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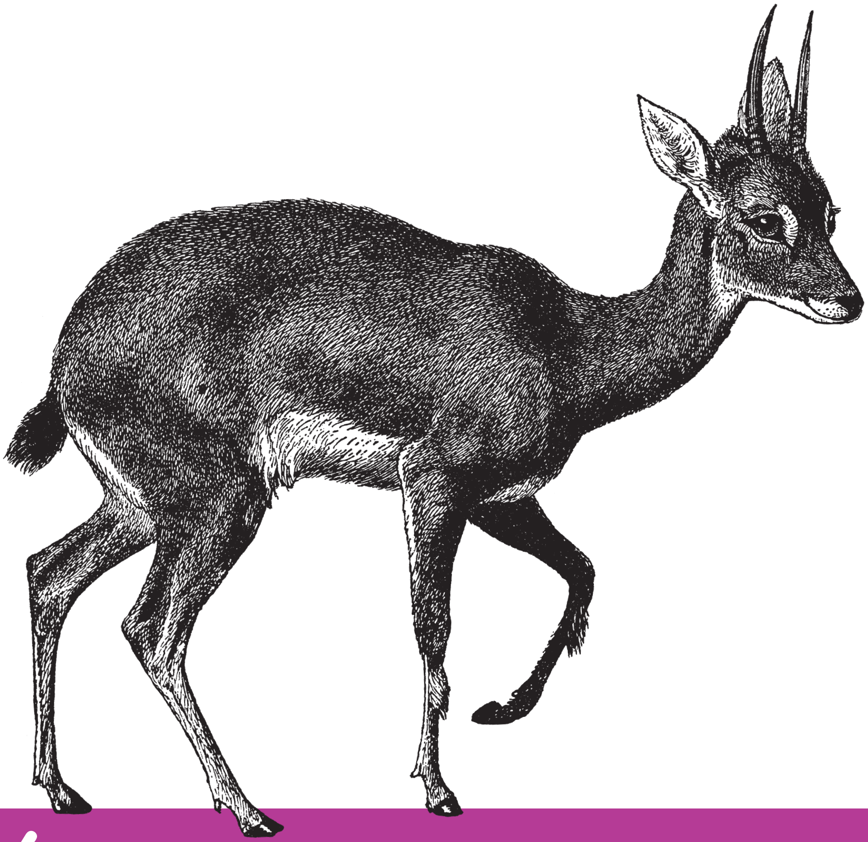

Études for ClojureScript

COMPANION EXERCISES FOR INTRODUCING CLOJURESCRIPT

J. David Eisenberg

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Études for ClojureScript

A short composition that provides practice material for a particular musical skill is called an étude. In this hands-on book, you'll find more than 30 études to help you practice ClojureScript skills for specific programming areas, ranging from functions and variables to asynchronous processing. Each of these small projects includes a description of a program that you will compose (write) in ClojureScript.

Though not as difficult as their musical counterparts, these programming études will help you stretch beyond the material and examples that you find in most ClojureScript books or online references. One chapter features études for an open-ended project that will help you put together what you've learned. Solutions to each étude are revealed in the appendix.

Programming areas include:

- Working with functions and variables with *def* and *let*
- Interacting with JavaScript and web pages, using several libraries
- Lists, vectors, and higher-order map, filter, and reduce functions
- Data mapping with ClojureScript
- Using different ClojureScript libraries to program with React
- Adding, subtracting, multiplying, and dividing rational and complex numbers with *defprotocol* and *defrecord*
- Asynchronous processing with *core.async*

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by J. David Eisenberg

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Preface

What's an Étude?

An étude, according to Wikipedia, is "an instrumental musical composition, usually short and of considerable difficulty, usually designed to provide practice material for perfecting a particular musical skill."

What Are Études for ClojureScript?

In this book, you will find descriptions of programs that you can compose (write) in ClojureScript. The programs will usually be short, and each one has been designed to provide practice material for a particular ClojureScript programming area. Unlike musical études, these programs have not been designed to be of considerable difficulty, though they may ask you to stretch a bit beyond the immediate material and examples that you find in most ClojureScript books or online references.

These études are not intended to introduce you to individual ClojureScript concepts. That ground is covered quite nicely by *ClojureScript Koans*, *4Clojure*, and *ClojureScript Unraveled*. Instead, these études take the form of small projects that do something that is (somewhat) useful. They are much along the lines of the programming katas given in chapter 10 of *Living Clojure* by Carin Meier (O'Reilly). If *Koans*, *4Clojure*, and *ClojureScript Unraveled* ask you to write programs at the level of chemical elements, in this book, you are constructing simple molecules.

This book is open source, so if you'd like to contribute, make a correction, or otherwise participate in the project, check out https://github.com/oreillymedia/etudes_for_clojurescript for details. If we accept your work, we'll add you to the contributors chapter.

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CHAPTER 1

Functions and Variables

This chapter starts with a couple of "warm-up exercises" so that you can get comfortable with your ClojureScript development environment. First, a quick review of how to define functions. Here is the generic model for a function:

```
(defn function-name [parameters] function-body)
```

Here is a function that takes an acceleration and an amount of time as its parameters and returns the distance traveled:

```
(defn distance [accel time] (/ (* accel time time) 2.0)
```

You can also put a documentation string between the function name and parameter list:

```
(defn distance
  "Calculate distance traveled by an object moving
  with a given acceleration for a given amount of time."
  [accel time]
  (/ (* accel time time) 2.0)
```

Étude 1-1: Defining a Function in the REPL

Create a project named *formulas* (see "Creating a ClojureScript Project" on page 112) and start a browser REPL (read/evaluate/print/loop). If you haven't yet installed ClojureScript, follow the instructions in Appendix B, and create a project to work with. In the REPL, type the preceding `distance` function and test it.

Étude 1-2: Defining Functions in a Source File

Defining functions in the REPL is fine for a quick test, but it is not something you want to do on an application-level scale. Instead, you want to define the functions in a source file. In the *formulas* project, open the *src/formulas/core.cljs* file and create functions for these formulas:

- Distance equals one-half acceleration multplied by time squared: $d = \frac{1}{2}at^2$
- Kinetic energy equals one-half the mass times velocity squared: $K = \frac{1}{2}mv^2$
- Centripetal acceleration is velocity squared over the radius: $a_c = \frac{v^2}{r}$

Here is some sample output. `(in-ns 'formulas.core)` switches you to that *namespace* so that you can type the function name without having to specify the module that it is in. If you update the source, `(require 'formulas.core :reload)` will recompile the code:

```
cljs.user=> (in-ns 'formulas.core)
nil
formulas.core=> (require 'formulas.core :reload)
nil
formulas.core=> (distance 9.8 5)
122.5
formulas.core=> (kinetic-energy 35 4)
280
formulas.core=> (centripetal 30 2)
450
```

See a suggested solution: "Solution 1-2" on page 65.

Étude 1-3: Using def

The `def` special form lets you bind a symbol to a value. The symbol is globally available to all functions in the namespace where it is defined. Add a function named `gravitational-force` that calculates the gravitational force between two masses whose centers of mass are at a distance *r* from each other to your code:

$$F = \frac{Gm_1m_2}{r^2}\text{, where the gravitational constant } G = 6.67384 \times 10^{-11}$$

Use a `def` for the gravitational constant.

Here is the calculation for two masses of 100 kg that are 5 m apart:

```
formulas.core=> (gravitational-force 100 100 5)
2.67136e-8
```

Redefining and def

ClojureScript’s `def` creates an ordinary JavaScript variable. Note that it is possible to rebind a symbol to a value with code like this:

```
(def x 5)
(def x 6)
(def x (+ 1 x))
```

However, this is somewhat frowned upon. Global, shared, mutable (changeable) variables can be problematic, as described in this answer to a question on StackExchange. You will find that ClojureScript’s functional programming model makes the need for such global variables much less frequent. As a beginning programmer, when you create a variable with `def`, treat it as if it were an (unalterable) algebraic variable and do not change its value.

See a suggested solution: “Solution 1-3” on page 66

Étude 1-4: Using let

To create local bindings of symbols to values within a function, you use `let`. The `let` is followed by a vector of symbol and value pairs.[1]

In this étude, you will write a function named `monthly-payment` that calculates monthly payments on a loan. Your function will take the amount of the loan, the annual percentage rate, and the number of years of the loan as its three parameters. Calculate the monthly payment according to this formula:

$$payment = p \cdot \frac{r(1+r)^n}{(1+r)^n - 1}$$

- p is the principal (the amount of the loan).
- r is the *monthly* interest rate.
- n is the number of *months* of the loan.

Use `let` to make local bindings for:

- The monthly interest rate r, which equals the annual rate divided by 12
- The number of months n, which equals the number of years times 12
- The common subformula $(1 + r)^n$

To raise a number to a power, invoke the JavaScript `pow` function with code in this format:

[1] Technically, `let` is followed by a vector of *binding forms* and values. Binding forms include *destructuring* as well as simple symbols.

```
(.pow js/Math number power)
;; Thus, to calculate 3 to the fifth power:
(.pow js/Math 3 5)
```

You can also use this shorthand:

```
(js/Math.pow 3 5)
```

You will learn more about interacting with JavaScript in Chapter 2.

