8 bringing it all together

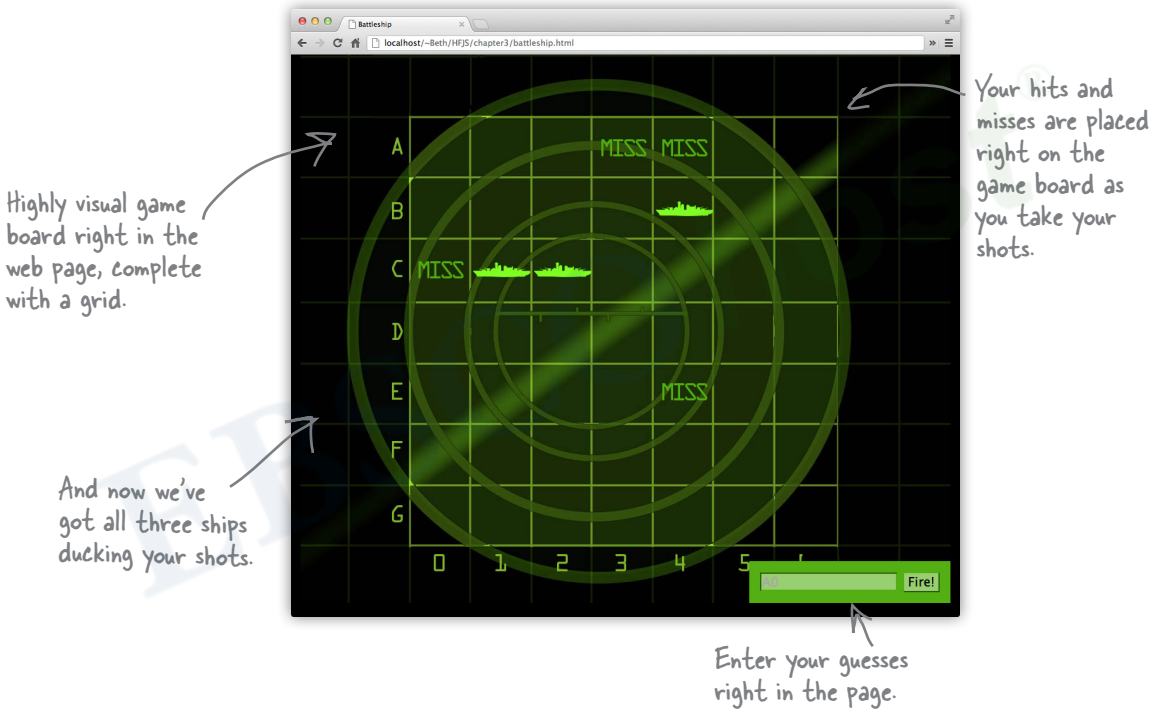
Building an app

Put on your toolbelt. That is, the toolbelt with all your new coding skills, your knowledge of the DOM, and even some HTML & CSS. We're going to bring everything together in this chapter to create our first true **web application**. No more **silly toy games** with one battleship and a single row of hiding places. In this chapter we're building the **entire experience**: a nice big game board, multiple ships and user input right in the web page. We're going to create the page structure for the game with HTML, visually style the game with CSS, and write JavaScript to code the game's behavior. Get ready: this is an all out, pedal to the metal development chapter where we're going to lay down some serious code.

This time, let's build a REAL Battleship game

Sure, you can feel good because back in Chapter 2 you built a nice little battleship game from scratch, but let's admit it: that was a bit of a *toy* game—it worked, it was playable, but it wasn't exactly the game you'd impress your friends with, or use to raise your first round of venture capital. To really impress, you'll need a visual game board, snazzy battleship graphics, and a way for players to enter their moves right in the game (rather than a generic browser dialog box). You'll also want to improve the previous version by supporting all three ships.

In other words, you'll want to create something like this:



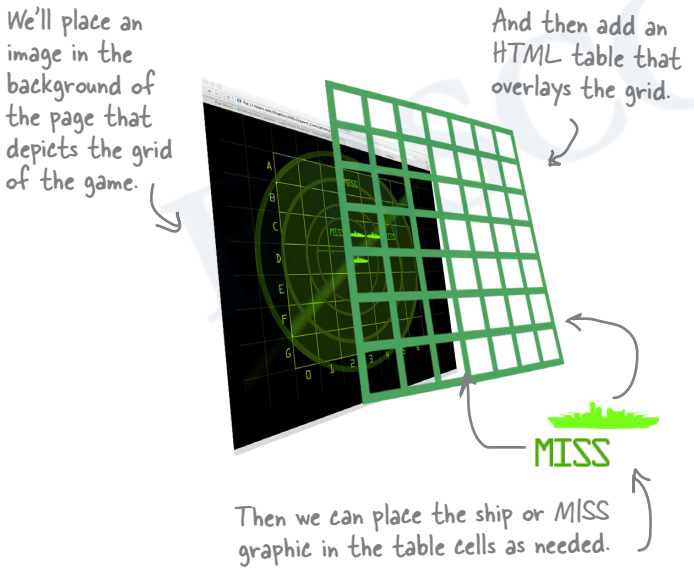
Forget JavaScript for a minute... look at the Battleship mockup above. If you focus on the structure and visual represention of the page, how would you create it using HTML and CSS?

Stepping back... to HTML and CSS

To create a modern, interactive web page, or *app*, you need to work with three technologies: HTML, CSS and JavaScript. You already know the mantra "HTML is for structure, CSS is for style and JavaScript is for behavior." But rather than just stating it, in this chapter we're going to fully embody it. And we're going to start with the HTML and CSS first.

Our first goal is going to be to reproduce the look of the game board on the previous page. But not *just* reproduce it; we need to implement the game board so it has a structure we can use in JavaScript to take player input and place hits, misses and messages on the page.

To pull that off we're going to do things like use an image in the background to give us the slick grid over a radar look, and then we'll lay a more functional HTML table over that so we can place things (like ships) on top of it. We'll also use an HTML form to get the player input.



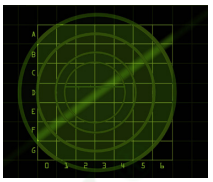
So, let's build this game. We're going to take a step back and spend a few pages on the crucial HTML and CSS, but once we have that in place, we'll be ready for the JavaScript.

GET YOUR BATTLESHIP TOOLKIT

Here's a toolkit to get you started on this new version of Battleship.

INVENTORY includes...

board.jpg



ship.png

miss.png

This toolkit contains three images, "board.jpg", which is the main background board for the game including the grid; "ship.png", which is a small ship for placement on the board—notice that it is a PNG image with transparency, so it will lay right on top of the background—and finally we have "miss.png", which is also meant to be placed on the board. True to the original game, when we hit a ship we place a ship in the corresponding cell, and when we miss we place a miss graphic there.

Download everything you need for the game at http://wickedlysmart.com/hfjs

Creating the HTML page: the Big Picture

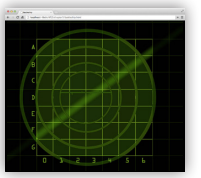
Here's the plan of attack for creating the Battleship HTML page:

1. First we'll concentrate on the background of the game, which includes setting the background image to black and placing the radar grid image in the page.

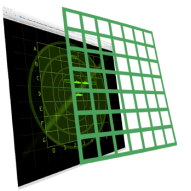
2. Next we'll create an HTML table and lay it on top of the background image. Each cell in the table will represent a board cell in the game.

3. Then we'll add an HTML form element where players can enter their guesses, like "A4". We'll also add an area to display messages, like "You sank my battleship!"

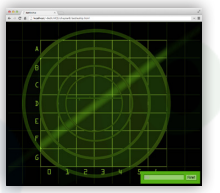
4. Finally, we'll figure out how to use the table to place the images of a battleship (for a hit) and a MISS (for a miss) into the board.



We're placing an image in the background to give the game its cool, green phosphorus radar feel.



An HTML table on top of the background creates a game board for the game to play out in.



An HTML form for player input.

We'll use these images and place them into the table as needed.

Step 1: The Basic HTML

Let's get started! First we need an HTML page. We're going to start by creating a simple HTML5-compliant page; we'll also add some styling for the background image. In the page we're going to place a `<body>` element that contains a single `<div>` element. This `<div>` element is going to hold the game grid.

Go ahead and check out the next page that contains our starter HTML and CSS.

A little rusty?

If you're feeling a bit rusty on your HTML and CSS, *Head First HTML and CSS* was written to be the companion to this book.

```
<!doctype html>
<html lang="en">
  <head>
    <meta charset="utf-8">
    <title>Battleship</title>
    <style>
      body {
        background-color: black;
      }

      div#board {
        position: relative;
        width: 1024px;
        height: 863px;
        margin: auto;
        background: url("board.jpg") no-repeat;
      }
    </style>
  </head>
  <body>
    <div id="board">

    </div>
    <script src="battleship.js"></script>
  </body>
</html>
```

Just a regular HTML page.

And we want the background of the page to be black.

We want the game board to stay in the middle of the page, so we're setting the width to 1024px (the width of the game board), and the margins to auto.

Here's where we add the "board.jpg" image to the page, as the background of the "board" element. We're positioning this relative, so that we can position the table we add in the next step relative to this .

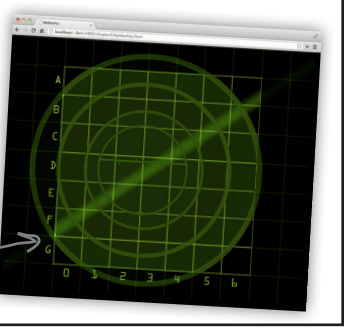
We're going to put the table for the game board and the form for getting user input here.

We'll put our code in the file "battleship.js". Go ahead and create a blank file for that.

A Test Drive

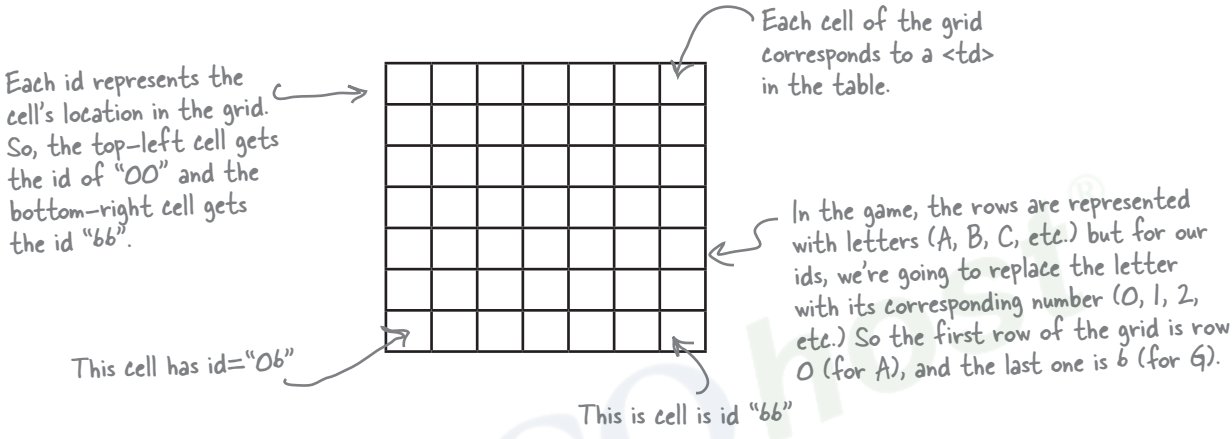
Go ahead and enter the code above (or download all the code for the book from http://wickedlysmart.com/hfjs) into the file "battleship.html" and then load it in your browser. Our test run is below.

Here's what the web page looks like so far...



Step 2: Creating the table

Next up is the table. The table will overlay the visual grid in the background image, and provide the area to place the hit and miss graphics where you play the game. Each cell (or if you remember your HTML, each <td> element) is going to sit right on top of a cell in the background image. Now here is the trick: we'll give each cell its own id, so we can manipulate it later with CSS and JavaScript. Let's check out how we're going to create these ids and add the HTML for the table:



Here's the HTML for the table. Go ahead and add this between the tags:

We're nesting the table inside the "board" .

```
<div id="board">
  <table>
    <tr>
      <td id="00"></td><td id="01"></td><td id="02"></td><td id="03">
</td><td id="04"></td> <td id="05"></td><td id="06"></td>
    </tr>
    <tr>
      <td id="10"></td><td id="11"></td><td id="12"></td><td id="13"></td>
<td id="14"></td> <td id="15"></td><td id="16"></td>
    </tr>
    ...
    <tr>
      <td id="60"></td><td id="61"></td><td id="62"></td><td id="63"></td>
<td id="64"></td><td id="65"></td><td id="66"></td>
    </tr>
  </table>
</div>
```

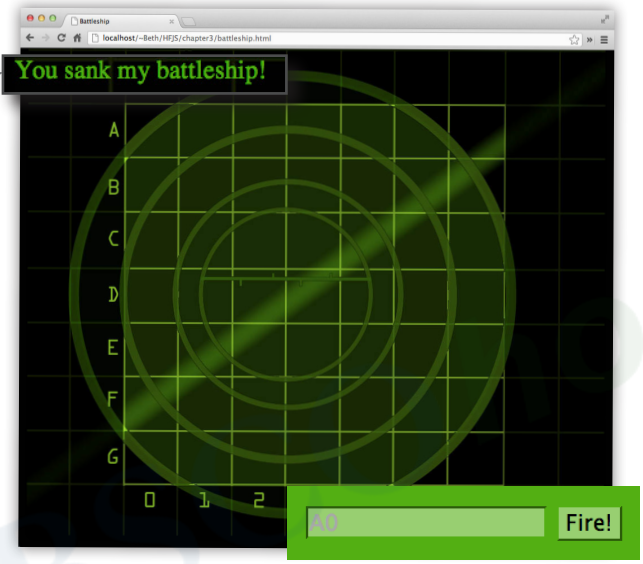
Make sure each <td> gets the correct id corresponding to its row and column in the grid.

We've left out a few rows to save some trees, but we're sure you can fill these in on your own.

Step 3: Player interaction

Okay, now we need an HTML element to enter guesses (like "A0" or "E4"), and an element to display messages to the player (like "You sank my battleship!"). We'll use a `<form>` with a text `<input>` for the player to submit guesses, and a `<div>` to create an area where we can message the player:

We'll notify players when they've sunk battleships with a message up in the top left corner.



And here's where players can enter their guesses.

```
<div id="board">
  <div id="messageArea"></div>
  <table>
    ...
  </table>
  <form>
    <input type="text" id="guessInput" placeholder="A0">
    <input type="button" id="fireButton" value="Fire!">
  </form>
</div>
```

The messageArea will be used to display messages from code.

The <form> has two inputs: one for the guess (a text input) and one for the button. Note the ids on these elements. We'll need them later when we write the code to get the player's guess.

Notice that the message area , the <table>, and the <form> are all nested within the "board" . This is important for the CSS on the next page.

Adding some more style

If you load the page now (go ahead, give it a try), most of the elements are going to be in the wrong places and the wrong size. So we need to provide some CSS to put everything in the right place, and make sure all the elements, like the table cells, have the right size to match up with the game board image.

To get the elements into the right places, we're going to use CSS positioning to lay everything out. We've positioned the "board" `<div>` element using position relative, so we can now position the message area, table, and form at specific places within the "board" `<div>` to get them to display exactly where we want them.

Let's start with the "messageArea" `<div>`. It's nested inside the "board" `<div>`, and we want to position it at the very top left corner of the game board:

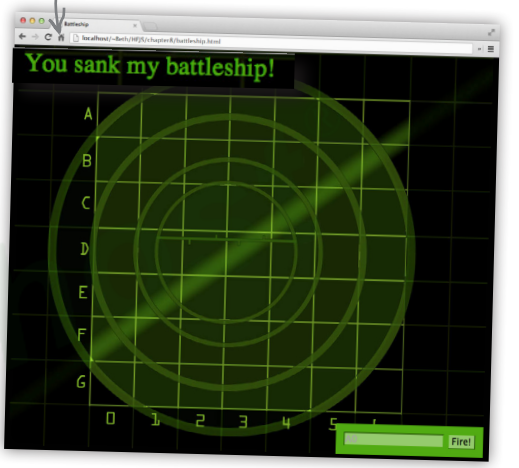
```
body {
    background-color: black;
}
div#board {
    position: relative;
    width: 1024px;
    height: 863px;
    margin: auto;
    background: url("board.jpg") no-repeat;
}
div#messageArea {
    position: absolute;
    top: 0px;
    left: 0px;
    color: rgb(83, 175, 19);
}
```

The "board" is positioned relative, so everything nested within this can be positioned relative to it.

