Chapter 9
Abstraction and Libraries
Abstraction

*abstraction* is the process of ignoring minutiae and focusing on the big picture

- in modern life, we are constantly confronted with complexity
- we don't necessarily know how it works, but we know how to use it

  e.g., how does a TV work? a car? a computer?
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we survive in the face of complexity by abstracting away details

- to use a TV/car/computer, it's not important to understand the inner workings
- we ignore unimportant details and focus on those features relevant to using it

  e.g., TV has power switch, volume control, channel changer, ...
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JavaScript functions (like Math.sqrt) provide computational abstraction
- a function encapsulates some computation & hides the details from the user
- the user only needs to know how to call the function, not how it works

  Chapter 7 introduced simple user-defined functions
  - could encapsulate the statements associated with a button, call the function as needed
General Function Form

to write general-purpose functions, we can extend definitions to include:
1) parameters, 2) local variables, and 3) return statements

function FUNCTION_NAME(PARAMETER1, PARAMETER2, ..., PARAMETERn)
// Assumes: DESCRIPTION OF ASSUMPTIONS MADE ABOUT PARAMETERS
// Returns: DESCRIPTION OF VALUE RETURNED BY FUNCTION
{
 var LOCAL1, LOCAL2, ..., LOCALn;
 STATEMENTS_TO_PERFORM_THE_DESIZED_COMPUTATION
 return OUTPUT_VALUE;  // optional
}

- **parameters** are variables that correspond to the function’s inputs (if any)
  - parameters appear in the parentheses, separated by commas

- **local variables** are temporary variables that are limited to that function only
  - if require some temporary storage in performing calculations, then declare local variables
  - using the keyword `var`, separated by commas
  - a local variable exists only while the function executes, so no potential conflicts with other functions

- a **return statement** is a statement that specifies an output value
  - consists of the keyword return followed by a variable or expression
Declaring Local Variables

we have seen that variables are useful for storing intermediate steps in a complex computation
- within a user-defined function, the programmer is free to create new variables and use them in specifying the function’s computation
- however, by default, new variables used in a function are *global* (i.e., exist and are accessible anywhere in the page)

- *but what if the same variable name is already used elsewhere?*
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  - *but what if the same variable name is already used elsewhere?*

To avoid name conflicts, the programmer should declare temporary variables to be *local*
- a variable declaration is a statement that lists all local variables to be used in a function (usually the first statement in a function)
- general form:

  ```
  var LOCAL_1, LOCAL_2, ..., LOCAL_n;
  ```
consider a simple ESP test

1. user thinks of a number between 1-4
2. clicks on the button to see the computer's pick

number is declared local to "pickNumber"
• only exists while the function executes
most of the predefined function we have considered expect at least one input
e.g., Math.sqrt takes a number as input, and returns its square root as output
   Math.sqrt(9) → 3
   Math.sqrt(25) → 5
   Math.sqrt(0) → 0

e.g., Math.max takes two numbers as inputs, and returns the maximum as output
   Math.max(7, 3) → 7
   Math.max(12, 15) → 15

in English, the word parameter refers to some aspect of a system that can be varied in order to control its behavior

- in JavaScript, a parameter is a variable (declared inside the function's parentheses) whose value is automatically initialized to the corresponding input value when the function is called
- parameters allow the same function to perform different (but related) tasks when called with different input values
better design: have a button for each guess

- to guess 1, the user clicks the 'Guess 1' button
- instead of 4 different functions (that behave similarly), have 1 function with a parameter

- the number corresponding to the guess is passed in as an input, displayed as the guess
Multiple Inputs

if a function has more than one input,

- parameters in the function definition are separated by commas
- input values in the function call are separated by commas
- values are matched to parameters by order
  1\textsuperscript{st} input value in the function call is assigned to the 1\textsuperscript{st} parameter in the function
  2\textsuperscript{nd} input value in the function call is assigned to the 2\textsuperscript{nd} parameter in the function
  ...

```javascript
function OldMacVerse(animal, sound)
// Assumes: animal is the name of an animal, sound is the sound it makes
// Results: displays a verse of the song "Old MacDonald Had a Farm" in outputDiv
{
    document.getElementById('outputDiv').innerHTML =
    '<p>Old MacDonald had a farm, E-I-E-I-O.<br>+
    'And on that farm he had a ' + animal + ', E-I-E-I-O.<br>+
    'With a ' + sound + ' - ' + sound + ' here, and a ' + sound + ' - ' + sound + ' there,<br>+
    ' here a ' + sound + ', there a ' + sound + ', everywhere a ' + sound + '+ sound + '.<br>+
    'Old MacDonald had a farm, E-I-E-I-O.</p>';}
```

