Announcements

- CLUE Tutoring
  - Wednesday nights 7-8:30PM MGH 058
  - 2 extra-credit points for each session you attend from last week through the end of the quarter
  - Sign the attendance list to get credit!

Announcements

- Veteran's Day on Wednesday
  - Official UW holiday
  - CLUE Tutoring is on Monday night this week only
    - 7-8:30pm
  - If you have Wednesday lab section,
    - Attend a drop-in lab this week
    - Get 2 points extra credit for attending CLUE Tutoring—sign the attendance sheet

Announcements

- Tour of Living Computer Museum
  - Opens to the public in January
  - Our tours:
    - This week: Thursday, Friday
    - Next week: Monday, Tuesday
    - Signup on WebQ linked from Calendar by Tuesday 10pm
    - Directions on GoPost
    - SODO near Sears & Qwest Field

Announcements

- Due Tuesday night
  - Labs 6/7
  - Signup for museum tour

Announcements

- Labs 8/9
  - Thursday this week and Monday/Tuesday labs next week

Announcements

- The Museum Tour and Labs 8/9 are optional—for extra credit.
  - Choose one or the other

Announcements

- Repeat:
  - D.A.'s office hours have changed and moved to the drop-in lab
    - MGH 430 Tuesday nights 5-6pm
  - I'm always happy to answer questions after lecture, too.

Announcements

- Chapter 21 for today
- Handy references for lab
  - *The JavaScript Phrasebook*
  - W3 Schools JavaScript tutorial

Concepts of Algorithmic Thinking

Iterations, or Loops

Once is not Enough

D.A. Clements

Objectives

- Learn the syntax of loops
- Use loops to count down or count up
- Recognize the World-Famous Iteration
- Learn how to start, increment, and end a loop
- Describe the structure of nested loops

Play it again, Sam.

ITERATION

Definitions

- Iteration, or looping, is the process of repetition:
  - looping through a sequence of statements to repeat them

Major Types of Iterations

- For loop
  1. Baby
  2. Count up
  3. Count down
- While loop
  4. Count up
  5. Count down

Try the examples in Week 5 on the course Web site!

Repetition is good

FOR LOOPS

The **`for`** Loop Basic Syntax

for (<initialization>; <continuation>; <next iteration>**)**
{
    <statement list>
}

- The whole sequence of statements in the statement list is performed for each iteration
  - Computer completes the whole statement sequence of the <statement list> before beginning the next iteration

Control specification

- The three operations in the parentheses of the **`for`** loop
  - Control the number of times the loop iterates
  - by using an *iteration variable* (must be declared)

How a **`for`** Loop Works

- Consider a computation on declared variables **`j`** and **`text`**

```
text = "She said ";
for ( var j = 1; j <= 3; j = j + 1 )
{
    text = text + "Never! ";
}
alert(text);
```


How a **`for`** Loop Works

- Consider a computation on declared variables **`j`** and **`text`**

```
text = "She said ";
for ( var j = 1; j <= 3; j = j + 1 )
{
    text = text + "Never! ";
}
alert(text);
```

Control specification

How a **for** Loop Works

- Consider a computation on declared variables **j** and **text**

```
text = "She said ";
for ( var j = 1; j <= 3; j = j + 1 )
{
    text = text + "Never! ";
}
alert(text);
```

Starting point

How a **for** Loop Works

- Consider a computation on declared variables **j** and **text**

```
text = "She said ";
for ( var j = 1; j <= 3; j = j + 1 )
{
    text = text + "Never! ";
}
alert(text);
```

Continuation condition

How a **for** Loop Works

- Consider a computation on declared variables **j** and **text**

```
text = "She said ";
for (var j = 1; j <= 3; j = j + 1 )
{
    text = text + "Never! ";
}
alert(text);
```

Step size or increment

How a **for** Loop Works

- Demo:

```
text = “The two-year-old said ";
for ( j = 1; j <= 3; j = j + 1 ) {
    text = text + "No! ";
    alert(text);
}
```


Processing **for** loops

- Example:

```
for ( j = 1 ; j <= 3 ; j = j + 1) {
   <statement list>
}
```

  - The first operation is the *<initialization>*
    - Sets the iteration variable's value for the first iteration of the loop. Done only once.
  - The next operation is *<continuation>*
    - Test. If the test has a false outcome, the <statement list> is skipped and control passes to the next statement after the for loop
    - If the test has a true outcome, the <statement list> is performed. When the statements are complete, the
  - *<next iteration>* operation is performed
    - Repeats with the continuation test, performs same sequence of steps.

