Unit 5 Lesson 1

Introduction to Event-Driven Programming

Resources
Unit 5 Lesson 2

Multi-Screen Apps

Resources
Unit 5 Lesson 3

Building an App: Multi-Screen App

Resources
Activity Guide - Multi-screen App

Multi-screen App
You will be creating your own multi-screen app to practice designing user interfaces and writing event-driven programs. You have a lot of freedom to choose what your application will be but some ideas might include:

- A personal app about you and your hobbies / interests
- A “Top 3” app for a category of your choosing
- An informational app for an organization or club
- A flash card app for studying for quizzes
- A short “choose-your-own adventure” game
- An app with a different game on each screen

Requirements
Your application must have the following components:

- Your app must have some kind of purpose
  - Even if the purpose is simple like “Celebrating all my favorite foods to eat”, there must be an underlying purpose that thematically ties the whole thing together.
  - The title of your app should make it pretty clear.
- Your app will have at least 4 screens.
- Your app should include text, images, and buttons (and optionally sound).
- No “getting stuck” on a screen.
  - It should always be possible to navigate from a screen in your app to some other screen.
  - The user should also be able to “get back to the start” somehow. There are many ways to do this (e.g., screens go in a cycle, or every screen can navigate back to the home screen, etc.) but you should make sure you plan accordingly.
- Your program code should follow good style, particularly by giving UI elements descriptive and meaningful IDs.
- Your user interface should be intuitive to use.

Process
- Choose the theme and purpose of your app.
- Complete the Planning Guide to decide how you will display your information.
- Informally Share the sketch of your idea with a classmate to get some basic feedback and to see if they have any ideas you hadn’t thought of. Possible discussion points:
  - Does the way users navigate through pages intuitive?
  - Is the design / layout clear and present the information well?
  - Anything you would add? Anything you would take out?
- Program your app following the plan you develop in the Planning Guide.
- Peer Review at least one of your classmates’ apps using the Peer Review Rubric.
Outline Your App
You will be sketching out the layout of your application using the rectangles below. Each rectangle represents a screen of your app. For each screen you should:

- **Decide** what information will be included on that screen.
- Give the screen a **descriptive ID**.
- Add any **notes** about the content that will be featured in that screen.
- Within each rectangle, **draw the elements** that will appear in that screen.
- **Draw arrows** to / from your screen showing how a user will be able to navigate through the app.
Outline Example

My Top 3 Favorite Songs

#1: "Never Gonna Give You Up"  
   Rick Astley  
   Screen ID: song1  
   Notes:  
   "Listen to Clip" button plays audio clip of song

#2: "Hotline Bling"  
   Drake  
   Screen ID: song2  
   Notes:  
   "Listen to Clip" button plays audio clip of song

#3: "Shake It Off"  
   Taylor Swift  
   Screen ID: song3  
   Notes:  
   "Listen to Clip" button plays audio clip of song

Let's Go! ->
### Peer Review Rubric

**Project being reviewed:**

**Reviewer:**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Yes</th>
<th>Almost</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intended purpose of the app is clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project includes at least 4 screens.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application includes images, text, and buttons. (bonus points for sound)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>You cannot get “stuck” on any screen. It is always possible to get to the rest of the app.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text on screen is clear and descriptive.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element IDs are descriptive and meaningful. (Look at the code.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The app is visually appealing and the user interface is intuitive to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit 5 Lesson 4

Controlling Memory with Variables

Resources
Unit 5 Lesson 5

Building an App: Clicker Game

Resources
Activity Guide - The Clicker Game

The Clicker Game
You will be creating your own “clicker” game similar to the Apple Grabber game you worked on in this lesson. The general object of the game is to click on an element that jumps around every time you click it. You will pick your own theme and decide what the rules are and how to keep score.

Template
A template for the app is provided in Code Studio. The template has 4 screens and some basic navigation functionality and event handlers set up for you. The game play screen uses the images from the Apple Grabber game, but you should replace these with images related to your chosen theme.

Your main tasks are to:
- pick a theme for your game and add appropriate images and styling
- add variables to track some data during game play
- add code to event handlers to update the variables and display appropriately

Requirements
Your application must have the following components:
- Your game must end - there must be a way to “win” and a way to “lose.”
- You must use at least one variable (but you may use as many as you like) to keep track of some data during game play (such as a score, or a number of attempts remaining, number of times a certain element was clicked, etc.).
- Your app will have at least 4 screens:
  1. A welcome screen that explains what your game is and how to play, and lets the user start
  2. A screen for game play that displays some data on the screen that updates during play (such as the running score, number of attempts remaining, etc.)
  3. A “win” screen to show a congratulatory message if the player “wins” the game
  4. A “loss” screen to show when the player “loses” the game
- From the the win/loss screens, it must be possible to start the game over without simply re-running the app from scratch; this means resetting all variables and displays back to initial values.
- Your program code should follow good style, particularly by making sure to create global variables in the first few lines of code and giving UI elements and variables descriptive and meaningful IDs.
- Your user interface should be intuitive to use.

Process
- Choose the theme of your game: what is jumping around the screen that the user is trying to click? Many themes and metaphors are possible.
- Program your app: it’s suggested you start by adding some functionality before style. Add one variable into the program, and add code to update and display it properly.
- Have a peer test it out to see if there are any more improvements you should make.
- Make any necessary final adjustments.
- Peer Review: you will review at least one of your classmates’ apps using the Peer Review Rubric, and someone will review yours.

Advanced option: use getTime() to factor time into your game
In the toolbox you’ll see a function called getTime() which returns a number that’s called a timestamp, representing the moment in time (to the millisecond) when the function was called. If you store a timestamp in a variable when the player starts the game and then grab a timestamp when they win, you can calculate how long it took and you could factor this into your score. Read the documentation for getTime() to see how it works.
Peer Review Rubric

Project being reviewed:

Reviewer:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Yes</th>
<th>Almost</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Using the App / Playing the game</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welcome screen explains the game, how to win or lose, and allows the player to start.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least one value is shown on screen that changes during game play (for example: a running score).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is possible to win, and the app switches to a “win” screen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is possible to lose, and the app switches to a “loss” screen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is possible to start the game over without having to restart the program (i.e., the win/loss screens allow you to navigate back to the welcome screen).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When you start over, variables or other data and displays are properly reset to initial values.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The app is visually appealing and the user interface is intuitive to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The Code</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The code contains at least one global variable; it appears at or near the first lines of code.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>You can find the line or lines of code in an event handler function that updates a global variable.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UI elements have meaningful/descriptive IDs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit 5 Lesson 6
User Input and Strings

Resources
Create a Mad Libs App
You will be creating an instructional Mad Libs® app that allows a user to submit input of different types (e.g., noun, verb, plural noun, etc.) and then combines them with text you’ve written to create a single (usually funny) message.

The main criteria of your project are as follows:

- Your Mad Libs app should be structured as instructions for completing some task.
- You must include at least three steps in your instructions.
- You must accept at least three pieces of input from your user.
- You must set at least one piece of input to always be uppercase or lowercase.

Example
Here you can see how you might plan out the “Learn to Drive” example found in Code Studio.

<table>
<thead>
<tr>
<th>Inputs:</th>
<th>Output Text:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[plural noun] make lowercase</td>
<td>Learning to drive is a tricky process. There are a few rules you must follow.</td>
</tr>
<tr>
<td>[noun 1] made lowercase</td>
<td>1. Keep two [plural noun] on the steering wheel at all times.</td>
</tr>
<tr>
<td>[noun 2] made lowercase</td>
<td>2. Step on the [noun 1] to speed up and the [noun 2] to slow down.</td>
</tr>
<tr>
<td>[song] make lowercase</td>
<td>3. Your parents will just LOVE it if you play [song] on the radio.</td>
</tr>
<tr>
<td>[verb] made uppercase</td>
<td>4. Make sure to honk your horn when you see [verb] on a street sign.</td>
</tr>
</tbody>
</table>

Brainstorm
Use this space to brainstorm components of your own Mad Libs app.
Unit 5 Lesson 7
If-statements unplugged
Resources
Let’s play a game: “Will it Crash?”