<input type="button" value="Cow Verse"
onclick="OldMacVerse('cow', 'moo');">
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        'Old MacDonald had a farm, E-I-E-I-O.<p>;
    }
```
Parameters and Locals

parameters play an important role in functions

- they facilitate the creation of generalized computations
- i.e., the function defines a formula, but certain values within the formula can differ each time the function is called

parameters are special instances of local variables

- when the function is called, memory cells are allocated for the parameters and each input from the call is assigned to its corresponding parameter
- once a parameter has been assigned a value, you can refer to that parameter within the function just as you would any other variable
- when the function terminates, the parameters “go away,” and their associated memory cells are freed

parameters are declared and initialized automatically

- do not declare them as local variables
Functions with Return

displaying results using an INNERHTML assignment or alert is OK for some functions

- for full generality, we need to be able to return an output value, which can then be used in other computations

  e.g.,

  \[
  \text{number} = \text{Math.sqrt}(9);
  \]

  \[
  \text{cm} = \text{InchesToCentimeters}(\text{in});
  \]
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  e.g.,

  ```javascript
  var number = Math.sqrt(9);
  var cm = InchesToCentimeters(in);
  ```

  ```javascript
  function InchesToCentimeters(inches) {
    // Assumes: inches is a distance, measured in inches
    // Returns: the corresponding distance in centimeters
    var cm;
    cm = inches * 2.54;
    return cm;
  }

  function CentimetersToInches(cm) {
    // Assumes: cm is a distance, measured in centimeters
    // Returns: the corresponding distance in inches
    var inches;
    inches = cm / 2.54;
    return inches;
  }
  ```

  a return statement can be added to a function to specify its output value

  - when the return statement is reached, the variable or expression is evaluated and its value is returned as the function's output

  - general form:
    ```javascript
    return OUTPUT_VALUE;
    ```
Function Libraries

functions such as InchesToCentimeters can be added to the HEAD of a page

- tedious if the function is to be used in many pages
- involves creating lots of copies that all must be maintained for consistency

the alternative for general purpose functions is to place them in a library file

- a library file is a separate text file that contains the definitions of one or more JavaScript functions
- it can be loaded into any page by adding an HTML element to the HEAD

```html
<script type="text/javascript" src="LIBRARY_FILENAME"></script>
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advantages of library files:

- avoids duplication (only one copy of the function definition)
- makes it easy to reuse functions (simply load the library file into any page)
- makes it easy to modify functions (a single change to the library file automatically affects all pages that load the library)
the convert.js library file is loaded into the page

- this makes the InchesToCentimeters function accessible within the page

- since ConvertToCm is specific to this page, it directly in the HEAD (as opposed to a library file)
the random.js library contains useful functions for generating random values

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<thead>
<tr>
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<th>Output</th>
</tr>
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<tbody>
<tr>
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<td>Two numbers (low and high limits of a range); e.g., RandomNum(2, 4.5)</td>
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<tr>
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<td>Two integers (low and high limits of a range); e.g., RandomInt(1, 10)</td>
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</tr>
<tr>
<td>RandomChar</td>
<td>A nonempty string; e.g., RandomChar('abcd')</td>
<td>A random character taken from the string</td>
</tr>
<tr>
<td>RandomOneOf</td>
<td>A list of options in square brackets, separated by commas; e.g.,</td>
<td>A random value taken from the list of options</td>
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<td>RandomOneOf(['yes', 'no'])</td>
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random.js Library

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Any page can utilize the functions by first loading the random.js library.

```html
<script type="text/javascript" src="http://balance3e.com/random.js"></script>
```

For example, could revise the ESP Test page to use RandomInt:

```javascript
number = RandomInt(1, 4);
```
Errors to Avoid

When beginning programmers attempt to load a JavaScript code library, errors of two types commonly occur:

1. if the SCRIPT tags are malformed or the name/address of the library is incorrect, the library will fail to load
   - this will not cause an error in itself, but any subsequent attempt to call a function from the library will produce
   - **Error: Object Expected** (using Internet Explorer)
   - or
   - **Error: XXX is not a function** (using Firefox), where XXX is the entered name

2. when you use the SRC attribute in a pair of SCRIPT tags to load a code library, you cannot place additional JavaScript code between the tags
   - think of the SRC attribute as causing the contents of the library to be inserted between the tags, overwriting any other code that was erroneously placed there

```html
<script type="text/javascript" src="FILENAME">
    ANYTHING PLACED IN HERE WILL BE IGNORED
</script>
```

- if you want additional JavaScript code or another library, you must use another pair of SCRIPT tags
Designing Functions

functions do not add any computational power to the language
  ▪ a function definition simply encapsulates other statements

still, the capacity to define and use functions is key to solving complex problems, as well as to developing reusable code
  ▪ encapsulating repetitive tasks can shorten and simplify code
  ▪ functions provide units of computational abstraction – user can ignore details
  ▪ functions are self-contained, so can easily be reused in different applications
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when is it worthwhile to define a function?
- if a particular computation is complex—meaning that it requires extra variables and/or multiple lines to define
- if you have to perform a particular computation repeatedly

when defining a function, you must identify
- the inputs
- the computation to be performed using those inputs
- the output
Design Example

consider the task of designing an online Magic 8-ball® (Mattell, Inc.)
- must be able to ask a yes/no type question
- receive an answer (presumably, at random)

could use:
- a text box for entering the question
- a DIV element for displaying the answer
- a clickable image for initiating the action – which involves calling a function to process the question, select an answer, and display it in the DIV