We're positioning the message area at the top left of the board.

The messageArea is nested inside the board , so its position is specified relative to the board . So it will be positioned 0px from the top and 0px from the left of the top left corner of the board .

We want the message area to be positioned at the top left corner of the game board.



BULLET POINTS

- "position: relative" positions an element at its normal location in the flow of the page.
- "position: absolute" positions an element based on the position of its most closely positioned parent.
- The top and left properties can be used to specify the number of pixels to offset a positioned element from its default position.

We can also position the table and the form within the "board" , again using absolute positions to get these elements precisely where we want them. Here's the rest of the CSS:

```
body {
    background-color: black;
}
div#board {
    position: relative;
    width: 1024px;
    height: 863px;
    margin: auto;
    background: url("board.jpg") no-repeat;
}
div#messageArea {
    position: absolute;
    top: 0px;
    left: 0px;
    color: rgb(83, 175, 19);
}
table {
    position: absolute;
    left: 173px;
    top: 98px;
    border-spacing: 0px;
}
td {
    width: 94px;
    height: 94px;
}
form {
    position: absolute;
    bottom: 0px;
    right: 0px;
    padding: 15px;
    background-color: rgb(83, 175, 19);
}
form input {
    background-color: rgb(152, 207, 113);
    border-color: rgb(83, 175, 19);
    font-size: 1em;
}
```

We position the <table> 173 pixels from the left of the board and 98 pixels from the top, so it aligns with the grid in the background image.

Each <td> gets a specific width and height so that the cells of the <table> match up with the cells of the grid.

We're placing the <form> at the bottom right of the board. It obscures the bottom right numbers a bit, but that's okay (you know what they are). We're also giving the <form> a nice green color to match the background image.

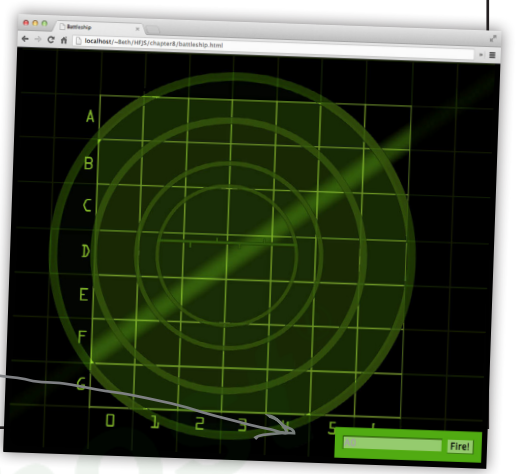
And finally, a bit of styling on the two <input> elements so they fit in with the game theme, and we're done!

A Test Drive

It's time for another game checkpoint. Get all the HTML and CSS entered into your HTML file and then reload the page in your browser. Here's what you should see:

Even though you can't see it (because it's invisible), the table is sitting right on top of the grid.

The form input is ready to take your guesses, although nothing will happen until we write some code.



Step 4: Placing the hits and misses

The game board is looking great don't you think? However, we still need to figure out how to visually add hits and misses to the board—that is, how to add either a "ship.png" image or a "miss.png" image to the appropriate spot on the board for each guess. Right now we're only going to worry about how to craft the right markup or style to do this, and then later we'll use the same technique in code.

ship.png

miss.png

So how do we get a "ship.png" image or a "miss.png" image on the board? A straightforward way is to add the appropriate image to the background of a `<td>` element using CSS. Let's try that by creating two classes, one named "hit" and the other "miss". We'll use the `background` CSS property with these images so an element styled with the "hit" class will have the "ship.png" in its background, and an element styled with the "miss" class will have the "miss.png" image in its background. Like this:

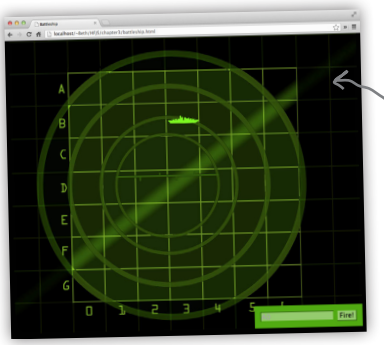
If an element is in the hit class it gets the ship.png image. If the element is in the miss class, it gets the miss.png image in its background.

```
.hit {
    background: url("ship.png") no-repeat center center;
}
.miss {
    background: url("miss.png") no-repeat center center;
}
```

Each CSS rule places a single, centered image in the selected element.

Using the hit and miss classes

Make sure you've added the hit and miss class definitions to your CSS. You may be wondering how we're going to use these classes. Let's do a little experiment right now to demonstrate: imagine you have a ship hidden at "B3", "B4" and "B5", and the user guesses "B3"—a hit! So, you need to place a "ship.png" image at B3. Here's how you can do that: first convert the "B" into a number, 1 (since A is 0, B is 1, and so on), and find the `<td>` with the id "13" in your table. Now, add the class "hit" to that `<td>`, like this:



Here we've added the "hit" class to the <td>.

```
<tr>
<td id="10"></td> <td id="11"></td> <td id="12"></td> <td id="13" class="hit"></td>
<td id="14"></td> <td id="15"></td> <td id="16"></td>
</tr>
```

Make sure you've added the hit and miss classes from the previous page to your CSS.

What we see when we add the class "hit" to element with id "13".

Now when you reload the page, you'll see a battleship at location "B3" in the game board.

PRACTICE DRILLS

Before we write the code that's going to place hits and misses on the game board, get a little more practice to see how the CSS works. Manually play the game by adding the "hit" and "miss" classes into your markup, as dictated by the player's moves below. Be sure to check your answers!

```
Ship 1: A6, B6, C6
Ship 2: C4, D4, E4
Ship 3: B0, B1, B2
```

Remember, you'll need to convert the letters to numbers, with A = 0, ... G = 6.

and here are the player's guesses:

```
A0, D4, F5, B2, C5, C6
```

Check your answer at the end of the chapter before you go on.

When you're done, remove any classes that you've added to your <td> elements so you'll have an empty board to use when we start coding.

there are no Dumb Questions

Q: I didn't know it was okay to use a string of numbers for the id attributes in our table?

A: Yes. As of HTML5, you are allowed to use all numbers as an element id. As long as there are no spaces in the id value, it's fine. And for the Battleship application, using numbers for each id works perfectly as a way to keep track of each table position, so we can access the element at that position quickly and easily.

Q: So just to make sure I understand, we're using each td element as a cell in the gameboard, and we'll mark a cell as being a hit or a miss with the class attribute?

A: Right, there are a few pieces here: we have a background image grid that is just for eye candy, we have a transparent HTML table overlaying that, and we use the classes "hit" and "miss" to put an image in the background of each table cell when needed. This last part will all be done from code, when we're going to dynamically add the class to an element.

Q: It sounds like we're going to need to convert letters, as in "A6", to numbers so we get "06". Will JavaScript do this automatically for us?

A: No, we're going to have to do that ourselves, but we have an easy way to do it—we're going to use what you know about arrays to do a quick conversion… stay tuned.

Q: I'm not sure I completely remember how CSS positioning works.

A: Positioning allows you to specify an exact position for an element. If an element is positioned "relative", then the element is positioned based on its normal location in the flow of the page. If an element is positioned "absolute", then that element is positioned at a specific location, relative to its most closely positioned parent. Sometimes that's the entire page, in which case the position you specify could be its top left position based on the corner of the web browser. In our case, we're positioning the table and message area elements absolutely, but in relation to the game board (because the board is the most closely positioned parent of the table and the message area).

If you need a more in-depth refresher on CSS positioning, check out Chapter 11 of *Head First HTML and CSS*.

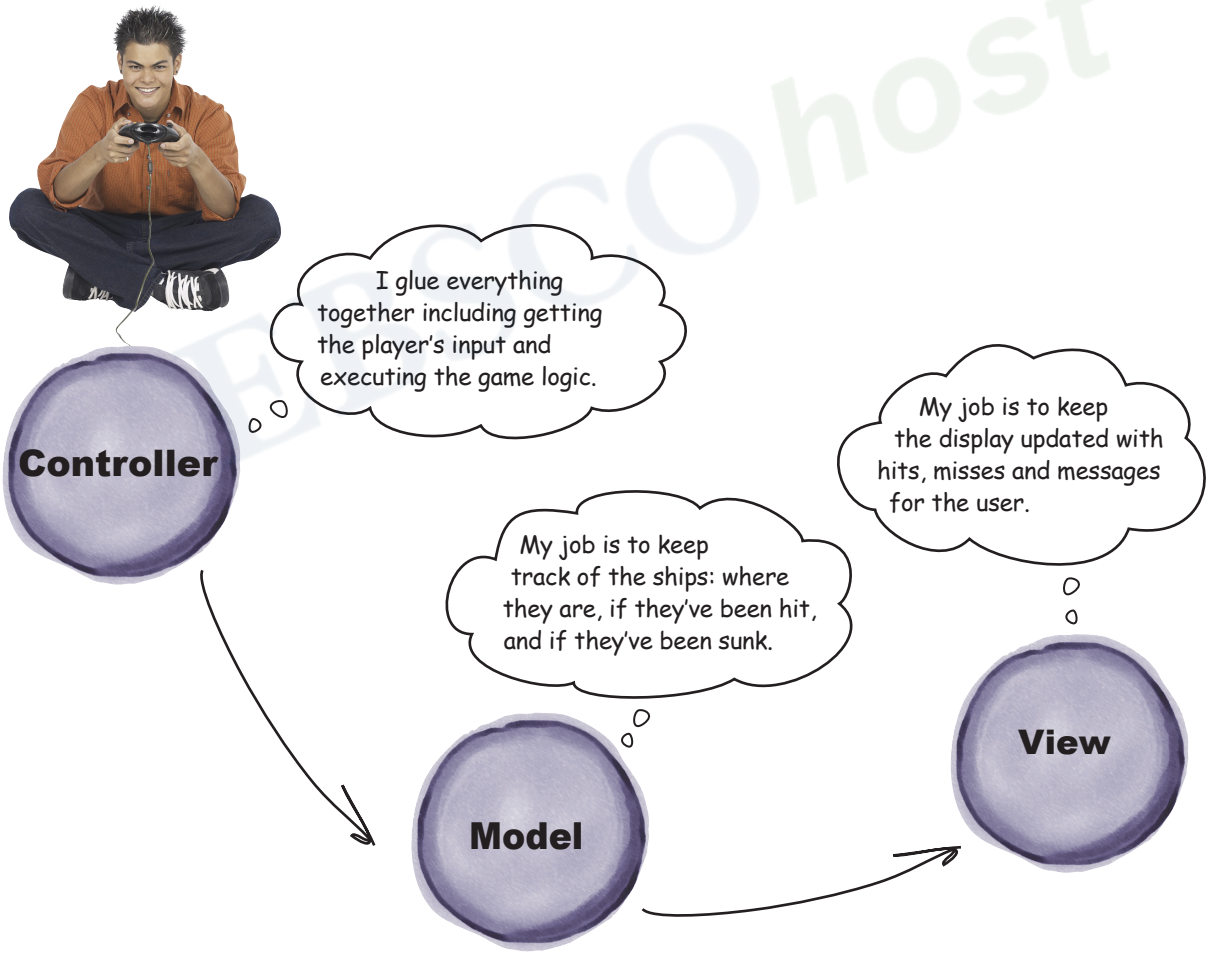
Q: When I learned about the HTML form element, I was taught there is an action attribute that submits the form. Why don't we have one?

A: We don't need the action attribute in the <form> because we're not submitting the form to a server-side application. For this game, we're going to be handling everything in the browser, using code. So, instead of submitting the form, we're going to implement an event handler to be notified when the form button is clicked, and when that happens, we'll handle everything in our code, including getting the user's input from the form. Notice that the type of the form button is "button", not "submit", like you might be used to seeing if you've implemented forms that submit data to a PHP program or another kind of program that runs on the server. It's a good question; more on this later in the chapter.

How to design the game

With the HTML and CSS out of the way, let's get to the real game design. Back in Chapter 2, we hadn't covered functions or objects or encapsulation or learned about object-oriented design, so when we built the first version of the Battleship game, we used a procedural design—that is, we designed the game as a series of steps, with some decision logic and iteration mixed in. You also hadn't learned about the DOM, so the game wasn't very interactive. This time around, we're going to organize the game into a set of objects, each with its own responsibilities, and we're going to use the DOM to interact with the user. You'll see how this design makes approaching the problem a lot more straightforward.

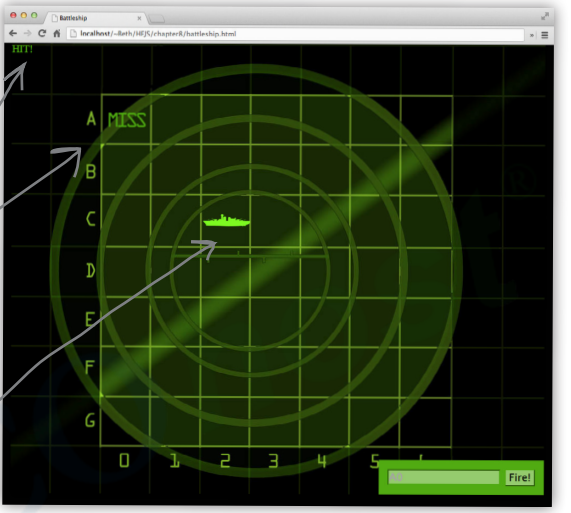
Let's first get introduced to the objects we're going to design and implement. There are three: the *model*, which will hold the state of the game, like where each ship is located and where it's been hit; the *view*, which is responsible for updating the display; and the *controller*, which glues everything together by handling the user input, making sure the game logic gets played and determining when the game is over.



Exercise

It's time for some object design. We're going to start with the view object. Now, remember, the view object is responsible for updating the view. Take a look at the view below and see if you can determine the methods we want the view object to implement. Write the declarations for these methods below (just the declarations; we'll code the bodies of the methods in a bit) along with a comment or two about what each does. We've done one for you. *Check your answers before moving on:*

Here's a message. Messages will be things like "HIT!", "You missed." and "You sank my battleship!"



Here the display has a MISS placed on the grid.

And here the display has a ship placed on the grid.

Notice we're defining an object and assigning it to the variable view.

```
var view = {

   // this method takes a string message and displays it
   // in the message display area
   displayMessage: function(msg) {
          // code to be supplied in a bit!
   }




};
```

Your methods go here!

Implementing the View

If not, shame on you. Do it now!

If you checked the answer to the previous exercise, you've seen that we've broken the view into three separate methods: `displayMessage`, `displayHit` and `displayMiss`. Now, there is no one right answer. For instance, you might have just two methods, `displayMessage` and `displayPlayerGuess`, and pass an argument into `displayPlayerGuess` that indicates if the player's guess was a hit or a miss. That is a perfectly reasonable design. But we're sticking with our design for now... so let's think through how to implement the first method, `displayMessage`:

Here's our view object.

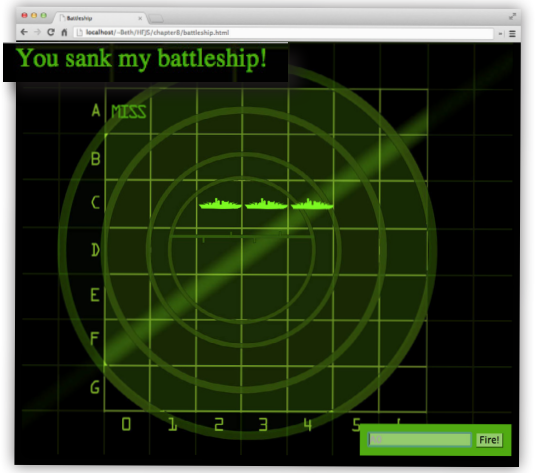
```
var view = {
   displayMessage: function(msg) {

   },
   displayHit: function(location) {
   },
   displayMiss: function(location) {
   }
};
```

We're going to start here.

