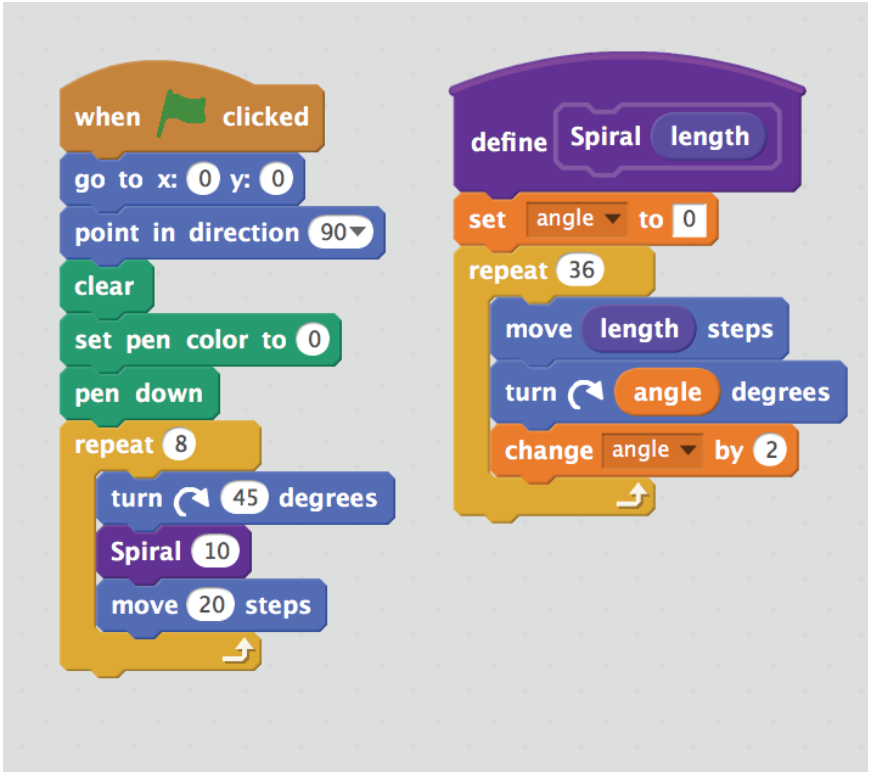
Let's use a function to draw a bunch of different size squares. Can you draw some other size squares?



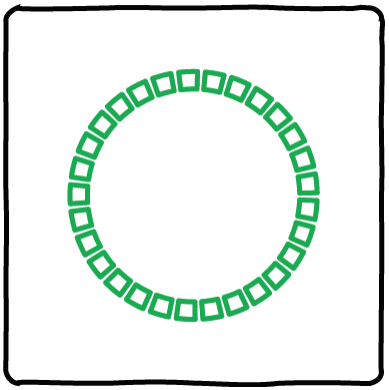
Project: Spiral Rose



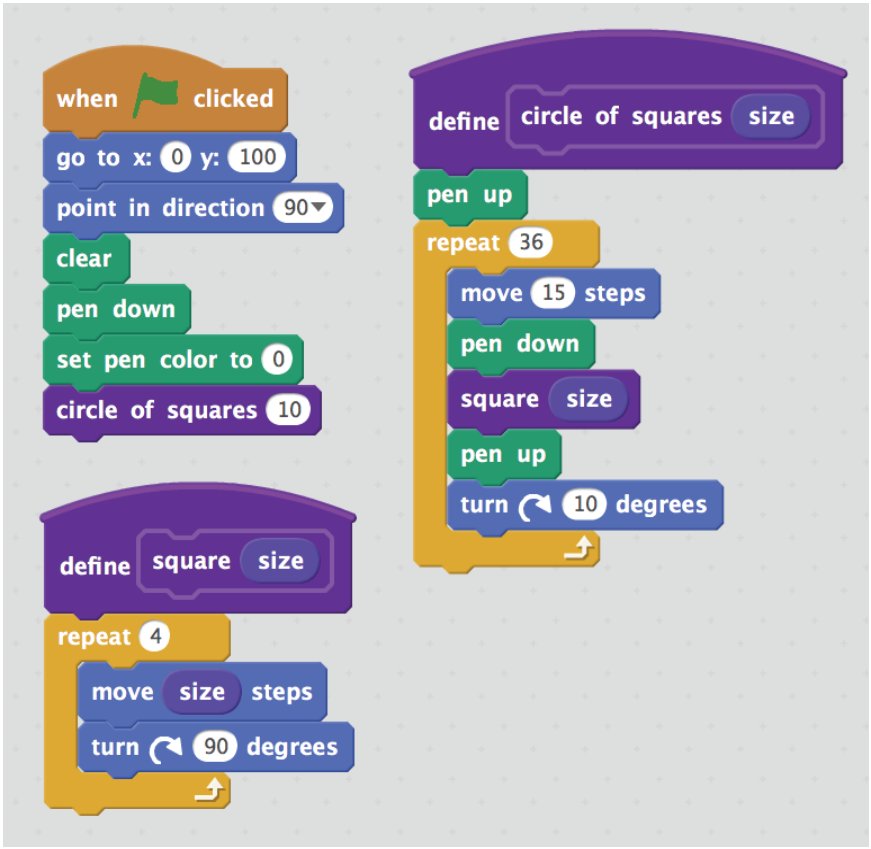
We can combine repeats and functions to make the spiral rose to the left.



Project: Circle of Squares

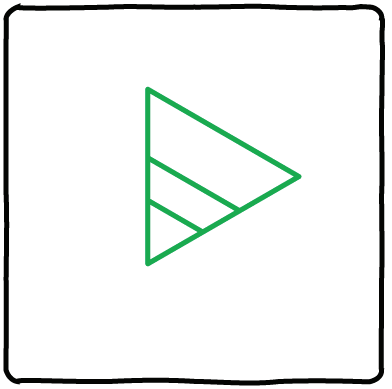


You can make a lot of complicated things easily with functions. In this function, the command penup is used to stop the pen from making marks while it is moving.

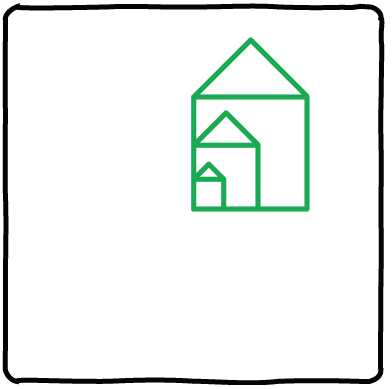


Ch 9: Practice Problems

1) Can you make a function that will help you draw different size triangles?