Here is some sample output for a loan of $1,000.00 at 5.5% for 15 years. You can also check the results of your function against the results of the `PMT` function in your favorite spreadsheet:

```
formulas.core=> (monthly-payment 1000 5.5 15)
8.17083454621138
```

See a suggested solution: "Solution 1-4" on page 66.

Étude 1-5: More Practice with def and let

Here's a somewhat more complicated formula—determining the amount of sunlight in a day, given the day of year and the latitude of your location. Write a function named `daylight` with two parameters: a latitude in degrees and a Julian day. The function returns the number of minutes of sunshine for the day, using the formula explained at the Ask Dr. Math website. The latitude is in degrees, but JavaScript's trigonometric functions use radians, so you will need a function to convert degrees to radians, and I'll give you that for free:

```
(defn radians
  "Convert degrees to radians"
  [degrees]
  (* (/ (.-PI js/Math) 180) degrees))
```

The expression `(.-PI js/Math)` gets the `PI` property of the JavaScript `Math` object.

- You will want a variable that holds the latitude converted to radians.
- Calculate $P = \arcsin(0.39795 \cdot \cos(0.2163108 + 2 \cdot \arctan(0.9671396 \cdot \tan(0.00860 \cdot (day - 186)))))$
- Calculate $D = 24 - 7.63944 \cdot \arccos\left(\frac{\sin(0.01454) + \sin(latitude) \cdot \sin(p)}{\cos(latitude) \cdot \cos(p)}\right)$

The variable D holds the number of hours of daylight, so multiply that by 60 for your final result. If you feel that these formulas are a bit too complicated to type as single expressions (I certainly did!), break them down by using `let` for the parts.

On Mac OSX or Linux, you can get a Julian date with the `date` command:

```
$ date '+%j' # today
127
$ date -d '2015-09-15' '+%j' # arbitrary date
258
```

Your results should be very close to those generated by the National Oceanic and Atmospheric Administration spreadsheets, which use a *far* more complicated algorithm than the one given here.

See a suggested solution: "Solution 1-5" on page 66.

CHAPTER 2

Interacting with JavaScript and Web Pages

Since ClojureScript compiles to JavaScript, you need to have a way to interact with native JavaScript and with web pages. In this chapter, you will discover five different ways to do this:

1. Direct use of JavaScript
2. The Google Closure library
3. The Dommy library
4. The Domina library
5. The Enfocus library

> All of these methods are fairly "old school." As of this writing, all the Cool Kids™ are using libraries such as Facebook's React to handle the user interface. I still think it is useful to have knowledge of the older methods, as they might sometimes be the right tool to solve a problem. Chapter 5 describes how to work with React.

You'll be doing the same task with each of these: calculating the number of hours of daylight based on a latitude and Julian date, as in "Étude 1-5: More Practice with def and let" on page 4. Here is the relevant HTML:

```
<!DOCTYPE html>
<html>
    <head>
        <title>Daylight Minutes</title>
        <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
    </head>
    <body>
        <h1>Daylight Minutes</h1>
        <p>
        Latitude: <input type="text" size="8" id="latitude" />&#176;<br />
        Day of year: <input type="text" size="4" id="julian" /><br />
        <input type="button" value="Calculate" id="calculate"/>
        </p>

        <p>
        Minutes of daylight: <span id="result"></span>
        </p>

        <script src="out/project_name.js" type="text/javascript"></script>
    </body>
</html>
```

I suggest you create a new project for each of these études and copy the preceding HTML into the project's *index.html* file. Remember to make the `src` attribute of the `script` element match your project name.

If your project name has a hyphen in it, such as `my-project`, Clojure and ClojureScript will convert the hyphens to underscores when creating directories, so you will end up with a `src/my_project` directory.

Étude 2-1: Direct Use of JavaScript

This is the most direct method to interact with a page, and is the least ClojureScript-like in its approach.

Invoking Methods

In order to invoke JavaScript methods directly, you use expressions of the general form:

```
(.methodname JavaScript object arguments)
```

Here are some examples you can try in the REPL:

```
;; call the sqrt function from JavaScript's Math object with an argument 3
(.sqrt js/Math 3)

;; equivalent of window.parseFloat("3.5")
(.parseFloat js/window "3.5")

;; equivalent of "shouting".toUpperCase()
(.toUpperCase "shouting")

;; equivalent of "ClojureScript".substr(2,3)
(.substr "ClojureScript" 2 3)

;; equivalent of document.getElementById("latitude")
(.getElementById js/document "latitude")
```

You can also use a different form for methods that belong to the special `js` namespace. (It is not a real ClojureScript namespace, as it references the underlying JavaScript structure rather than ClojureScript code.)

```
;; call the sqrt function from JavaScript's Math object with an argument 3
(js/Math.sqrt 3)

;; equivalent of window.parseFloat("3.5")
(js/Window.parseFloat "3.5")

;; equivalent of document.getElementById("latitude")
(js/document.getElementById "latitude")
```

Accessing Properties

To access an object's properties, use `.-`. Before you try these in the browser REPL, type something into the `latitude` field in the form:

```
;; equivalent of Math.PI
(.-PI js/Math)

;; equivalent of "ClojureScript".length
(.-length "ClojureScript")

;; equivalent of document.getElementById("latitude").value
(.-value (.getElementById js/document "latitude"))

;; setting properties: equivalent of
;; document.getElementById("latitude").value = 23.5;
(set! (.-value (.getElementById js/document "latitude")) 23.5)
```

Creating JavaScript Objects

This étude doesn't need you to create any JavaScript objects, but if you are interacting with an existing library, you may need to do so. To create an object, give the class name followed by a period:

```
;; equivalent of d = new Date
(def d (js/Date.))

;; now you can use it
(.getHours d)

;; if you need a true JavaScript Array object
(def arr (js/Array. 10 20 30))
(get arr 2)
```

Listening for Events

In JavaScript, if you want an HTML element to respond to an event, you add an event listener to that element, tell it what type of event you want to listen for, and give it the name of a function that handles the event. That event-handling function must have one parameter to hold the event object. In ClojureScript, you need to define functions before you use them, so you have to write the event handler first and then invoke `addEventListener`. Here is an example of what I did in the REPL (my project name was `daylight-js`):

```
cljs.user=> (in-ns 'daylight-js.core)
nil
daylight-js.core=> (defn testing [evt] (.alert js/window "You clicked me!!!"))
#'daylight-js/testing
daylight-js.core=> (let [btn (.getElementById js/document "calculate")]
(.addEventListener btn "click" testing))
nil
```

The first line switches to the correct namespace for the project. The second line defines the event handler, which calls JavaScript's `alert()` function to display a message. The third line tells the "Calculate" button to listen for `click` events and call the `testing` function when they occur.

Given this information, complete the code for the project such that, when you click the "Calculate" button, the program will read the values from the latitude and Julian day field, calculate the number of daylight hours, and place the result in the `<span id="result">`. (Hint: use the `innerHTML` property.) You may also want to write a function that takes a form field name as its argument and returns the floating-point value from that field.

See a suggested solution: "Solution 2-1" on page 67.

Étude 2-2: Using Google Closure

Using JavaScript directly is all well and good; one advantage is that if you're a JavaScript programmer, you already know this stuff. The bad news is that you have all the problems of getting JavaScript to work on multiple browsers and platforms. Enter Google Closure, a library of JavaScript utilities that has all of those nasty compatibility parts all figured out for you. In this étude, you'll use Closure for the interaction.

Putting Google Closure into Your Project

To use Google Closure, you need to change the first lines of your *core.cljs* file to require the code that maniuplates the DOM and handles events. In this example, the project has been named `daylight-gc`:

```
(ns daylight-gc.core
  (:require [clojure.browser.repl :as repl]
            [goog.dom :as dom]
            [goog.events :as events]))
```

In the REPL, type `(require 'goog.dom :as dom)` to access the code.

Using Google Closure to Access the DOM

When accessing DOM elements, the main difference between Closure and pure JavaScript is that you use `dom/getElement` instead of `.getElementById js/document`. Thus, after starting the browser REPL and typing 55 into the latitude input area:

```
cljs.user=> (require 'daylight-gc.core)
nil
cljs.user=> (in-ns 'daylight-gc.core)
nil
daylight-gc.core=> (require '[goog.dom :as dom])
nil
daylight-gc.core=> (dom/getElement "latitude")
#<[object HTMLInputElement]>
daylight-gc.core=> (.-value (dom/getElement "latitude"))
"55"
daylight-gc.core=> (set! (.-value (dom/getElement "latitude")) -20)
-20
daylight-gc.core=> ;; Closure has its own way to set an element's text
daylight-gc.core=> (dom/setTextContent (dom/getElement "result")
"Here is some text")
nil
```

Using Google Closure to Handle Events

Again, the code is quite similar to what you would do with plain JavaScript; you use `events/listener` instead of `.addListener`. The following adds a listener to the "Calculate" button:

```
daylight-gc.core=> (defn testing [evt] (.alert js/window "Clickety-click"))
#'daylight-gc.core/testing
daylight-gc.core=> (events/listen (dom/getElement "calculate") "click" testing)
#<[object Object]>
```

After you test it, you may want to remove the listener so that it doesn't interfere with the code you put in your source *core.cljs* file:

```
daylight-gc.core=> (events/unlisten (dom/getElement "calculate") "click" testing)
true
```

Given this information, complete the code for the project. Note: if you created a new project and just copy/pasted the *index.html* file, make sure you change the `<script>` element to refer to the right file.

