The Beauty and Joy of Computing

Lab Exercise 1: Introduction to Scratch/BYOB - Animations and Communication

Objectives

By completing this lab exercise, you should learn to

- understand the basic user interface components of BYOB;
- use BYOB, open, edit, and run a project;
- understand the various components of the BYOB system and interface;
- work with sprites to create basic animations;
- coordinate actions of sprites through broadcast messages.

Background (Pre-Lab Reading)

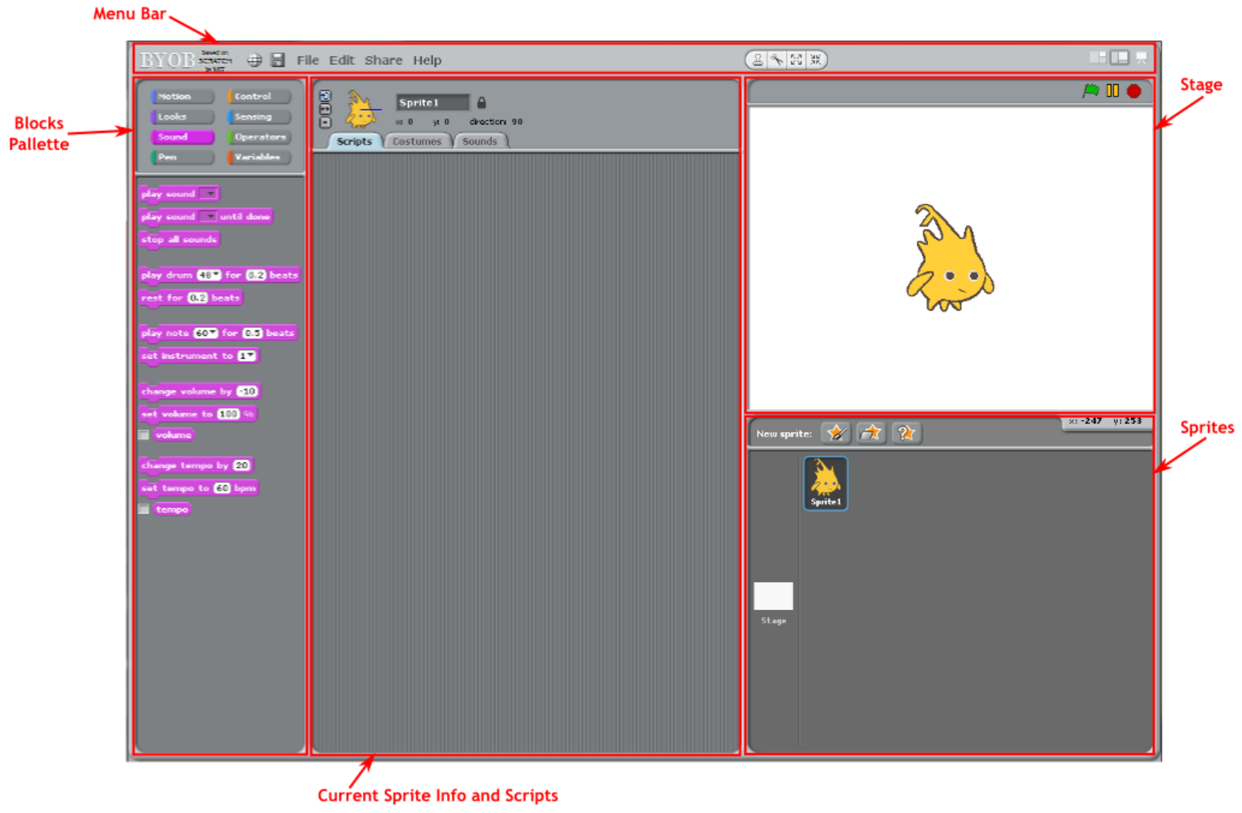
Programming exercises in this class will be done using **BYOB**, an extension to the Scratch programming environment. Scratch was developed by the Lifelong Kindergarten Group at MIT, and is a designed to be an easy-to-use environment for creating animations and simple games (see http://scratch.mit.edu/). Scratch avoids bogging students down with textual syntax concerns by graphically representing programming constructs with blocks, similar to puzzle pieces, that can be snapped together to make more complex actions. While Scratch was designed to be usable by middle school and younger students, it has many features that make it a nice introduction to programming concepts, even for older students.

The BYOB ("Build Your Own Blocks" - see http://byob.berkeley.edu) project extends Scratch by adding some advanced features, including the ability to create your own programming puzzle pieces, or blocks, which is the source of the name. This capability allows a programmer to do the kind of top-down design that is vital to modern programming, and allows the use of recursion and other powerful programming techniques which we will see later in the course. BYOB was created at the University of California at Berkeley, specifically for the Berkeley class that is the model and inspiration for our class.

BYOB and Scratch are both free to download, install, and use. The most recent version of BYOB (renamed to "Snap!") runs in the browser so doesn't require any installation; however, as nice as that is, there are some things missing from the latest versions that we make use of in this course, so we use an older version (version 3.1.1 of BYOB). For more information on BYOB, see the web site at http://byob.berkeley.edu. The specific lab exercises are described in general terms, making little or no assumptions about whether you are doing these on your own computer or in a school computer lab. If you are working in a school computer lab, your instructor may provide another document that provides instructions specific to your school.