The World-Famous Iteration

```
for ( j = 0; j < n; j++ ) {…}
```

- Most frequently written **for** loop of all time
- Easy to see iteration count:
  - Always *n* times
    - When n is 3
      - 0 is first loop
      - 1 is second loop
      - 2 is third loop
      - 3 is fourth and it doesn't run.

Running through a `for` loop

Table 21.1 The sequence of operations on `j` from the `for` loop with control specification (`j=1; j<=3; j=j+1`)

	Operation	Operation Result	Role
1	`j = 1`	j's value is 1	Initialize iteration variable
	`j <= 3`	true, `j` is *less than* 3	First <*continuation*> test, continue
2	`j = j + 1`	j's value is 2	First <*next iteration*> operation
	`j <= 3`	true, `j` *is less than* 3	Second <*continuation*> test, continue
3	`j = j + 1`	j's value is 3	Second <*next iteration*> operation
	`j <= 3`	true, `j` *is equal* to 3	Third <*continuation*> test, continue
	`j = j + 1`	j's value is 4	Third <*next iteration*> operation
	`j <= 3`	false, `j` *is greater than* 3	Fourth <*continuation*> test, terminate

Rules: counter and start point

- The Iteration Variable: **`j = 1;`**
  - Must be declared, and follow rules for variable identifiers
  - i, j, and k are the most common choices
- The Starting Point
  - Iteration can begin anywhere, including negative numbers

Rules: Continuation & Step Size

- Continuation/Termination Test **`j <= 3`**
  - *Test* is any expression resulting in a Boolean value (true/false)
  - Continuation must involve iteration variable to avoid infinite loop
- Step Size **`j = j + 1`**
  - Amount of change from one iteration to the next
  - Often called the *increment* or *decrement*
    - Increment: j + 1
    - Decrement: j - 1

Experiments with Flipping Coins

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads=0, tails=0;          //Counters
      var i;                         //iteration variable
      for (i=0; i<100; i++ )
      {
        if (randNum(2) == 1)
          heads++;
        else
          tails++;
      }
      alert("Heads: " + heads + " and Tails: " + tails);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```


Experiments with Flipping Coins

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads=0, tails=0;          //Counters
      var i;                         //iteration variable
      for (i=0; i<100; i++ )
      {
        if (randNum(2) == 1)
          heads++;
        else
          tails++;
      }
      alert("Heads: " + heads + " and Tails: " + tails);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```


Experiments with Flipping Coins

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads=0, tails=0;          //Counters
      var i;                         //iteration variable
      for (i=0; i<100; i++ )
      {
        if (randNum(2) == 1)
          heads++;
        else
          tails++;
      }
      alert("Heads: " + heads + " and Tails: " + tails);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```

Experiments with Flipping Coins

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads=0, tails=0;          //Counters
      var i;                         //Iteration variable
      for (i=0; i<100; i++ )
      {
        if (randNum(2) == 1)
          heads++;
        else
          tails++;
      }
      alert("Heads: " + heads + " and Tails: " + tails);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```

0 = 1x
99 = +99x
100 times!

Experiments with Flipping Coins

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads=0, tails=0;          //Counters
      var i;                         //Iteration variable
      for (i=0; i<100; i++ )
      {
        if (randNum(2) == 1)
          heads++;
        else
          tails++;
      }
      alert("Heads: " + heads + " and Tails: " + tails);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```


Demo—100 coin tosses

- Try the Coin Toss
  - Example 6 in Module 6 of our course Web site

Nested **`for`** Loop Basic Syntax

for (<initialization j >; <continuation j >; <next iteration j >**)**
{
  for (<initialization i >; <continuation i >; <next iteration i >**)**
  {
    <statement list>
  }
  <more statements>
}

Experiment 2—with Five Trials

- A Nested Loop
  - To run several trials, consider the entire loop we just looked at as one Trial
  - Create another **`for`** loop containing this Trial unit, adding a couple of needed statements
  - We have a loop within a loop (*nested loop*) which causes the Trial loop (0-99) to run five times