Each row in the table below presents a small program that uses if-statements and robot commands. Trace the code and plot the movements of the robot for the 3 scenarios shown to the right of the code. If the robot is directed to move onto a black square, it “crashes” and the program ends. If the robot doesn’t crash, then draw a triangle showing its ending location and direction.

There are a few patterns to the ways if-statements are typically used:

- Basic If-statements
- Sequential If-statements
- Basic If-else statements
- Nested If and if-else statements.
- Combinations of all of the above

Each section below presents an example of one of these common patterns, followed by a few problems for you to try. For each type study, and make sure you understand, the example and why each of the 3 scenarios ends up in the state shown.

**EXAMPLE: Basic If-statement**

```plaintext
Code is executed sequentially from top to bottom. The code inside the if-block executes ONLY if the condition is true, otherwise the block is skipped and execution picks up on the first line after the if-block.

MOVE_FORWARD ()
IF (CAN_MOVE (forward))
{
    MOVE_FORWARD ()
    MOVE_FORWARD ()
}
ROTATE_LEFT ()
MOVE_FORWARD ()
```

**Scenario 1:**
![Scenario 1 Diagram]

**Scenario 2:**
![Scenario 2 Diagram] Use the diagram to trace each robot move.

**Scenario 3:**
![Scenario 3 Diagram] CRASH!

**YOU TRY IT - Basic If-statement**

```plaintext
ROTATE_LEFT ()
IF (CAN_MOVE (left))
{
    ROTATE_LEFT ()
}
MOVE_FORWARD ()
MOVE_FORWARD ()
```

**Scenario 1:**
![You Try It Scenario 1 Diagram]

**Scenario 2:**
![You Try It Scenario 2 Diagram]

**Scenario 3:**
![You Try It Scenario 3 Diagram]
EXAMPLE: Sequential If-statements

Lines of code, including if statements, are evaluated separately, one at a time, in order from top to bottom. An if-block executes ONLY if the expression is true. Note that an earlier if-statement might change the state of the world for an if-statement that comes later. This makes it hard to predict what will happen unless you trace the robot moves and take each line one at a time.

IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}
IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}
ROTATE_LEFT ()
IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}  

YOU TRY IT - Sequential If-statements

ROTATE_LEFT ()
IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}
ROTATE_RIGHT ()
IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}
ROTATE_LEFT ()
IF (CAN_MOVE (forward))
{  MOVE_FORWARD ()
}  

IF (CAN_MOVE ( left ))
{  ROTATE_LEFT ()
    MOVE_FORWARD ()
}  

IF (CAN_MOVE ( left ))
{  ROTATE_LEFT ()
    MOVE_FORWARD ()
}  

IF (CAN_MOVE ( left ))
{  ROTATE_LEFT ()
    MOVE_FORWARD ()
}
### EXAMPLE: If-else Statement

The code in the if-block executes ONLY if the expression is true, otherwise the code in the else block will run. But one or the other must execute. An else statement can be attached to a single if-statement.

```c
ROTATE_LEFT ();
IF (CAN_MOVE (forward))
{
    MOVE_FORWARD ();
}
ELSE{
    ROTATE_LEFT ();
    ROTATE_LEFT ();
}
MOVE_FORWARD ();
```

### YOU TRY IT - Simple If-Else

Here is a block-based version of a very similar program.

```c
MOVE_FORWARD
IF (CAN_MOVE (forward))
{
    MOVE_FORWARD ();
}
ELSE{
    ROTATE_LEFT();
    MOVE_FORWARD ();
    ROTATE_RIGHT();
    MOVE_FORWARD ();
}
```

```c
IF (CAN_MOVE (left))
{
    ROTATE_LEFT ();
    MOVE_FORWARD ();
}
ELSE{
    ROTATE_RIGHT ();
    MOVE_FORWARD ();
}
```

```c
IF (CAN_MOVE (right))
{
    ROTATE_RIGHT ();
    MOVE_FORWARD ();
}
ELSE{
    ROTATE_LEFT ();
}
```

### NOTE: Easy to miss

MOVE_FORWARD on the last line
EXAMPLE: Nested Statements

You can put if- and if-else statements inside other if-statements. All previous rules apply, but tracing the code can be tricky.

```c
IF (CAN_MOVE(forward))
{
    MOVE_FORWARD();
}
ELSE
{
    IF(CAN_MOVE(backward))
    {
        ROTATE_LEFT();
        MOVE_FORWARD();
    }
    MOVE_FORWARD();
}
MOVE_FORWARD();
```

YOU TRY IT - Nested If-statements

```c
IF (CAN_MOVE(forward))
{
    IF (CAN_MOVE(left))
    {
        ROTATE_LEFT();
    }
    ELSE{
        ROTATE_RIGHT();
    }
    MOVE_FORWARD();
}
ELSE
{
    ROTATE_LEFT();
    MOVE_FORWARD();
}
MOVE_FORWARD();
```
Challenge: putting it all together — if, if-else, sequential if, nested statements

```c
if (CAN_MOVE (forward))
{
    MOVE_FORWARD ()
    if (CAN_MOVE (left))
    {
        if (CAN_MOVE (right))
        {
            ROTATE_RIGHT()
        }
        else
        {
            ROTATE_LEFT()
        }
    }
    else
    {
        ROTATE_RIGHT()
    }
    MOVE_FORWARD ()
}
else
{
    ROTATE_LEFT()
    ROTATE_LEFT()
}
MOVE_FORWARD ()
```
Now you try it!

Now that you’ve had a bunch of practice reading and tracing code with if-statements, try writing your own pseudocode robot program that uses if-statements.

Problem statement:
Write a program to make the robot end up on the target gray square facing any direction...but your code must be able to handle the possibility of an obstacle that could appear in any one of the other squares (i.e. squares that aren’t the start or target squares - numbered 1-7 in the diagram)

You must write the code without knowing ahead of time where the obstacle will be. In other words, you must write one program that can handle any possibility that might occur. For this exercise, there 8 possible locations where obstacle might be, we’ll call them scenarios 0-7:

Write your program by hand below and test it by tracing it against each of the 8 possible scenarios. Your code should get the robot to the target no matter where the obstacle appears.

Goal: When the program ends, the robot is on the gray square -- it can be facing any direction

Tip: When hand-writing code you don’t need to follow the pseudocode syntax strictly, as long as your intent is clear. For example, using abbreviations and/or omitting the curly-braces and just indenting is fine.
Selection

**Text:**
IF (condition)  
{  
   <block of statements>  
}

**Block:**

```
IF [condition]  
<block of statements>
```

**Commentary:**
The code in block of statements is executed if the Boolean expression condition evaluates to true; no action is taken if condition evaluates to false.

```
An if-statement might execute some code or it might not. It checks to see if something is true (the "condition"). If it is true, then run some code contained inside the if-statement. Otherwise, if the condition is false, just ignore the whole block and pick up executing the code that comes after it.
```

**Text:**
IF (condition)  
{  
   <first block of statements>  
}  
ELSE  
{  
   <second block of statements>  
}

**Block:**

```
IF [condition]  
First block of statements
ELSE  
second block of statements
```

**Commentary:**
The code in first block of statements is executed if the Boolean expression condition evaluates to true; otherwise the code in second block of statements is executed.

```
An if-else statement is an "either or". You are saying: "I want to run either this block of code or this other one". An if-else guarantees that one of the two blocks of statements will execute. If the condition is true, then run the first block of statements and ignore the other block. If the condition is FALSE, then ignore the first block and run the second one.
```

**Important Note:** While an if statement can stand on its own (see above), an ELSE statement cannot - it must be "attached" to an IF statement, and no lines of code can be inserted between an if and else.

Robot

**Text:**
MOVE_FORWARD ()

**Block:**

```
MOVE_FORWARD
```

The robot moves one square forward in the direction it is facing.

**Text:**
ROTATE_LEFT ()

**Block:**

```
ROTATE_LEFT
```

The robot rotates in place 90 degrees counterclockwise (i.e., makes an in-place left turn).