Overview of BYOB

BYOB is a graphical programming environment, and when it starts the interface has 5 distinct areas which are called **panes** (as in "panes in a window" - get it?), labeled in the following picture of the BYOB interface:



The "**Stage**" is the area in the upper right corner of the BYOB window, and this is where your program or animation plays out. Once you write a program, you can use the controls above the stage to start the animation (by clicking the green flag), pause or stop the animation.

Stretched out across the top of the BYOB window is a **menu bar**, which is similar to the menu bar in most applications that you are probably familiar with: it has a File menu, Edit menu, etc. There are also some buttons off on the far right that are important: the three buttons above the right side of the stage can be used to change the size of the stage. By default the stage is "medium sized" (as shown in the picture above), but can be made small (the first button), or full-screen (the last button). If you experiment with this and try full-screen mode, use the ESC key to exit full-screen mode.

In the picture above, you see a character drawn on the stage - this is "**Alonzo**," the BYOB mascot. Characters like this can be controlled by programs you write in BYOB, and in animation and game software (not just BYOB) such characters are called "**sprites.**" A sprite is an object that can be defined to set how it looks (called the sprite's "**costume**"), sounds it can make, and actions (or "**scripts**") that control its behavior. When you are creating a program in BYOB, you work with one sprite at a time, selected using the "**sprites pane**" in the lower right corner of the

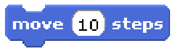
BYOB window. In our example picture, there are two items in the sprites pane: Alonzo (named "Sprite1") and the Stage. While the Stage isn't exactly a sprite, it does have some behaviors that can be controlled, such as setting a background image, playing music, etc. The three buttons at the top of the sprites pane provide three different ways to create a new sprite: the first button (the star with the paintbrush) allows you to draw whatever picture you want; the second button (the star with the folder) allows you to load a sprite picture from a file; the third button (the star with the question mark) gives you a random picture. If you forget what these do, you can "hover" the mouse pointer over any button and it will give you a description of what the button does.

The middle and largest area of the BYOB window, called the "**sprite info pane,**" shows information on the sprite that is currently selected in the sprites pane - notice the three tabs in the sprite info pane identifying the three components of the current sprite: "Scripts" controls the behavior of the sprite (this is for programming), "Costumes" are pictures that show all the different looks or poses of the sprite, and "Sounds" are audio clips that can be played from sprite scripts. You will most commonly work in the Scripts tab of the sprite info pane, and for convenience we will simply call that the "**scripts area**."

The only pane we haven't described yet is the interesting looking "**blocks palette**" on the left side of the window. This pane contains a collection of puzzle pieces (called **blocks**) that you use to create scripts - we'll look at how this works next.

The Blocks Palette and Creating Scripts

All of the blocks that can be used to control the actions of your sprites are located in the blocks palette. Some blocks can cause the sprite to do something (move, say something, change costume, etc.), so we call these **action blocks** - when one of these blocks performs its action, we say that the block **executes** its action, and we refer to this happening as the block's **execution**. Here's an example of an action block:



When this block executes, the sprite will move 10 spaces in the direction that it is facing (we'll talk about what a "space" below). To make this block part of the sprite's program, you simply drag it out from the blocks palette and drop it in the script area. To execute the block, you can click on the block either in the blocks palette or in the script area. To create more complex actions, multiple blocks can be drug out to the script area and connected together - this will make more sense when you do it in the activities. When we have multiple blocks together in a script, executing the scripted sequence is referred to as **running** the script.

Most blocks have parts that can be changed, called **parameters** - for example, the "move..." block above has a single parameter, which controls how far the sprite moves. The value that is sent to the block (like the number 10) is called an **argument**. You can type a different argument value into this block to make the sprite move by 20, 40, or however many spaces you want. You can even have another part of your program provide the argument, so that the sprite doesn't move the same distance every time this block is executed. The difference between the terms "parameter" and "argument" is a little subtle - if you don't understand the difference right now, don't worry about it - we'll get back to it later in the class when defining our own blocks, and it should make more sense in that context.

In addition to action blocks, there are blocks blocks control the execution of other blocks, so we call these **control blocks**. For example, a control block can make it so that our sprite moves when another sprite collides with it.

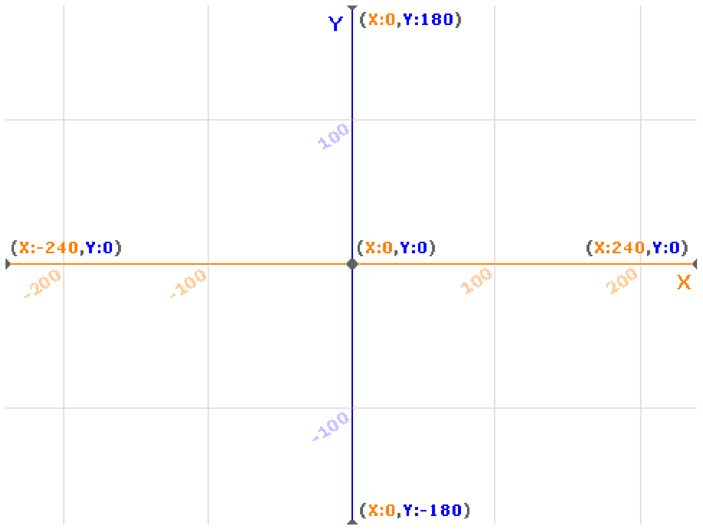
There are a lot of different actions that can be programmed in a sprite, so in order to organize things in a reasonable way the blocks are divided into eight different types of blocks, or **categories**, indicated by the different colored blocks at the top of the block palette. These categories are motion, looks, sound, pen, control, sensing, operators, and variables. The example block above is a "motion" block, and is colored blue as a visual indication of the type of block.