Experiment 2—the original trial

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads = 0, tails = 0;
      var i, j, text='';             //Iteration vars
      for (j = 0; j < 5; j++)        //Outer loop start
      {
        for (i=0; i<100; i++)        //Trial line 1
        {
        if (randNum(2) == 1)         //Trial line 2
          heads++;                   //Trial line 3
        else                         //Trial line 4
        tails++;                     //Trial line 5
        }                            //Trial line 6
        text = text + 'Trial ' + j + ': '; //Add line to message that will print at end
        for (i = 0; i < (Math.abs(heads-50)); i++)
        {
          text = text + '*';         //Add to message
        }
        text = text + '\n';          //Add line break (html <br /> cannot be used for alerts)
        heads = 0; tails = 0;        //Additional
      }                              //Outer loop end
      alert(text);
      function randNum(range)
      {
        return Math.floor(range*Math.random());
      }
  </script>
</head>
```

Experiment 2—outer loop

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads = 0, tails = 0;
      var i, j, text='';              //Iteration vars
      for (j = 0; j < 5; j++)         //Outer loop start
      {
          for (i=0; i<100; i++)       //Trial line 1
          {
          if (randNum(2) == 1)        //Trial line 2
            heads++;                  //Trial line 3
          else                        //Trial line 4
          tails++;                    //Trial line 5
          }                           //Trial line 6

          text = text + 'Trial ' + j + ': '; //Add line to message that will print at end
          for (i = 0; i < (Math.abs(heads-50)); i++)
          {
            text = text + '*';        //Add to message
          }
          text = text + '\n';         //Add line break (html <br /> cannot be used for alerts)
          heads = 0; tails = 0;       //Additional
      }                               //Outer loop end
      alert(text);
      function randNum(range)
      {
          return Math.floor(range*Math.random());
      }
  </script>
</head>
```

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Experiment 2—declare i and j

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads = 0, tails = 0;
      var i, j, text='';              //Iteration vars
      for (j = 0; j < 5; j++)         //Outer loop start
      {
          for (i=0; i<100; i++)       //Trial line 1
          {
          if (randNum(2) == 1)        //Trial line 2
            heads++;                  //Trial line 3
          else                        //Trial line 4
          tails++;                    //Trial line 5
          }                           //Trial line 6

          text = text + 'Trial ' + j + ': '; //Add line to message that will print at end
          for (i = 0; i < (Math.abs(heads-50)); i++)
          {
            text = text + '*';        //Add to message
          }
          text = text + '\n';         //Add line break (html <br /> cannot be used for alerts)
          heads = 0; tails = 0;       //Additional
      }                               //Outer loop end
      alert(text);
      function randNum(range)
      {
          return Math.floor(range*Math.random());
      }
  </script>
</head>
```

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Experiment 2—set heads, tails to zero

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads = 0, tails = 0;
      var i, j, text='';              //Iteration vars
      for (j = 0; j < 5; j++)         //Outer loop start
      {
          for (i=0; i<100; i++)       //Trial line 1
          {
          if (randNum(2) == 1)        //Trial line 2
            heads++;                  //Trial line 3
          else                        //Trial line 4
          tails++;                    //Trial line 5
          }                           //Trial line 6

          text = text + 'Trial ' + j + ': '; //Add line to message that will print at end
          for (i = 0; i < (Math.abs(heads-50)); i++)
          {
            text = text + '*';        //Add to message
          }
          text = text + '\n';         //Add line break (html <br /> cannot be used for alerts)
          heads = 0; tails = 0;       //Additional
      }                               //Outer loop end
      alert(text);
      function randNum(range)
      {
          return Math.floor(range*Math.random());
      }
  </script>
</head>
```

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Experiment 2—how far from 50%?

```
<html xmlns="http://www.w3.org/1999/xhtml" lang="en" xml:lang="en">
<head>
    <meta http-equiv="content-type"
        content="text/html;charset=utf-8" />
    <meta http-equiv="Content-Style-Type" content="text/css" />
    <title>For loop example with coin toss</title>
  <script type="text/javascript">
      var heads = 0, tails = 0;
      var i, j, text='';              //Iteration vars
      for (j = 0; j < 5; j++)         //Outer loop start
      {
          for (i=0; i<100; i++)       //Trial line 1
          {
          if (randNum(2) == 1)        //Trial line 2
            heads++;                  //Trial line 3
          else                        //Trial line 4
          tails++;                    //Trial line 5
          }                           //Trial line 6

          text = text + 'Trial ' + j + ': '; //Add line to message that will print at end
          for (i = 0; i < (Math.abs(heads-50)); i++)
          {
            text = text + '*';        //Add to message
          }
          text = text + '\n';         //Add line break (html <br /> cannot be used for alerts)
          heads = 0; tails = 0;       //Additional
      }                               //Outer loop end
      alert(text);
      function randNum(range)
      {
          return Math.floor(range*Math.random());
      }
  </script>
</head>
```

40

Demo—Five Trials

- Try the Five-Trial Coin Toss
  - Example 7 in Module 6 of our course Web site

Summary

- Learn the syntax of loops
- Use loops to count down or count up
- Recognize the World-Famous Iteration
- Learn how to start, increment, and end a loop
- Describe the structure of nested loops

Quiz topics for next week

- For loops

End papers…

- A computer lets you make more mistakes faster than any invention in human history—with the possible exceptions of handguns and tequila.

  ~Mitche Ratcliffe