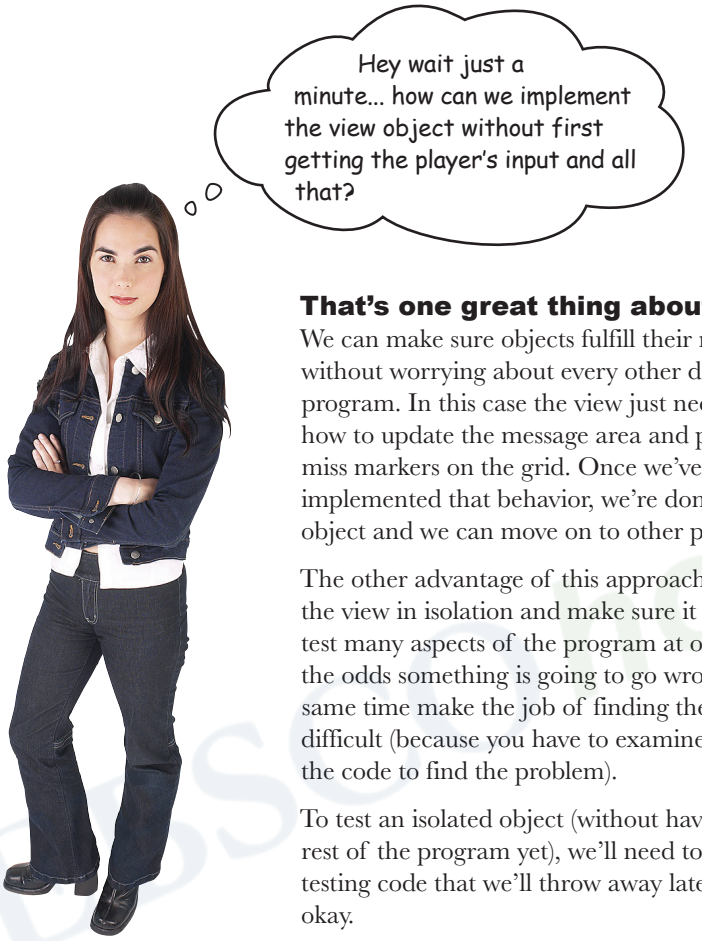
How displayMessage works

To implement the `displayMessage` method you need to review the HTML and see that we have a `<div>` with the id "messageArea" ready for messages:

```
<div id="board">
  <div id="messageArea"></div>
    ...
</div>
```



We'll use the DOM to get access to this `<div>`, and then set its text using `innerHTML`. And remember, whenever you change the DOM, you'll see the changes immediately in the browser. Here's what we're going to do…



That's one great thing about objects. We can make sure objects fulfill their responsibility without worrying about every other detail of the program. In this case the view just needs to know how to update the message area and place hit and miss markers on the grid. Once we've correctly implemented that behavior, we're done with the view object and we can move on to other parts of the code.

The other advantage of this approach is we can test the view in isolation and make sure it works. When we test many aspects of the program at once, we increase the odds something is going to go wrong and at the same time make the job of finding the problem more difficult (because you have to examine more areas of the code to find the problem).

To test an isolated object (without having finished the rest of the program yet), we'll need to write a little testing code that we'll throw away later, but that's okay.

So let's finish the view, test it, and then move on!

Implementing displayMessage

Let's get back to writing the code for `displayMessage`. Remember it needs to:

- Use the DOM to get the element with the id "messageArea".
- Set that element's `innerHTML` to the message passed to the `displayMessage` method.

So open up your blank "battleship.js" file, and add the view object:

```
var view = {
    displayMessage: function(msg) {
        var messageArea = document.getElementById("messageArea");
        messageArea.innerHTML = msg;
    },
    displayHit: function(location) {
    },
    displayMiss: function(location) {
    }
};
```

The displayMessage method takes one argument, a msg.

We get the messageArea element from the page...

...and update the text of the messageArea element by setting its innerHTML to msg.

Now before we test this code, let's go ahead and write the other two methods. They won't be incredibly complicated methods, and this way we can test the entire object at once.

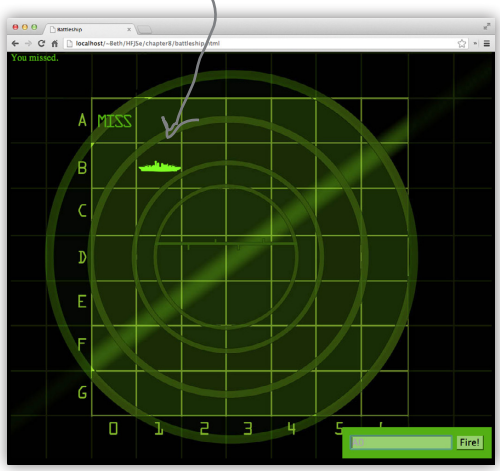
How displayHit and displayMiss work

So we just talked about this, but remember, to have an image appear on the game board, we need to take a `<td>` element and add either the "hit" or the "miss" class to the element. The former results in a "ship.png" appearing in the cell and the latter results in "miss.png" being displayed.

We can affect the display by adding the "hit" or "miss" class to the <td> elements. Now we just need to do this from code.

```
<tr>
<td id="10"></td> <td class="hit" id="11"></td> <td id="12"></td> ...
</tr>
```

Now in code, we're going to use the DOM to get access to a `<td>`, and then set its class attribute to "hit" or "miss" using the `setAttribute` element method. As soon as we set the class attribute, you'll see the appropriate image appear in the browser. Here's what we're going to do:



- Get a string id that consists of two numbers for the location of the hit or miss.
- Use the DOM to get the element with that id.
- Set that element's class attribute to "hit" if we're in `displayHit`, and "miss" if we're in `displayMiss`.

Implementing displayHit and displayMiss

Both `displayHit` and `displayMiss` are methods that take the location of a hit or miss as an argument. That location should match the id of a cell (or `<td>` element) in the table representing the game board in the HTML. So the first thing we need to do is get a reference to that element with the `getElementById` method. Let's try this in the `displayHit` method:

```
displayHit: function(location) {
    var cell = document.getElementById(location);
},
```

Remember the location is created from the row and column and matches an id of a <td> element.

The next step is to add the class "hit" to the cell, which we can do with the `setAttribute` method like this:

```
displayHit: function(location) {
    var cell = document.getElementById(location);
    cell.setAttribute("class", "hit");
},
```

We then set the class of that element to "hit". This will immediately add a ship image to the <td> element.

Now let's add this code to the view object, and write `displayMiss` as well:

```
var view = {
    displayMessage: function(msg) {
        var messageArea = document.getElementById("messageArea");
        messageArea.innerHTML = msg;
    },

    displayHit: function(location) {
        var cell = document.getElementById(location);
        cell.setAttribute("class", "hit");
    },

    displayMiss: function(location) {
        var cell = document.getElementById(location);
        cell.setAttribute("class", "miss");
    }
};
```

We're using the id we created from the player's guess to get the correct element to update.

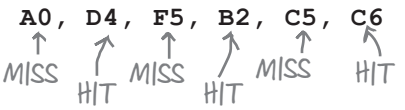
And then setting the class of that element to "hit".

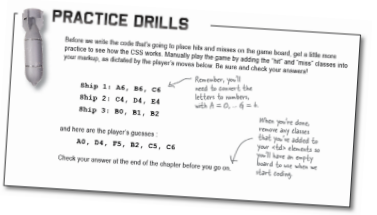
We do the same thing in displayMiss, only we set the class to "miss" which adds a miss image to the element.

Make sure you add the code for `displayHit` and `displayMiss` to your "battleship.js" file.

Another Test Drive...

Let's put the code through its paces before moving on…in fact, let's take the guesses from the previous Practice Drills exercise and implement them in code. Here's the sequence we want to implement:





To represent that sequence in code, add this to the bottom of your "battleship.js" JavaScript file:

```
view.displayMiss("00");
view.displayHit("34");
view.displayMiss("55");
view.displayHit("12");
view.displayMiss("25");
view.displayHit("26");
```

"A0"
"D4"
"F5"
"B2"
"C5"
"C6"

Remember, displayHit and displayMiss take a location in the board that's already been converted from a letter and a number to a string with two numbers that corresponds to an id of one of the table cells.

And, let's not forget to test `displayMessage`:

Any message will do for simple testing...

```
view.displayMessage("Tap tap, is this thing on?");
```

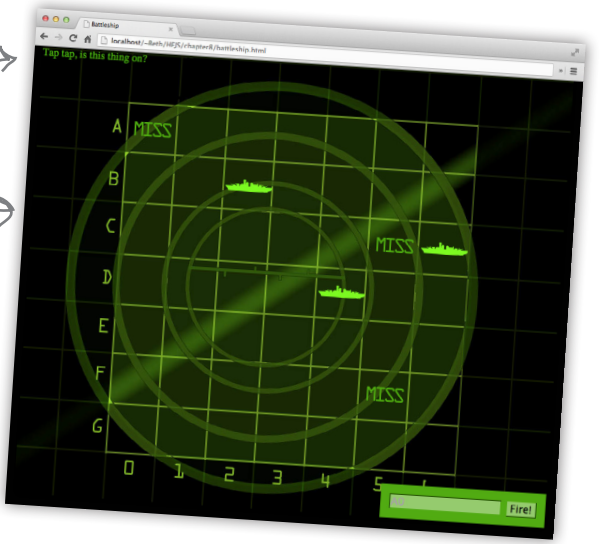
After all that, reload the page in your browser and check out the updates to the display.

One of the benefits of breaking up the code into objects and giving each object only one responsibility is that we can test each object to make sure it's doing its job correctly.

The "tap tap" message is displayed up here at the top left of the view.

And the hits and misses we displayed using the view object are displayed in the game board.

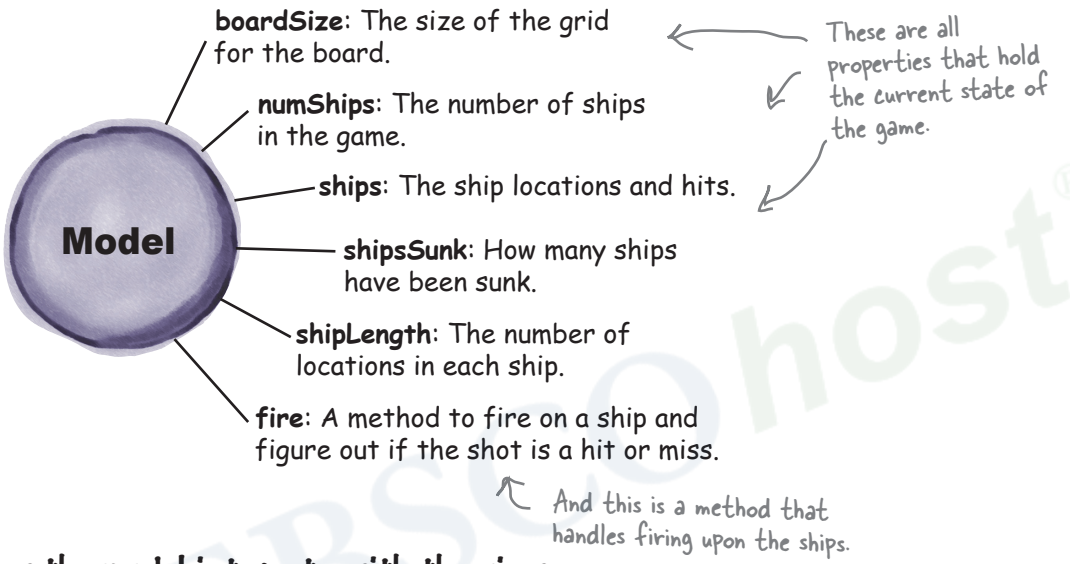
Check each one to make sure it's in the right spot.



The Model

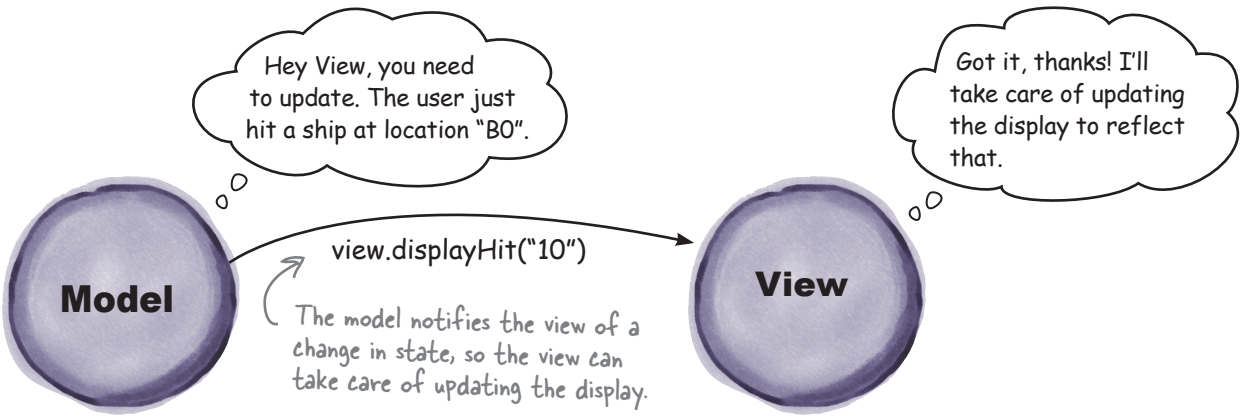
With the view object out of the way, let's move on to the model. The model is where we keep the *state* of the game. The model often also holds some *logic* relating to how the state changes. In this case the state includes the location of the ships, the ship locations that have been hit, and how many ships have been sunk. The only logic we're going to need (for now) is determining when a player's guess has hit a ship and then marking that ship with a hit.

Here's what the model object is going to look like:



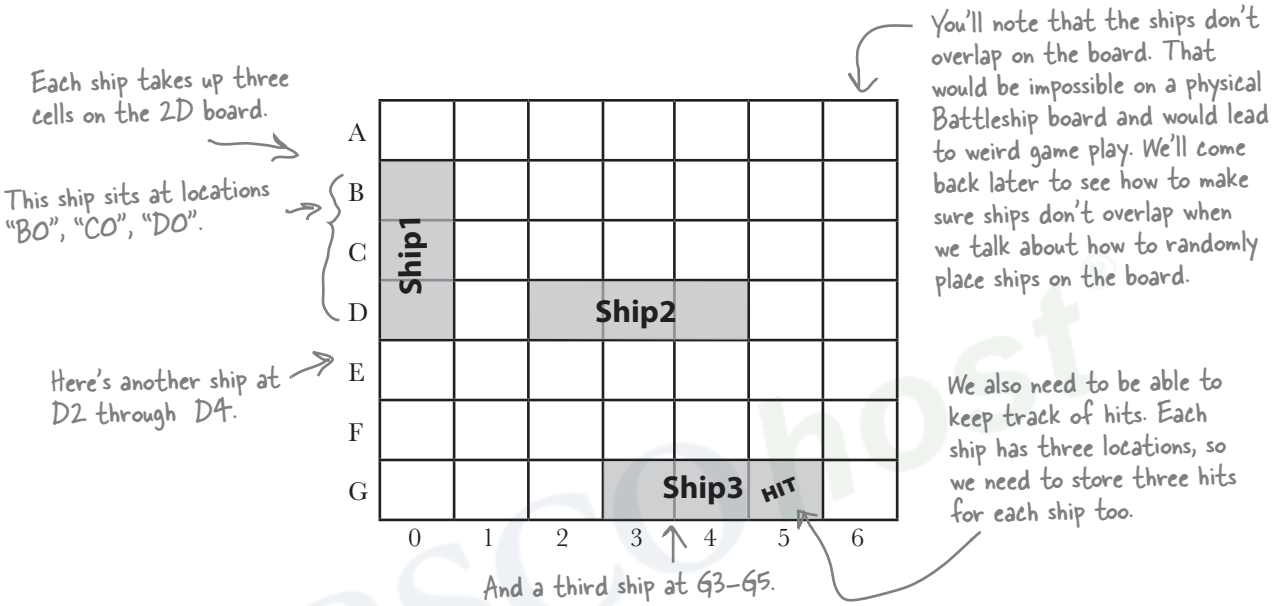
How the model interacts with the view

When the state of the game changes—that is, when you hit a ship, or miss—then the view needs to update the display. To do this, the model needs to talk to the view, and luckily we have a few methods the model can use to do that. We'll get our game logic set first in the model, then we'll add code to update the view.



You're gonna need a bigger boat... and game board

Before we start writing model code, we need to think about how to represent the state of the ships in the model. Back in Chapter 2 in the simple Battleship game, we had a single ship that sat on a 1x7 game board. Now things are a little more complex: we have *three* ships on a 7x7 board. Here's how it looks now:



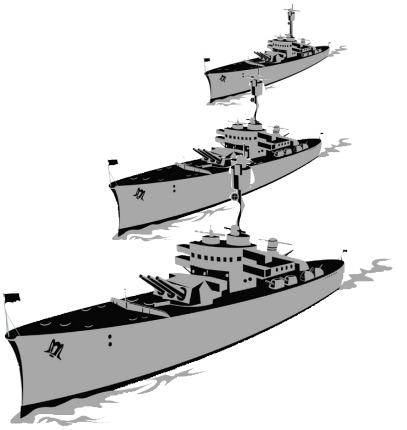
Sharpen your pencil

Given how we've described the new game board above, how would you represent the ships in the model (just the locations, we'll worry about hits later). Check off the best solution below.