See a suggested solution: "Solution 2-2" on page 68.

Étude 2-3: Using dommy

While Google Closure gives you a lot of great code, it's still JavaScript, and it "feels" like JavaScript. What you would like is a library that gives you the capabilities, but in a more functional way. One of those libraries is dommy. In this étude, you will use dommy to interact with the web page.

Putting dommy into Your Project

To use dommy, you need to change the first lines of your *core.cljs* file to require the code that maniuplates the DOM and handles events. In this example, the project has been named `daylight-dommy`:

```
(ns daylight-dommy.core
  (:require [clojure.browser.repl :as repl]
            [dommy.core :as dommy :refer-macros [sel sel1]]))
```

The `:refer-macros` is new and beyond the scope of this book. The oversimplified explanation is that ClojureScript macros are like functions with extra superpowers. I *will* explain the `sel` and `sel1` later.

You also need to change the *project.clj* file to specify dommy as one of your project's dependencies. The additional code is highlighted:

```
  :dependencies [[org.clojure/clojure "1.7.0-beta2"]
                 [org.clojure/clojurescript "0.0-3211"]
                 [prismatic/dommy "1.1.0"]]
```

Using dommy to Access the DOM

Dommy has two functions for accessing elements: `sel1` and `sel`. `sel1` will return a single HTML node; `sel` will return a JavaScript array of all matching elements. The *index.html* file has three `<input/>` elements. Compare the results:

```
cljs.user=> ;; set up namespaces
cljs.user=> (require 'daylight-dommy.core)
nil
cljs.user=> (in-ns 'daylight-dommy.core)
nil
daylight-dommy.core=> (require '[dommy.core :as dommy :refer-macros [sel sel1]])
nil
daylight-dommy.core=> ;; access the first <input> element
daylight-dommy.core=> (sel1 "input")
#<[object HTMLInputElement]>
daylight-dommy.core=> ;; access all the <input> elements
daylight-dommy.core=> (sel "input")
#js [#<[object HTMLInputElement]>
#<[object HTMLInputElement]> #<[object HTMLInputElement]>]
daylight-dommy.core=> ;; since IDs are unique, you use sel1 for them.
daylight-dommy.core=> (sel1 "#latitude")
#<[object HTMLInputElement]>
```

To access values of form fields, use dommy's `value` and `set-value!` functions. (I typed 55 into the latitude field before doing these commands.) Similarly, `text` and `set-text!` let you read and write text content of elements. `html` and `set-html!` let you read and write HTML content of an element. Notice that you can use either a string or a keyword as an argument to `sel`:

```
daylight-dommy.core=> ;; retrieve and set form field
daylight-dommy.core=> (dommy/value (sel1 "#latitude"))
"55"
daylight-dommy.core=> (dommy/set-value! (sel1 "#latitude") 10.24)
#<[object HTMLInputElement]>
daylight-dommy.core=> ;; set and retrieve text content
daylight-dommy.core=> (dommy/set-text! (sel1 :#result) "some text")
#<[object HTMLSpanElement]>
daylight-dommy.core=> (dommy/text (sel1 :#result))
"some text"
daylight-dommy.core-> (dommy/set-html! (sel1 :#result) "<i>Yes!</i>")
```

Using dommy to Handle Events

Here is the code to add and remove an event listener. You may use either keywords or strings for event names. If you use a keyword for the event name, such as `:click` when you listen for events, you *must* use a keyword when you remove the listener:

```
daylight-dommy.core=> (defn testing [event] (.alert js/window "Clicked."))
#'daylight-dommy.core/testing
daylight-dommy.core=> (dommy/listen! (sel1 :#calculate) :click testing)
#<[object HTMLInputElement]>
daylight-dommy.core=> ;; the web page should now respond to clicks. Try it.
daylight-dommy.core=> ;; now remove the listener.
daylight-dommy.core=> (dommy/unlisten! (sel1 "#calculate") :click testing)
#<[object HTMLInputElement]>
daylight-dommy.core=>
```

Given this information, complete the code for the project. Note: if you created a new project and just copy/pasted the *index.html* file, make sure you change the `<script>` element to refer to the right file.

See a suggested solution: "Solution 2-3" on page 68.

Étude 2-4: Using Domina

The Domina library is very similar in approach to dommy. In this étude, you will use Domina to interact with the web page.

Putting Domina into Your Project

To use Domina, you need to change the first lines of your *core.cljs* file to require the code that maniuplates the DOM and handles events. In this example, the project has been named `daylight-domina`:

```
(ns daylight-domina.core
  (:require [clojure.browser.repl :as repl]
            [domina]
            [domina.events :as events]))
```

You also need to change the *project.clj* file to specify Domina as one of your project's dependencies. The additional code is highlighted:

```
  :dependencies [[org.clojure/clojure "1.7.0"]
                 [org.clojure/clojurescript "1.7.48"]
                 [domina "1.0.3"]]
```

Using Domina to Access the DOM

In Domina, you can access an item by its ID, by a CSS class, or by an XPath expression. This étude only uses the first of these methods with the `by-id` function:

```
cljs.user=> ;; set up namespaces
cljs.user=> (require 'daylight-domina.core)
nil
cljs.user=> (in-ns 'daylight-domina.core)
nil
daylight-domina.core=> (require 'domina)
nil
daylight-domina.core=> (require '[domina.events :as events])
nil
daylight-domina.core=> (domina/by-id "latitude")
#<[object HTMLInputElement]>
```

To access values of form fields, use Domina's `value` and `set-value!` functions. (I typed 55 into the latitude field before doing these commands.) Similarly, `text` and `set-text!` let you read and write text content of elements. `html` and `set-html!` let you read and write HTML content of an element. Notice that you can use either a string or a keyword as an argument to `sel`:

```
daylight-domina.core=> ;; retrieve and set form field
daylight-domina.core=> (domina/value (domina/by-id "latitude"))
"55"
daylight-domina.core=> (domina/set-value! (domina/by-id "latitude") 10.24)
#<[object HTMLInputElement]>
daylight-domina.core=> ;; set and retrieve text content
daylight-domina.core=> (domina/set-text! (domina/by-id :result) "Testing 1 2 3")
#<[object HTMLSpanElement]>
daylight-domina.core=> (def resultspan (domina/by-id :result)) ;; to save typing
#<[object HTMLSpanElement]>
```

```
daylight-domina.core=> (domina/text resultspan)
"Testing 1 2 3"
daylight-domina.core-> (domina/set-html! resultspan "<i>Yes!</i>")#
<[object HTMLSpanElement]>
daylight-domina.core=> ;; look at web page to see result
```

Using Domina to Handle Events

Here is the code to add and remove an event listener. You may use either keywords or strings for event names. You may use either a string or keyword when you remove the listener. The `unlisten!` function removes *all* listeners associated with the event type:

```
daylight-domina.core=> (defn testing [event]
(.alert js/window "You clicked me."))
#'daylight-domina.core/testing
daylight-domina.core=> (events/listen! (domina/by-id "calculate") :click testing)
#<[object HTMLInputElement]>
daylight-domina.core=> ;; the web page should now respond to clicks. Try it.
daylight-domina.core=> ;; now remove the listener.
daylight-domina.core=> (events/unlisten! (domina/by-id "calculate") "click")
#<[object HTMLInputElement]>
daylight-domina.core=>
```

Given this information, complete the code for the project. Note: if you created a new project and just copy/pasted the *index.html* file, make sure you change the `<script>` element to refer to the right file.

See a suggested solution: "Solution 2-4" on page 69.

Étude 2-5: Using Enfocus

The Enfocus library is very different from dommy and Domina.

Putting Enfocus into Your Project

To use Enfocus, you need to change the first lines of your *core.cljs* file to require the code that maniuplates the DOM and handles events. In this example, the project has been named `daylight-enfocus`:

```
(ns daylight-dommy.core
  (:require [clojure.browser.repl :as repl]
            [enfocus.core :as ef]
            [enfocus.events :as ev]))
```

You also need to change the *project.clj* file to specify Enfocus as one of your project's dependencies. The additional code is highlighted:

```
  :dependencies [[org.clojure/clojure "1.7.0-beta2"]
                 [org.clojure/clojurescript "0.0-3211"]
                 [enfocus "2.1.0"]]
```

Using Enfocus to Access the DOM

The idea behind Enfocus is that you select a node and then do transformations on it. This is a very powerful concept, but this étude will use only its simplest forms. First, set up namespaces:

```
cljs.user=> (require 'daylight-enfocus.core)
nil
cljs.user=> (in-ns 'daylight-enfocus.core)
nil
daylight-enfocus.core=> (require '[enfocus.core :as ef])
nil
daylight-enfocus.core=> (require '[enfocus.events :as ev])
nil
```

Enfocus lets you select an element by its ID either as a CSS selector, an Enlive selector, or an XPath Selector. In this case, let's just stick with the old familar CSS form. To access values of form fields, use Enfocus's `from` function to select the field, then use the `get-prop` transformation to extract the value. (I typed 55 into the latitude field before doing these commands.) Similarly, `at` selects an element you want to alter, and the `content` and `html-content` transformation lets you set an element's content:

```
daylight-enfocus.core=> (ef/from "#latitude" (ef/get-prop :value))
"55"
daylight-enfocus.core=> (ef/at "#latitude" (ef/set-prop :value 10.24))
nil
daylight-enfocus.core=> (ef/at "#result" (ef/content "New text"))
nil
daylight-enfocus.core=> (ef/at "#result" (ef/html-content
"<i>Improved text</i>"))
nil
daylight-enfocus.core=> ;; look at web page to see result
```

Note: when you use the `content` transformation, the argument must be a string or a node. You can't use a number—you must convert it to a string:

```
daylight-enfocus.core=> (ef/at "#result" (ef/content (.toString 3.14159)))
nil
```

Using Enfocus to Handle Events

Here is the code to add and remove an event listener:

```
daylight-enfocus.core=> (defn testing [evt] (.alert js/window "Click-o-rama"))
#'daylight-enfocus.core/testing
daylight-enfocus.core=> (ef/at "#calculate" (ev/listen :click testing))
nil
daylight-enfocus.core=> ;; the web page should now respond to clicks. Try it.
daylight-enfocus.core=> ;; now remove the listener.
daylight-enfocus.core=> (ef/at "#calculate" (ev/remove-listeners :click))
nil
```

Given this information, complete the code for the project. Note: if you created a new project and just copy/pasted the *index.html* file, make sure you change the `<script>` element to refer to the right file.