**Text:**
The robot rotates in place 90 degrees clockwise (i.e., makes an in-place
<table>
<thead>
<tr>
<th>Block:</th>
<th>CAN_MOVE (direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text:</td>
<td>Evaluates to <strong>true</strong> if there is an open square one square in the direction relative to where the robot is facing; otherwise evaluates to <strong>false</strong>. The value of direction can be left, right, forward, or backward.</td>
</tr>
</tbody>
</table>

**Commentary:**
CAN_MOVE is a *condition* that you can use in an if-statement - it will either be true or false. Example: IF( CAN_MOVE (forward)) is a way to check if the space in front of the robot is open.
1  ROTATE LEFT ()
2  IF (CAN MOVE (forward))
3   {
4     MOVE FORWARD ()
5   }
6  ROTATE LEFT ()
7  IF (CAN MOVE (forward))
8   {
9     MOVE FORWARD ()
10  }

**Commentary**

**Before:**
The starting scenario before any lines have been executed.

Before reading the rest of the page, you might want to try to predict where the robot will end up.

---

1  >  ROTATE LEFT ()
2   IF (CAN MOVE (forward))
3     {
4       MOVE FORWARD ()
5     }
6   ROTATE LEFT ()
7   IF (CAN MOVE (forward))
8     {
9       MOVE FORWARD ()
10    }

**Commentary**

**Line 1 executes:**
Robot turns 90 degrees to the left

---

1  ROTATE LEFT ()
2   >  IF (CAN MOVE (forward))
3     {
4       MOVE FORWARD ()
5     }
6   ROTATE LEFT ()
7   IF (CAN MOVE (forward))
8     {
9       MOVE FORWARD ()
10    }

**Commentary**

**Line 2 executes:**
Check to see if the robot can move forward. TRUE - it can. So the code is said to “enter the if-statement block” ...

---

1  ROTATE LEFT ()
2   >  IF (CAN MOVE (forward))
3     {
4       MOVE FORWARD ()
5     }
6   ROTATE LEFT ()
7   IF (CAN MOVE (forward))
8     {
9       MOVE FORWARD ()
10    }

**Commentary**

**Line 4 executes:**
Since the condition was TRUE, execute the line(s) of code inside the if-statement - in this case: move_forward.

**NOTE:** Lines 3 and 5: The “curly braces” { } encapsulate the lines of code to execute if the condition is true.

---

1  ROTATE LEFT ()
2   IF (CAN MOVE (forward))
3     {
4       MOVE FORWARD ()
5     }

**Commentary**

**Line 6 executes:**
Rotate the robot 90 degrees to the left
4 MOVE FORWARD ()
5 )
6 > ROTATE LEFT ()
7 IF (CAN MOVE (forward))
8 {
9 MOVE FORWARD ()
10 }

Line 7: Check to see if the robot can move forward now...
FALSE - it cannot move forward. The condition fails, so IGNORE the block of code in the curly braces. The robot actually does nothing here.

NOTE: the condition of an if-statement is always executed - the blocks inside it though, only run if the condition is TRUE.

End state:
Since there are no more lines of code to execute, the program ends in this state.

All lines have been processed. If there were any code starting on line 11, we would attempt to execute that next.

You try it - Same Code, Different Scenario
Because the code that runs depends on the conditions at the time of execution, the same program might end up with different results given a different starting scenario. Try tracing through the same program again, but with a different initial robot setup. What happens? Where does the robot end up?
Unit 5 Lesson 8

Boolean Expressions and "if" Statements

Resources
The Types of Questions You Can Ask a Computer

When we make decisions as humans, we usually consider complex sets of conditions, like the circumstances surrounding the decision, past experience, or even just how we feel. When we want to write programs that make decisions, we need to represent our decisions in a way the computer can understand.

Decision Making with a Computer

- The computer evaluates some statement (also called an expression) that can only be true or false. This means that the result can be represented by a single bit.
- This result determines which of two parts of the program will run next.

The types of statements that a computer can evaluate as either true or false are also limited by the fact that information stored in the computer is binary. As a result, most true/false statements you will use in your programs are comparing two values in the computer's memory. Here are the most common types of comparisons you'll see:

<table>
<thead>
<tr>
<th>Comparison Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>__ is equal to __</td>
<td>age &gt; 16?</td>
</tr>
<tr>
<td>__ is not equal to __</td>
<td>grade &lt; 70?</td>
</tr>
<tr>
<td>__ is greater than __</td>
<td>home team score &gt; away team score?</td>
</tr>
<tr>
<td>__ is greater than or equal to __</td>
<td>home team score ≥ away team score?</td>
</tr>
<tr>
<td>__ is less than __</td>
<td>day ≠ Saturday?</td>
</tr>
<tr>
<td>__ is less than or equal to __</td>
<td>day ≤ Sunday?</td>
</tr>
</tbody>
</table>

Creating Computer Questions

It can take a little practice to convert a question you might ask as a human into a binary statement that can be evaluated by a computer. Here are some examples:

<table>
<thead>
<tr>
<th>Human Question</th>
<th>Computer Question</th>
<th>Human Question</th>
<th>Computer Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you old enough to drive?</td>
<td>Is age greater than or equal to 16?</td>
<td>Is it lunch time?</td>
<td>Is the time equal to 12?</td>
</tr>
<tr>
<td>Did I fail the test?</td>
<td>Is grade less than 70?</td>
<td>Is it the weekend?</td>
<td>Is the day equal to Saturday? If not, is the day equal to Sunday?</td>
</tr>
<tr>
<td>Was it a tied game?</td>
<td>Was the home team score equal to the away team score?</td>
<td>Is this person a teenager?</td>
<td>Is age greater than 12? If yes, is age less than 20?</td>
</tr>
</tbody>
</table>

Your Turn! Change the following human questions into computer questions:

<table>
<thead>
<tr>
<th>Human Question</th>
<th>Computer Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could this water freeze right now?</td>
<td></td>
</tr>
<tr>
<td>Did I get a baker's dozen of donuts?</td>
<td></td>
</tr>
<tr>
<td>Am I old enough to vote?</td>
<td></td>
</tr>
<tr>
<td>Were you born before the millennium?</td>
<td></td>
</tr>
<tr>
<td>Are you an only child?</td>
<td></td>
</tr>
</tbody>
</table>
Flowchart Components

One way that programmers plan complex programs with decisions in them is to create diagrams called Flowcharts, which demonstrate the logic they want for their program. Flowcharts have a couple different components. Each component is a different shape to signify its purpose. Check out the table below as a build to flowcharts.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="Image" alt="Diamond" /></td>
<td>A <strong>diamond</strong> represents a decision to be made within your program, based on a binary question or expression (one that has only two possible responses). We will see more about binary questions later in this activity.</td>
</tr>
<tr>
<td><img src="Image" alt="True and False Arrows" /></td>
<td><strong>True</strong> and <strong>False arrows</strong> designate the paths taken, based on the result of a decision (diamond). Note once again that every decision may have only 2 possible paths that result from it, one for true and one for false.</td>
</tr>
</tbody>
</table>
| ![Action Outside If Statement](Image) | A **rectangle** represents an action that is performed. Some actions may be performed as the direct result of a decision, while others are performed every time a program is run. The examples we’ll see usually use the following style:  
  - Action that is always performed: wide orange rectangle  
  - Action performed based on decision: narrow blue rectangle  

**When you draw your own flowcharts, you may use a single style of rectangle for all actions.** |
| ![Simple Arrow](Image)         | A **simple arrow** indicates that we are moving from one action to the next without considering any decision. These will generally be used to link a set of actions to be completed one after the other. |
The Results of Questions You Can Ask a Computer
So far we have only created questions, but in order to use them to make decisions, we need to specify actions that get performed depending on the result. Check out the examples of flowcharts below:

- Get the age
  - Is your age greater than 16?
    - True: You can have a license
    - False: You have to wait

Sometimes you need to get multiple pieces of information to make your decision.

- Get the home team score
- Get the away team score
  - Was your score equal to the score from the other team?
    - True: You tied!
    - False: You did not tie

Sometimes you want to ask a follow up question to your original question based on a certain answer.