2) Make a function that will let you draw different size houses.

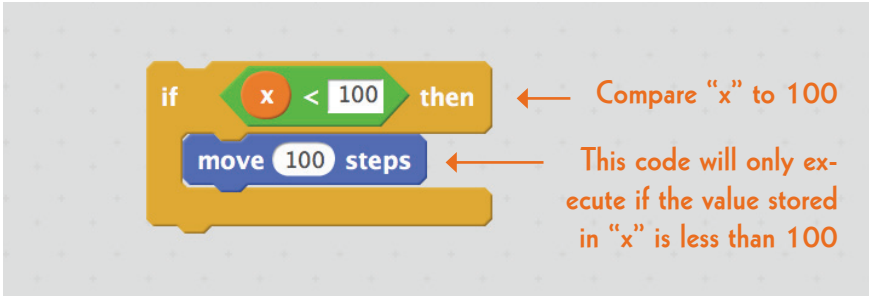


If Statements

10

What if you wanted your pen to do different things based on the current value of a variable? If the variable's value is greater than zero, the pen should rotate 45 degrees. If the variable's value is equal to zero, the pen should rotate 90 degrees. An easy way to program this is to use an if statement.

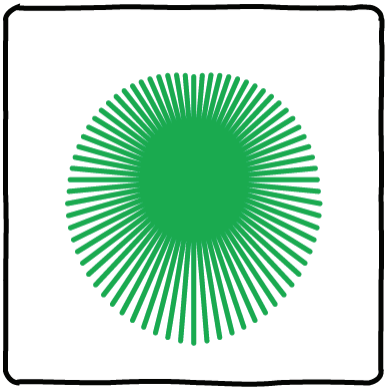
If Statement The if statement tells your program to execute a certain section of code only if a particular condition is true. If it is true, the code between the brackets will be executed. If it is false, Scratch will simply ignore the code between the brackets.



Conditional Statements Scratch lets you compare values to see if one is greater than the other, less than the other or equal to the other value.

Conditional Statements		
Command	**Example**	**Command In Scratch**
equal to	5 = 6	
less than	10 < 3	
greater than	8 > 5	

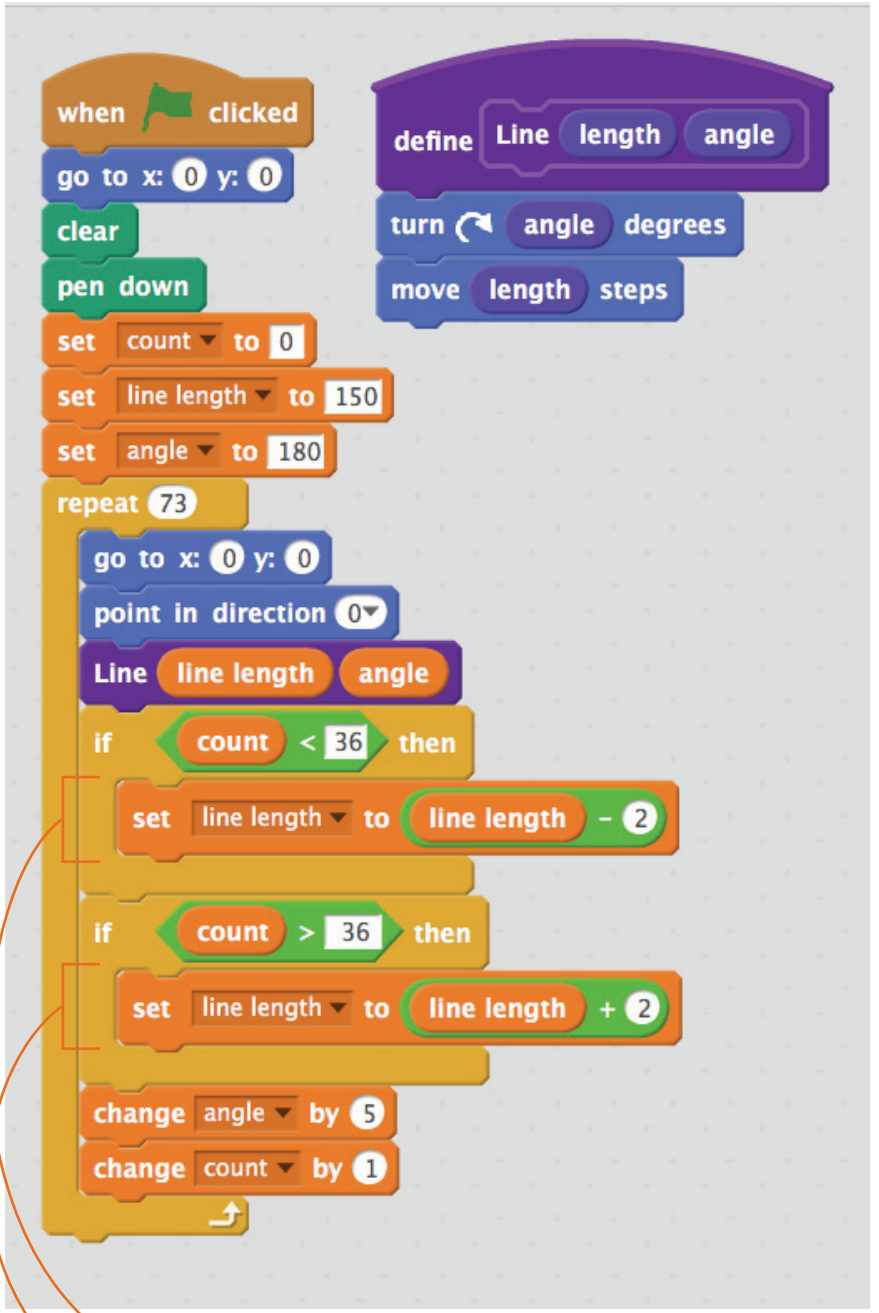
Project: Radiating Lines



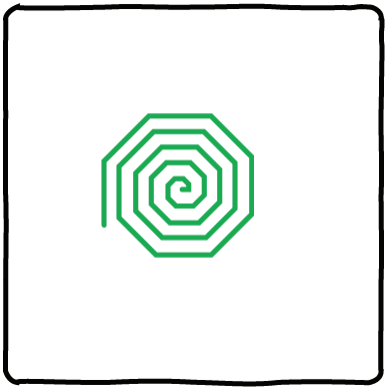
To make the image to the left, we used two if statements to adjust the length of the lines.