Sprite Positions and Stage Coordinates

In the previous example, we used a block that moved the sprite 10 "spaces" - what's a "space?" Positions on the stage are given using x,y coordinates, just like x/y-axis graphs that you've worked with in math classes, and the correct name for each space is a **pixel** (short for "**picture element**"). The center of the stage is location (0,0), and positive x values go to the right, and positive y values go up. Here's what the Scratch Wiki documentation says about the size of the stage:

> *The screen is a 480x360 rectangle, such that: the X position can range from 240 to -240, where 240 is the rightmost a sprite can be and -240 is the leftmost, and the Y position can range from 180 to -180, where 180 is the highest it can be and -180 is the lowest it can be.*

Unfortunately, this statement isn't quite right - it's close enough for almost everything you'd want to do, but every one of those numbers is slightly wrong. More about this in the "Self-Assessment Questions" below, but for now here's the picture they provide for help in visualizing the coordinate space:



Every sprite keeps track of it’s position as x/y coordinates, and each sprite also has a current direction that says which way the sprite is facing. If the sprite is facing to the right and we move the sprite 10 spaces, what this really means is that the x coordinate of the sprite is increased by 10.

Self-Assessment Questions

Use these questions to test your understanding of the Background reading. Answers can be found at the end of the lab exercise.

1. What does BYOB stand for?
2. What is wrong with this statement: “A sprite is a picture.”
3. What is the difference between an action block and a control block?
4. Fill in the blank: The behavior of a block can be modified by changing a ________ of the block.
5. What are the x/y coordinates of the lower-right corner of the stage?
6. If the x coordinates range from -240 to +240, how many pixels wide would the stage be? Do you see an inconsistency with the description given in the pre-lab reading? Figure out what’s wrong on your own, but then check the answers at the end of the handout for correct information about the Scratch/BYOB screen dimensions.

Activities (In-Lab Work)

To complete this lab, you must complete four specific activities - for each activity there is a minimum set of required activities, and you are encouraged to explore beyond the minimum required to see what you can discover and create. You can’t hurt anything by exploring, so feel free to click on different items in the BYOB interface to see what they will do. We provide some suggestions of other activities to try, but do not feel constrained by our suggestions!

Activity 1: Meet BYOB

To start the BYOB environment, select BYOB from the BYOB folder in the Start menu (assuming a Windows system) - on some systems there might also be a shortcut on the desktop that you can double-click. This will open up the BYOB interaction window, which should look familiar from the pre-lab reading.

Alonzo comes up as the default sprite, so try clicking on each of the three tabs in the sprite info pane to see what is displayed. To start with, Alonzo has no scripts defined, no sounds, and only one costume. Try clicking on the Stage in the sprites pane, and you’ll notice that it looks very similar to a sprite, but the “Costumes” tab is replaced with a “Backgrounds” tab - this is how you set the background of your stage!

After exploring the BYOB interface a little bit, you should create a second sprite to go along with Alonzo. For our first experiment, let’s load a sprite from a file, so click on the star with the folder. Are you curious about what’s in all of those folders? You should be! Click on any of the folders and look through the sprites that are available - if you enter a folder and want to return to where you were before, you can click the up arrow. After you click around a bit to get familiar with what's there, pick one particular sprite that you like - for example, let's pick "dragon1-a" under "Fantasy." If you do this, it will create a new sprite in the sprites pane, and it will draw it on the stage - centered, so it's right on top of Alonzo! You can use the mouse to move these around on the stage, so move them so that the dragon is to the right of Alonzo. Your stage should now look like this:

Note that by clicking on the sprite in the sprites pane, you select that sprite to work with in the middle sprite info pane, so you can switch back and forth between working on Alonzo and working on your new sprite.

We'd like for our dragon to talk to Alonzo, but unfortunately, she's facing the wrong way! How can we fix this? We need to edit the sprite's look, or costume - select the dragon sprite in the sprites pane, and then select the Costumes tab in the middle area. This will show the "dragon1-a" costume, along with "Edit" and "Copy" buttons. Click on "Edit" and the image editor will pop up. The window that pops up should look familiar if you've ever used a paint or image editing program on a computer, but the editor that comes with BYOB does not have all the capabilities of a full-featured image editor - if you want to do anything particularly fancy, you can export the costume to a file (right click on the costume to see the export option), edit using a program like Photoshop or GIMP, and then import the modified version back into your project. The action buttons include one that looks like ◫ - if you hover the mouse over this button you'll see the hint that lets you know that this will flip the image horizontally, which is what we want to do. Click the button, and you'll see that the dragon is now facing to the left, so it can talk to Alonzo!