- Get the home team score
  - Get the away team score
    - Was your score equal to the score from the other team?
      - True: You lost the game.
      - False: You won the game!

- Get the day of the week
  - Is it the weekend? (Stay home)
    - True: It’s the weekend. Stay home.
    - False: It’s not the weekend. Go to school.
  - Is the day equal to Saturday?
    - True: It’s the weekend. Stay home.
    - False: It’s not the weekend. Go to school.
  - Is the day equal to Sunday?
    - True: It’s the weekend. Stay home.
    - False: It’s not the weekend. Go to school.
Your turn!
Refer back to your Human-Computer Questions you worked on before. Can you make flow charts for them? The questions are copied below for your reference.

<table>
<thead>
<tr>
<th>Human Question</th>
<th>Flow Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could this water freeze right now?</td>
<td></td>
</tr>
<tr>
<td>Did I get a baker’s dozen of donuts?</td>
<td></td>
</tr>
<tr>
<td>Human Question</td>
<td>Flow Chart</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Am I old enough to vote?</td>
<td></td>
</tr>
<tr>
<td>Were you born before this millennium?</td>
<td></td>
</tr>
<tr>
<td>Are you an only child?</td>
<td></td>
</tr>
</tbody>
</table>
Unit 5 Lesson 9
"if-else-if" and Conditional Logic
Resources
Worksheet - Compound Conditionals

Chained and Nested Conditionals
In order to express more complex decisions, we’ve used **chained conditionals** \((\text{else} / \text{else-if})\) and **nested conditionals** \((\text{if} \, \text{statements inside of if statements})\). These are powerful tools which **can be combined to express any complex boolean condition**.

**Practice**: Using what you know about writing \(\text{if, if-else, and if-else-if statements}\), write **pseudocode** to accomplish the tasks given below.\(^1\) Assume that you are writing an application which asks the user to input the day of the week (a string) and his age (a number) and that these are stored in variables called \(\text{day}\) and \(\text{age}\).

- **EXAMPLE**: If the day is Friday, write, “Thank goodness it’s Friday.” Otherwise, write, “How long till Friday?”
  
  ```
  if day == Friday
    write “Thank goodness it’s Friday.”
  else
    write “How long till Friday?”
  ```

- If the day is any day but “Monday” the program writes, “At least it’s not Monday.”

- If the user is a teenager, the program writes, “You are a teenager.” Otherwise, it writes, “You are not a teenager.” (Remember that you can assume there is a variable called \(\text{age}\) that you can refer to.)

- If the day is a weekend day, the program writes, “It is the weekend.” Otherwise, it writes, “It is not the weekend.”

\(^1\) Writing **pseudocode** means you should use the structural conventions of a programming language, but it is intended for human reading rather than machine reading. Even if pseudocode sometimes looks very close to a real programming language, there is no expectation that it be syntactically perfect - it’s about expressing and communicating your ideas for a program.
Improving Conditionals with Boolean Operators

As we noted before, nested and chained conditionals can be used to create any possible boolean condition. Unfortunately, however, the resulting code will often be long, cumbersome, and redundant. To help simplify the expression of complex conditionals we will be introducing three new logical operators: NOT, AND, and OR.

NOT

When creating more complex boolean expressions you will encounter instances when you want to know if a statement is false rather than true. You have seen the != ("is not equal") operator before, but previously we might also have accomplished this by using the else statement. Sometimes, expressing logical conditions is a challenge and you might feel like you need to write an if statement just to use the else clause. Here is simple example.

Example:

```javascript
if(day == "Monday"){
}
else {
    write("At least it’s not Monday.");
}
```

But writing an empty if statement just to use the else clause is bad practice (some would call it ugly code). There are many instances in programming where an operation doesn’t have a convenient logical inverse (like == and !=) and we simply want to say if some condition is NOT true. The single ! is the NOT operator. Here’s an example:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Truth Table</th>
<th>JavaScript Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT expr</td>
<td>Evaluates to the opposite truth value of the statement provided as input</td>
<td>!expr</td>
<td>!</td>
</tr>
</tbody>
</table>

Note the truth table shown above. A truth table is a simple tool used to show how every possible value of the input will be treated by a logical operation. Here we use "expr" to stand in for any expression that might evaluate to true or false. This table shows that when NOT is applied to a boolean expression, the result is the opposite truth value.

Also note that the JavaScript syntax for NOT is a single exclamation point. As good practice, you should place the expression to which you want to apply the NOT within parentheses. Here’s our example from before, simplified with the NOT operation.

Updated Example:

```javascript
if(!(day == "Monday")){
    write("At least it’s not Monday.");
}
```

Practice: Circle whether each expression evaluates to true or false. The variable `day` is initialized as shown.

1. !(day == "Monday") (Evaluates to true) (Evaluates to false)
2. !(2 > 3) (Evaluates to true) (Evaluates to false)
3. !(day == "Tuesday") (Evaluates to true) (Evaluates to false)
AND

When we’ve wanted to check whether multiple conditions are true, we have been making use of nested conditionals. Here’s how we might approach determining whether a user is a teenager, based on the variable `age`.

Example:
```javascript
if(age >= 13){
    if(age < 20){
        write("You are a teenager.");
    } else {
        write("You are not a teenager.");
    }
} else {
    write("You are not a teenager.");
}
```

Not only is this code long, but there is redundancy introduced by having to write “You are not a teenager.” at two different points. We can improve the expression of this complex condition with the AND operator.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Truth Table</th>
<th>JavaScript Syntax</th>
</tr>
</thead>
</table>
| statement1 AND statement2 | Evaluates to true only when both boolean statements it connects are true | \[\begin{array}{ccc}
  expr1 & expr2 & expr1 && expr2 \\
  T & T & T \\
  T & F & F \\
  F & T & F \\
  F & F & F \\
\end{array} \] | &&               |

Notice that the truth table for AND includes columns for two statements, “a” and “b,” and that every possible true / false combination of their values is shown in the columns.

When using the AND operator, we can significantly improve the code we wrote in the example above (see below). We’ve actually improved the code in two ways. First, notice that we’ve removed the redundant lines of code. Second, since all of the logic of the conditional can now be found in one line, it is easier to read and understand, making it a better expression of what you are trying say.

Updated Example:
```javascript
if((age >= 13) && (age < 20)){
    write("You are a teenager.");
} else {
    write("You are not a teenager.");
}
```

It is recommended that you place each boolean expression inside of its own parentheses, as shown here. This ensures that the expressions are evaluated in the order you intend.

Practice: Circle whether each expression evaluates to true or false. The variable `age` is initialized as shown.

1. `(age > 12) && (age < 18)` (Evaluates to true) (Evaluates to false)
2. `(age != 12) && (age > 18)` (Evaluates to true) (Evaluates to false)
3. `(age != 12) && (2 > 3)` (Evaluates to true) (Evaluates to false)
OR
When we’ve wanted to check whether at least one of many conditions is true we have been making use of chained conditionals. Here’s how we might approach determining whether it is the weekend based on the variable “day”.

Example:
```
if(day == "Saturday"){
    write("It is the weekend.");
} else if(day == "Sunday"){
    write("It is the weekend.");
} else {
    write("It is not the weekend.");
}
```

Once again, this code is long and introduces redundancies. We can improve the expression of this complex condition with the OR operator.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Description</th>
<th>Truth Table</th>
<th>JavaScript Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>statement1 OR statement2</td>
<td>Evaluates to true as long as at least one of the boolean statements it connects is true</td>
<td></td>
<td></td>
</tr>
<tr>
<td>expr1</td>
<td>expr2</td>
<td>expr1</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

The syntax for OR in JavaScript is two vertical pipe characters that you probably have not used very much outside of programming. When using the OR operator, we can significantly improve the code we wrote in the example above. Once again we’ve removed redundancy and improved the overall readability of our code.

Updated Example:
```
if((day == "Saturday") || (day == "Sunday")){
    write("It is the weekend.");
} else {
    write("It is not the weekend.");
}
```

Notice that once again we have placed each boolean expression inside of its own parentheses. This is not strictly necessary, but it makes it clear which expressions are being grouped together.