- ❏ Use nine variables for the ship locations, similar to the way we handled the ships in Chapter 2.
- ❏ Use an array with an item for each cell in entire board (49 items total). Record the ship number in each cell that holds part of a ship.
- ❏ Use an array to hold all nine locations. Items 0-2 will hold the first ship, 3-5 the second, and so on.
- ❏ Use three different arrays, one for each ship, with three locations contained in each.
- ❏ Use an object named ship with three location properties. Put all the ships in an array named ships.
- ❏ _____

Or write in your own answer.

How we're going to represent the ships



As you can see there are many ways we can represent ships, and you may have even come up with a few other ways of your own. You'll find that no matter what kind of data you've got, there are many choices for storing that data, with various tradeoffs depending on your choice—some methods will be space efficient, others will optimize run time, some will just be easier to understand, and so on.

We've chosen a representation for ships that is fairly simple—we're representing each ship as an object that holds the locations it sits in, along with the hits it's taken. Let's take a look at how we represent one ship:

Each ship is an object.

The ship has a locations property and a hits property.

```
var ship1 = {
              locations: ["10", "20", "30"],
              hits: ["", "", ""]
            };
```

The locations property is an array that holds each location on the board.

The hits property is also an array that holds whether or not a ship is hit at each location. We'll set the array items to the empty string initially, and change each item to "hit" when the ship has taken a hit in the corresponding location.

Note that we've converted the ship locations to two numbers, using 0 for A, 1 for B, and so on.

Here's what all three ships would look like:

Each ship has an array of three locations and an array to track hits.

```
var ship1 = { locations: ["10", "20", "30"], hits: ["", "", ""] };
var ship2 = { locations: ["32", "33", "34"], hits: ["", "", ""] };
var ship3 = { locations: ["63", "64", "65"], hits: ["", "", "hit"] };
```

And, rather than managing three different variables to hold the ships, we'll create a single array variable to hold them all, like this:

We're assigning to ships an array that holds all three ships.

Note the plural name, ships.

```
var ships = [{ locations: ["10", "20", "30"], hits: ["", "", ""] },
             { locations: ["32", "33", "34"], hits: ["", "", ""] },
             { locations: ["63", "64", "65"], hits: ["", "", "hit"] }];
```

Here's the first ship...

...and the second...

...and the third.

Note this ship has a hit at location "65" on the grid.

Ship Magnets

Use the following player moves, along with the data structure for the ships, to place the ship and miss magnets onto the game board. Does the player sink all the ships? We've done the first move for you.

Here are the moves:

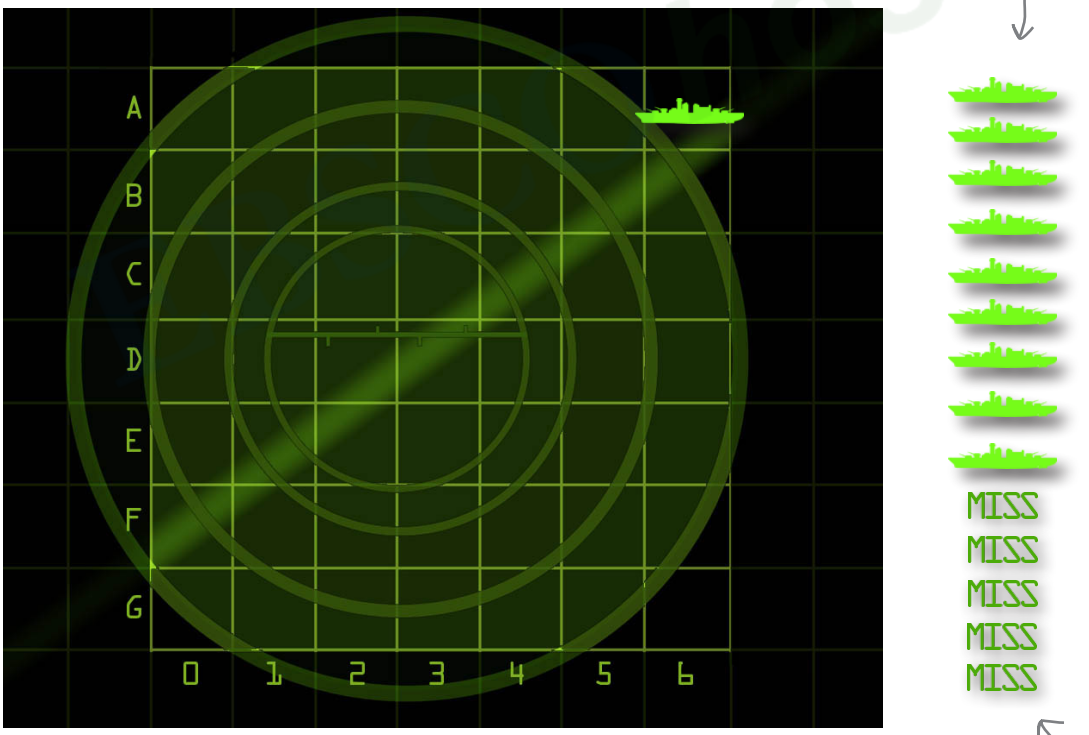
A6, B3, C4, D1, B0, D4, F0, A1, C6, B1, B2, E4, B6

Execute these moves on the game board.

```
var ships = [{ locations: ["06", "16", "26"], hits: ["hit", "", ""] },
             { locations: ["24", "34", "44"], hits: ["", "", ""] },
             { locations: ["10", "11", "12"], hits: ["", "", ""] }];
```

Here is the data structure. Mark each ship with a hit as the game is played.

And here's the board and your magnets.



You might have leftover magnets.

Sharpen your pencil

Let's practice using the ships data structure to simulate some ship activities. Using the ships definition below, work through the questions and the code below and fill in the blanks. Make sure you check your answers before moving on, as this is an important part of how the game works:

```
var ships = [{ locations: ["31", "41", "51"], hits: ["", "", ""] },
             { locations: ["14", "24", "34"], hits: ["", "hit", ""] },
             { locations: ["00", "01", "02"], hits: ["hit", "", ""] }];
```

Which ships are already hit?_____ And, at what locations? _____

The player guesses "D4", does that hit a ship?_____ If so, which one? _____

The player guesses "B3", does that hit a ship?_____ If so, which one? _____

Finish this code to access the second ship's middle location and print its value with console.log.

```
var ship2 = ships[____];
var locations = ship2.locations;
console.log("Location is " + locations[____]);
```

Finish this code to see if the third ship has a hit in its first location:

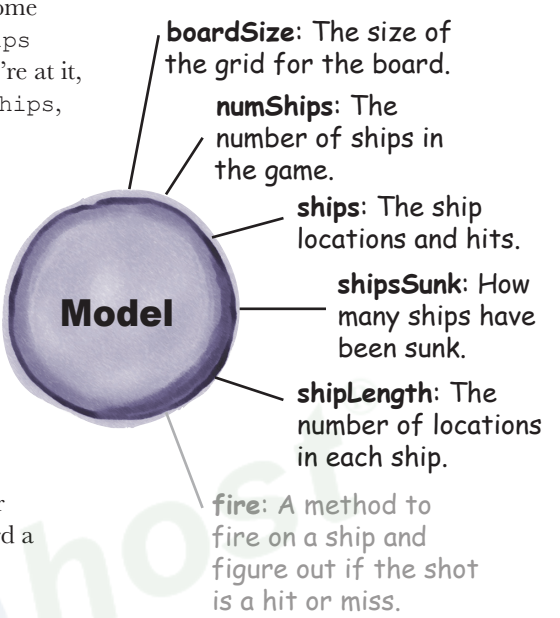
```
var ship3 = ships[____];
var hits = ship3._____;
if (_____ === "hit") {
   console.log("Ouch, hit on third ship at location one");
}
```

Finish this code to hit the first ship at the third location:

```
var ______ = ships[0];
var hits = ship1._______;
hits[____] = ________;
```

Implementing the model object

Now that you know how to represent the ships and the hits, let's get some code down. First, we'll create the model object, and then take the `ships` data structure we just created, and add it as a property. And, while we're at it, there are a few other properties we're going to need as well, like `numShips`, to hold the number of ships we have in the game. Now, if you're asking, "What do you mean, we know there are three ships, why do we need a `numShips` property?" Well, what if you wanted to create a new version of the game that was more difficult and had four or five ships? By not "hardcoding" this value, and using a property instead (and then using the property throughout the code rather than the number), we can save ourselves a future headache if we need to change the number of ships, because we'll only need to change it in one place.



Now, speaking of "hardcoding", we *are* going to hardcode the ships' initial locations, for now. By knowing where the ships are, we can test the game more easily, and focus on the core game logic for now. We'll tackle the code for placing random ships on the game board a little later.

So let's get the model object created:

The model is an object.

```
var model = {
    boardSize: 7,
    numShips: 3,
    shipLength: 3,
    shipsSunk: 0,

    ships: [{ locations: ["06", "16", "26"], hits: ["", "", ""] },
            { locations: ["24", "34", "44"], hits: ["", "", ""] },
            { locations: ["10", "11", "12"], hits: ["", "", ""] }]

};
```

These three properties keep us from hardcoding values. They are: boardSize (the size of the grid used for the board), numShips (the number of ships in the game), and shipLength (the number of locations in each ship, 3).

shipsSunk (initialized to 0 for the start of the game) keeps the current number of ships that have been sunk by the player.

We've got quite a bit of state already!

Later on, we'll generate these locations for the ships so they're random, but for now, we'll hardcode them to make it easier to test the game.

The property ships is the array of ship objects that each store the locations and hits of one of the three ships. (Notice that we've changed ships from a variable, which we used before, to a property for the model object.)

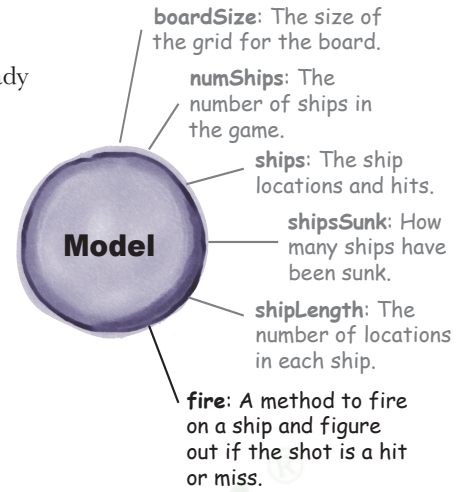
Note we're also hardcoding the sizes of the locations and hits arrays. You'll learn how to dynamically create arrays later in the book.

Thinking about the fire method

The `fire` method is what turns a player's guess into a hit or a miss. We already know the `view` object is going to take care of displaying the hits and misses, but the `fire` method has to provide the game logic for determining if a hit or a miss has occurred.

Knowing that a ship is hit is straightforward: given a player's guess, you just need to:

- Examine each ship and see if it occupies that location.
- If it does, you have a hit, and we'll mark the corresponding item in the `hits` array (and let the view know we got a hit). We'll also return `true` from the method, meaning we got a hit.
- If no ship occupies the guessed location, you've got a miss. We'll let the view know, and return `false` from the method.



Now the `fire` method should also determine if a ship isn't just hit, but if it's sunk. We'll worry about that once we have the rest of the logic worked out.

Setting up the fire method

Let's get a basic skeleton of the `fire` method set up. The method will take a guess as an argument, and then iterate over each ship to determine if that ship was hit. We won't write the hit detection code just yet, but let's get the rest set up now:

```
var model = {
    boardSize: 7,
    numShips: 3,
    shipsSunk: 0,
    shipLength: 3,
    ships: [{ locations: ["06", "16", "26"], hits: ["", "", ""] },
            { locations: ["24", "34", "44"], hits: ["", "", ""] },
            { locations: ["10", "11", "12"], hits: ["", "", ""] }],

    fire: function(guess) {

        for (var i = 0; i < this.numShips; i++) {
            var ship = this.ships[i];
        }
    }
};
```

Don't forget to add a comma here!

The method accepts a guess.

Then, we iterate through the array of ships, examining one ship at a time.

Here we have our hands on a ship. We need to see if the guess matches any of its locations.

Looking for hits

So now, each time through the loop, we need to see if the guess is one of the locations of the ship:

```
for (var i = 0; i < this.numShips; i++) {
    var ship = this.ships[i];
    locations = ship.locations;

}
```

And we're stepping through each ship.

And we've accessed the ship's set of locations. Remember this is a property of the ship that contains an array.

What we need is the code that determines if the guess is in this ship's locations.

Here's the situation: we have a string, `guess`, that we're looking for in an array, `locations`. If `guess` matches one of those locations, we know we have a hit:

```
guess = "16";
locations = ["06", "16", "26"];
```

We need to find out if the value in guess is one of the values in the ship's locations array.

We could write yet another loop to go through each item in the `locations` array, compare the item to `guess`, and if they match, we have a hit.

But rather than write another loop, we have an easier way to do this:

```
var index = locations.indexOf(guess);
```

The indexOf method searches an array for a matching value and returns its index, or –1 if it can't find it.

So, using `indexOf`, we can write the code to find a hit like this:

```
for (var i = 0; i < this.numShips; i++) {
    var ship = this.ships[i];
    locations = ship.locations;
    var index = locations.indexOf(guess);
    if (index >= 0) {
        // We have a hit!
    }
}
```

Notice that the indexOf method for an array is similar to the indexOf string method. It takes a value and returns the index of that value in the array (or –1 if it can't find the value).

So if we get an index greater than or equal to zero, the user's guess is in the location's array, and we have a hit.

Using `indexOf` isn't any more efficient than writing a loop, but it is a little clearer and it's definitely less code. We'd also argue that the intent of this code is clearer than if we wrote a loop: it's easier to see what value we're looking for in an array using `indexOf`. In any case, you now have another tool in your programming toolbelt.

Putting that all together...

To finish this up, we have one more thing to determine here: if we have a hit, what do we do? All we need to do, for now, is mark the hit in the model, which means adding a "hit" string to the `hits` array. Let's put all the pieces together:

```
var model = {
    boardSize: 7,
    numShips: 3,
    shipsSunk: 0,
    shipLength: 3,
    ships: [ { locations: ["06", "16", "26"], hits: ["", "", ""] },
             { locations: ["24", "34", "44"], hits: ["", "", ""] },
             { locations: ["10", "11", "12"], hits: ["", "", ""] } ],

    fire: function(guess) {
        for (var i = 0; i < this.numShips; i++) {
            var ship = this.ships[i];
            var locations = ship.locations;
            var index = locations.indexOf(guess);
            if (index >= 0) {
                ship.hits[index] = "hit";
                return true;
            }
        }
        return false;
    }
};
```

For each ship...

If the guess is in the locations array, we have a hit.

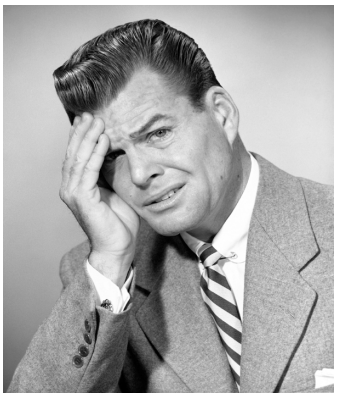
So mark the hits array at the same index.

Oh, and we need to return true because we had a hit.

Otherwise, if we make it through all the ships and don't have a hit, it's a miss, so we return false.

That's a great start on our model object. There are only a couple of other things we need to do: determine if a ship is sunk, and let the view know about the changes in the model so it can keep the player updated. Let's get started on those…

Wait, can we talk about your verbosity again?



Sorry, we have to bring this up again. You're being a bit verbose in some of your references to objects and arrays. Take another look at the code:

```
for (var i = 0; i < this.numShips; i++) {
  var ship = this.ships[i];
  var locations = ship.locations;
  var index = locations.indexOf(guess);
  ...
}
```

First we get the ship...
Then we get the locations in the ship...
Then we get the index of the guess in the locations.

Some would call this code overly verbose. Why? Because some of these references can be shortened using *chaining*. Chaining allows us to string together object references so that we don't have to create temporary variables, like the `locations` variable in the code above.

Now you might ask why `locations` is a temporary variable? That's because we're using `locations` only to temporarily store the `ship.locations` array so we can then turn around and call the `indexOf` method on it to get the `index` of the `guess`. We don't need `locations` for anything else in this method. With chaining, we can get rid of that temporary `locations` variable, like this:

```
var index = ship.locations.indexOf(guess);
```

We've combined the two lines highlighted above into a single line.

How chaining works...