The repeat command is going to run 73 times. We are going to use a variable called count to keep track of what number repeat we are on. If the count is less than 36, we will decrease the line length. If the count is greater than 36, we will increase the line length.

You can use this technique to draw different shapes depending on your if statements. What will happen if you use four if statements instead of the two in the example?

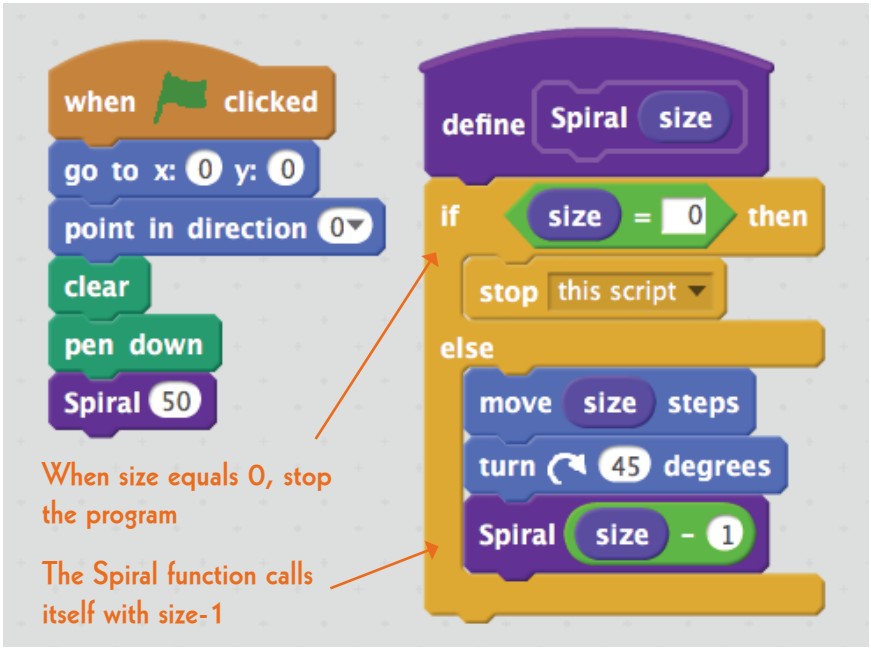

when clicked
go to x: 0 y: 0
clear
pen down
set count to 0
set line length to 150
set angle to 180
repeat 73
go to x: 0 y: 0
point in direction 0
Line line length angle
if count < 36 then
set line length to line length - 2
if count > 36 then
set line length to line length + 2
change angle by 5
change count by 1
define Line length angle
turn angle degrees
move length steps
If the count is less than 36, decrease the line length
If the count is less than 36, increase the line length

Project: Recursive Spiral

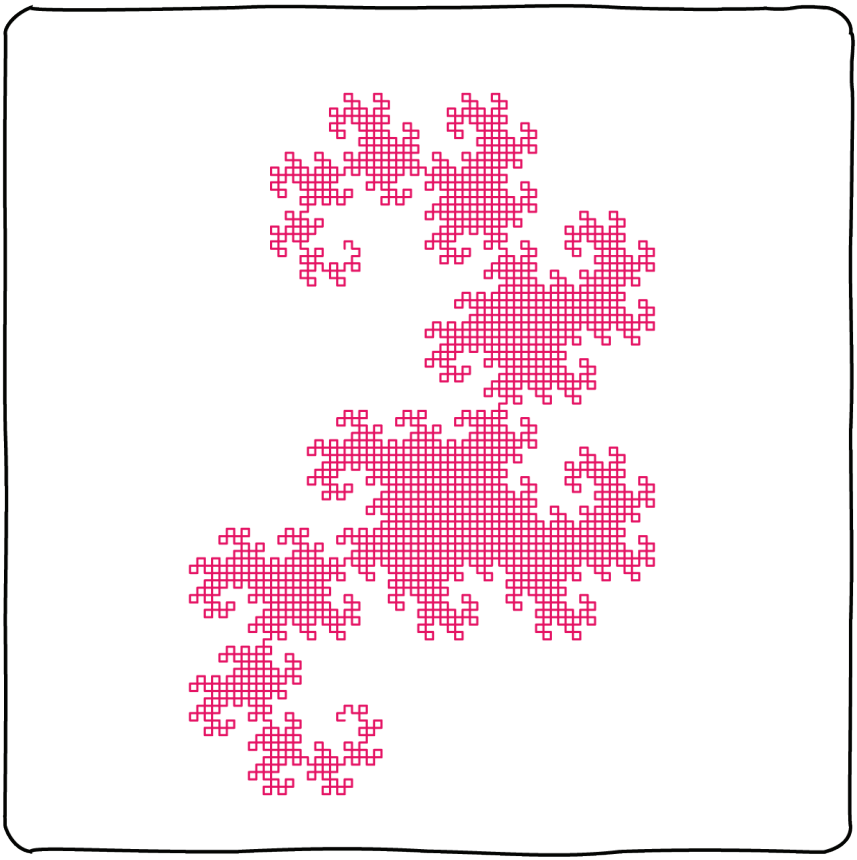


An interesting thing about functions is that they can call themselves. Whenever a function calls itself, it is called recursion. The only problem with this technique is that we need a way to stop the calling process or else the program will run forever!

If loops are helpful for stopping the program because we can tell the program to stop once a certain condition has been met. For example, we could initially call the loop with the variable "size" that has been initialized to 100. Each time the loop calls itself, the "size" decreases by 1. When the value of "size" reaches 0, the program will stop.