Practice: Circle whether each expression evaluates to true or false. Assume the variable day is initialized as shown.

```
var day = "Monday";
```

1. (day == "Mon") || (day == "Monday") (Evaluates to true) (Evaluates to false)
2. (day == "Tues") || (day == "Tuesday") (Evaluates to true) (Evaluates to false)
3. (day == "Tues") || (5 < 10) (Evaluates to true) (Evaluates to false)
Activity

Evaluating Compound Conditionals: Determine if the follow statements evaluate to true or false. Assume in every case that the two variables age and day have been initialized with the values shown.

```javascript
var age = 16;
var day = "Monday";
```

4. `(age > 10) && (age < 20)`  
   (Evaluates to true)  
   (Evaluates to false)

5. `!(age > 10)`  
   (Evaluates to true)  
   (Evaluates to false)

6. `(day == "Tuesday") || (age < 12)`  
   (Evaluates to true)  
   (Evaluates to false)

7. `!((age == 16) || (day == "Monday"))`  
   (Evaluates to true)  
   (Evaluates to false)

8. `!((age == 16) && !(day == "Monday"))`  
   (Evaluates to true)  
   (Evaluates to false)

Challenge Problems

9. `((age == 16) && (day == "Monday")) && (day == "Tuesday")`  
   (Evaluates to true)  
   (Evaluates to false)

10. `((age == 16) && (day == "Monday")) || (day == "Tuesday")`  
    (Evaluates to true)  
    (Evaluates to false)

11. `((age > 10) && ((age + 5) > 20))`  
    (Evaluates to true)  
    (Evaluates to false)
Unit 5 Lesson 10
Building an App: Color Sleuth
Resources
How the Color Sleuth Project Meets the AP Create Performance Task Requirements

The Color Sleuth App, written as suggested in this lesson, is an example of a program that can meet the minimum bar for the AP Create Performance Task. Here’s how.

**Iterative Design Process (rows 2-3 of AP Create Task Scoring Guidelines)** - for the AP you must discuss your overall “incremental and iterative development process” as well as two points along the way where you saw an opportunity, or some difficulty, that you worked out and it ended up in the final program.

Alexis and Michael’s discussion throughout the tutorial is an excellent example of working collaboratively to iteratively write a program - they wrote in small parts, testing each part along the way, modifying it, or adding new functionality. The realization to use a parameterized function is a good opportunity to talk about. And any time they re-organized the code or changed their course of action is a response to some difficulty they were trying to overcome.

**Algorithms (rows 4-6)** - For the AP you need to show code of an algorithm that includes two or more algorithms where at least one of the included algorithms contains mathematical or logical concepts.

For a program structured like Color Sleuth, the main algorithm (or “parent”) and included algorithms (“children”) will likely be spread out across separate functions. An example of a choice that could be made along with arguments for the written responses is shown in the diagram. Note: the student would select all three of these functions as the “algorithm”.

**Abstraction (rows 7-8)** - for the AP the code must contain a student-written abstraction that helps manage the complexity of the program. The functions in this program are strong evidence of using abstraction to manage complexity in the code.

A function with a parameter is often a good one to choose because the fact that the function has a parameter means that the problem has been abstracted so it can handle different types of input. `checkCorrect(buttonId)` and `updateScore(amt)` would be good choices that you should be able to justify easily in the written responses about how they help manage complexity.
# Color Sleuth Project Rubric

## Overview
The Color Sleuth lesson walks you through a scenario of two fictional students planning and writing code for an app of their design. You are asked to mimic the code they write by transcribing from the pseudocode sketches they make along the way (the tutorial). At the end you’re on your own to write code that decides how the came ends and who wins.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Yes</th>
<th>Almost</th>
<th>No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features Covered in Tutorial</strong> Students are guided through building these components of the game by the tutorial. These features should be clear from quickly playing the game and reviewing the code.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Game Board Changes:</strong> Buttons change colors when any one of them is clicked, one button has a slightly different color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Score Updates:</strong> Clicking buttons updates and displays score for the correct player</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Switching Turns:</strong> Players switch turns after each click - whose turn it is clearly indicated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Code Style:</strong> Code is neatly organized and broken into functions in the style suggested by the tutorial.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Features Student(s) Write Independently</strong> Students are asked to independently write code to end the game. Assessing this feature may require reading code, playing the game to its conclusion, or changing the starting score of the game to force the game to end.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Game over:</strong> UI indicates game is over</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Game over:</strong> Code written so that game can end - contains logic to check whether game is over.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Who won:</strong> UI indicates winning player</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Who won:</strong> Code contains logic to determine which player won (if game is over).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit 5 Lesson 11

While Loops

Resources
Activity Guide - Flowcharts with while Loops

Introduction

We are going to be learning a new programming structure today called while loops. while loops allow us to control program flow by repeating a set of commands until a condition is met. When we control program flow it is often helpful to think about the ideas in a visual way first. You will use flowcharts to begin thinking about while loops.

Flowchart Components

As a reminder we have included the flowchart components here as a reference for you as you work on this sheet.

Real-Life while Loops

Each flowchart below contains a “loop” that runs “while” a condition is true. Investigate each flowchart, mark how many times you believe the loop will run on the line provided, and then justify your reasoning. Note: There may be many possible answers, so pick the one you believe makes the most sense.

How many times will the loop run?

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Never          A few times        Forever</td>
</tr>
</tbody>
</table>

Justification:____________________________________________
Programming with while Loops

The next two examples begin making the transition from real-life while loops to ones you might see while programming. Use the space provided to write the output that would be generated from the program.

```javascript
var counter = 0;

while (counter < 5) {
    console.log("Hi!");
    counter = counter + 1;
}

console.log("Done!");
```
```javascript
var counter = 0;

TRUE

counter != 10

FALSE

console.log("Hi!");
counter = counter + 3;

console.log("Done!");
```

Output:
Unit 5 Lesson 12
Loops and Simulations
Resources
Worksheet - Flipping Coins

**Flip a coin until you get 5 total heads.** How many flips did it take? ________

Record your flips in the space below by writing "H" or "T" for each flip.

**Flip a coin until you get 3 heads in a row.** How many flips did it take? ________

Record your flips in the space below by writing "H" or "T" for each flip.

**Predict**

The **most flips** it took someone (including you) to get **5 total heads** ________

The **fewest flips** it took someone (including you) to get **5 total heads** ________

The **most flips** it took someone (including you) to get **3 heads in a row** ________

The **fewest flips** it took someone (including you) to get **3 heads in a row** ________

**Make a Hypothesis**

We’ll be developing a **simulation** that flips coins for us. As a result we can test how many flips it takes to get many more total heads and longer strings of heads. Before we make our simulation, predict the following.

What is the **most flips** you expect to see in order to get **10,000 total heads**? ________

What is the **fewest flips** you expect to see in order to get **10,000 total heads**? ________

**Explain your reasoning:**

What is the **most flips** you expect to see in order to get **12 heads in a row**? ________

What is the **fewest flips** you expect to see in order to get **12 heads in a row**? ________

**Explain your reasoning:**
Extend Your Hypothesis
You may have observed that flipping tens of thousands of coins takes some time on a computer. If we want to simulate even larger problems, it may be difficult for even a computer to complete the full simulation in a time frame that makes sense. Luckily, you should have developed some intuitions about how these problems develop, based on your earlier simulation. Try to make a reasonable prediction for the questions below, based on the results from the simulation that you ran today.

What is the most flips you expect to see in order to get 10,000,000 total heads? 

What is the fewest flips you expect to see in order to get 10,000,000 total heads? 

Explain your reasoning, making reference to the results of your simulation.

What is the most flips you expect to see in order to get 20 heads in a row? 

What is the fewest flips you expect to see in order to get 20 heads in a row? 

Explain your reasoning, making reference to the results of your simulation.
Unit 5 Lesson 13

Introduction to Arrays

Resources
Unit 5 Lesson 14

Building an App: Image Scroller

Resources
Unit 5 Lesson 15

Processing Arrays

Resources
Algorithms with Lists

Once you know how to write programs that can store data in lists, the next step is to think about how you might write code, or develop algorithms, to process those lists to find or do interesting things with the data.