Chaining is really just a shorthand for a longer series of steps to access properties and methods of objects (and arrays). Let's take a closer look at what we just did to combine two statements with chaining.

```
var ship = { locations: ["06", "16", "26"], hits: ["", "", ""] };
var locations = ship.locations;
var index = locations.indexOf(guess);
```

Here's a ship object.
We were grabbing the locations array from the ship
And then using it to access the indexOf method.

We can combine the bottom two statements by chaining together the expressions (and getting rid of the variable `locations`):

```
ship.locations.indexOf(guess)
```

1. Evaluates to the ship object.
2. Which has a locations property, which is an array.
3. Which has a method named indexOf.

Meanwhile back at the battleship...

Now we need to write the code to determine if a ship is sunk. You know the rules: a battleship is sunk when all of its locations are hit. We can add a little helper method to check to see if a ship is sunk:

We'll call the method isSunk. It's going to take a ship and return true if it's sunk and false if it is still floating.

This method takes a ship, and then checks every possible location for a hit.

```
isSunk: function(ship) {
    for (var i = 0; i < this.shipLength; i++)  {
        if (ship.hits[i] !== "hit") {
            return false;
        }
    }
    return true;
}
```

If there's a location that doesn't have a hit, then the ship is still floating, so return false.

Otherwise this ship is sunk! Return true.

Go ahead and add this method to your model object, just below fire.

Now, we can use that method in the `fire` method to find out if a ship is sunk:

```
fire: function(guess) {
    for (var i = 0; i < this.numShips; i++) {
        var ship = this.ships[i];
        var index = ship.locations.indexOf(guess);
        if (index >= 0) {
            ship.hits[index] = "hit";
            if (this.isSunk(ship)) {
                this.shipsSunk++;
            }
            return true;
        }
    }
    return false;
},
isSunk: function(ship) { ... }
```

We'll add the check here, after we know for sure we have a hit. If the ship is sunk, then we increase the number of ships that are sunk in model's shipsSunk property.

Here's where we added the new isSunk method, just below fire. Don't forget to make sure you've got a comma between each of the model's properties and methods!

A view to a kill...

That's about it for the model object. The model maintains the state of the game, and has the logic to test guesses for hits and misses. The only thing we're missing is the code to notify the view when we get a hit or a miss in the model. Let's do that now:

This is the whole model object so you can see the entire thing in one piece.

```
var model = {
    boardSize: 7,
    numShips: 3,
    shipsSunk: 0,
    shipLength: 3,
    ships: [ { locations: ["06", "16", "26"], hits: ["", "", ""] },
             { locations: ["24", "34", "44"], hits: ["", "", ""] },
             { locations: ["10", "11", "12"], hits: ["", "", ""] } ],
    fire: function(guess) {
        for (var i = 0; i < this.numShips; i++) {
            var ship = this.ships[i];
            var index = ship.locations.indexOf(guess);
            if (index >= 0) {
                ship.hits[index] = "hit";
                view.displayHit(guess);
                view.displayMessage("HIT!");
                if (this.isSunk(ship)) {
                    view.displayMessage("You sank my battleship!");
                    this.shipsSunk++;
                }
                return true;
            }
        }
        view.displayMiss(guess);
        view.displayMessage("You missed.");
        return false;
    },
    isSunk: function(ship) {
        for (var i = 0; i < this.shipLength; i++)  {
            if (ship.hits[i] !== "hit") {
                return false;
            }
        }
        return true;
    }
};
```

Notify the view that we got a hit at the location in guess.

And ask the view to display the message "HIT!".

Let the player know that this hit sank the battleship!

Notify the view that we got a miss at the location in guess.

And ask the view to display the message "You missed.".

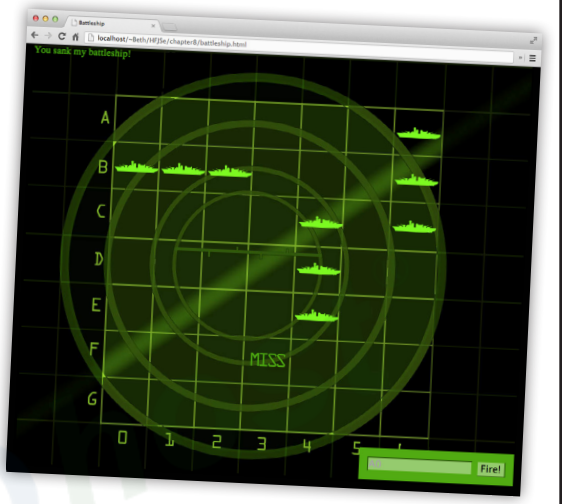
Remember that the methods in the view object add the "hit" or "miss" class to the element with the id at row and column in the guess string. So the view translates the "hit" in the hits array into a "hit" in the HTML. But keep in mind, the "hit" in the HTML is just for display; the "hit" in the model represents the actual state.

A Test Drive

Add all the model code to "battleship.js". Test it by calling the model's fire method, passing in a row and column of a guess each time. Our ships are hardcoded still, so it'll be easy for you to hit them all. Try adding some of your own as well (a few more misses). (Download "battleship_tester.js" to see our version of the test code.)

You'll need to remove or comment out the previous view testing code to get the same results as we show here. You can see how to do that in battleship_tester.js.

```
model.fire("53");

model.fire("06");
model.fire("16");
model.fire("26");

model.fire("34");
model.fire("24");
model.fire("44");

model.fire("12");
model.fire("11");
model.fire("10");
```



Reload "battleship.html". You should see your hits and misses appear on the game board.

there are no Dumb Questions

Q: Is using chaining to combine statements better than keeping statements separate?

A: Not necessarily better, no. Chaining isn't much more efficient (you save one variable), but it does make your code shorter. We'd argue that short chains (2 or 3 levels at most) are easier to read than multiple lines of code, but that's our preference. If you want to keep your statements separate, that's fine. And if you do use chaining, make sure you don't create really long chains; they will be harder to read and understand if they're too long.

Q: We have arrays (locations) inside an object (ship) inside an array (ships). How many levels deep can you nest objects and arrays like this?

A: Pretty much as deep as you want. Practically, of course, it's unlikely you'll ever go too deep (and if you find yourself with more than three or four levels of nesting, it's likely your data structure is getting too complex and you should rethink things a bit).

Q: I noticed we added a property named boardSize to the model, but we haven't used it in the model code. What is that for?

A: We're going to be using model.boardSize, and the other properties in model, in the code coming up. The model's responsibility is to manage the state of the game, and boardSize is definitely part of the state. The controller will access the state it needs by accessing the model's properties, and we'll be adding more model methods later that will use these properties too.

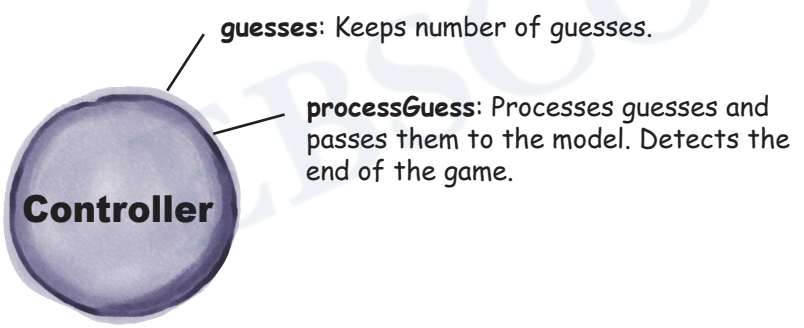
Implementing the Controller

Now that you have the view and the model complete, we're going to start to bring this app together by implementing the controller. At a high level, the controller glues everything together by getting a guess, processing the guess and getting it to the model. It also keeps track of some administrative details, like the current number of guesses and the player's progress in the game. To do all this the controller relies on the model to keep the state of the game and on the view to display the game.

More specifically, here's the set of responsibilities we're giving the controller:

- Get and process the player's guess (like "A0" or "B1").
- Keep track of the number of guesses.
- Ask the model to update itself based on the latest guess.
- Determine when the game is over (that is, when all ships have been sunk).

Let's get started on the controller by first defining a property, `guesses`, in the controller object. Then we'll implement a single method, `processGuess`, that takes an alpha-numeric guess, processes it and passes it to the model.



Here's the skeleton of the controller code; we'll fill this in over the next few pages:

```
var controller = {
   guesses: 0,

   processGuess: function(guess) {
     // more code will go here
   }
};
```

Here we're defining our controller object, with a property, guesses, initialized to zero.

And here's the beginning of the processGuess method, which takes a guess in the form "A0".

Processing the player's guess

The controller's responsibility is to get the player's guess, make sure it's valid, and then get it to the model object. But, where does it get the player's guess? Don't worry, we'll get to that in a bit. For now we're just going to assume, at some point, some code is going to call the controller's `processGuess` method and give it a string in the form:

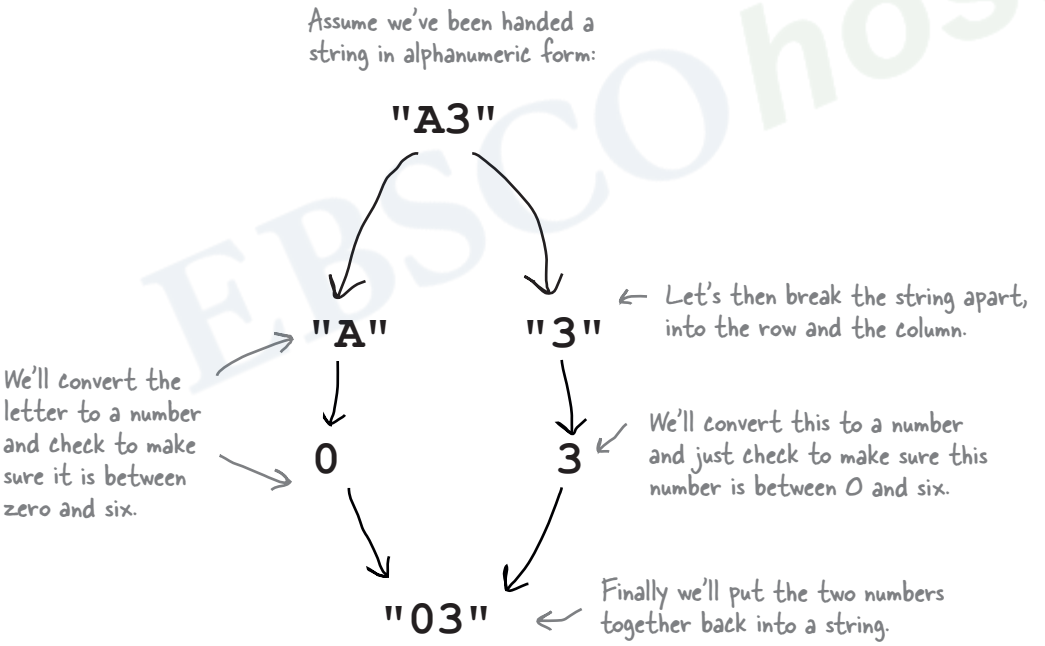
This is a great technique when you are coding. Focus on the requirements for the specific code you're working on. Thinking about the whole problem at once is often a less successful technique.

```
"A3"
```

You know the Battleship–style guess format at this point: it's a letter followed by a number.

Now after you receive a guess in this form (an alpha-numeric set of characters, like "A3"), you'll need to transform the guess into a form the model understands (a string of two numeric characters, like "03"). Here's a high level view of how we're going to convert a valid input into the number-only form:

Surely a player would never enter in an invalid guess, right? Ha! We'd better make sure we've got valid input.



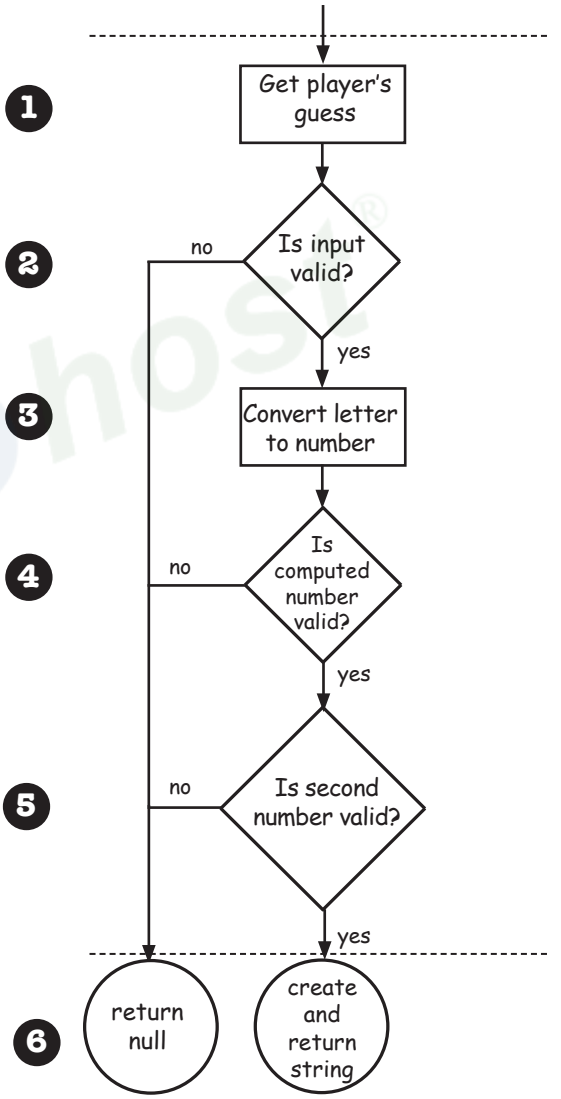
But first things first. We also need to check that the input is valid. Let's plan this all out before we write the code.

Planning the code...

Rather than putting all this guess-processing code into the `processGuess` method, we're going to write a little helper function (after all we might be able to use this again). We'll name the function `parseGuess`.

Let's step through how it is going to work before we start writing code:

1. We get a player's guess in classic Battleship-style as a single letter followed by a number.
2. Check the input to make sure it is valid (not null or too long or too short).
3. Take the letter and convert it to a number: A to 0, B to 1, and so on.
4. See if the number from step 3 is valid (between 0 and 6).
5. Check the second number for validity (also between 0 and 6).
6. If any check failed, return null. Otherwise concatenate the two numbers into a string and return the string.



Implementing parseGuess

We have a solid plan for coding this, so let's get started:

1—2 Let's tackle steps one and two. All we need to do is accept the player's guess and check to make sure it is valid. At this point we're just going to define validity as accepting a non-null string and a string that has exactly two characters in it.

The guess is passed into the guess parameter.

And then we check for null and to make sure the length is 2 characters.

```
function parseGuess(guess) {
   if (guess === null || guess.length !== 2) {
      alert("Oops, please enter a letter and a number on the board.");
   }
}
```

If not, we alert the player.

3 Next, we take the letter and convert it to a number by using a helper array that contains the letters A-F. To get the number, we can use the indexOf method to get the index of the letter in the array, like this:

An array loaded with each letter that could be part of a valid guess.

```
function parseGuess(guess) {
   var alphabet = ["A", "B", "C", "D", "E", "F", "G"];

   if (guess === null || guess.length !== 2) {
      alert("Oops, please enter a letter and a number on the board.");
   } else {
      firstChar = guess.charAt(0);
      var row = alphabet.indexOf(firstChar);
   }
}
```

Grab the first character of the guess.

Then, using indexOf, we get back a number between zero and six that corresponds to the letter. Try a couple of examples to see how this works.

4—5 Now we'll handle checking both characters of the guess to see if they are numbers between zero and six (in other words, to make sure they are both valid positions on the board).

```
function parseGuess(guess) {
   var alphabet = ["A", "B", "C", "D", "E", "F", "G"];

   if (guess === null || guess.length !== 2) {
      alert("Oops, please enter a letter and a number on the board.");
   } else {
      firstChar = guess.charAt(0);
      var row = alphabet.indexOf(firstChar);
      var column = guess.charAt(1);

      if (isNaN(row) || isNaN(column)) {
         alert("Oops, that isn't on the board.");
      } else if (row < 0 || row >= model.boardSize ||
                 column < 0 || column >= model.boardSize) {
         alert("Oops, that's off the board!");
      }
   }
}
```

Here we've added code to grab the second character in the string, which represents the column.

And we're checking to see if either of the row or column is not a number using the isNAN function.

We're also making sure that the numbers are between zero and six.

Actually we're being even more general here. Instead of hardcoding the number six, we're asking the model to tell us how big the board is and using that number for comparison.

Notice we're using type conversion like crazy here! column is a string, so when we check to make sure its value is 0–6, we rely on type conversion to convert it to a number for comparison.

Rather than hard-coding the value six as the biggest value a row or column can hold, we used the model's boardSize property. What advantage do you think that has in the long run?