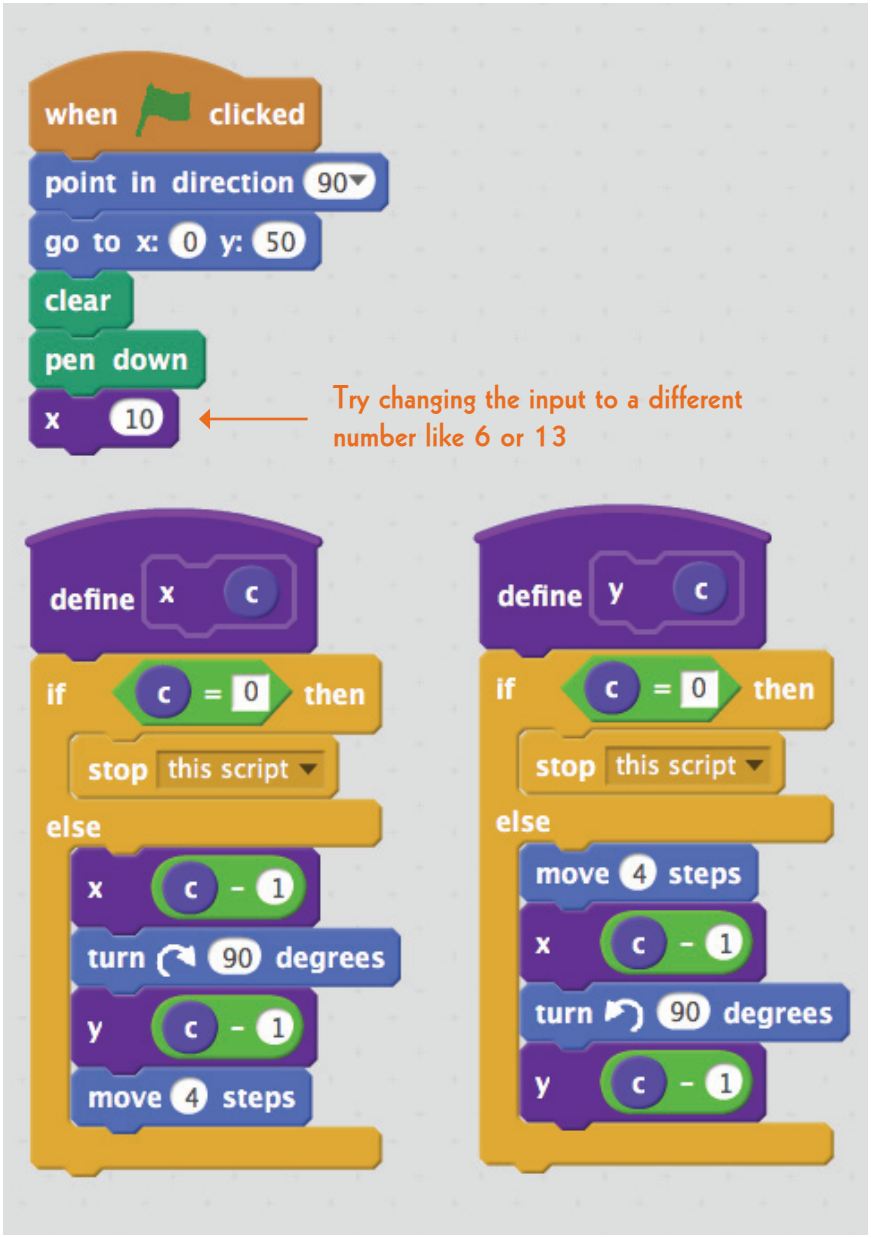


Project: Dragon Curve

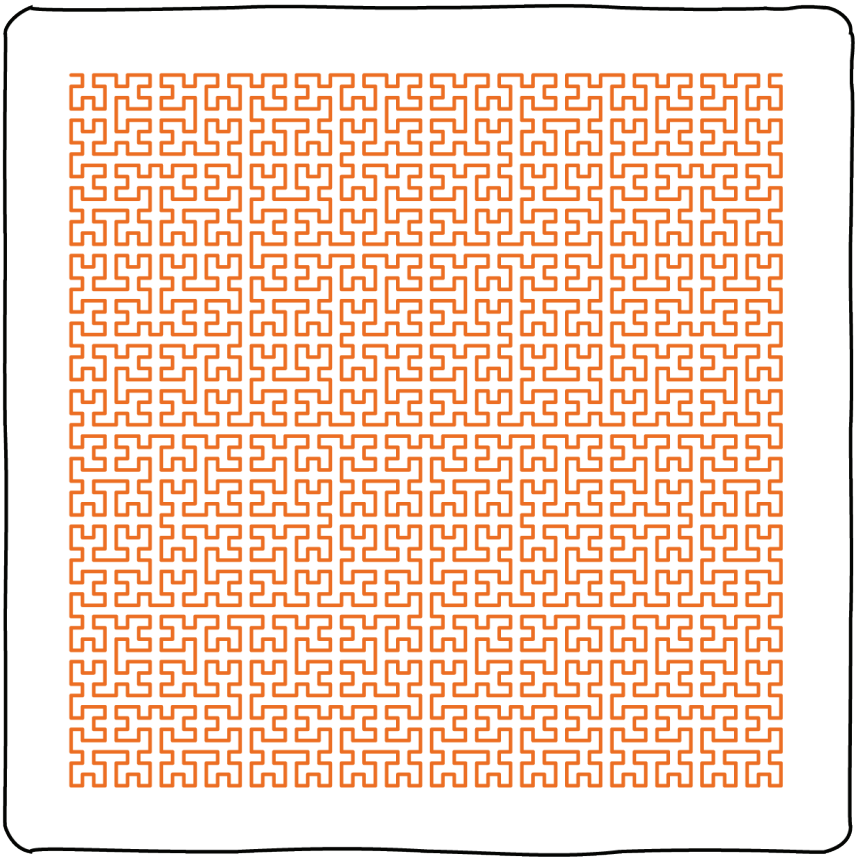


Programmers like recursion a lot because it lets them make really complicated drawings using relatively few lines of code. If we tried to draw the dragon curve above only by using functions and repeat loops, it would take us hours, and hundreds of lines of code, to complete.

Try experimenting with the code below by calling the function with different inputs (for example call the function x with x 6 or x 13).