We often get started thinking about algorithms by trying to rigorously act them out ourselves. Because we know *something* about how computer programs work, we can keep the limitations of a computer in mind when we are “acting as the machine.”

In this activity, you'll design an algorithm to find the smallest item in a list. Obviously, if we were really writing instructions for a person, we could simply tell them: “find the smallest item in a list.” But that won’t work for a computer. We need to describe the process that a person must go through when they are finding the smallest item. What are they *really* doing?

Setup and Rules:

- We'll use playing cards face down on the table to represent a list of items. Start with 8 cards face down in a row. Any card on the table must be face down.

- When acting as the machine, you can pick up a card with either hand, but you can only hold one card at a time in each hand.

- You can also compare the values on playing cards to determine which one is greater than the other (based on its face value).

- You can put a card back down on the table (face down), but once a card is face down on the table, you cannot remember (or memorize) its value or position in the list.

Task:

Write an algorithm to find the card with the lowest value in the row of cards.

- Goal: The algorithm must have a clear end to it. The last instruction should be to say: “I found it!” and hold up the card with the lowest value.

- The algorithm should be written so that it would theoretically work for any number of cards (1 or 1 million).

- Write your algorithm out on paper as a clear list of instructions in “pseudocode.” Your instructions can refer to cards, and a person’s hands, etc., but you must give a systematic way for finding the smallest card.
<table>
<thead>
<tr>
<th>Algorithm To Find Minimum Card</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>
Analyzing Algorithms

Linear Search
A common way to process a list is to find out if it contains a specific item. We implemented one algorithm to do this called **linear search**. Linear search is pretty simple. You start at the beginning of the list, look at every item, one at a time, and see if it matches what you are looking for. Stop once you've found it, or when there are no more items to consider.

Cost and Efficiency
In computer science, we measure the "cost" or "efficiency" of an algorithm by how much work - roughly, how many primitive operations - the computer has to execute to arrive at the answer. All computers perform roughly the same set of primitive commands, but some are much faster at running them than others. Measuring the total number of primitive commands, rather than the time it takes to run a program, is a better way to compare one algorithm to another, since it does not depend on the speed of the computer running it.

Worst-Case Analysis
The same algorithm might take a different amount of time to run based on the input it is given. Consider linear search. This algorithm will likely require more work to run on larger lists, since we may need to look at every item. At the same time, we could always get lucky and find the item in the first place we look. To make it easier to compare efficiencies of algorithms, we usually **consider the worst-case scenario**. In other words, we consider the input that would cause the algorithm to do the most work. Then we can guarantee that our algorithm can't do worse than that.

Worst-Case Analysis of Linear Search
The worst case for linear search (and most searching algorithms) is that the item you're looking for is not in the list. This would make the algorithm look at every item once to verify that it wasn't there. We typically talk about the efficiency of an algorithm in **comparison to the size of the input, or data, that it must consider**. Therefore, we would say that if a list has \( N \) items, linear search requires that you look at all \( N \) items in the worst case. (For most searching algorithms, the only primitive command we consider is accessing an item in the list.) Based on this analysis, we can compare linear search to other searching algorithms.

Searching on Sorted Lists

Different Algorithms for Different Inputs
Linear search can find an item in any list, no matter how it's ordered. If we know the items in the list are in **sorted order**, however, then there are more efficient algorithms we could use to search for an item.

Challenge: Develop a searching algorithm for a sorted list
Develop an algorithm that searches for an item in a **sorted list**. Your algorithm should be as efficient as possible, as measured by a **worst-case analysis**. Note the list \([1, 2, 3, 4, 5]\) is sorted, but so is \([1, 1, 1, 1, 2]\) and \([1, 2, 2, 2, 2]\).

How To Do It
On the next page you have space to **write out your algorithm in pseudocode**. Your algorithm should be written to work on any list, but you might want some manipulatives, such as a **deck of cards**, that you can use to test out your ideas as you go. If you are having trouble expressing your algorithm in pseudocode, it is fine to just describe it so that a friend could run it on a small row of cards.
My Algorithm for Searching a Sorted List

Write the steps of your algorithm below.

Analyze Your Algorithm

Worst-Case Analysis
Share your algorithm with a classmate. Once you understand one another’s algorithms, try to come up with the worst-case input for each algorithm. What is the sorted list that would make it perform the most work?

Quantify Your Results
For the purposes of comparison, we’ll consider the most important primitive command when comparing searching algorithms: accessing an item in a list. In the worst case, we know that linear search must look at every item in a list. Try to determine how many items your algorithm must look at in the worst case for the different-sized inputs shown below.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>8 items</th>
<th>16 items</th>
<th>32 items</th>
<th>64 items</th>
<th>100 items</th>
<th>1,000 items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Search</td>
<td>8</td>
<td>16</td>
<td>32</td>
<td>64</td>
<td>100</td>
<td>1,000</td>
</tr>
<tr>
<td>Your Algorithm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit 5 Lesson 16

Functions with Return Values

Resources
Activity - Return Values with Go Fish

Functions with Return Values

Today you and your group are going to play the classic card game of Go Fish. You will work as a group to break down the game into functions in order to explore writing our own functions with return values.

Rules of Go Fish

Goal: Obtain as many sets of 4-of-a-kind as possible.

Game Play:
- Each player is dealt 5 cards.
- Remaining cards are spread out in the middle.
- Moving clockwise, players take turns asking one other player in the group for a card of a particular rank. You can only ask for a rank that you currently have in your hand.
  - For example: if you have a 7 in your hand you could ask, “Sarah, do you have any 7s?”
- If you ask someone for a card, they must give up all the cards of that rank to you. Then you get to ask for another card from any of the players.
- If you ask someone for a card and they don’t have any, they will say “Go Fish!”, and you can pull one card from the table.
- Once you have obtained a set of 4-of-a-kind, remove them from your hand and place them in front of you.
- If you ever run out of cards in your hand, pick up 5 new cards from the middle of the table.
- The game is over when there are no more cards on the table.
- The winner is the person who has the most complete sets of 4-of-a-kind.

Task

1. Spend 5 minutes playing Go Fish with your group.
2. Answer the questions to explore the functions in Go Fish.

Reflection

1. What part(s) of your algorithm could be written using a list or array?

2. What part(s) of your algorithm could be written using a function?
There are two different types of people in the game of Go Fish:

1. Asker: The person asking the question
2. Responder: The person responding

We are going to focus on the algorithm for the Responder, as it is a function which gets called by the Asker.

3. What parameters would the Responder function have? i.e., What information does the Asker need to give the Responder?

4. What information/objects does the Responder have to give the Asker at the end of the function?

5. What programming commands have you seen which have behavior like the interaction between the Asker and Responder?

6. Write a pseudocode algorithm for the Responder, using the parameters you specified above.
   a. When you want to give information from the Responder back to the Asker, use the word RETURN.
      i. For example: RETURN card.
   b. Note: Obviously, if we were really writing instructions for a person, we could simply tell them: “Find all the cards that match the Asker’s request.” But that won’t work for a computer. We need to describe the process that a person must go through when they are finding all those items. What are they really doing?
Unit 5 Lesson 17

Building an App: Canvas Painter

Resources
Unit 5 Lesson 18

Practice PT - Create Your Own App

Resources
Background

We have reached the end of the programming unit! Congrats! This means you have a solid foundation in programming and hopefully feel ready to try your hand at something creative of your own choosing.

As a way to wrap up the unit, we are going to practice for the AP® Create Performance Task. This will be something you need to complete at the end of the course with very minimal assistance from a teacher, so by practicing now, you can get used to the process of completing the work necessary for the AP Create Performance Task.

You will submit this project and write responses to the reflection questions in the style of the AP Create Performance Task. The document below has been constructed to mimic the AP Create Performance Task. Some but not all of the language is pulled directly from the AP document. Some of the prompts have been modified slightly or simply omitted for clarity and to better fit the project.