Finally, try the "File" menu and select "Save As..." - this will prompt you for a name for your project, which in this case consists of just two sprite definitions, and will save it. Go ahead and save this as "Lab1-v1" - then exit BYOB and restart, so that you see only the default project with Alonzo, and then use "File / Open" to restore your previous project to the workspace. Now you know how to save your work so you can resume later. Specific information about where you should store your program depends on your specific computing environment - your instructor should explain your setup to you, and describe how you can save your work.

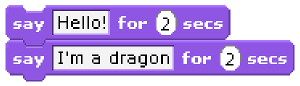
Activity 2: Basic Animation

In this activity, we'll explore the blocks palette to add some actions to our sprites. We will start by making the dragon talk by adding a talking "bubble" (comic strip style). The results of this activity will be saved in a file named "Lab1-v2," so it's a good idea to start the activity by using "Save As …" in the File menu to save your current work (the result of Activity 1) as "Lab1-v2" - this way, you can save (or **checkpoint**) your work by clicking on the save button as you proceed through the activity. By doing the "Save As" at the beginning of this activity, you ensure that you have a new file to save things in, and the "Lab1-v1" file won't be changed by accidentally saving over it. This is a fairly long activity, so it's good to save every now and then to make sure you don't lose your work.

First, get the BYOB workspace into a state that we can work with: Make sure the dragon is selected in the sprites pane, and select the "Scripts" tab in the sprite info pane. Next, click the purple "Looks" button at the top of the blocks palette. Each of the blocks that is displayed will somehow alter the way the dragon looks - if you want to see what they do, you can click on the block in the block palette. For example, click the "hide" block, and the dragon will disappear! Don't worry - the dragon hasn't been deleted, it's just (temporarily) not displayed on the stage. Click the "show" button, and it will re-appear! Click the "Change size by …" button a few times and watch the dragon grow in size - you can undo these changes by clicking the "set size to 100%" button, which will reset the size to normal.

Now click the "say Hello! for 2 secs" button to see how to make the dragon say something. After 2 seconds (do you see why?) the speech bubble will disappear.

Obviously, if you had to go through and click each button to cause each action, it would be really tedious. Scripts are a way of chaining actions together to form more complex actions, and to define actions that should be performed in response to user actions or other events. To start, drag the "say Hello! for 2 secs" over to the sprite info pane (if you followed the directions above, the "Scripts" tab should be selected in that pane). Next, drag the same block over to the middle area again - when you get near the first block you placed, a highlight bar will appear either above or below the existing piece, and if you release it when the bottom edge is highlighted the new piece will "snap" into place on that side of the existing piece. Once you have snapped these two pieces together, click on the first parameter ("Hello!") in the bottom block, and change the text to "I'm a dragon". Your two-block component should now look like this:


```
say Hello! for 2 secs
say I'm a dragon for 2 secs
```

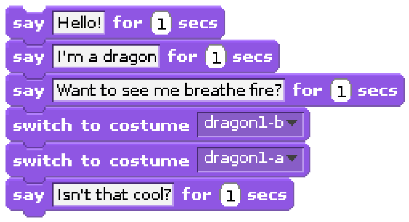
This is now a sequence of two actions which will be done in sequence. Click on any of the purple parts, and you'll see the first speech bubble appear with "Hello!", and then two seconds later it will be replaced by a second bubble that says "I'm a dragon". Note that you can adjust the timing by clicking on either of the numbers and changing the argument for the number of seconds that the bubble is displayed - these don't need to be whole numbers, so you could have "Hello!" only appear for 0.5 seconds if you'd like. Play around with this a little bit to get the timing the way you like it.

Try switching between sprites in the sprites pane, and notice that these blocks that you drug out are only visible when the dragon is selected. We say that this script is **local** to the dragon sprite, meaning that they are attached to that specific sprite and blocks like "say" operate only on that sprite. If you want another sprite to say something, you must select that other sprite and add blocks to its local scripts.

Next, add another "say" block below these to say "Want to see me breathe fire?" for 2 seconds (or however long you'd like). Now you should have a sequence of three speech bubbles - and now we want the dragon to breathe fire! To do this, we need to change the dragon's picture to include fire - recall that the dragon's picture is called its "costume," so click on the "Costumes" tab on the center area. Click the "Import" button at the top, and you'll see the same file browser that you saw when you first created the dragon sprite; however, now when you click on an image it will not create a new sprite, but rather add an alternate costume for the current sprite. Find the picture of the dragon breathing fire (it's called "dragon1-b") and select it - once it's loaded as a costume, you'll notice that it is facing the wrong way, just like our original dragon picture. Do you remember how to flip the picture horizontally? Do it!

Now you have two different costumes for the dragon, and we'll have the regular dragon switch to the fire breathing dragon after the third speech bubble. To do this, switch back to the dragon's "Scripts" tab, and drag the "switch to costume..." block out and put it under the speaking blocks. Make sure the costume name to switch to says "dragon1-b", and now run the 4-block component by clicking on a purple part. Cool!