See a suggested solution: "Solution 2-5" on page 69.

CHAPTER 3

Lists, Vectors, and Higher-Order Functions

In this chapter, you will work with lists and vectors, along with the `map`, `filter`, and `reduce` functions. All of these take functions as one of their arguments, and are thus higher-order functions.

Étude 3-1: Move the Zeros

This is a quick warm-up étude. Given a list of integers that have zeros interspersed throughout, move all the zeros to the end. Name the function `move-zeros`; it accepts a list as an argument and returns a new list with the zeros at the end. I saw the problem at this page, solved in Java, and wondered if I could do it in ClojureScript. Answer: yes, I could. And so can you. Hint: `filter` is useful. After I solved it, I realized just how much my thinking about functional programming had changed the way I look at imperative code. You may have the same experience:

```
move-zeros.core=> (move-zeros [1 0 0 2 0 3 0 4 5 0 6])
(1 2 3 4 5 6 0 0 0 0 0)
```

See a suggested solution: "Solution 3-1" on page 70.

Étude 3-2: More List Manipulation

Write a function named `ordinal-day` that takes a day, month, and year as its three arguments and returns the ordinal (Julian) day of the year. Bonus points if you return zero for invalid dates such as 29-02-2015 or 40-40-2015. Don't worry about handling dates before the year 1584 correctly.

You will need to know if a year is a leap year or not. I'll give you that one for free:

```
(defn leap-year?
  "Return true if given year is a leap year; false otherwise"
  [year]
  (or (and (= 0 (rem year 4)) (not= 0 (rem year 100)))
    (= 0 (rem year 400))))
```

Some sample output from the REPL:

```
formulas.core=> (ordinal-day 1 3 2015)
60
formulas.core=> (ordinal-day 1 3 2016)
61
formulas.core=> (ordinal-day 1 13 2015)
0
formulas.core=> (ordinal-day 29 2 2015)
0
formulas.core=> (ordinal-day 29 2 2016)
60
formulas.core=> (ordinal-day 31 9 2015)
0
```

Then, modify the daylight calculator from Chapter 2 to allow entry of a date in the form *yyyy-mm-dd*. You will need to split the input data into individual numbers. You can use either the `split` method for JavaScript strings or the `split` method from the `clojure.string` library. If you want to use the latter method, you will need to add that library to your `require`:

```
(ns stats.core
  (:require [clojure.browser.repl :as repl]
            [clojure.string :as str]))
```

To specify a regular expression for `split`, prefix a string with `#`. Here is some sample output from the REPL. Using JavaScript's `split` returns a JavaScript array. Notice that you do not need to escape backslashes in patterns (see the last example):

```
formulas.core=> (require '[clojure.string :as str])
nil
formulas.core=> (.split "a:b:c:d" #":")
#js ["a" "b" "c" "d"]
formulas.core=> (str/split "a:b:c:d" #":")
["a" "b" "c" "d"]
formulas.core=> (str/split "abc123def456ghi789jkl" #"\d+")
["abc" "def" "ghi" "jkl"]
formulas.core=>
```

Bonus points: display the daylight as hours and minutes. Here is the relevant HTML to put in your *index.html* file:

```
<h1>Amount of Daylight</h1>
<p>
Latitude: <input type="text" size="8" id="latitude" />°<br />
```

```
Enter date in format <em>yyyy-mm-dd</em>:
<input type="text" size="15" id="gregorian" /><br />
<input type="button" value="Calculate" id="calculate"/>
</p>

<p>
Amount of daylight: <span id="result"></span>
</p>
```

See a suggested solution: "Solution 3-2" on page 70.

Étude 3-3: Basic Statistics

Create a project named *stats* and write these functions, each of which takes a list of numbers as its argument:

`mean`

Calculates the arithmetic average of the list by summing the numbers (hint: use `reduce` or `apply +`) and dividing by the number of items in the list.

`median`

Calculates the median of the numbers. The algorithm is as follows:

1. Sort the list (hint: use `sort`).
2. If n, the number of items in the list, is odd, take the item at position $(n - 1) / 2$.
3. Otherwise, take the average of the items at positions $n / 2$ and $(n - 1) / 2$.

I used `drop` in my solution rather than `nth`.

`stdev`

Calculates the standard deviation of the numbers. Use the computational formula: $\sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{(n-1)}}$, which works out to this algorithm:

1. Get the sum of the squares of all the numbers in the list.
2. Get the sum of all the numbers of the list, and square that result.
3. Divide the result of step 2 by n.
4. Subtract the result of step 3 from the result of step 1.
5. Divide the result of step 4 by n—1.
6. Take the square root of the result of step 5.

You could write two functions that use `reduce`: one to get the sum of the list and another to get the sum of squares, but, as a challenge, try to write a single function to get both numbers. Hint: there is no law that says the "accumulator" of the function that you give to `reduce` has to be a single number. It could just as well be a vector of two items. If you take this approach, you might want to make the reducing function a separate function rather than an anonymous function.

See a suggested solution: "Solution 3-3" on page 71.

Étude 3-4: Basic Statistics in a Web Page

Now that you have the functions working, connect them to a web page where people can enter a list of numbers and the program will display the resulting statistics when the input field changes. Here's the HTML:

```
<!DOCTYPE html>
<html>
    <head>
        <title>Basic Statistics</title>
        <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
    </head>
    <body>
        <h1>Basic Statistics</h1>
        <p>
        Enter numbers, separated by blanks or commas:
        <input type="text" size="50" id="numbers"/>
        </p>

        <p>
        Mean: <span id="mean"></span><br />
        Median: <span id="median"></span><br />
        Standard deviation: <span id="stdev"></span>
        </p>

        <script src="out/stats.js" type="text/javascript"></script>
    </body>
</html>
```

Once you have the individual items, you have to use `js/window.parseFloat` to convert them to numbers. You must do this because ClojureScript's (and JavaScript's) `+` operator works differently on strings than on numbers: `(+ "12" "30")` works out to `"1230"`, not 42. Hint: use `map`.

Use whichever method of interacting with JavaScript (see Chapter 2) that you prefer. In this étude, you will listen for a `change` event, and you may want to use the JavaScript `event.target` property. Given a function like `(defn handler [evt] ...)`, here is how you access the value of a form field via the target property:

Library	ClojureScript
JavaScript Google Closure	`(.-value (.-target evt))`
dommy	`(dommy/value (.-target evt))`
Domina	`(domina/value (domina.events/target evt))`
Enfocus	`(ef/at (.-target evt) (ef/get-prop :value))`

See a suggested solution: "Solution 3-4" on page 72.

Étude 3-5: Dental Hygiene

OK, I'll admit this is a fairly strange étude, but I couldn't resist. Dentists check the health of your gums by checking the depth of the "pockets" at six different locations around each of your 32 teeth. The depth is measured in millimeters. If any of the depths is greater than or equal to four millimeters, that tooth needs attention. (Thanks to Dr. Patricia Lee, DDS, for explaining this to me.)

Your task is to write a function named `alert` that takes a vector of 32 vectors of six numbers as its input. If a tooth isn't present, it is represented by the empty vector `[]` instead of the six numbers. The function produces a list of the tooth numbers that require attention. The numbers must be in ascending order.

Here's a definition of a set of pocket depths for a person who has had her upper wisdom teeth, numbers 1 and 16, removed. Just copy and paste it into your project. Note that list entries may be separated by either a comma or by spaces:

```
(def pocket-depths
  [[], [2 2 1 2 2 1], [3 1 2 3 2 3],
  [3 1 3 2 1 2], [3 2 3 2 2 1], [2 3 1 2 1 1],
  [3 1 3 2 3 2], [3 3 2 1 3 1], [4 3 3 2 3 3],
  [3 1 1 3 2 2], [4 3 4 3 2 3], [2 3 1 3 2 2],
  [1 2 1 1 3 2], [1 2 2 3 2 3], [1 3 2 1 3 3], [],
  [3 2 3 1 1 2], [2 2 1 1 3 2], [2 1 1 1 1 2],
  [3 3 2 1 1 3], [3 1 3 2 3 2], [3 3 1 2 3 3],
  [1 2 2 3 3 3], [2 2 3 2 3 3], [2 2 2 4 3 4],
  [3 4 3 3 3 4], [1 1 2 3 1 2], [2 2 3 2 1 3],
  [3 4 2 4 4 3], [3 3 2 1 2 3], [2 2 2 2 3 3],
  [3 2 3 2 3 2]])
```

And here's the output:

```
cljs.user=> (in-ns 'teeth.core)
nil
teeth.core=> (alert pocket-depths)
[9 11 25 26 29]
teeth.core=>
```

See a suggested solution: "Solution 3-5" on page 73.