6 Now for our final bit of code for the parseGuess function... If any check for valid input fails, we'll return null. Otherwise we'll return the row and column of the guess, combined into a string.

```
function parseGuess(guess) {
   var alphabet = ["A", "B", "C", "D", "E", "F", "G"];

   if (guess === null || guess.length !== 2) {
      alert("Oops, please enter a letter and a number on the board.");
   } else {
      firstChar = guess.charAt(0);
      var row = alphabet.indexOf(firstChar);
      var column = guess.charAt(1);

      if (isNaN(row) || isNaN(column)) {
         alert("Oops, that isn't on the board.");
      } else if (row < 0 || row >= model.boardSize ||
                 column < 0 || column >= model.boardSize) {
         alert("Oops, that's off the board!");
      } else {
         return row + column;
      }
   }
   return null;
}
```

At this point, everything looks good, so we can return a row and column.

Notice we're concatenating the row and column together to make a string, and returning that string. We're using type conversion again here: row is a number and column is a string, so we'll end up with a string.

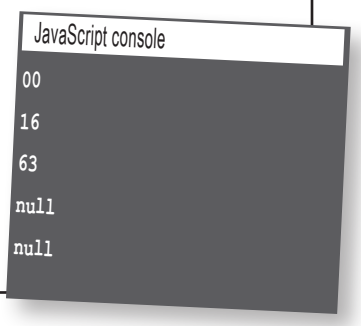
If we get here, there was a failed check along the way, so return null.

A Test Drive

Okay, make sure all this code is entered into "battleship.js" and then add some function calls below it all that look like this:

```
console.log(parseGuess("A0"));
console.log(parseGuess("B6"));
console.log(parseGuess("G3"));
console.log(parseGuess("H0"));
console.log(parseGuess("A7"));
```

Reload "battleship.html", and make sure your console window is open. You should see the results of parseGuess displayed in the console and possibly an alert or two.



Meanwhile back at the controller...

Now that we have the `parseGuess` helper function written we move on to implementing the controller. Let's first integrate the `parseGuess` function with the existing controller code:

```
var controller = {
   guesses: 0,

   processGuess: function(guess) {
      var location = parseGuess(guess);
      if (location) {

      }
   }
};
```

We'll use parseGuess to validate the player's guess.

And as long as we don't get null back, we know we've got a valid location object.

Remember null is a falsey value.

And the rest of the code for the controller will go here.

That completes the first responsibility of the controller. Let's see what's left:

- ~~Get and process the player's guess (like "A0" or "B1").~~
- Keep track of the number of guesses.
- Ask the model to update itself based on the latest guess.
- Determine when the game is over (that is, when all ships have been sunk).

We'll tackle these next.

Counting guesses and firing the shot

The next item on our list is straightforward: to keep track of the number of guesses we just need to increment the `guesses` property each time the player makes a guess. As you'll see in the code, we've chosen not to penalize players if they enter an invalid guess.

Next, we'll ask the model to update itself based on the guess by calling the model's `fire` method. After all, the point of a player's guess is to fire hoping to hit a battleship. Now remember, the `fire` method takes a string, which contains the row and column, and by some luck we get that string by calling `parseGuess`. How convenient.

Let's put all this together and implement the next step…

```
var controller = {
   guesses: 0,

   processGuess: function(guess) {
      var location = parseGuess(guess);
      if (location) {
         this.guesses++;
         var hit = model.fire(location);
      }
   }
};
```

If the player entered a valid guess we increase the number of guesses by one.

Remember, this.guesses++ just adds one to the value of the guesses property. It works just like i++ in for loops.

Also notice if the player enters an invalid board location, we don't penalize them by counting the guess.

And then we pass the row and column in the form of a string to the model's fire method. Remember, the fire method returns true if a ship is hit.

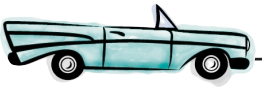
Game over?

All we have left is to determine when the game is complete. How do we do that? Well, we know that when three ships are sunk the game is over. So, each time the guess is a hit, we'll check to see if there are three sunken ships, using the `model.shipsSunk` property. Let's generalize this a bit, and instead of just comparing it to the number 3, we'll use the model's `numShips` property for the comparison. You might decide later to set the number of ships to, say, 2 or 4, and this way, you won't need to revisit this code to make it work correctly.

```
var controller = {
   guesses: 0,

   processGuess: function(guess) {
      var location = parseGuess(guess);
      if (location) {
         this.guesses++;
         var hit = model.fire(location);
         if (hit && model.shipsSunk === model.numShips) {
               view.displayMessage("You sank all my battleships, in " +
                                   this.guesses + " guesses");
         }
      }
   }
};
```

If the guess was a hit, and the number of ships that are sunk is equal to the number of ships in the game, then show the player a message that they've sunk all the ships.

We'll show the player the total number of guesses they took to sink the ship. The guesses property is a property of "this" object, the controller.

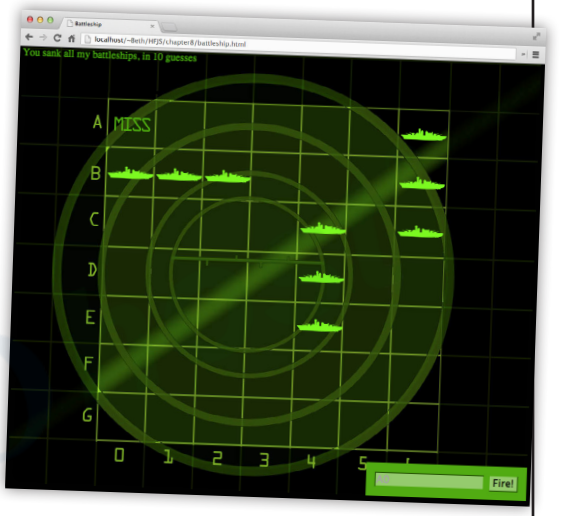


A Test Drive

Okay, make sure all the controller code is entered into your "battleship.js" file and then add some function calls below it all to test your controller. Reload your "battleship.html" page and note the hits and misses on the board. Are they in the right places? (Download "battleship_tester.js" to see our version.)

Again, you'll need to remove or comment out the previous testing code to get the same results as we show here. You can see how to do that in battleship_tester.js.

```
controller.processGuess("A0");

controller.processGuess("A6");
controller.processGuess("B6");
controller.processGuess("C6");

controller.processGuess("C4");
controller.processGuess("D4");
controller.processGuess("E4");

controller.processGuess("B0");
controller.processGuess("B1");
controller.processGuess("B2");
```

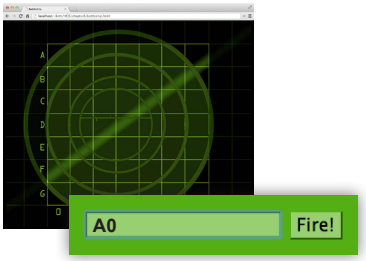


We're calling the controller's processGuess method and passing in guesses in Battleship format.

We let the player know the game ended in the message area, after they sink all three ships. But the player can still enter guesses. If you wanted to fix this so a player isn't allowed to enter guesses after they've sunk all the ships, how would you handle that?

Getting a player's guess

Now that you've implemented the core game logic and display, you need a way to enter and retrieve a player's guesses so the game can actually be played. You might remember that in the HTML we've already got a `<form>` element ready for entering guesses, but how do we hook that into the game?

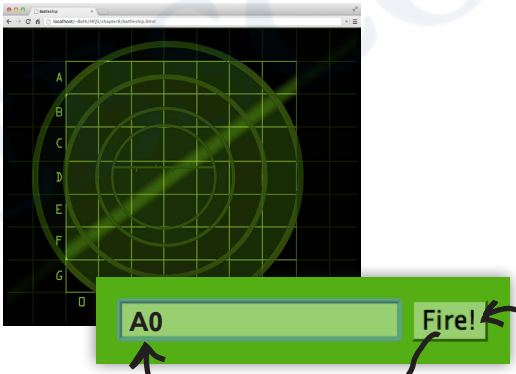


Here's our HTML form element, ready to take user input.

To do that we need an *event handler*. We've talked a little about event handlers already. For now, we're going to spend just enough time with event handlers again to get the game working, and we'll undertake learning the nitty-gritty details of event handlers in the next chapter. Our goal is for you to get a high-level understanding of how event handlers work with form elements, but not necessarily understand everything about how it works at the detailed level, right now.

Here's the big picture:

1. The player enters a guess and clicks on the Fire! button.
2. When Fire! is clicked, a pre-assigned event handler is called.
3. The handler for the Fire! button grabs the player's input from the form and hands it to the controller.



3

```
function handleFireButton() {
    // get the player's guess from the form
    // and get it to the controller.
}
```

How to add an event handler to the Fire! button

To get this all rolling the first thing we need to do is add an event handler to the Fire! button. To do that, we first need to get a reference to the button using the button's id. Review your HTML again, and you'll find the Fire! button has the id "fireButton". With that, all you need to do is call `document.getElementById` to get a reference to the button. Once we have the button reference, we can assign a handler function to the `onclick` property of the button, like this:

We need somewhere for this code to go, so let's create an init function.

First, we get a reference to the Fire! button using the button's id:

```
function init() {
   var fireButton = document.getElementById("fireButton");
   fireButton.onclick = handleFireButton;
}
```

Then we can add a click handler function named handleFireButton to the button.

And let's not forget to get a handleFireButton function started:

Here's the handleFireButton function. This function will be called whenever you click the Fire! button.

```
function handleFireButton() {
   // code to get the value from the form
}

window.onload = init;
```

We'll write this code in just a sec.

Just like we learned in Chapter 6, we want the browser to run init when the page is fully loaded.

Getting the player's guess from the form

The Fire! button is what initiates the guess, but the player's guess is actually contained in the "guessInput" form element. We can get the value from the form input by accessing the input element's `value` property. Here's how you do it:

First, we get a reference to the input form element using the input element's id, "guessInput".

```
function handleFireButton() {
    var guessInput = document.getElementById("guessInput");
    var guess = guessInput.value;
}
```

Then we get the guess from the input element. The guess is stored in the value property of the input element.

We have the value, now all we need is to do something with it. Luckily we have lots of code already that's ready to do something with it. Let's add that next.

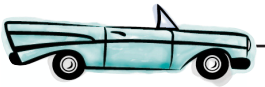
Passing the input to the controller

Here's where it all comes together. We have a controller waiting—just dying—to get a guess from the player. All we need to do is pass the player's guess to the controller. Let's do that:

```
function handleFireButton() {
    var guessInput = document.getElementById("guessInput");
    var guess = guessInput.value;
    controller.processGuess(guess);

    guessInput.value = "";
}
```

We're passing the player's guess to the controller, and then everything should work like magic!

This little line just resets the form input element to be the empty string. That way you don't have to explicitly select the text and delete it before entering the next guess, which would be annoying.

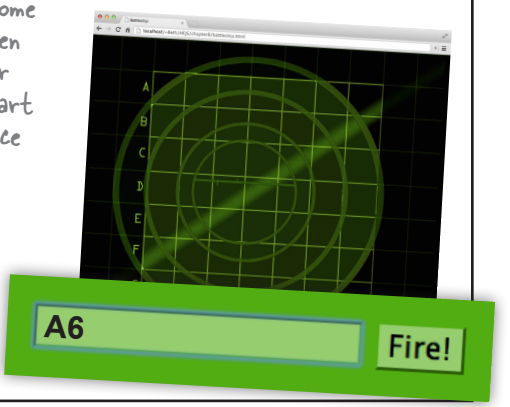


A Test Drive

This is no mere test drive. You're finally ready to play the real game! Make sure you've added all the code to "battleship.js", and reload "battleship.html" in your browser. Now, remember the ship locations are hardcoded, so you'll have a good idea of how to win this game. Below you'll find the winning moves, but be sure to fully test this code. Enter misses, invalid guesses and downright incorrect guesses.

```
A6
B6
C6

C4
D4
E4

B0
B1
B2
```

These are the winning guesses, in order by ship. But you don't have to enter them all in order. Try mixing them up a bit. Enter some invalid guesses in between the correct ones. Enter misses too. That's all part of the Quality Assurance testing for the game.



Serious Coding

Finding it clumsy to have to click the Fire! button with every guess? Sure, clicking works, but it's slow and inconvenient. It would be so much easier if you could just press RETURN, right? Here's a quick bit of code to handle a RETURN key press:

```
function init() {
    var fireButton = document.getElementById("fireButton");
    fireButton.onclick = handleFireButton;
    var guessInput = document.getElementById("guessInput");
    guessInput.onkeypress = handleKeyPress;
}
```

Add a new handler. This one handles key press events from the HTML input field.

Here's the key press handler. It's called whenever you press a key in the form input in the page.

The browser passes an event object to the handler. This object has info about which key was pressed.

```
function handleKeyPress(e) {
    var fireButton = document.getElementById("fireButton");
    if (e.keyCode === 13) {
        fireButton.click();
        return false;
    }
}
```

If you press the RETURN key, the event's keyCode property will be set to 13. If that's the case, then we want to cause the Fire! button to act like it was clicked. We can do that by calling the fireButton's click method (basically tricking it into thinking it was clicked).

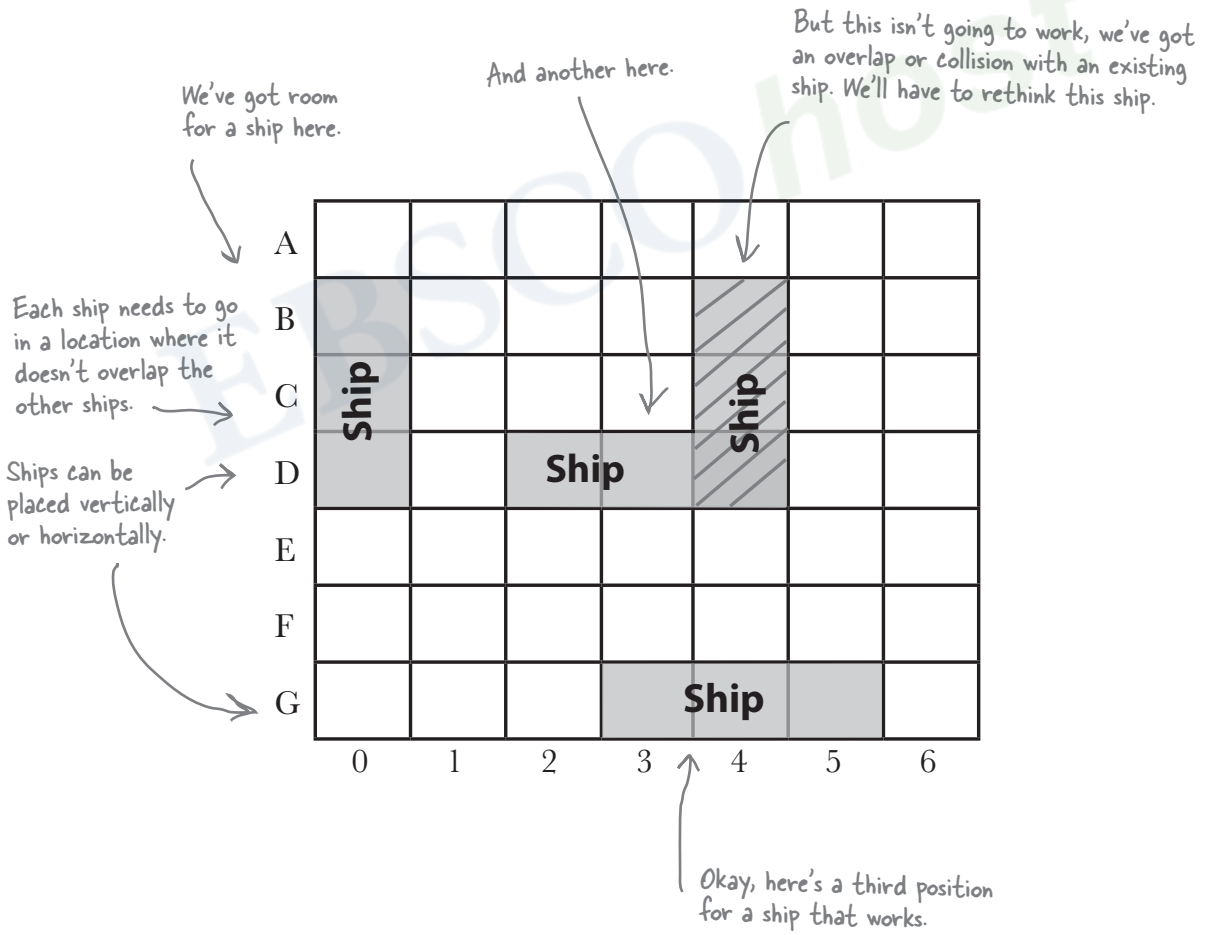
And we return false so the form doesn't do anything else (like try to submit itself).