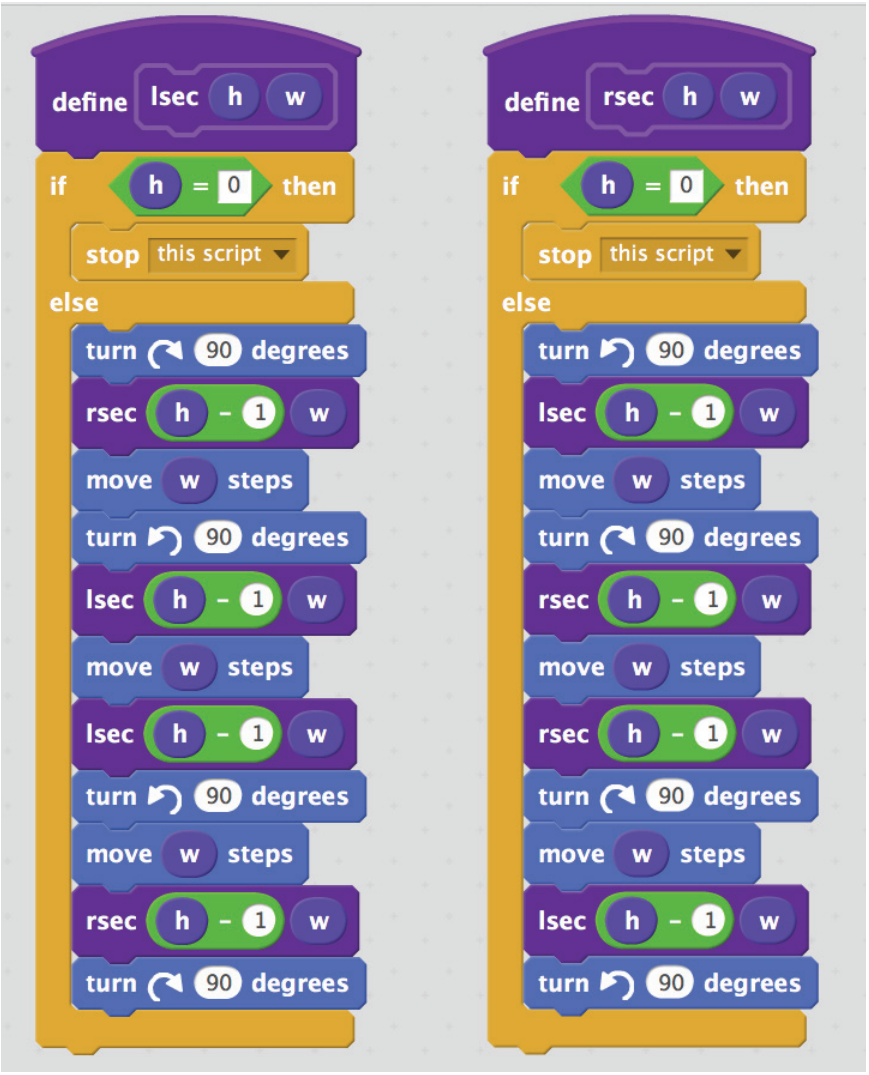

when clicked
point in direction 90
go to x: 0 y: 50
clear
pen down
x 10
Try changing the input to a different number like 6 or 13
define x c
if c = 0 then
stop this script
else
x c - 1
turn 90 degrees
y c - 1
move 4 steps
define y c
if c = 0 then
stop this script
else
move 4 steps
x c - 1
turn 90 degrees
y c - 1

Project: Hilbert Curve

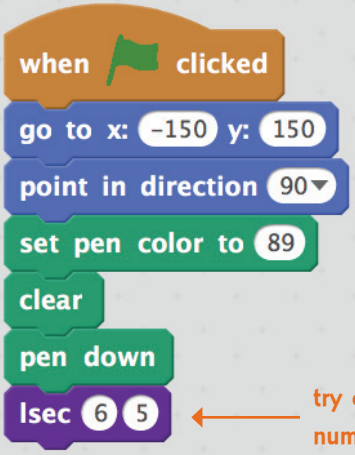


The labyrinth above is called the Hilbert curve. Like the dragon curve, it is really easy to draw with a recursive function.

After you copy the code into Scratch and run the program, try experimenting with altering the code. For instance, try changing the inputs for the LSec function call. For example, change the inputs in the last line of code to lsec 5 5 or lsec 3 3).



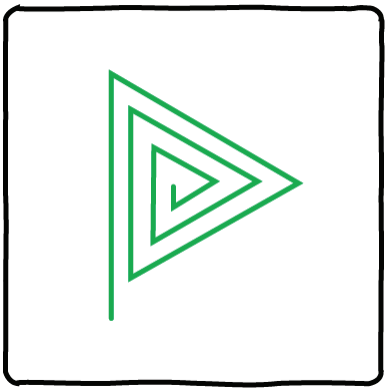
more code on next page



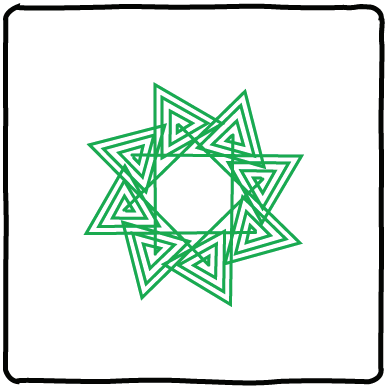
try changing the inputs to different numbers like (lsec 5 5) or (lsec 3 3)

Ch 10: Practice Problems

1) Can you make a recursive spiral tirangle?



2) Use the spiral triangle code from above to make a star. Experiment with different angles and lengths to create different types of stars.



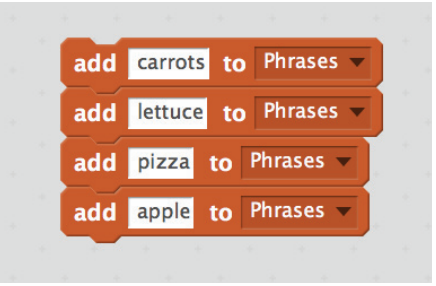
Making Lists

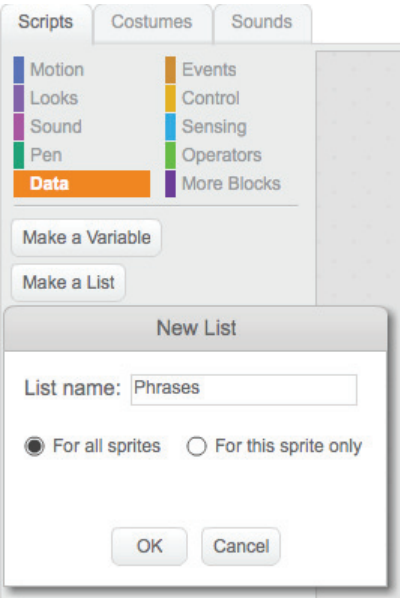
11

So far we have only used Scratch to manipulate numbers and variables one value at a time, but we can also store and manipulate lists of things.