Étude 3-6: Random Numbers—Generating a Vector of Vectors

How do you think I got the numbers for the teeth in the preceding étude? Do you really think I made up and typed all 180 of them? No, of course not. Instead, I wrote a

ClojureScript program to create the vector of vectors for me, and that's what you'll do in this étude.

ClojureScript is luckily provided with the `rand` function. It generates a random floating-point number from 0 up to but not including 1 (if given no argument); or, if given a single argument *n*, returns a random floating value from 0 up to *n*. More useful for this étude is the `rand-int` function, which takes one argument *n* and returns a random integer from 0 up to but not including *n*.

Create a project named *make_teeth* and write a function `generate-pockets` that takes two arguments. The first argument is a string consisting of the letters `T` and `F`. A `T` indicates that the tooth is present, and an `F` indicates a missing tooth. The second argument is a floating-point number between 0 and 1.0 (inclusive) that indicates the probability that a tooth will be a good tooth.

The result is a vector of vectors, one subvector per tooth. If a tooth is present, the subvector has six entries; if a tooth is absent, the sublist is empty: `[]`. Here is some sample output from the REPL:

```
make_teeth.core=> (generate-pockets "TFTT" 0.75)
[[1 2 2 3 1 1] [] [2 3 1 1 3 2] [4 2 2 3 2 3]]
```

These are the helper functions I needed:

`(generate-list` *`teeth-present probability result`*`)`

The first two arguments are the same as for `generate_pockets`; the third argument is the accumulated list. If a tooth isn't present, add `[]` to the result; otherwise, add the return value of `generate_tooth` with the probability of a good tooth as its argument.

`(one-tooth` *`present probability`*`)`

This function takes as its arguments a single-character string (`"T"` or `"F"`) to signiify the presence or absence of a tooth and the probability of a good tooth. If there's no tooth, it returns `[]`. Otherwise, it sets a "base depth" for all the pockets by generating a random number between 0 and 1. If that number is less than the probability of a good tooth, base depth is 2; otherwise, it's 3. It then generates a vector of six numbers, each time randomly adding an integer from -1 to 1 to the base depth.

I imagine that, with a great deal of effort, I could have found a way to use `map` and `reduce` to give me the results I wanted, but I was too lazy. Instead, I used `recur` in `generate-list` and `loop`/`recur` in `one-tooth`.

See a suggested solution: "Solution 3-6" on page 73.

Étude 3-7: Monthly Daylight

This étude puts together a lot of the things you have been doing in this chapter into one rather large-ish project. The project name is *daylight_summary*, and it gives a table of average minutes of daylight per month for a given latitude or city (selected from a drop-down menu). Here is the HTML:

```
<!DOCTYPE html>
<html>
    <head>
        <title>Amount of Daylight</title>
        <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
        <style type="text/css">
          th, td {
            border: 1px solid gray;
            padding: 0.5em;
          }
        </style>
    </head>
    <body>
        <h1>Amount of Daylight</h1>
        <p>
        <input type="radio" name="locationType" id="menu" checked="checked">
          <select id="cityMenu">
            <option value="39.9075">Beijing</option>
            <option value="52.52437">Berlin</option>
            <option value="-15.77972">Brasília</option>
            <option value="30.06263">Cairo</option>
            <option value="-35.28346">Canberra</option>
            <option value="-17.82772">Harare</option>
            <option value="-12.04318">Lima</option>
            <option value="51.50853">London</option>
            <option value="55.75222">Moscow</option>
            <option value="-1.28333">Nairobi</option>
            <option value="28.63576">New Delhi</option>
            <option value="12.36566">Ouagadougou</option>
            <option value="59.91273">Oslo</option>
            <option value="48.85341">Paris</option>
            <option value="35.6895">Tokyo</option>
            <option value="38.89511">Washington, D. C.</option>
          </select>
          <input type="radio" id="userSpecified" name="locationType">
          Other latitude: <input type="text" size="8" id="latitude"/>
          <input type="button" value="Calculate" id="calculate"/>
        </p>

        <h2>Monthly Average Daylight</h2>
        <table>
          <thead><tr><th>Month</th><th>Average</th></tr></thead>
          <tbody>
```

```
                <tr><td>January</td><td id="m1"></td></tr>
                <tr><td>February</td><td id="m2"></td></tr>
                <tr><td>March</td><td id="m3"></td></tr>
                <tr><td>April</td><td id="m4"></td></tr>
                <tr><td>May</td><td id="m5"></td></tr>
                <tr><td>June</td><td id="m6"></td></tr>
                <tr><td>July</td><td id="m7"></td></tr>
                <tr><td>August</td><td id="m8"></td></tr>
                <tr><td>September</td><td id="m9"></td></tr>
                <tr><td>October</td><td id="m10"></td></tr>
                <tr><td>November</td><td id="m11"></td></tr>
                <tr><td>December</td><td id="m12"></td></tr>

              </tbody>
            </table>
            <script src="out/daylight_summary.js" type="text/javascript"></script>
        </body>
    </html>
```

In this program, don't worry about leap years; do the calculation based on a 365-day year. To determine which of the radio buttons is selected, you use code like this in Enfocus, where `ef` is the abbreviation for the `enfocus.core` namespace:

```
(ef/from "input[name='locationType']" (ef/get-prop :checked)))
```

The selector is a CSS style selector, and the expression returns a list of the status of the two radio buttons, with `true` if selected and `false` if not.

If you are using Domina, use code like this, again using a CSS selector:

```
(def radio (domina/nodes (domina.css/sel "input[name='locationType']")))
(domina/value (first radio))
```

The result of the second expression is the string `"on"` if the radio button is selected, `nil` if not.

See a suggested solution: "Solution 3-7" on page 74.

CHAPTER 4

Maps

In this chapter, you will work with maps (not to be confused with the `map` function, though you can use `map` on a map). Also, the études are designed to run on the server side with Node.js®, so you may want to see how to set that up in Appendix D.

Étude 4-1: Condiments

If you spend some time going through open datasets such as those from data.gov, you will find some fairly, shall we say, esoteric data. Among them is MyPyramid Food Raw Data from the Food and Nutrition Service of the United States Department of Agriculture.

One of the files is *Foods_Needing_Condiments_Table.xml*, which gives a list of foods and condiments that go with them. Here is what part of the file looks like, indented and edited to eliminate unnecessary elements, and placed in a file named *test.xml*:

```
<Foods_Needing_Condiments_Table>
  <Foods_Needing_Condiments_Row>
    <Survey_Food_Code>51208000</Survey_Food_Code>
    <display_name>100% Whole Wheat Bagel</display_name>
    <cond_1_name>Butter</cond_1_name>
    <cond_2_name>Tub margarine</cond_2_name>
    <cond_3_name>Reduced calorie spread (margarine type)</cond_3_name>
    <cond_4_name>Cream cheese (regular)</cond_4_name>
    <cond_5_name>Low fat cream cheese</cond_5_name>
  </Foods_Needing_Condiments_Row>
  <Foods_Needing_Condiments_Row>
    <Survey_Food_Code>58100100</Survey_Food_Code>
    <display_name>"Beef burrito (no beans):"</display_name>
    <cond_1_name>Sour cream</cond_1_name>
    <cond_2_name>Guacamole</cond_2_name>
    <cond_3_name>Salsa</cond_3_name>
  </Foods_Needing_Condiments_Row>
  <Foods_Needing_Condiments_Row>
    <Survey_Food_Code>58104740</Survey_Food_Code>
    <display_name>Chicken & cheese quesadilla:</display_name>
    <cond_1_name>Sour cream</cond_1_name>
    <cond_2_name>Guacamole</cond_2_name>
    <cond_3_name>Salsa</cond_3_name>
  </Foods_Needing_Condiments_Row>
</Foods_Needing_Condiments_Table>
```

Your task, in this étude, is to take this XML file and build a ClojureScript map whose keys are the condiments and whose values are vectors of foods that go with those condiments. Thus, for the sample file, if you run the program from the command line, the output would be this map (formatted and quotemarked for ease of reading):

```
[etudes@localhost nodetest]$ node condiments.js test.xml
{"Butter" ["100% Whole Wheat Bagel"],
"Tub margarine" ["100% Whole Wheat Bagel"],
"Reduced calorie spread (margarine type)" ["100% Whole Wheat Bagel"],
"Cream cheese (regular)" ["100% Whole Wheat Bagel"],
"Low fat cream cheese" ["100% Whole Wheat Bagel"],
"Sour cream" ["Beef burrito (no beans):" "Chicken & cheese quesadilla:"],
"Guacamole" ["Beef burrito (no beans):" "Chicken & cheese quesadilla:"],
"Salsa" ["Beef burrito (no beans):" "Chicken & cheese quesadilla:"]}
```