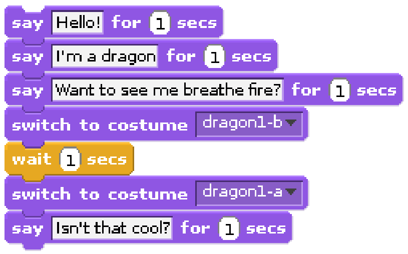
The problem now is that the dragon is left breathing fire - we would like the fire breathing to be temporary, so add another "switch to costume..." block under the last one, and switch back to the normal dragon. Finally add a "say" block to say "Isn't that cool?" Now your script should look like this:



```
say Hello! for 1 secs
say I'm a dragon for 1 secs
say Want to see me breathe fire? for 1 secs
switch to costume dragon1-b
switch to costume dragon1-a
say Isn't that cool? for 1 secs
```

Run the script - did you see the fire? Better look fast! What's the problem?

The problem is that you switch costumes twice in a row, at computer speed, so you the fire breathing flashes by so fast that it's difficult to see. This is a place where we want to put in a delay, so that we can slow down the sequence to see the effects of one block before going right into the next one. The block we need is a "Control" block, so click the orange "Control" button at the top of the block palette. Find the block that says "wait for 1 secs" and drag it out - position it carefully so that it goes between the two costume change blocks, so that your script looks like this:



```
say [Hello!] for (1) secs
say [I'm a dragon] for (1) secs
say [Want to see me breathe fire?] for (1) secs
switch to costume [dragon1-b]
wait (1) secs
switch to costume [dragon1-a]
say [Isn't that cool?] for (1) secs
```

Now run it - looks better, right?

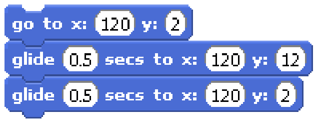
Next, let's try adding motion by having the dragon move up and down slightly, imitating a hovering look. In the pre-lab reading, we talked about how each sprite keeps track of its current position. You can see the current position of the selected sprite in the sprite info pane, at the top - right above the tabs it will say something like

x: 120   y: 2   direction: 90

Your numbers will probably be different, and we won't worry about the "direction" for now, but this tells me that my dragon is at position (120,2). Grab the dragon picture and move it around, and you'll see these coordinates change - after moving the dragon around, leave it in a reasonable starting position for this animation. Now click the "Motion" button at the top of the block palette, find the button that says "go to x: 120 y: 2" (again, your numbers will probably be different). Drag this block out to the Scripts tab for your dragon, and place it down, but do not connect it to the previous component - just drop it in a clear spot of the scripts area. If the numbers in this block do not match your current dragon position, change them to match. Now what happens if you click this block? If you did everything right, nothing will happen - it "move" the dragon to the same position it's currently in - why would you want to do this?

The answer to that last question is this: When an animation ends, if sprites have been moving around, they will be in unpredictable positions. To start the animation with sprites in the correct positions, you should always put one of these "go to" blocks at the beginning of your motion sequence. You can think about this as a "reset button" for the position of the sprite.

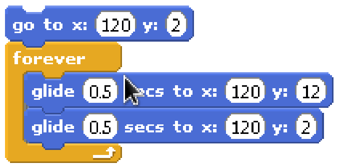
Next we want to move the dragon up and down, as if it is hovering. To do this, drag the "glide" block out and snap it in place below the "go to" block. The first number controls the speed (the time, in seconds, of the glide), and the last numbers give the final location of the end of the glide path. We want the dragon to go up a little, so set the (x,y) coordinates at the end of the glide path to the same x value as the beginning position, and the y coordinate to be 10 greater - for example, if the starting position is (120,2), then you should glide to (120,12). Finally, put another glide block below this one to glide back to the original position, and experiment with time values to get a something that looks right to you. For example, your final movement block might look like this:



```
go to x: (120) y: (2)
glide (0.5) secs to x: (120) y: (12)
glide (0.5) secs to x: (120) y: (2)
```

Next we want to keep doing these operations over and over. Going back to the "Control" blocks, find the "forever" block. Note that this block looks different from the ones you've used before -

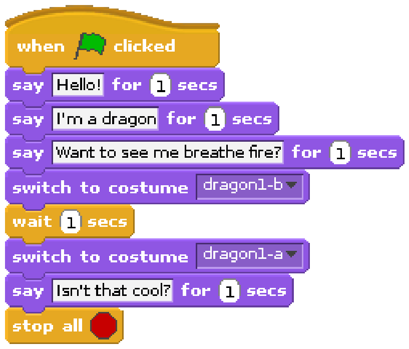
it's a "**C block**" (named after its shape), and has other blocks not only before and after it, but also inside it. The effect of this particular block is to repeat the sequence of actions inside it over and over - forever! If you're careful about how you move it out, you can click it around the two "glide" blocks so that it looks like this:



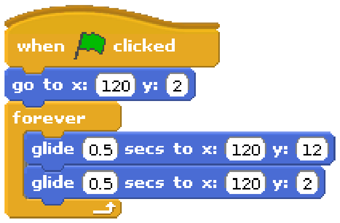
```
go to x: 120 y: 2
forever
    glide 0.5 secs to x: 120 y: 12
    glide 0.5 secs to x: 120 y: 2
```

Now click at the beginning, and the dragon will float up and down repeatedly. This will go on forever (that's the name of the block!) unless you stop it, which is what the red stop-sign button at the top right of the stage does. Try starting and stopping this a few times to see how this works.