Lists Remember when we learned about variables? Variables are a way to store one thing in memory. Sometimes we need to store multiple things in memory but we don't want to do a lot of tedious typing. Lists let us store many values in a single structure.

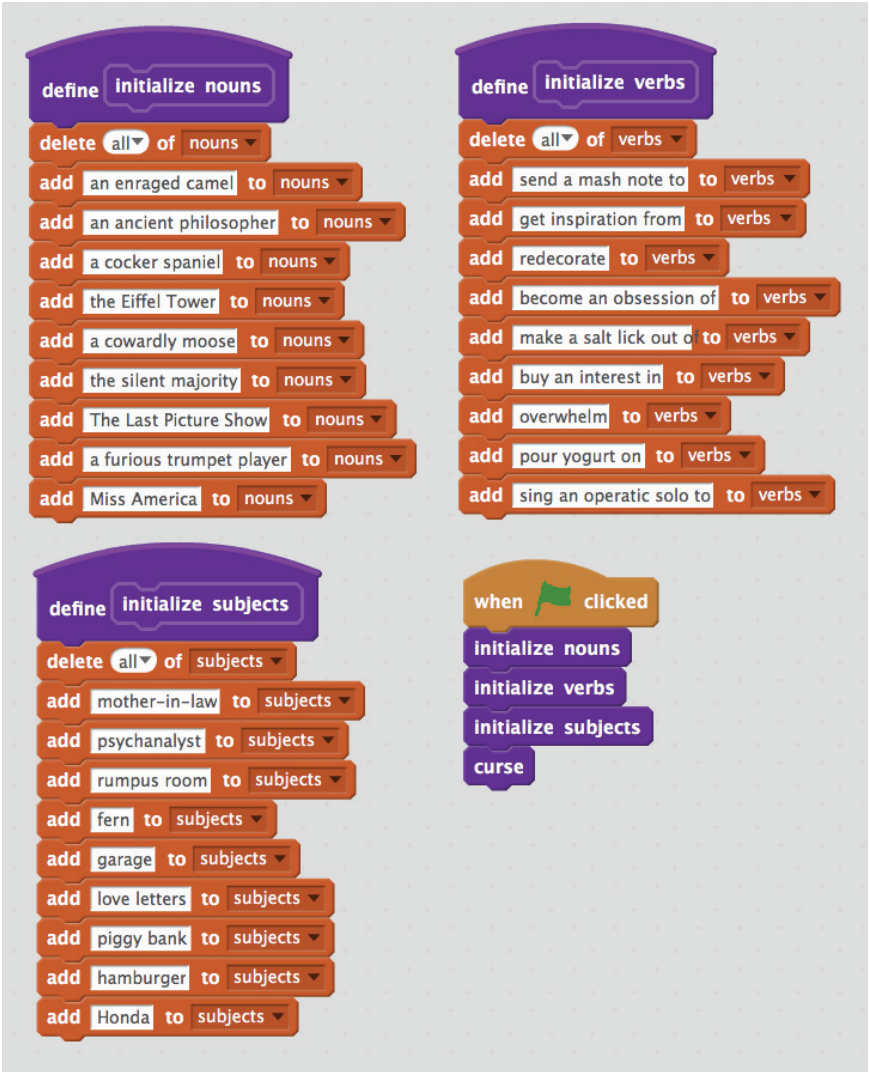
Making Lists Making lists is like making a variable. Go to the Data Section and click the "***Make List***" button then enter the name of the list. You can then use the add block to add items to the list.

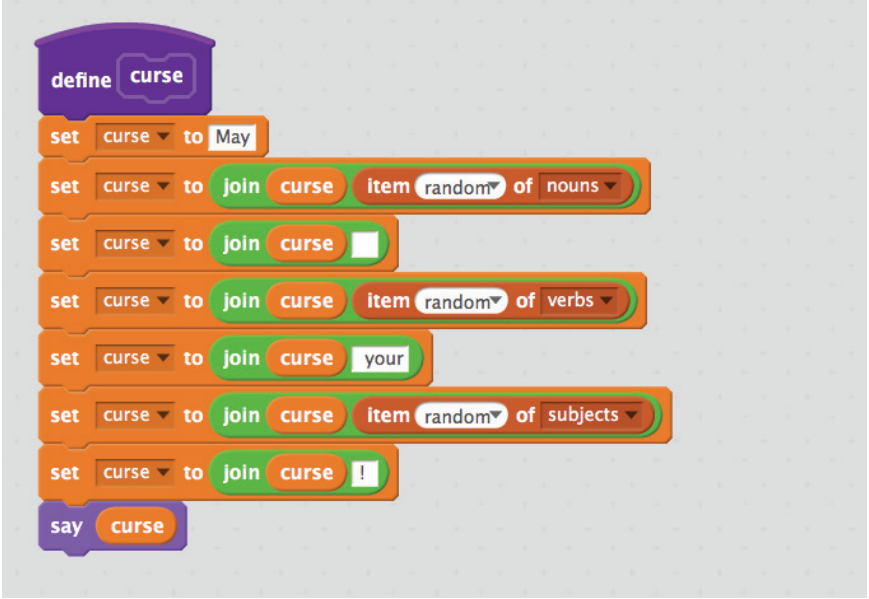




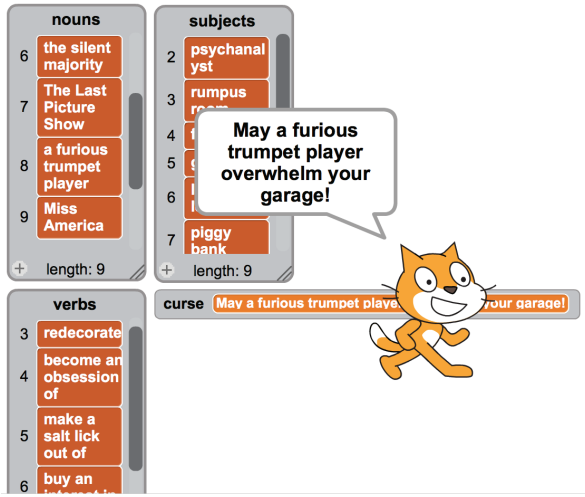
Project: Curses

This program is based on the work of Tom Dwyer and Margot Critchfield in 1978. It uses lists. What does it do?