Overview

Programming is a collaborative and creative process that brings ideas to life through the development of software. Programs can help solve problems, enable innovations, or express personal interests. In this Performance Task, you will be developing a program which builds on or extends ideas found in a previous project. Your development process should include iteratively designing, implementing, and testing your program. You are strongly encouraged to work with another student in your class.

Please note that once this performance task has been assigned as an assessment (rather than as practice), you are expected to complete the task with minimal assistance from anyone other than your collaborative partner. A collaborative partner can be someone working on the same project or a different project. They are just another set of eyes to provide feedback. Try to use your classmates as resources as much as possible during this practice, in order to get used to this process.

You will be provided class time to complete and submit the following:

- A video of your program running
- Written responses about your program and development process
- Program Code

Your teacher will share submission guidelines that include suggestions for creating video and PDF files.

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**Project Description**

You are going to create a project of your own design. It is strongly suggested that you pick one of the previous programs you created and build on it. However if you want to take inspiration from a past project and start something new, that is all right as well.

Here is a list of all the past projects and some of the "mini apps" you have worked on to help you in getting started:

- Chaser Game - [https://studio.code.org/s/csp5/stage/2/puzzle/15](https://studio.code.org/s/csp5/stage/2/puzzle/15)
- Clicker Game - [https://studio.code.org/s/csp5/stage/5/puzzle/21](https://studio.code.org/s/csp5/stage/5/puzzle/21)
- Mad Libs - [https://studio.code.org/s/csp5/stage/6/puzzle/14](https://studio.code.org/s/csp5/stage/6/puzzle/14)
- Dice Game - [https://studio.code.org/s/csp5/stage/8/puzzle/17](https://studio.code.org/s/csp5/stage/8/puzzle/17)
- Secret Number - [https://studio.code.org/s/csp5/stage/9/puzzle/7](https://studio.code.org/s/csp5/stage/9/puzzle/7)
- Color Sleuth - [https://studio.code.org/s/csp5/stage/10/puzzle/23](https://studio.code.org/s/csp5/stage/10/puzzle/23)
- Coin Simulation - [https://studio.code.org/s/csp5/stage/12/puzzle/12](https://studio.code.org/s/csp5/stage/12/puzzle/12)
- Word/Image Scroller - [https://studio.code.org/s/csp5/stage/14/puzzle/10](https://studio.code.org/s/csp5/stage/14/puzzle/10)

You may work alone or in pairs, but some large part of the final program must be your own, as you will have to write about the work you did by yourself.

You will submit your own project and written reflection, but you can receive help and advice from classmates.

**General Requirements**

This performance task requires you to develop a program on a topic that interests you or one that solves a problem. It is strongly recommended that a portion of the program involve some form of collaboration with another student in your class. Your program development process must involve a significant portion of work completed independently that requires a significant level of planning, designing, and program development.

You are required to:
- Iteratively design, implement, and test your program.
- Independently create at least one significant part of your program.
- Create a video that displays the running of your program and demonstrates its functionality.
- Write responses to questions about your program.
- Include your entire program code.

**Programming Requirements**

Your program must demonstrate a variety of capabilities and implement several different language features that, when combined, produce a result that cannot easily be accomplished without computing tools and techniques. Your program should draw upon mathematical and logical concepts, such as use of numbers, variables, mathematical expressions with arithmetic operators, logical and Boolean operators and expressions, decision statements, iteration, and/or collections.

Your program must demonstrate:
- Use of several effectively integrated mathematical and logical concepts, from the language you are using.
- Implementation of an algorithm that integrates other algorithms and integrates mathematical and/or
logical concepts.
● Development and use of abstractions to manage the complexity of your program (e.g., procedures; abstractions provided by the programming language; APIs).

Submission Requirements

1. Video
Submit one video in .mp4, .wmv, .avi, or .mov format that demonstrates the running of at least one significant feature of your program. Your video must not exceed 1 minute in length and must not exceed 30MB in size.

2. Written Responses
Submit one PDF document in which you respond directly to each prompt. Clearly label your responses 2a – 2e in order. Your response to all prompts combined must not exceed 750 words, exclusive of the Program Code. (The 750 words does not include the code you wrote for your program.)

Program Purpose and Development

a. Identify the programming language and identify the purpose of your program. Explain your video using one of the following:
   ● A written summary of what the video illustrates OR
   ● An audio narration in your video. If you choose this option, your response to the written summary should read, “The explanation is located in the video.” (Approximately 150 words)

b. Describe the incremental and iterative development process of your program, focusing on two distinct points in that process. Describe the difficulties and/or opportunities you encountered and how they were resolved or incorporated. In your description, clearly indicate whether the development described was collaborative or independent. At least one of these points must refer to independent program development; the second could refer to either collaborative or independent program development. (Approximately 200 words)

c. Capture and paste the program code segment that implements an algorithm (marked with an oval in 2e below) that is fundamental for your program to achieve its intended purpose. Your code segment must include an algorithm that integrates other algorithms and integrates mathematical and/or logical concepts. Describe how each algorithm within your selected algorithm functions independently, as well as in combination with others, to form a new algorithm that helps to achieve the intended purpose of the program. (Approximately 200 words)

d. Capture and paste the program code segment that contains an abstraction you developed (marked with a rectangle in 2e below). Your abstraction should integrate mathematical and logical concepts. Explain how your abstraction helped manage the complexity of your program. (Approximately 200 words)

Program Code

e. Capture and paste your entire program code into the PDF.
   ● Mark with an oval the segment of program code that implements the algorithm you created for your program that integrates other algorithms and integrates mathematical and/or logical concepts.
   ● Mark with a rectangle the segment of program code that represents an abstraction you developed.
   ● Include comments or citations for program code that has been written by someone else.
# Rubric - Improve Your App