Finally, in an animation, we don't really want to start a single sequence of operations for just one sprite - we want to start the entire animation at once. We have defined two sequences of actions now: the speaking and fire breathing sequence, and the flying sequence. Drag out the "When (green flag) clicked" block (in the control category) out and put it at the top of both of these sequences, and put the "stop all" (also in the control set) out and put it at the end of the speech sequence. Now you have two blocks that look like this:



```
when clicked
say Hello! for 1 secs
say I'm a dragon for 1 secs
say Want to see me breathe fire? for 1 secs
switch to costume dragon1-b
wait 1 secs
switch to costume dragon1-a
say Isn't that cool? for 1 secs
stop all
```



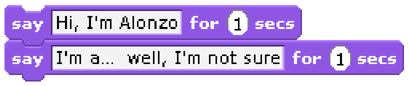
```
when clicked
go to x: 120 y: 2
forever
    glide 0.5 secs to x: 120 y: 12
    glide 0.5 secs to x: 120 y: 2
```

Click the green flag above the stage, and both sequences will be run. The dragon will fly up and down while it is talking and breathing fire!

Now that you've done all of this, save this project as "Lab1-v2".

Activity 3: Coordinating Multiple Sprites

So far, only our dragon has done anything - what about Alonzo? Let's have Alonzo say something after the dragon says "I'm a dragon" and before she says "Want to see me breathe fire?" Switch over to the Alonzo sprite, and add a script that does the following:



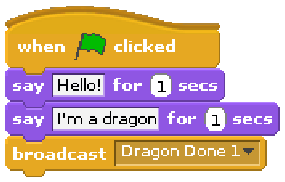
```
say Hi, I'm Alonzo for 1 secs
say I'm a...  well, I'm not sure for 1 secs
```

Tip: If you need to change several parameters, click on the first one - in this example, change the first text to "Hi, I'm Alonzo." After you type the text, you don't need to take your hands off the keyboard to select the next parameter with the mouse - just hit the “Tab” key and it will switch over to the next parameter, which you can type in. It’s often faster to drag a bunch of blocks that you need out, snap them together without worrying about the arguments, and then change all the arguments at once by tabbing between them.

The problem is to figure out how to make Alonzo say this at the right time. If you had him say it when the green flag was pressed, he’d be talking at the same time as the dragon (try it!). The answer to this problem is to have the sprites “signal” each other when they get to different parts of their scripts.

What we need is a way for the dragon to signal Alonzo that it is finished talking, and is ready for Alonzo to talk (isn’t that polite and civilized? sometimes these signals in real life would help!). This is precisely what “**broadcast messages**” are for - to allow sprites to signal each other about certain events.

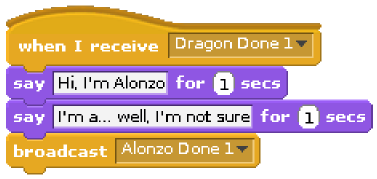
To Do: On the scripts page for the dragon, use the mouse to grab the block where the dragon says “Want to see me breathe fire?” and drag it away - notice how this separates that block and everything below it from the big dragon script. Now, in the blocks palette, select the “Control” category, and drag the “broadcast” block out to add to the dragon’s initial dialog script. The only parameter in the broadcast block is blank (unless you have been experimenting with messages already!), so click on it and select “New” from the popup menu. You should now be prompted for a message name - any sprite can send a message for any reason, which is hard to keep track of in a complex animation, so it is important to give messages meaningful names that help you remember their purpose. For example, what we want to signal here is that the dragon is done speaking for the first time, so let’s call this message “Dragon Done 1” - your first dragon script block should now look like this:



```
when [flag] clicked
say [Hello!] for (1) secs
say [I'm a dragon] for (1) secs
broadcast [Dragon Done 1 v]
```

Note that you can also name sprites, so changing those names from “Sprite1” and “Sprite2” to something more meaningful (like “Alonzo” and “Dragon”) would be a good idea.

Now that the dragon can broadcast a message, there needs to be some way to receive that message and make it trigger an action. For this, use the “when I receive...” block - switch over to Alonzo, separate the actions from the “when green flag clicked” block (if you put that block in), and start Alonzo’s dialog with the “when I receive...” block - you should select the “Dragon Done 1” message for this block’s parameter. Next, put another broadcast block at the end of Alonzo’s dialog, named something like “Alonzo Done 1” - now Alonzo’s script should look like this:



```
when I receive [Dragon Done 1]
say [Hi, I'm Alonzo] for (1) secs
say [I'm a... well, I'm not sure] for (1) secs
broadcast [Alonzo Done 1]
```

Finally, remember those blocks that you separated from the dragon's script at the beginning of this activity? Make them run when they receive the "Alonzo Done 1" message. If you have done all of this correctly, then you can click the green flag, and you will have an animation of a synchronized dialog between Alonzo and the dragon, while the dragon is flying and breathes fire. Not exactly a Pixar short, but still pretty cool for a first try! Save this project as "Lab1-v3".

Activity 4: Get Creative!

You have now experimented with the basics of BYOB, and should have a decent understanding of what sprites are and how you can program them with sequences of actions. Now you should play around with this to see if you can animate something of your choosing - for example, take a brief exchange from a movie or a TV show, or make something up. You can do whatever you want, but must satisfy the following minimum requirements: you must have at least two characters (i.e., sprites) in your animation, each must have at least two distinct sequences of actions (e.g., dialog sequences), and the actions of the two characters must be coordinated with each other using broadcast signals. Browse through the available sprite images for fun characters, or if you're really ambitious see if you can get images from the Internet imported as sprite costumes. And most importantly: Have fun with it! Save your creation as "Lab1-myscript".