Parsing XML

How do you parse XML using Node.js? Install the `node-xml-lite` module:

```
[etudes@localhost ~]$ npm install node-xml-lite
npm http GET https://registry.npmjs.org/node-xml-lite
npm http 304 https://registry.npmjs.org/node-xml-lite
npm http GET https://registry.npmjs.org/iconv-lite
npm http 304 https://registry.npmjs.org/iconv-lite
node-xml-lite@0.0.3 node_modules/node-xml-lite
└── iconv-lite@0.4.8
```

Bring the XML parsing module into your *core.cljs* file:

```
(def xml (js/require "node-xml-lite"))
```

The following code will parse an XML file and return a JavaScript object:

```
(.parseFileSync xml "test.xml")
```

And here is the JavaScript object that it produces:

```
  {:name "Foods_Needing_Condiments_Table", :childs [
    {:name "Foods_Needing_Condiments_Row", :childs [
      {:name "Survey_Food_Code", :childs ["51208000"]}
      {:name "display_name", :childs ["100% Whole Wheat Bagel"]}
      {:name "cond_1_name", :childs ["Butter"]}
      {:name "cond_2_name", :childs ["Tub margarine"]}
      {:name "cond_3_name", :childs ["Reduced calorie spread (margarine type)"]}
      {:name "cond_4_name", :childs ["Cream cheese (regular)"]}
      {:name "cond_5_name", :childs ["Low fat cream cheese"]}
    ]}
    {:name "Foods_Needing_Condiments_Row", :childs [
      {:name "Survey_Food_Code", :childs ["58100100"]}
      {:name "display_name", :childs ["Beef burrito (no beans):"]}
      {:name "cond_1_name", :childs ["Sour cream"]}
      {:name "cond_2_name", :childs ["Guacamole"]}
      {:name "cond_3_name", :childs ["Salsa"]}
    ]}
    {:name "Foods_Needing_Condiments_Row", :childs [
      {:name "Survey_Food_Code", :childs ["58104740"]}
      {:name "display_name", :childs ["Chicken & cheese quesadilla:"]}
      {:name "cond_1_name", :childs ["Sour cream"]}
      {:name "cond_2_name", :childs ["Guacamole"]}
      {:name "cond_3_name", :childs ["Salsa"]}
    ]}
  ]}
```

Command-line Arguments

While you can hardcode the XML file name into your program, it makes the program less flexible. It would be much nicer if (as in the description of the étude) you could specify the file name to process on the command line.

To get command-line arguments, use the `arg` property of the global `js/process` variable. Element 0 is `"node"`, element 1 is the name of the JavaScript file, and element 2 is where your command line arguments begin. Thus, you can get the file name with:

```
(nth (.-argv js/process) 2)
```

Mutually Recursive Functions

In my solution, I created two separate functions: the `process-children` function iterates through all the `childs`, calling the `process-child` function for each of them. However, a child element could itself have children, so `process-child` had to be able to call `process-children`. The term for this sort of situtation is that you have *mutually recursive functions*. Here's the problem: ClojureScript requires you to define a function before you can use it, so you would think that you can't have mutually recursive functions. Luckily, the inventor of Clojure foresaw this sort of situation and created the `declare` form, which lets you declare a symbol that you will define later. Thus, I was able to write code like this:

```
(declare process-child)

(defn process-children [...]
   (process-child ...))

(defn process-child [...]
   (process-children ...))
```

Just because I used mutually recursive functions to solve the problem doesn't mean you have to. If you can find a way to do it with a single recursive function, go for it. I was following the philosophy of "the first way you think of doing it that works is the right way."

There's a lot of explanation in this étude, and you are probably thinking this is going to be a huge program. It sure seemed that way to me while I was writing it, but it turned out that was mostly because I was doing lots of tests in the REPL and looking things up in documentation. When I looked at the resulting program, it was only 45 lines. Here it is: "Solution 4-1" on page 76.

Étude 4-2: Condiment Server

Now that you have the map from the previous étude, what can you do with it? Well, how many times have you been staring at that jar of mustard and asking yourself "What food would go well with this?" This étude will cure that indecision once and for all. You will write a server using Express, which, as the website says, is a "minimalist web framework for Node.js." This article about using ClojureScript and Express was very helpful when I was first learning about the subject; I strongly suggest you read it.

Let's set up a simple server that you can use as a basis for this étude. The server presents a form with an input field for the user's name. When the user clicks the submit button, the data is submitted back to the server and it echoes back the form and a message: "Pleased to meet you, *username*."

Setting Up Express

You will need to do the following:

1. Add `[express "4.11.1"]` to the `:node-dependencies` in your *project.clj* file.
2. Add `[cljs.nodejs :as nodejs]` to the `(:require...)` clause of the namespace declaration at the beginning of *core.cljs*.
3. Add `(def express (nodejs/require "express"))` in your *core.cljs* file
4. Make your `main` function look like this:

   ```
   (defn -main []
     (let [app (express)]
       (.get app "/" generate-page!)
   ```

```
        (.listen app 3000
                 (fn []
                   (println "Server started on port 3000")))))
```

This starts a server on port 3000, and when it receives a `get` request, calls the `generate-page!` function. (You can also set up the server to accept `post` requests and route them to other URLs than the server root, but that is beyond the scope of this book.)

Generating HTML from ClojureScript

To generate the HTML dynamically, you will use the `html` function of the hiccups library. The function takes as its argument a vector that has a keyword as an element name, an optional map of attributes and values, and the element content. Here are some examples:

HTML	Hiccup
<h1>Heading</h1>	(html [:h1 “Heading"])
<p id="intro">test</p>	(html [:p {:id “intro"} test])
<p>Click to <a href="page2.html">go to page two</a>.</p>	(html [:p “Click to " [:a {:href “page2.html"} “go to page two"] “."])

You add `[hiccups "0.3.0"]` to your *project.clj* dependencies and modify your *core.cljs* file to require hiccups:

```
(ns servertest.core
  (:require-macros [hiccups.core :as hiccups])
  (:require [cljs.nodejs :as nodejs]
            [hiccups.runtime :as hiccupsrt]))
```

You are now ready to write the `generate-page!` function, which has two parameters: the HTTP request that the server received, and the HTTP response that you will send back to the client. The property `(.-query request)` is a JavaScript object with the form names as its properties. Consider a form entry like this:

```
<input type="text" name="userName"/>
```

You would access the value via `(.-userName (.-query request))`.

The `generate-page!` function creates the HTML page as a string to send back to the client; you send it back by calling `(.send response` ***`html-string`***`)`. The HTML page will contain a form whose `action` URL is the server root (`/`). The form will have an input area for the user name and a submit button. This will be followed by a paragraph that has the text “Pleased to meet you, *username*.” (or an empty paragraph if there’s no username). You can either figure out this code on your own or see a suggested solution. I’m giving you the code here because the purpose of this étude is to process the condiment map in the web page context rather than setting up the web page in the first place. (Of course, I strongly encourage you to figure it out on your own; you will learn a lot—I certainly did!)

Putting the Étude Together

Your program will use the previous étude's code to build the map of condiments and compatible foods from the XML file. Then use the same framework that was developed in "Generating HTML from ClojureScript" on page 31, with the generated page containing:

- A form with a `<select>` menu that gives the condiment names (the keys of the map). You may want to add an entry with the text "Choose a condiment" at the beginning of the menu to indicate "no choice yet." When you create the menu, remember to select the `selected="selected"` attribute for the current menu choice.
- A submit button for the form.
- An unordered list that gives the matching foods for that condiment (the value from the map), or an empty list if no condiment has been chosen.

Your code should alphabetize the condiment names and compatible foods. Some of the foods begin with capital letters, others with lowercase. You will want to do a case-insensitive form. (Hint: use the form of `sort` that takes a comparison function.)

See a suggested solution: "Solution 4-2B" on page 78. To make the program easier to read, I put the code for creating the map into a separate file with its own namespace.

Étude 4-3: Maps—Frequency Table

This étude uses an excerpt of the Montgomery County, Maryland (USA) traffic violation database, which you may find at this URL. I have taken only the violations for July 2014, removed several of the columns of the data, and put the result into a tab-separated value file named *traffic_july_2014_edited.csv*, which you may find in the GitHub repository. (Yes, I know CSV should be comma-separated, but using the Tab key makes life much easier.)

Here are the column headings:

- Date of Stop, in format *mm/dd/yyyy*
- Time of Stop, in format *hh:mm:ss*
- Description
- Accident (Yes/No)
- Personal Injury (Yes/No)
- Property Damage (Yes/No)
- Fatal (Yes/No)

- State (two-letter abbreviation)
- Vehicle Type
- Year
- Make
- Model
- Color
- Violation Type (Warning/Citation/ESERO [Electronic Safety Equipment Repair Order])
- Charge (Maryland Government traffic code section)
- Race
- Gender
- Driver's State (two-letter abbreviation)
- Driver's License State (two-letter abbreviation)

As you can see, you have a treasure trove of data here. For example, one reason I chose July is that I was interested in seeing if the number of traffic violations was greater around the July 4 holiday (in the United States) than during the rest of the month.