Update your init function and add the handleKeyPress function anywhere in your code. Reload and let the game play begin!

What's left? Oh yeah, darn it, those hardcoded ships!

At this point you've got a pretty amazing browser-based game created from a little HTML, some images, and roughly 100 lines of code. But, the one aspect of this game that is a little unsatisfying is that the ships are always in the same location. You still need to write the code to generate random locations for the ships every time we start a new game (otherwise, it'll be a pretty boring game).

Now, before we start, we want to let you know that we're going to cover this code at a slightly faster clip—you're getting to the point where you can read and understand code better, and there aren't a lot of new things in this code. So, let's get started. Here's what we need to consider:



Code Magnets

An algorithm to generate ships is all scrambled up on the fridge. Can you put the magnets back in the right places to produce a working algorithm? Check your answer at the end of the chapter before you go on.

An algorithm is just a fancy word for a sequence of steps that solve a problem.

```
Generate a random
location for the new ship.
```

```
Loop for the number of
ships we want to create.
```

```
Generate a random direction
(vertical or horizontal)
for the new ship.
```

```
Add the new ship's locations
to the ships array.
```

```
Test to see if the new ship's
locations collide with any
existing ship's locations.
```

How to place ships

There are two things you need to consider when placing ships on the game board. The first is that ships can be oriented either vertically or horizontally. The second is that ships don't overlap on the board. The bulk of the code we're about to write handles these two constraints. Now, as we said, we're not going to go through the code in gory detail, but you have everything you need to work through it, and if you spend enough time with the code you'll understand each part in detail. There's nothing in it that you haven't already encountered so far in the book (with one exception that we'll talk about). So let's dive in…

We're going to organize the code into three methods that are part of the model object:

- **generateShipLocations**: This is the master method. It creates a `ships` array in the model for you, with the number of ships in the model's `numShips` property.
- **generateShip**: This method creates a single ship, located somewhere on the board. The locations may or may not overlap other ships.
- **collision**: This method takes a single ship and makes sure it doesn't overlap with a ship already on the board.

The generateShipLocations function

Let's get started with the `generateShipLocations` method. This method iterates, creating ships, until it has filled the model's `ships` array with enough ships. Each time it generates a new ship (which it does using the `generateShip` method), it uses the `collision` method to make sure there are no overlaps. If there is an overlap, it throws that ship away and keeps trying.

One thing to note in this code is that we're using a new iterator, the **do while** loop. The do while loop works almost exactly like **while**, except that you *first* execute the statements in the body, and *then* check the condition. You'll find certain logic conditions, while rare, work better with do while than with the while statement.

We're adding this method to the model object.

```
generateShipLocations: function() {
    var locations;
    for (var i = 0; i < this.numShips; i++) {
        do {
            locations = this.generateShip();
        } while (this.collision(locations));
        this.ships[i].locations = locations;
    }
},
```

For each ship we want to generate locations for.

We generate a new set of locations...

... and check to see if those locations overlap with any existing ships on the board. If they do, then we need to try again. So keep generating new locations until there's no collision.

We're using a do while loop here!

Once we have locations that work, we assign the locations to the ship's locations property in the model.ships array.

Writing the generateShip method

The `generateShip` method creates an array with random locations for one ship without worrying about overlap with other ships on the board. We'll go through this method in a couple of steps. The first step is to randomly pick a direction for the ship: will it be horizontal or vertical? We're going to determine this with a random number. If the number is 1, then the ship is horizontal; if it's 0, then the ship is vertical. We'll use our friends the `Math.random` and `Math.floor` methods to do this as we've done before:

Generating a random 0 or 1 is kind of like tossing a coin.

This method also is added to the model object.

We use Math.random to generate a number between 0 and 1, and multiply the result by 2, to get a number between 0 and 2 (not including 2). We then turn that into a 0 or a 1 using Math.floor.

```
generateShip: function() {
    var direction = Math.floor(Math.random() * 2);
    var row, col;

    if (direction === 1) {
        // Generate a starting location for a horizontal ship
    } else {
        // Generate a starting location for a vertical ship
    }

    var newShipLocations = [];
    for (var i = 0; i < this.shipLength; i++) {
        if (direction === 1) {
            // add location to array for new horizontal ship
        } else {
            // add location to array for new vertical ship
        }
    }
    return newShipLocations;
},
```

We're saying that if the direction is a 1, that means we'll create a horizontal ship...

... and if direction is 0, that means we'll create a vertical ship.

First, we'll create a starting location, like row = 0 and column = 3, for the new ship. Depending on the direction, we need different rules to create the starting location (you'll see why in just a sec).

For the new ship locations, we'll start with an empty array, and add the locations one by one.

We'll loop for the number of locations in a ship...

... and add a new location to the newShipLocations array each time through the loop. Again we need slightly different code to generate a location depending on the direction of the ship.

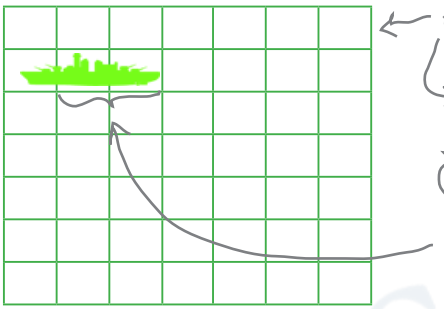
Once we've generated all the locations, we return the array.

We'll be filling in the rest of this code starting on the next page...

Generate the starting location for the new ship

Now that you know how the ship is oriented, you can generate the locations for the ship. First, we'll generate the starting location (the first position for the ship) and then the rest of the locations will just be the next two columns (if the ship is horizontal) or the next two rows (if it's vertical).

To do this we need to generate two random numbers—a row and a column—for the starting location of the ship. The numbers both have to be between 0 and 6, so the ship will fit on the game board. But remember, if the ship is going to be placed *horizontally*, then the starting *column* must be between 0 and 4, so that we have room for the rest of the ship:



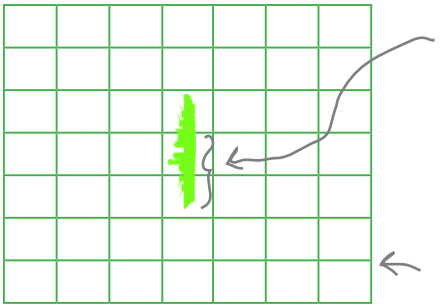
A horizontal ship can be located in any row...

```
row = Math.floor(Math.random() * this.boardSize);
col = Math.floor(Math.random() * (this.boardSize - 3));
```

... but the first column must leave room for the other two locations of the ship.

So we subtract 3 from the boardSize (7), so the starting column is always between 0 and 4. (Remember, boardSize is a property of the model.)

And, likewise, if the ship is going to be placed *vertically*, then the starting *row* must be between 0 and 4, so that we have room for the rest of the ship:



A vertical ship must start at row 0–4 to leave room for the next two locations...

```
row = Math.floor(Math.random() * (this.boardSize - 3));
col = Math.floor(Math.random() * this.boardSize);
```

... but can be located in any column.

Completing the generateShip method

Plugging that code in, now all we have to do is make sure we add the starting location along with the next two locations to the `newShipLocations` array.

```
generateShip: function() {
    var direction = Math.floor(Math.random() * 2);
    var row, col;

    if (direction === 1) {
        row = Math.floor(Math.random() * this.boardSize);
        col = Math.floor(Math.random() * (this.boardSize - this.shipLength));
    } else {
        row = Math.floor(Math.random() * (this.boardSize - this.shipLength));
        col = Math.floor(Math.random() * this.boardSize);
    }

    var newShipLocations = [];
    for (var i = 0; i < this.shipLength; i++) {
        if (direction === 1) {
            newShipLocations.push(row + "" + (col + i));
        } else {
            newShipLocations.push((row + i) + "" + col);
        }
    }
    return newShipLocations;
},
```

Here's the code to generate a starting location for the ship on the board.

We replaced 3 (from the previous page) with this.shipLength to generalize the code, so we can use it for any ship length.

This is the code for a horizontal ship. Let's break it down...

Here, we use parentheses to make sure i is added to col before it's converted to a string.

We're pushing a new location onto the newShipLocations array.

That location is a string made up of the row (the starting row we just computed above)...

... and the column + i. The first time through the loop, i is 0, so it's just the starting column. The second time, it's the next column over, and the third, the next column over again. So we'll get something like "01", "02", "03" in the array.

Same thing here only for a vertical ship.

So now, we're increasing the row instead of the column, adding i to the row each time through the loop.

For a vertical ship, we'll get something like "31", "41", "51" in the array.

Remember, when we add a string and a number, + is concatenation not addition, so we get a string.

Once we've filled the array with the ship's locations, we return it to the calling method, generateShipLocations.

Avoiding a collision!

The `collision` method takes a ship and checks to see if any of the locations overlap—or collide—with any of the existing ships already on the board.

Look back at page 364 to see where we call the collision method.

We've implemented this using two nested for loops. The outer loop iterates over all the ships in the model (in the `model.ships` property). The inner loop iterates over all the new ship's locations in the `locations` array, and checks to see if any of those locations is already taken by an existing ship on the board.

locations is an array of locations for a new ship we'd like to place on the board.

```
collision: function(locations) {
    for (var i = 0; i < this.numShips; i++) {
        var ship = model.ships[i];
        for (var j = 0; j < locations.length; j++) {
            if (ship.locations.indexOf(locations[j]) >= 0) {
                return true;
            }
        }
    }
    return false;
}
```

For each ship already on the board...

...check to see if any of the locations in the new ship's locations array are in an existing ship's locations array.

We're using indexOf to check if the location already exists in a ship, so if the index is greater than or equal to 0, we know it matched an existing location, so we return true (meaning, we found a collision).

Returning from inside a loop that's inside another loop stops the iteration of both loops immediately, exiting the function and returning true.

If we get here and haven't returned, then we never found a match for any of the locations we were checking, so we return false (there was no collision).

In this code, we have two loops: an outer loop to iterate over all the ships in the model, and an inner loop to iterate over each of the locations we're checking for a collision. For the outer loop, we used the loop variable i, and for the inner loop, we used the loop variable j. Why did we use two different loop variable names?

Two final changes

We've written all the code we need to generate random locations for the ships; now all we have to do is integrate it. Make these two final changes to your code, and then take your new Battleship game for a test drive!

```
var model = {
    boardSize: 7,
    numShips: 3,
    shipLength: 3,
    shipsSunk: 0,
    ships: [ { locations: ["06", "16", "26"], hits: ["", "", ""] },
             { locations: ["24", "34", "44"], hits: ["", "", ""] },
             { locations: ["10", "11", "12"], hits: ["", "", ""] } ],
    ships: [ { locations: [0, 0, 0], hits: ["", "", ""] },
             { locations: [0, 0, 0], hits: ["", "", ""] },
             { locations: [0, 0, 0], hits: ["", "", ""] } ],
    fire: function(guess) { ... },
    isSunk: function(ship) { ... },
    generateShipLocations: function() { ... },
    generateShip: function() { ... },
    collision: function(locations) { ... }
};

function init() {
    var fireButton = document.getElementById("fireButton");
    fireButton.onclick = handleFireButton;
    var guessInput = document.getElementById("guessInput");
    guessInput.onkeypress = handleKeyPress;

    model.generateShipLocations();
}
```

Remove the hardcoded ship locations...

... and replace them with arrays initialized with 0's instead.

And of course, add the call to generate the ship locations, which will fill in those empty arrays in the model.

We're calling model.generateShipLocations from the init function so it happens right when you load the game, before you start playing. That way all the ships will have locations ready to go when you start playing.

Don't forget you can download the complete code for the Battleship game at http://wickedlysmart.com/hfjs.

A Final Test Drive

This is the FINAL test drive of the real game, with random ship locations. Make sure you've got all the code added to "battleship.js", reload "battleship.html" in your browser, and play the game! Give it a good run through. Play it a few times, reloading the page each time to generate new ship locations for each new game.

Oh, and how to cheat!

To cheat, open up the developer console, and type `model.ships`. Press return and you should see the three ship objects containing the locations and hits arrays. Now you have the inside scoop on where the ships are sitting in the game board. But, you didn't hear this from us!

JavaScript console

```
> model.ships
[ Object,                Object,                Object ]
  hits: Array[3],          hits: Array[3],        hits: Array[3]
  locations: Array[3],     locations: Array[3],   locations: Array[3]
     0: "63"                  0: "20"                0: "60"
     1: "64"                  1: "21"                1: "61"
     2: "65"                  2: "22"                2: "62"
```

Beat the computer every time.

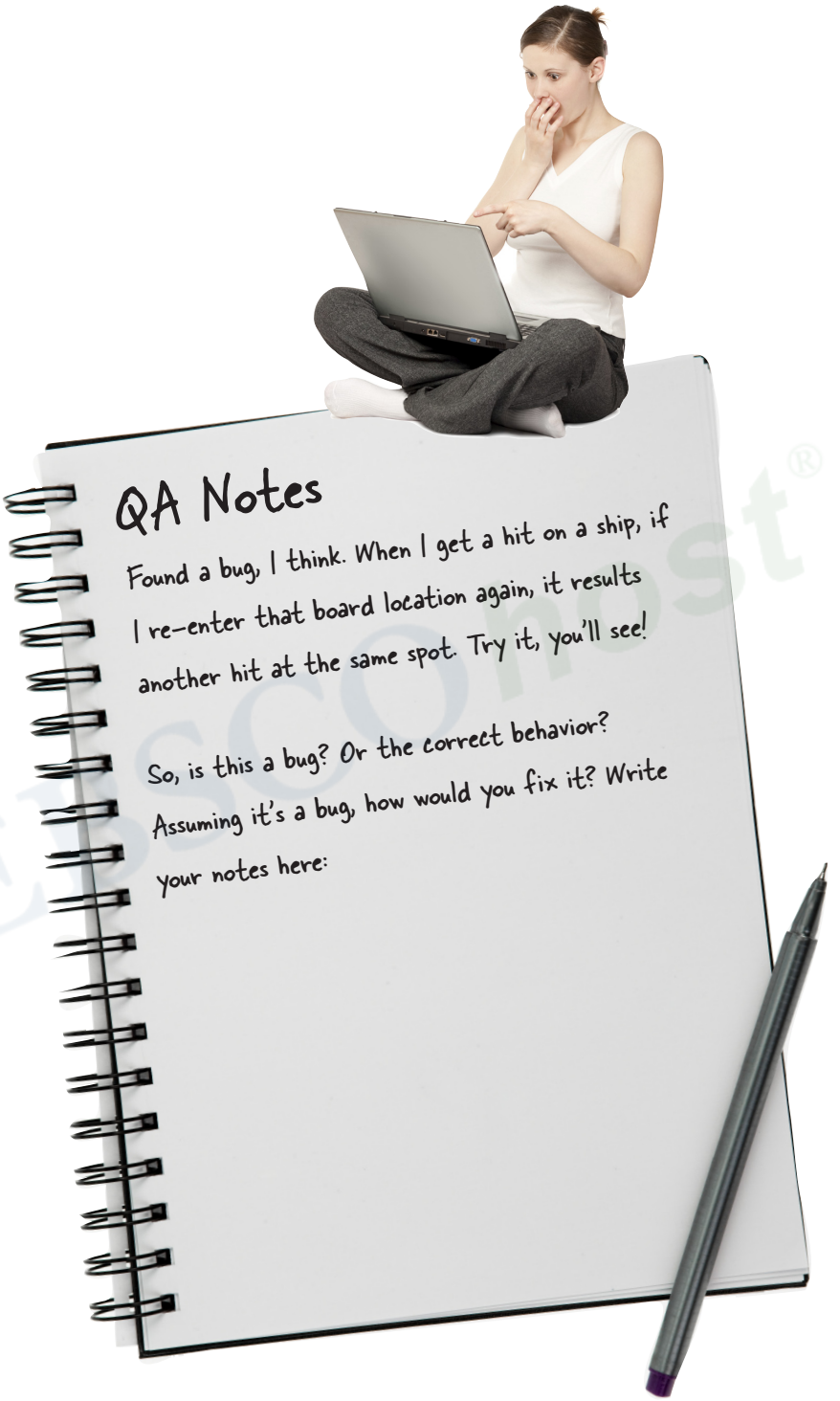
Congrats, It's Startup Time!

You've just built a great web application, all in 150 (or so) lines of code and some HTML & CSS. Like we said, the code is yours. Now all that's standing between you and your venture capital is a real business plan. But then again, who ever let that stand in their way!?