As a final note, there are a lot of examples that you can access under "File / Open" and selecting the "Examples" button on the left. These use a lot of features we haven't worked with yet, but it is still interesting to click through the examples and see what's there.

Discussion (Post-Lab Follow-up)

Beyond learning the basics of BYOB, there are a few important concepts that you were exposed to in this assignment, which are discussed here.

Problem Decomposition: This is the fancy way of saying that a big problem was broken down into smaller pieces that could be tackled individually. Our final Alonzo/Dragon conversation involved several pieces: Alonzo and the dragon talking, and the dragon flying. When you think about writing a program like this, your first step should be to identify all the pieces that can operate independently - don't think of it as one big program, but think "the dragon will say these things before waiting for a response," and "the dragon will fly while all of this is going on." Not only does this help you think about solving the problem, since you're working on smaller problems, but it also allows you to develop small pieces that can be constructed and tested individually before being put together in a larger program. This is one of the most important skills for a software developer: something like Microsoft Windows has tens of millions of lines of code (individual instructions), but in the design of the system it is decomposed into components that individual teams or programmers can work on independently. Imagine how impossible it would be if all the programmers had to work on the program as one big chunk of code! If you study more about construction and testing of large software systems, some terms that come up include *top-down design* (starting at the overall idea for your program and breaking it down into smaller pieces, and then those down into smaller pieces, and then those...), *unit testing* (testing individual pieces to make sure they work on their own), *integration testing* (making sure those individual pieces work together properly), and *system testing* (making sure the final product works as required).

Event-driven Programming: Each set of blocks you put together was "triggered" by something for it to start running, whether it was pressing the green flag or receiving a broadcast message. This style of programming is called "event-driven programming" and is common for highly interactive programs. Programming graphical user interfaces (GUIs) is an example of something that is highly event-driven - the programmer defines the interface elements (drop down menus, buttons, etc.) and then defines actions that are executed when these elements are interacted with (e.g., a button is pressed). Not all programming is like this, however - large computational tasks, like simulating a galaxy, do lots of computational number-crunching through well-defined operations, and there are no events to respond to. Picking the right style of programming is something that people get better at once they get experience in the different styles.

Concurrency: Concurrency means that different tasks are happening at the same time. For example, the sequence of instructions for the dragon talking are being executed at the same time as the sequence of instructions for the dragon flying. Notice that concurrency is very natural in BYOB: different actions that are triggered by the same event (like pressing the green flag) happen at the same time. What is interesting is that while this is very natural in BYOB and Scratch, more "advanced" programming languages like C++ or Python do not support concurrent operations in nearly as clean and nice a fashion. However, that's also understandable: concurrency in large systems, where many very complex actions can be happening at the same time, can be difficult to design and test. A final note on concurrency: You could define a dozen concurrent tasks in Scratch, and they would all execute concurrently - how does it do this if there is only one processor in the computer? The answer is that, unseen to you, the computer is not really executing all of these at the same time. It will execute one task for a very small amount of time (like a hundredth of a second), and then execute another one for a small amount of time, and will keep alternating between these tasks so quickly that it looks like they are all happening at the same time - this is similar to playing a movie, where individual still pictures are flashed before you at a fast enough rate to give you the impression that there is motion. Modern processors also have some capabilities for actually executing multiple things at the same time - for example, a "quad-core" processor could actually be running four tasks simultaneously. However, if you have 12 tasks defined, then each core could be switching rapidly between three different tasks.

Versioning: As you added more and more functionality to the animation with Alonzo and the dragon, you saved several times, with names "Lab1-v1", "Lab1-v2", and "Lab1-v3". One reason for this is because you are in a class and need to turn in all three versions, so you need different file names. However, if your initial goal was just to produce the final animation and not to document your work in the lab, you still might save multiple copies - or *versions* - like this, since it allows you to go back to a previous version if you decide you don't like your most recent additions. This is a very common practice, in both programming and general computer work - for example, when multiple people are collaboratively working on a word-processing document, it is common for people to save new versions with the date appended to the filename. By writing the date in the order year-month-date, a sorted list of files by filename will provide them in order. For example, the file named "Proposal-2012-05-23.doc" would be the version of the proposal written on May 23, 2012. Another common versioning practice is for authors to put their initials at the end of the filename, so you might know that a particular version was edited by "srt" (for example). Finally, professional software development teams often use software called "**Version Control Systems**" (VCS) which take care of versioning automatically - when software is saved (or "committed") to a VCS it is automatically assigned a new version number. Previous versions can always be accessed, and VCS systems always provide a way to reconcile and merge changes that are made by different team members.

Terminology

The following terms were introduced in this lab.