If you look at the data, you will notice the "Make" (vehicle manufacturer) column would need some cleaning up to be truly useful. For example, there are entries such as TOYOTA, TOYT, TOYO, and TOUOTA. Various other creative spellings and abbreviations abound in that column. Also, the Scion is listed as both a make and a model. Go figure.

In this étude, you are going to write a Node.js project named *frequency*. It will contain a function that reads the CSV file and creates a data structure (I suggest a vector of maps) for each row. For example:

```
[{:date "07/31/2014", :time "22:08:00" ... :gender "F", :driver-state "MD"},
  {:date "07/31/2014", :time "21:27:00" ... :gender "F", :driver-state "MD"},
   ...]
```

Hints:

- For the map, define a vector of heading keywords, such as:

  ```
  (def headings [:date :time ... :gender :driver-state])
  ```

  If there are columns you don't want or need in the map, enter `nil` in the vector.

- Use `zipmap` to make it easy to construct a map for each row. You will have to get rid of the `nil` entry; `dissoc` is your friend here.

You will then write a function named `frequency-table` with two parameters:

1. The data structure from the CSV file
2. A column specifier

You can take advantage of ClojureScript's higher-order functions here. The specifier is a function that takes one entry (a "row") in the data structure and returns a value. So, if you wanted a frequency table to figure out how many violations there are in each hour of the day, you would write code like this:

```
(defn hour [csv-row]
  (.substr (csv-row :time) 0 2))

(defn frequency-table [all-data col-spec]
  ;; your code here
)

;; now you do a call like this:
(frequency-table traffic-data hour)
```

Note that, because keyword access to maps works like a function, you could get the frequency of genders by doing this call:

```
(frequency-table traffic-data :gender)
```

The return value from `frequency-table` will be a vector that consists of:

- A vector of labels (the values from the specified column), sorted
- A vector giving the frequency counts for each label
- The total count

The return value from the call for gender looks like this: `[["F" "M" "U"] [6732 12776 7] 19515]`. Hint: build a map whose keys are labels and whose values are their frequency, then use `seq`.

Some frequency tables that might be interesting include the color of car (which colors are most likely to have a violation?) and the year of car manufacture (are older cars more likely to have a violation?). To be sure, there are other factors at work here. Car colors are not equally common, and there are fewer cars on the road that were manufactured in 1987 than were made last year. This étude is meant to teach you to use maps, not to make rigorous, research-ready hypotheses.

Reading the CSV File

Reading a file one line at a time from Node.js is a nontrivial matter. Luckily for you and me, Jonathan Boston (Twitter/GitHub: bostonou), author of the ClojureScript Made Easy blog, posted a wonderful solution just days before I wrote this étude. He has kindly given me permission to use the code, which you can get at this GitHub gist. Follow the instructions in the gist, and separate the Clojure and ClojureScript code. Your *src* directory will look like this:

```
src
├── cljs_made_easy
│   ├── line_seq.clj
│   └── line_seq.cljs
└── traffic
    └── core.cljs
```

Inside the *core.cljs* file, you will have these requirements:

```
(ns traffic.core
  (:require [cljs.nodejs :as nodejs]
            [clojure.string :as str]
            [cljs-made-easy.line-seq :as cme]))

(def filesystem (js/require "fs")) ;;require nodejs lib
```

You can then read a file like this, using `with-open` and `line-seq` very much as they are used in Clojure. In the following code, the call to `.openSync` has three arguments: the filesystem defined earlier, the filename, and the file mode, with `"r"` for reading:

```
(defn example [filename]
  (cme/with-open [file-descriptor (.openSync filesystem filename "r")]
             (println (cme/line-seq file-descriptor))))
```

Note: you may want to use a smaller version of the file for testing. The code repository contains a file named *small_sample.csv* with 14 entries.

See a suggested solution: "Solution 4-3" on page 80.

Étude 4-4: Complex Maps—Cross-Tabulation

Add to the previous étude by writing a function named `cross-tab`; it creates frequency cross-tabluations. It has these parameters:

- The data structure from the CSV file
- A row specifier
- A column specifier

Again, the row and column specifiers are functions. So, if you wanted a cross-tabulation with hour of day as the rows and gender as the columns, you might write code like this:

```
(defn hour [csv-row]
  (.substr (csv-row :time) 0 2))

(defn cross-tab [all-data row-spec col-spec]
  ;; your code here
  )

;; now you do a call like this:
(crosstab traffic-data hour :gender)
```

The return value from `cross-tab` will be a vector that consists of:

- A vector of row labels, sorted
- A vector of column labels, sorted
- A vector of vectors that gives the frequency counts for each row and column
- A vector of row totals
- A vector of column totals

The previous search on the full data set returns this result, reformatted to avoid excessively long lines:

```
(cross-tab traffic-data hour :gender)
[["00" "01" "02" "03" "04" "05" "06" "07" "08" "09" "10" "11" "12"
"13" "14" "15" "16" "17" "18" "19" "20" "21" "22" "23"] ["F" "M" "U"]
[[335 719 0] [165 590 0] [141 380 0] [96 249 0] [73 201 0] [63 119 0]
[129 214 2] [380 625 0] [564 743 1] [481 704 0] [439 713 1] [331 527 0]
[243 456 0] [280 525 0] [344 515 0] [276 407 0] [307 514 1] [317 553 0]
[237 434 1] [181 461 0] [204 553 1] [289 657 0] [424 961 0] [433 956 0]]
[1054 755 521 345 274 182 345 1005 1308 1185 1153 858 699 805 859 683
822 870 672 642 758 946 1385 1389] [6732 12776 7] 19515]
```

Here are some of the cross-tabulations that might be interesting:

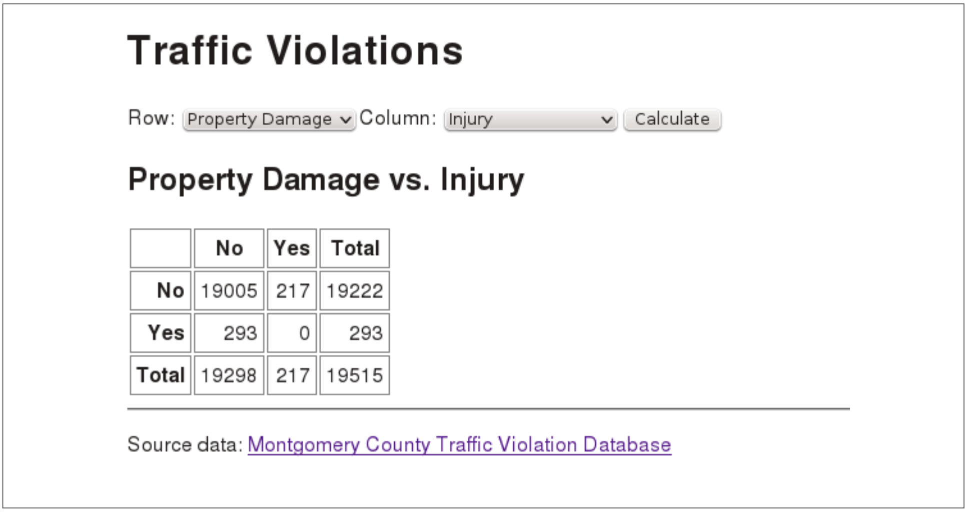
- Day by hour: the marginal totals will tell you which days and hours have the most violations. Are the days around July 4, 2014 (a US holiday) more active than other days? Which hours are the most and least active?
- Gender by color of vehicle: (although the driver might not be the person who purchased the car).
- Driver's state by property damage: are out-of-state drivers more likely to damage property than in-state drivers?

Bonus points: write the code such that if you give `cross-tab` a `nil` for the column specifier, it will still work, returning only the totals for the row specifier. Then, reimplement `frequency-table` by calling `cross-tab` with `nil` for the column specifier. Hint: you will have to take the vector of vectors for the "cross-tabulation" totals and make it a simple vector. Either `map` or `flatten` will be useful here.

See a suggested solution: "Solution 4-4" on page 82.

Étude 4-5: Cross-Tabulation Server

Well, as you can see, the output from the previous étude is ugly to the point of being nearly unreadable. This rather open-ended étude aims to fix that. Your mission, should you decide to accept it, is to set up the code in an Express server to deliver the results in a nice, readable HTML table. Here are some of the things I found out while coming up with a solution, a screenshot of which appears in Figure 4-1:



Traffic Violations

Row: Property Damage ⌄ Column: Injury ⌄ Calculate

Property Damage vs. Injury

	No	Yes	Total
No	19005	217	19222
Yes	293	0	293
Total	19298	217	19515

Source data: Montgomery County Traffic Violation Database

Figure 4-1. Screenshot of traffic cross-tabulation table

- I wanted to use as much of the code from "Étude 4-2: Condiment Server" on page 30 as possible, so I decided on drop-down menus to choose the fields. However, a map was not a good choice for generating the menu. In the condiment server, it made sense to alphabetize the keys of the food map. In this étude, the field names are listed by conceptual groups; it doesn't make sense to alphabetize them, and the keys of a map are inherently unordered. Thus, I ended up making a vector of vectors.
- I used `map-indexed` to create the option menu such that each option has a numeric value. However, when the server reads the value from the request, it gets a string, and 5 is not equal to `"5"`. The fix was easy, but I lost a few minutes figuring out why my selected item wasn't coming up when I came back from a request.
- The source file felt like it was getting too big, so I put the cross-tabulation code into a separate file named *crosstab.cljs* in the *src/traffic* directory.
- I wanted to include a CSS file, so I put the specification in the header of the hiccups code. However, to make it work, I had to tell Express how to serve static files, using `"."` for the root directory in:

  ```
  (.use app (.static express "path/to/root/directory"))
  ```

- Having the REPL is really great for testing.
- I finished the program late at night. Again, "the first way you think of doing it that works is the right way," but I am unhappy with the solution. I would really like to unify the cases of one-dimensional and two-dimensional tables, and there

seems to be a dreadful amount of unnecessary duplication. To paraphrase Don Marquis, my solution “isn’t moral, but it might be expedient.”