So now, after all the hard work, you can relax and play a few rounds of Battleship. Pretty darn engaging, right?

Oh, but we're just getting started. With a little more JavaScript horse power we're going to be able to take on apps that rival those written in native code.

For now, we've been through a lot of code in this chapter. Get some good food and plenty of rest to let it all sink in. But before you do that, you've got some bullet points to review and a crossword puzzle to do. Don't skip them; repetition is what really drives the learning home!

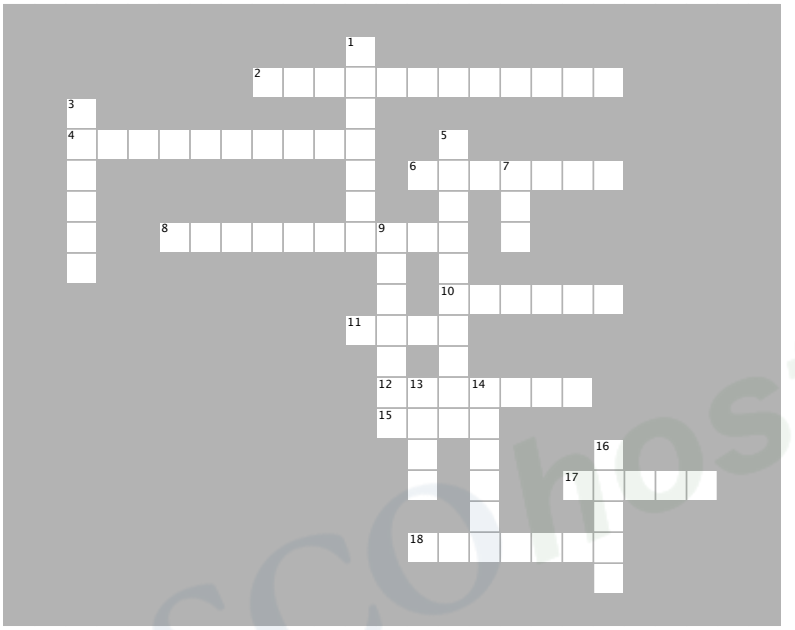


BULLET POINTS

- We use HTML to build the structure of the Battleship game, CSS to style it, and JavaScript to create the behavior.
- The id of each <td> element in the table is used to update the image of the element to indicate a HIT or a MISS.
- The form uses an input with type "button". We attach an **event handler** to the button so we can know in the code when a player has entered a guess.
- To get a value from a form input text element, use the element's **value** property.
- CSS positioning can be used to position elements precisely in a web page.
- We organized the code using three objects: a **model**, a **view**, and a **controller**.
- Each object in the game has one **primary responsibility**.
- The responsibility of the model is to store the state of the game and implement logic that modifies that state.
- The responsibility of the view is to update the display when the state in the model changes.
- The responsibility of the controller is to glue the game together, to make sure the player's guess is sent to the model to update the state, and to check to see when the game is complete.
- By designing the game with objects that each have a **separate responsibility**, we can build and test each part of the game independently.
- To make it easier to create and test the model, we initially hardcoded the locations of the ships. After ensuring the model was working, we replaced these hardcoded locations with random locations generated by code.
- We used properties in the model, like numShips and shipLength, so we don't hardcode values in the methods that we might want to change later.
- Arrays have an **indexOf** method that is similar to the string indexOf method. The array indexOf method takes a value, and returns the index of that value if it exists in the array, or -1 if it does not.
- With **chaining**, you can string together object references (using the dot operator), thus combining statements and eliminating temporary variables.
- The **do while** loop is similar to the while loop, except that the condition is checked after the statements in the body of the loop have executed once.
- **Quality assurance** (QA) is an important part of developing your code. QA requires testing not just valid input, but invalid input as well.

JavaScript cross

Your brain is frying from the coding challenges in this chapter. Do the crossword to get that final sizzle.



ACROSS

2. We use the _____ method to set the class of an element.

4. To add a ship or miss image to the board, we place the image in the _____ of a <td> element.

6. The _____ loop executes the statements in its body at least once.

8. Modern, interactive web apps use HTML, CSS and _____.

10. We represent each ship in the game with an _____.

11. The id of a <td> element corresponds to a _____ on the game board.

12. The responsibility of the collision function is to make sure that ships don't _____.

15. We call the _____ method to ask the model to update the state with the guess.

17. Who is responsible for state?

18. You can cheat and get the answers to Battleship using the _____.

DOWN

1. To get the guess from the form input, we added an event _____ for the click event.

3. Chaining is for _____ references, not just jailbirds.

5. The _____ is good at gluing things together.

7. To add a "hit" to the game board in the display, we add the ____ class to the corresonding <td> element.

9. Arrays have an _____ method too.

13. The three objects in our game design are the model, _____, and controller.

14. 13 is the keycode for the _____ key.

16. The _____ notifies the view when its state changes.

PRACTICE DRILLS SOLUTION

In just a few pages, you're going to learn how to add the MISS and ship images to the game board with JavaScript. But before we get to the real thing, you need to practice in the HTML simulator. We've got two CSS classes set up and ready for you to practice with. Go ahead and add these two rules to your CSS, and then imagine you've got ships hidden at the following locations:

Ship 1: A6, B6, C6

Ship 2: C4, D4, E4

Ship 3: B0, B1, B2

and that the player has entered the following guesses:

A0, D4, F5, B2, C5, C6

You need to add one of the two classes below to the correct cells in the grid (the correct <td> elements in the table) so that your grid shows MISS and a ship in the right places.

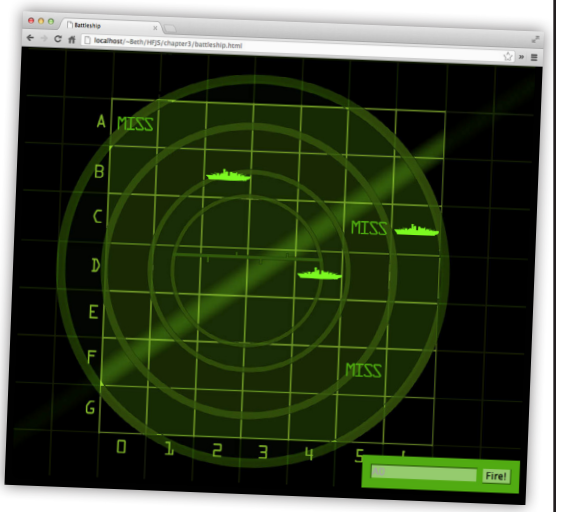
Make sure you've downloaded everything you need, including the two images you'll need for this exercise.


```
.hit {
    background: transparent url("ship.png") no-repeat center center;
}
.miss {
    background: transparent url("miss.png") no-repeat center center;
}
```

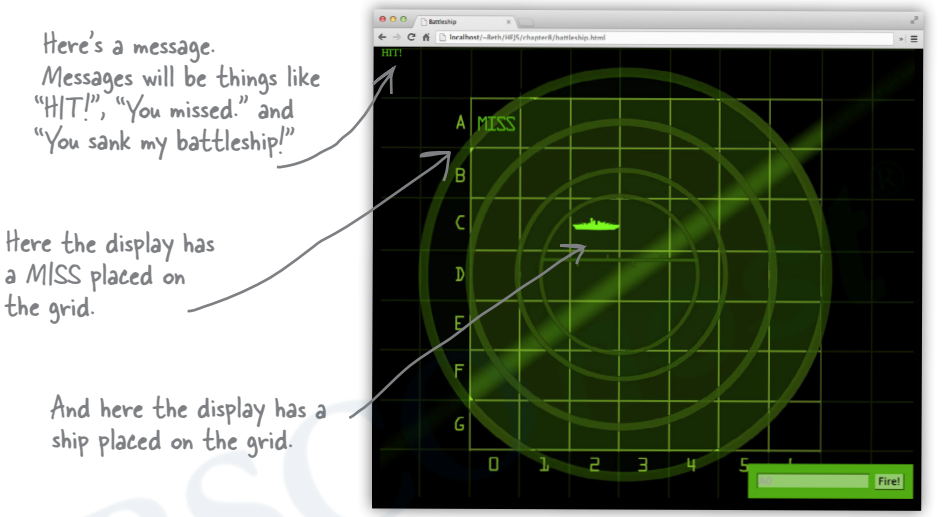
Here's our solution. The right spots for the .hit class are in <td>s with the ids: "00", "34", "55", "12", "25" and "26". To add a class to an element, you use the class attribute, like this:

```
<td class="miss" id="55">
```

After adding the classes in the right spots, your game board should look like this.



It's time for some object design. We're going to start with the view object. Now, remember, the view object is responsible for updating the view. Take a look at the view below and see if you can determine the methods we want the view object to implement. Write the declarations for these methods below (just the declarations; we'll code the bodies of the methods in a bit) along with a comment or two about what each does. Here's our solution:




```
var view = {

   // this method takes a string message and displays it
   // in the message display area
   displayMessage: function(msg) {
       // code to be supplied in a bit!
   },

   displayHit: function(location) {
       // code will go here
    },

    displayMiss: function(location) {
       // code will go here
    }
};
```

Notice we're defining an object and assigning it to the variable view.

Your methods go here!

Sharpen your pencil Solution

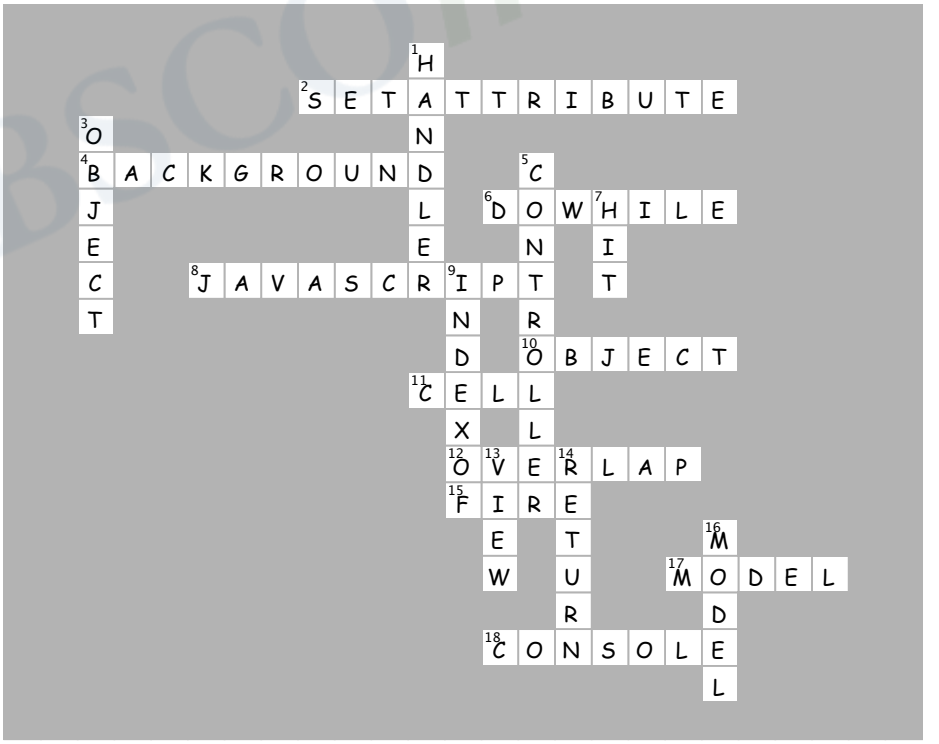
Given how we've described the new game board above, how would you represent the ships in the model (just the locations, we'll worry about hits later). Check off the best solution below.

- ❑ Use nine variables for the ship locations, similar to the way we handled the ships in Chapter 2.
- ❑ Use an array with an item for each cell in entire board (49 items total). Record the ship number in each cell that holds part of a ship.
- ❑ Use an array to hold all nine locations. Items 0-2 will hold the first ship, 3-5 the second, and so on.
- ❑ Use three different arrays, one for each ship, with three locations contained in each.
- ☑ Use an object named ship with three location properties. Put all the ships in an array named ships.
- ❑ _____

Or write in your own answer.

Any of these solutions could work! (In fact we tried each one when we were figuring out the best way to do it.) This is the one we use in the chapter.

JavaScript cross solution



Ship Magnets Solution

Use the following player moves, along with the data structure for the ships, to place the ship and miss magnets onto the game board. Does the player sink all the ships? We've done the first move for you.

Here are the moves:

A6, B3, C4, D1, B0, D4, F0, A1, C6, B1, B2, E4, B6

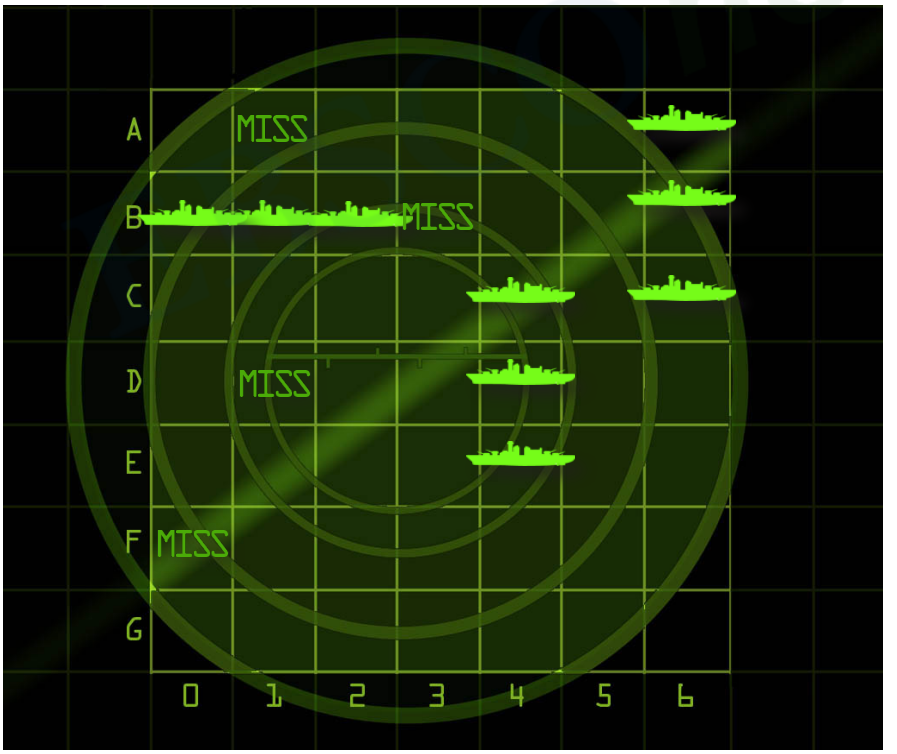
Execute these moves on the game board.

And here's our solution:

```
var ships = [{ locations: ["06", "16", "26"], hits: ["hit", "hit", "hit"] },
             { locations: ["24", "34", "44"], hits: ["hit", "hit", "hit"] },
             { locations: ["10", "11", "12"], hits: ["hit", "hit", "hit"] }];
```

All three ships are sunk!

And here's the board and your magnets.



MISS

Leftover magnets.

Sharpen your pencil Solution

Let's practice using the ships data structure to simulate some ship activities. Using the ships definition below, work through the questions and the code below and fill in the blanks. Make sure you check your answers before moving on, as this is an important part of how the game works:

```
var ships = [{ locations: ["31", "41", "51"], hits: ["", "", ""] },
             { locations: ["14", "24", "34"], hits: ["", "hit", ""] },
             { locations: ["00", "01", "02"], hits: ["hit", "", ""] }];
```

Which ships are already hit? Ships 2 and 3 And at what locations? C4, A0

The player guesses "D4", does that hit a ship? yes If so, which one? Ship 2

The player guesses "B3", does that hit a ship? no If so, which one? _____

Finish this code to access the second ship's middle location and print its value with console.log.

```
var ship2 = ships[ 1 ];
var locations = ship2.locations;
console.log("Location is " + locations[ 1 ]);
```

Finish this code to see if the third ship has a hit in its first location:

```
var ship3 = ships[ 2 ];
var hits = ship3.hits;
if (hits[0] === "hit") {
   console.log("Ouch, hit on third ship at location one");
}
```

Finish this code to hit the first ship at the third location:

```
var ship1 = ships[0];
var hits = ship1.hits;
hits[ 2 ] = "hit";
```

Code Magnets Solution

An algorithm to generate ships is all scrambled up on the fridge. Can you put the magnets back in the right places to produce a working algorithm? Here's our solution.

```
Loop for the number of
ships we want to create.

    Generate a random direction
    (vertical or horizontal)
    for the new ship.

    Generate a random
    location for the new ship.

    Test to see if the new ship's
    locations collide with any
    existing ship's locations.

    Add the new ship's locations
    to the ships array.
```