- action block: A block whose execution causes some direct action on or by a sprite (movement, sound, changing costume, talking, etc.).
- Alonzo: The BYOB mascot, and the first sprite that appears by default in an empty project.
- argument: A value that is provided for a parameter.
- block: A "puzzle piece" that defines a particular programmable action for a sprite.
- blocks palette: The left-most pane of the BYOB window, that contains all of the blocks that can be used in your scripts.
- broadcast message: A message sent out by a script, which can be received by other scripts. This is useful for synchronizing between scripts or sprites.
- BYOB: An enhanced version of the Scratch programming environment. Scratch was developed at MIT, and the BYOB extensions were developed at the University of California at Berkeley.
- C block: A block that is shaped like the letter C, so that other blocks can be put inside it and are then controlled by the C block. "C block" refers to the shape, but C blocks are always control blocks.
- category: Blocks belong to a category (such as "motion" or "looks") that describes what they do - the blocks palette is organized by category to make it easier to find blocks.
- checkpoint: Saving an intermediate version of your work so that you can return to that point later if your work gets messed up.
- concurrency: Multiple actions happening (or appearing to happen) at the same time.
- control block: A block that controls the execution of another block - it can control how many times a block will execute, or even whether it executes at all.
- costume: A graphical representation of a sprite. Sprites can have multiple costumes if they have different looks throughout the course of a program, and the sprite switches between costumes to change how it looks.
- event-driven programming: A style of programming in which scripts are designed to respond to events, such as keys being pressed, or broadcast messages being received.

- executes/execution: This refers to a block performing the action that it is programmed to do - we say that a block "executes" its action, and refer to that as the "execution" of the block.
- local: An item (script, variable, etc.) that is only defined in a limited context, like a script that is defined only for a specific sprite.
- menu bar: The narrow area across the top of the BYOB window that gives access to drop-down menus for loading or saving projects, setting options, etc.
- pane: An area of a window that serves a specific purpose, like selecting the current sprite (in the "sprites pane") or showing/defining characteristics of the current sprite (in the "sprite info pane").
- parameters: Positions in a block that define values that can be changed for different instances of the block.
- pixel: Short for "picture element," this is the basic unit of measurement in graphics. It corresponds to one dot on a display or in an image.
- problem decomposition: The process of taking a complex task, and breaking it down into simple pieces that can be worked on independently.
- run: The execution of a series of blocks that are connected together in a script. We can also talk about running a program, which is a collection of different scripts.
- script: Sequences of actions that can be initiated either by the programmer or by some event in the program (the green start flag being clicked, receiving a broadcast message, the user pressing a key, etc.).
- scripts area: A shorter way of saying "the scripts tab of the sprite info pane."
- sprite: A character or other object that has (optionally) actions/scripts, costumes, and/or sounds associated with it.
- sprite info pane: The center pane of the BYOB window, where you can define scripts, costumes, and sounds for the current sprite.
- sprites pane: The lower-right part of the BYOB window, where you can select a sprite to make the current sprite.
- stage: The space where your animations play out, and scripts are drawn. The stage can have a background that will be displayed behind any sprites that are on the stage.
- versioning: Using separate files to save a project as it develops and becomes more complex. This is useful if you ever have to return to (or "revert to") an older version.
- version control system: A software system that manages versions of files in a possibly complex project.

Submission

In this lab, you should have saved the following files: Lab1-v1, Lab1-v2, Lab1-v3, and Lab1-myscript. Turn these in using whatever submission mechanism your school has set up for you.

Answers to Pre-Lab Self-Assessment Questions

1. What does BYOB stand for?
   Answer: BYOB stands for "Build Your Own Blocks," which refers to the capability of a programmer to define their own blocks (in Scratch, the programmer was restricted to just

the blocks that appeared in the blocks palette - in BYOB you get to make your own blocks to use!).

2. What is wrong with this statement: "A sprite is a picture."
Answer: A sprite is much more than a picture - sure, it is usually seen as a picture, but that picture is one of potentially many costumes, and the sprite also contains sounds that it can make, and scripts or programs that control its actions.

3. What is the difference between an action block and a control block?
Answer: An action block controls the actions of a sprite. A control block controls the actions of other blocks.

4. Fill in the blank: The behavior of a block can be modified by changing a ________ of the block.
Answer: Argument. Saying "parameter" here is not correct - the value you put in the slot of the block is an argument. Again, we'll get into the distinctions between these two terms in more detail in a later lab.

5. What are the x/y coordinates of the lower-right corner of the stage?
Answer: Based on the information in the Pre-Lab Reading and the Scratch documentation, the correct answer should be (240,-180). However, in light of the correction given in question 6 below, the correct answer is actually (239,-179). Note that the x coordinate is at its highest possible positive value since the position is to the right, and the y coordinate is at its largest magnitude negative value since we want the bottom part of the stage.

6. If the x coordinates range from -240 to +240, how many pixels wide would the stage be? Do you see an inconsistency with the description given in the pre-lab reading?
Answer: The stage would be 481 pixels wide! There are 240 positive x values, 240 negative x values, and x can also be zero. This means the numbers given in the Scratch documentation are not consistent with each other, so something is wrong in their description. While errors in documentation can be frustrating, the nice thing about most computer programs is that you can experiment to find out the correct information yourself (you would need to know about some of the BYOB commands in order to do this experimentation) - yes, it's frustrating to have to do that, but at least it's possible! It turns out that Scratch/BYOB x coordinates actually range from -239 to +239, and y coordinates range from -179 to +179, giving a stage size of 479x359. In other words, every one of the numbers they gave in the Scratch documentation was wrong (they were all off by 1).