Change this program to suit your personality. Add more things to the lists. Take some things away. Change the pattern used to form the curse. Is the pattern for a blessing different from the pattern for a curse?



Ch 11: Practice Problems

1) Many computer programs have been developed that generate poetry or music. Some of them use a technique similar to the curses program. These programs often have large lists of words that are arranged according to some predefined patterns.

For example, you might draw from lists in a pattern like this:

Title
Adjective Noun
Verb Noun
Noun Preposition Noun Verb Noun
  Ending Phrase

How could you make your poem rhyme? How could you link the Title and Ending Phrase to give your poem a sense of order and completion?

2) Working in a group, modify your program so that is generates poetry instead of curses. Within in your group, select your three favorite computer generated poems.

3) Try making a program that generate haikus.

4) Make a Dadaist Poem in the style of Tristan Tzara:

a. Take a newspaper.
b. Choose an article as long as you are planning to make your poem.
c. Make a list containing each of the words that make up this article.
d. Make a poem by randomly choosing each word. Removing it after the word from the list after it is used.
e. The poem will be like you.

And here [is the computer] a writer, infinitely original and endowed with a sensibility that is charming though beyond the understanding of the vulgar.

~Tristan Tzara

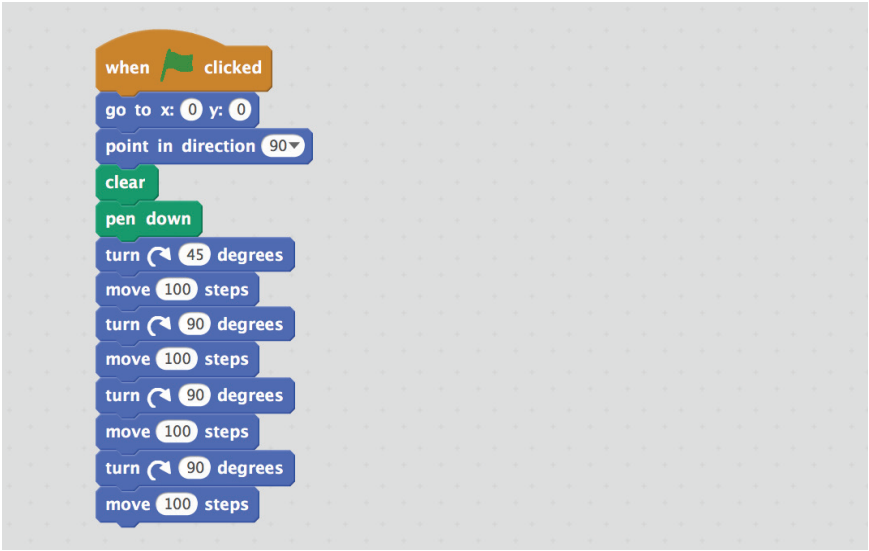
Problem Solutions

A1

2: First Program

1) There are many ways to draw a house. The code below shows one way to draw a house by first drawing the rectangle and then adding a triangle to the top of the image.

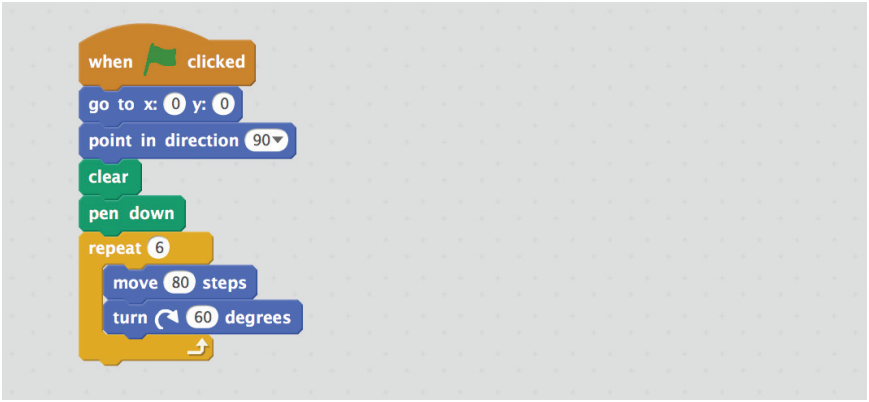
2) A diamond can be drawn in many ways. The code below shows a simple way to draw a diamond.



5: Repeat Command

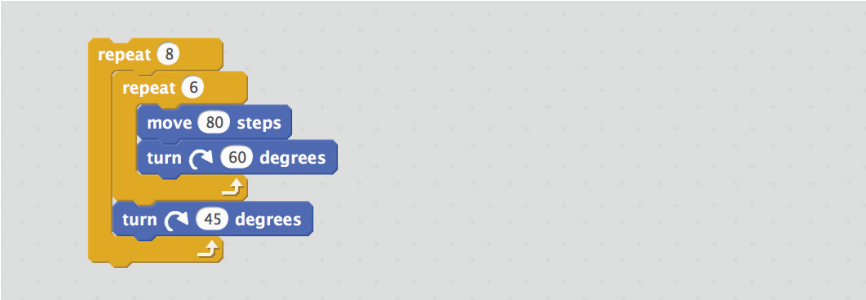
1) There are many ways to draw different size circles. The code below shows one way to draw two different size circles. The first repeat code draws the smaller inner circle and the second repeat code draws the bigger outer circle.

2) The easiest way to draw a hexagon is to draw 6 lines with an angle of 60 degrees between each line.

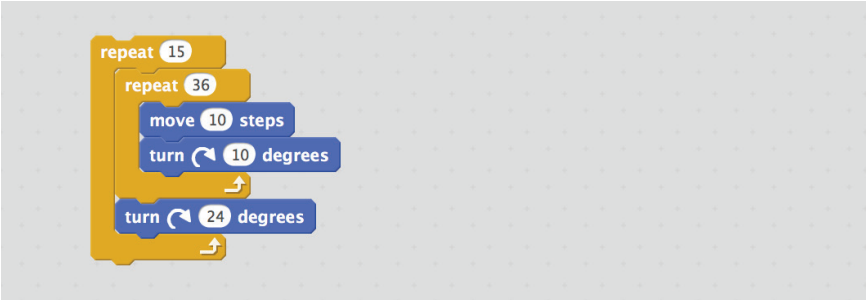


6: Nested Repeats

1) There are many ways to draw a shape consiting of hexagons. The code below describes one way to draw the shape.