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Video Format</strong></td>
<td>Video is not .mp4, .wmv, .avi, or .mov format. The video is longer than 1 minute in length. The video is greater than 30MB.</td>
<td>Some of the following criteria are met: Video is .mp4, .wmv, .avi, or .mov format. The video is less than a minute in length. The video is less than 30MB in size.</td>
<td>Video is .mp4, .wmv, .avi, or .mov format. The video is less than a minute in length. The video is less than 30MB in size.</td>
<td></td>
</tr>
<tr>
<td><strong>Demonstrates Significant Feature</strong></td>
<td>Video does not demonstrate how the program works or the main features of the program.</td>
<td>Video gives a general demonstration of how the program works and the main features of the program but does not show many details.</td>
<td>Video gives in-depth demonstration of how the program works and the main features of the program.</td>
<td></td>
</tr>
<tr>
<td><strong>Planning Document</strong></td>
<td><strong>Project Design</strong></td>
<td><strong>Project Design</strong></td>
<td><strong>Project Design</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The description and/or sketch/digital image of the design are simplistic and lacking in details. Not enough information is given to realistically build a program from.</td>
<td>The description and/or sketch/digital image are limited in details. While it might be possible to program from the design, there are too many details missing for the programming task to be easy.</td>
<td>The description and/or sketch/digital image are rich in details. A programmer would have few questions and find it easy to work from this design.</td>
<td></td>
</tr>
<tr>
<td><strong>Feedback Guide</strong></td>
<td>The feedback guides are incomplete. The feedback given is not detailed and does not reference the rubric.</td>
<td>There is some detailed feedback on the feedback guides but it does not reference the rubric.</td>
<td>A complete copy of the feedback guide is completed for student and collaborative partner. In-depth feedback is given and the rubric is referenced to support feedback.</td>
<td></td>
</tr>
<tr>
<td><strong>Individual Written Responses</strong></td>
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<tr>
<td><strong>Format of Written Response</strong></td>
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</tr>
<tr>
<td>Written responses are not submitted in a PDF. The length of the responses exceeds 750 words. The responses are not labeled. The responses are not in order. The student did not write “the explanation is located in the video” when they answered question (a) in the video narration.</td>
<td>Some of the following criteria are met: Written responses are submitted in a PDF document. The length of the responses is less than 750 words in length. The responses are labeled and in order. If the answer to question (a) is included as video narration, then on the written response, the student wrote “the explanation is located in the video.”</td>
<td>Written responses are submitted in a PDF document. The length of the responses is less than 750 words in length. The responses are labeled and in order. If the answer to question (a) is included as video narration, then on the written response, the student wrote “the explanation is located in the video.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>a. Program Purpose</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The write-up or video does not identify the programming language or does not identify the purpose of the program.</td>
<td>The video identifies the programming language but does not describe in detail what the purpose of the program is.</td>
<td>The write-up or video narration identifies the programming language. The write-up or video narration identifies in detail the purpose of the program.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>b. Program Development</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The response gives very few details about the incremental and iterative development process of the program.</td>
<td>The response gives some details about the incremental and iterative development process of the program.</td>
<td>The response fully describes the incremental and iterative development process of the program.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>b. Two Focus Points</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The program development overview highlights one distinct point in that process. The description indicates whether the development described was collaborative or independent but does not give many details.</td>
<td>The program development overview highlights two distinct points in that process. The description indicates whether the developments described were collaborative or independent but does not give many details. At least one of the points referred to is independent program development.</td>
<td>The program development overview focuses on two distinct points in that process. The description clearly indicates whether the developments described were collaborative or independent. At least one of the points referred to is independent program development.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>b. Difficulties and Opportunities</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>The response gives very minimal description of the difficulties and/or opportunities encountered and how they were resolved or incorporated but lacks details.</td>
<td>The response describes the difficulties and/or opportunities encountered and how they were resolved or incorporated.</td>
<td>The response fully describes the difficulties and/or opportunities encountered and how they were resolved or incorporated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Complex Algorithm</td>
<td>The write-up DOES NOT include a program code segment show an algorithm that integrates two or more algorithms and integrates mathematical and/or logical concepts. In the full program code, the complex algorithm code segment is marked with an oval.</td>
<td>The write-up includes a program code segment show an algorithm that integrates two or more algorithms and integrates mathematical and/or logical concepts. In the full program code, the code segment is NOT marked with an oval.</td>
<td>The write-up includes a program code segment show an algorithm that integrates two or more algorithms and integrates mathematical and/or logical concepts. In the full program code, the code segment is marked with an oval.</td>
<td></td>
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<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>c. Explain Complexity</td>
<td>The write-up provides a correct line-by-line summary of the selected algorithm OR a minimal description of an algorithm.</td>
<td>The write-up identifies the algorithm’s purpose in the program and accurately describes how the algorithm serves to achieve this purpose.</td>
<td>The write-up identifies the algorithm’s purpose in the program and accurately describes how at least two of the algorithms function independently as well as in combination to create a new algorithm to achieve the program’s purpose.</td>
<td></td>
</tr>
<tr>
<td>c. Mathematical and Logical Concepts</td>
<td>The write-up explains with very few details the mathematical and logical concepts used to develop the algorithm.</td>
<td>The write-up explains with a few details the mathematical and logical concepts used to develop the algorithm.</td>
<td>The write-up describes in detail the mathematical and logical concepts used to develop the algorithm.</td>
<td></td>
</tr>
<tr>
<td>d. Abstraction Code Segment</td>
<td>In the full program code, the abstraction code segment is marked with a rectangle but the write-up does not include a program code segment showing the section of the code that implements an abstraction.</td>
<td>The write-up includes a program code segment that contains an abstraction developed by the programmer. However the abstraction is NOT marked by a rectangle in the full program code.</td>
<td>The write-up includes a program code segment that contains an abstraction developed by the programmer. The abstraction is marked by a rectangle in the full program code.</td>
<td></td>
</tr>
<tr>
<td>d. Explain Abstraction</td>
<td>The write-up explains with few details how the abstraction helped manage the complexity of the program.</td>
<td>The write-up explains in some detail how the abstraction helped manage the complexity of the program.</td>
<td>The write-up explains in detail how the abstraction helped manage the complexity of the program.</td>
<td></td>
</tr>
<tr>
<td>e. Site Code</td>
<td>Includes few comments or citations for program</td>
<td>Includes some comments or citations for program code</td>
<td>Includes comments or citations for program code</td>
<td></td>
</tr>
<tr>
<td>code that has been written by someone else. Includes few comments or citations of program code written before start of the project.</td>
<td>that has been written by someone else. Includes some comments or citations of program code written before start of the project.</td>
<td>that has been written by someone else. Includes comments or citations of program code written before start of the project.</td>
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</tr>
</tbody>
</table>
Project Planning

Below, we have laid out a process for your group to brainstorm, plan, and eventually create your app. Go through each step. The outcome of the process will be a project plan (see next two pages) that indicates what you’re trying to create and who is doing what. Get started and have fun.

Understand the Problem & Timeline

Identify the problem to solve. It may sound obvious, but it’s hard to solve a problem if you don’t deeply understand it.

- Review the steps of the process for completing this project (see above and below).
- Review Practice PT Overview and Rubric - Improve Your App (also linked in Code Studio) to see what you need to create.
- Make sure you also understand the time constraints. There’s always too much to do and too little time! This will help you prioritize work later.

Brainstorm & Choose Your Project

You should feel free to choose any previous project you have worked on as your starting point.

What kind of project will you create? Make it rain with ideas! Whether you’re in a group or on your own, take the time to generate lots of different ideas for your App.

- Put a time limit on how long you will brainstorm.
- No criticism of ideas, only building up on ideas.

Once you have decided on what your project will do, complete the Project Description on the App Design Guide (below). It must contain a brief description and at least a rough sketch of what you are trying to create.

Find a Collaborative Partner

You should have a buddy for your work on this project:

- a partner for working on this project, or
- someone to whom you can lean over and ask a question when you get stuck; you will do the same for them.
Implement Plan

Carry out the plan and program the new components of your app. Be sure to pay attention to the time you have left to work and the rubric.

Consult for Feedback

Once you have implemented your plan, share your Feedback Guide with your collaborative partner.

The person giving feedback should look over the information provided. They should respond to the prompts on the Feedback Guide and consider the following questions:

- Do you agree with the choices your partner has made? Is there anything missing?
- Is there anything that’s particularly clever or gives you ideas for your own project?

Implement Feedback

After receiving feedback, you should consider which pieces of the feedback are most critical to improving the performance of your app.

Decide on 2 improvements which are most critical to make and work to make those improvements.

You can always tackle more later, if there is still time.

Complete Submission Items

In addition to your working program, you also need to create:

- A video
- A write-up

Make sure to give yourself time to complete these pieces of your project, in addition to your programming.
**App Design Guide**

**Project Description**

Once you have chosen your project, write a brief description of it below and include either a sketch or digital image that shows what you are aiming for.

**Project Title:**

**Collaborative Partner:**

**Short Description:**

_____________________________________________________________________________________________

_____________________________________________________________________________________________

_____________________________________________________________________________________________

Sketch/Design:
Feedback Guide

Project Overview

Once you have implemented the functionality of your program, share your program with your collaborative partner and have them give feedback on your work. If you and your collaborative partner are working on the same project, you may want to have someone outside your team provide feedback. You should fill out the first part of this sheet and they should fill out the bottom.

Project Title:                                                Programmer:                                       Reviewer:

Short Description:
_____________________________________________________________________________________________
_____________________________________________________________________________________________
_____________________________________________________________________________________________

Favorite Feature:
_____________________________________________________________________________________________
_____________________________________________________________________________________________
_____________________________________________________________________________________________

One Thing to Check On:
_____________________________________________________________________________________________
_____________________________________________________________________________________________
_____________________________________________________________________________________________

Partner Feedback

Consider as you look over your partner’s work:

- Is there anything that is particularly clever or gives you ideas for your own project?
- Do you agree with the choices your partner has made? Is there anything missing?

Favorite Feature(s):
_____________________________________________________________________________________________
_____________________________________________________________________________________________
_____________________________________________________________________________________________

Feedback: (Make sure you look at the rubric as you give your feedback.)
_____________________________________________________________________________________________
_____________________________________________________________________________________________
_____________________________________________________________________________________________