2) The code below describes one way to draw a shape made out of many circles.



8: All About Variables

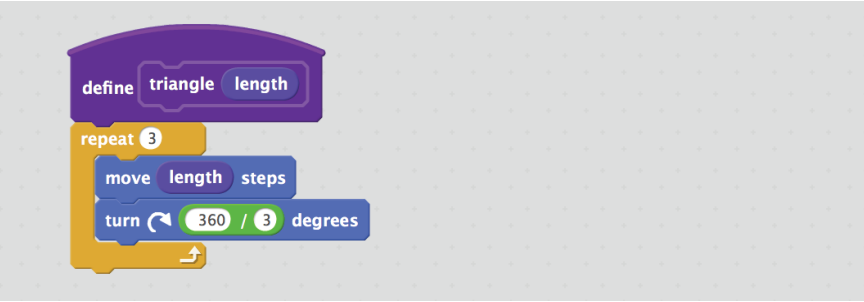
1) False. since the computer thinks lower and upper case letters are different, ‘myFirstVariable and ‘MYFIRST-VARIABLE do not mean the same thing to the computer.

2) The final value of w is**: 12**

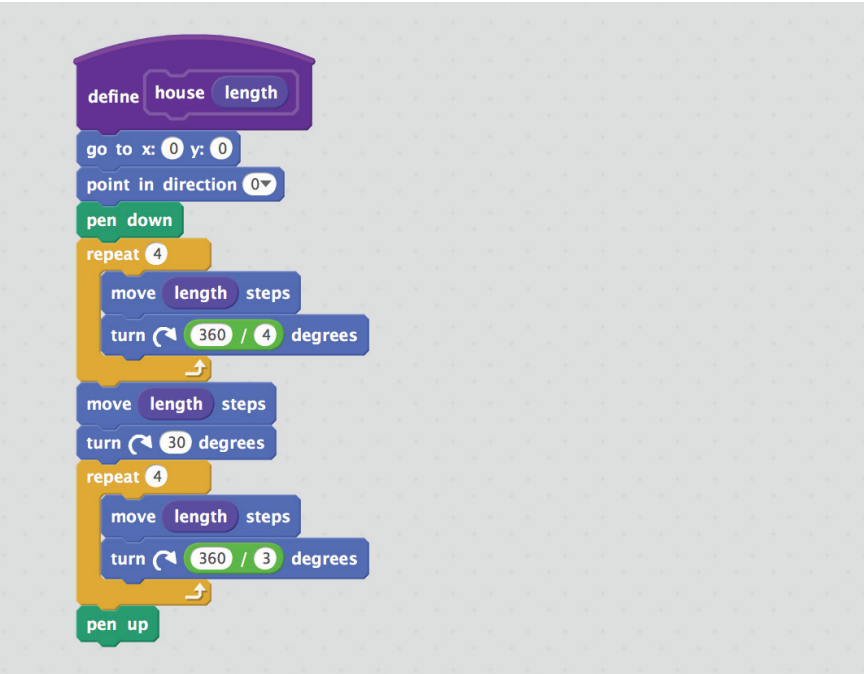
3) The final value of w is: **16**

9: Awesome Functions

1) There are many ways create a function that draws triangles. Below is one way to do it.

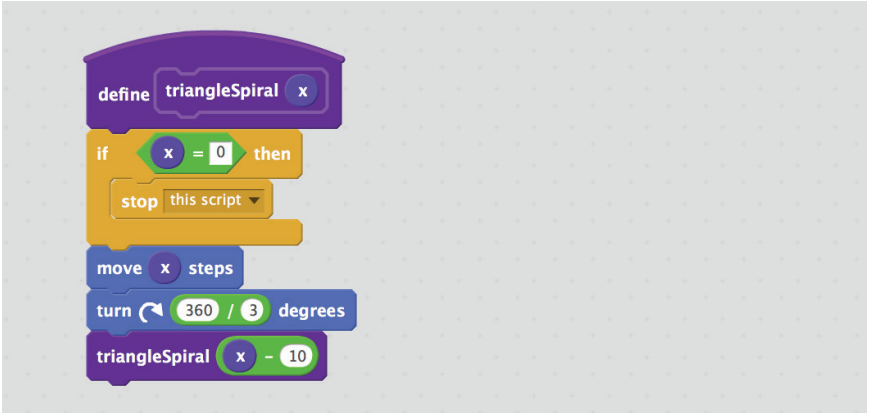


2) The code below shows you one way to draw a resizeable house.

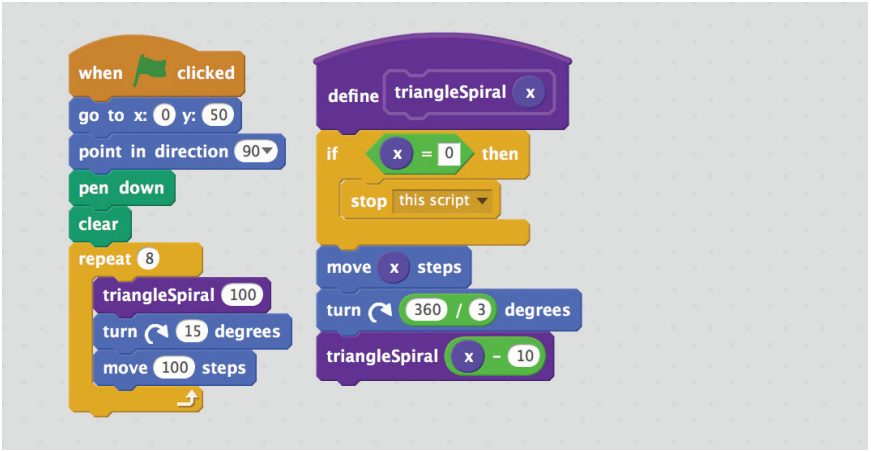


10: If Statements

1) There are many ways code a recursive triangle. Below is one way to do it.



2) To create the star in the picture provided, use this code:



Useful Resources

A2

- **Scratch Home Page**
  http://www.scratch.mit.edu
- **Snap! Home Page**
  http://snap.berkeley.edu
- **The Beauty and Joy of Computing**
  http://bjc.berkeley.edu/website/curriculum.html
- **Learn Scratch**
  http://learnscratch.org
- **Scratch for Budding Computer Scientists**
  http://cs.harvard.edu/malan/scratch/index.php