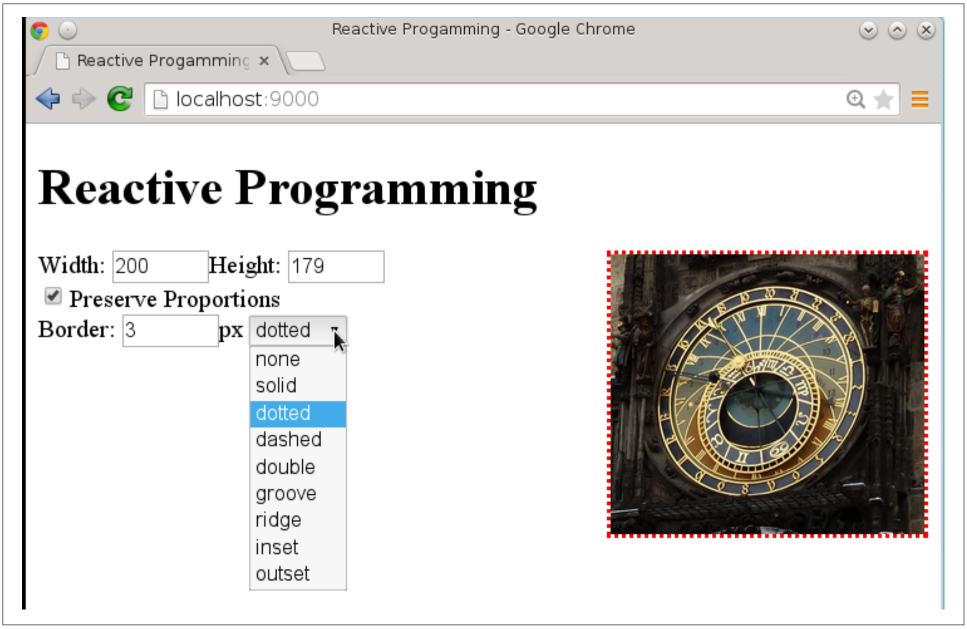
See a suggested solution (which I put in a project named *traffic*): “Solution 4-5” on page 84.

CHAPTER 5
Programming with React

Facebook®'s React JavaScript library is designed to make user interfaces easier to build and manage. React builds a virtual DOM to keep track of and render only the elements that change during user interaction. (As noted in Chapter 2, this is what all the Cool Kids™ are using.)

In this chapter, you will write études that use different ClojureScript libraries that interface with React. This blog post gives you a comparison of the libraries. The two we will use are Quiescent and Reagent.

These études will implement the same web page: a page that displays an image and lets you adjust its width, height, and (via CSS) its border width and style (Figure 5-1). In both libraries, you will build *components*, which are functions that, as the Quiescent documentation puts it, tell "how a particular piece of data should be rendered to the DOM." Since they are functions, they can use all of ClojureScript's computational power.



Reactive Programming

Width: 200 Height: 179

☑ Preserve Proportions

Border: 3 px dotted

Figure 5-1. Screenshot of image resize web page

The HTML for the page will include a `<div id="interface">`, which is where the components will go.

Both versions of this étude will declare an `atom` (with a slight variation for Reagant) to hold the state of the application in a map. Let's do a quick review of atoms by defining an atom with a single value:

```
(def quantity (atom 32))
cljs.user=> #<Atom:32>
```

To access the data in an atom, you must dereference it with the `@` operator:

```
cljs.user=>@quantity
32
```

To update an atom's data, use the `swap!` function (for individual map values) and `reset!` (for the entire value of the atom). The `swap!` function takes as its arguments:

- The atom to be modified
- A function to apply to the atom
- The arguments to that function (if any)

Thus, in the REPL:

```
cljs.user=> (swap! quantity inc)
33
```

```
cljs.user=> (swap! quantity * 2)
66
cljs.user=> (reset! quantity 47)
47
cljs.user=> quantity
#<Atom: 47>
cljs.user=> @quantity
47
```

However, in most ClojureScript programs, you do not create an atom for each part of the state you need to save. Instead, you will most often use a map:

```
cljs.user=> (def inventory (atom {:quantity 32 :price 3.75}))
#<Atom: {:quantity 32, :price 3.75}>
cljs.user=> (swap! inventory assoc :price 4.22)
{:quantity 32, :price 4.22}
cljs.user=> (swap! inventory update :quantity inc)
{:quantity 33, :price 4.22}
cljs.user=> @inventory
{:quantity 33, :price 4.22}
```

Back to the program for this étude. The page has to keep track of:

- The image's current width and height
- Whether you want the width and height to stay in proportion or not
- The border width and style (intially three pixels solid)—the color will be set to red for visibility
- The image's original width and height (needed to do proportional scaling properly)
- The image filename

That gives us this atom:

```
(defonce status
         (atom {:w 0 :h 0 :proportional true
                :border-width 3 :border-style "solid"
                :orig-w 0 :orig-h 0 :src "clock.jpg"}))
```

Étude 5-1: Reactive Programming with Quiescent

To use Quiescent, add `[quiescent "0.2.0-alpha1"]` to your project's dependencies, and add requirements to your namespace:

```
(:require [quiescent.core :as q]
  [quiescent.dom :as d])
```

As an example, let's define a simple component that displays an input area and some text that goes with the `w` field in the atom that was defined previously:

```
(q/defcomponent Example
  :name "Example"
  [status]
  (d/div {}
    "Your input here: "
    (d/input {:type "text"
              :value (:w status)
              :size "5"})
    (d/br)
    "Your input, squared: "
    (d/span {} (* (:w status) (:w status)))))
```

The general format for creating an HTML element inside a component is to give its element name, a map of its attributes (or the empty map `{}` if there are no attributes, as on the `div`), and the element content, which may contain other elements. The `:name` before the parameter list gives the component a name for React to use. The key/value pairs before the parameter list make up the component configuration; this is described in detail in the Quiescent Documentation. The value of the input field and `span` are provided by the current value of the `:w` key in the `status` atom.

The only thing remaining to do is to render the component. In Quiescent, the `q/render` function renders a component once. If you want continuous rendering, you can use JavaScript's `requestAnimationFrame` to repeat the process. Remember, when using React, only the components that have changed get rerendered, so you don't need to worry that using `requestAnimationFrame` will eat your CPU alive:

```
(defn render
  "Render the current state atom, and schedule a render on the next frame"
  []
  (q/render (Example @status) (aget (.getElementsByTagName js/document
                                                           "body") 0))
  (.requestAnimationFrame js/window render))

  (render)
```

Quiescent's `render` function takes two arguments: a call to the component with its argument—in this case, the dereferenced atom—and the DOM node where you want the component rooted. For this example, that's the first (and, we hope, only) `<body>` element.

If you compile this code and then load the *index.html* file, you will see a zero in the input and output area—but you will also find that you cannot type into the field. That is because Quiescent and React always keep the DOM value and the atom value synchronized, and since the value in the atom never changes, neither can the field. To fix that, add this code to the input element (it is in bold):

```
(d/input {:type "text"
        :value (:w status)
        :onChange update-value
        :size "5"})
```

Next, write the update-value function, which takes the value from the event target and puts it into the atom that keeps the page's state:

```
(defn update-value [evt]
  (swap! status assoc :w (.-value (.-target evt))))
```

Voilà—your page now updates properly.

Hints

1. You will have to initialize the values for the image's original width and height. To do this, you add an :onLoad clause to the properties of the image component. Its value is a function that handles the event by setting the width, height, original width, and original height. Use the naturalWidth and naturalHeight properties of the image. Those properties do not work with Internet Explorer 8 but will work in Intenet Explorer 9+.

2. Handling the checkbox also requires some extra care. The value of the checked attribute isn't the checkbox's value, so you will have to use :on-mount to initialize the checkbox, and you will have to directly change the checkbox status with code like this:

   ```
   (set! (.-checked (.getElementById js/document "prop"))
   ```

   Here is an example of :on-mount to initialize the example's input field to the current minute of the hour. :on-mount is followed by the definition of a function that has the current node as its argument:

   ```
   (q/defcomponent Example
     :name "Example"
     :on-mount (fn [node]
       (swap! status assoc :w (.getMinutes (js/Date.))))
     [status]
     ;; etc.
   ```

3. If you want to use a list to initialize the drop-down menu, you will need to define a component for menu options and then use apply and map cleverly. This took me a *long* time to get right, so I'm giving you the code for free with an abbreviated example:

   ```
   (q/defcomponent Option
     [item]
     (d/option {:value item} item))

   ;; then, in the component that builds the form:
   ```

```
    (apply d/select {:id "menu" :onChange change-border}
      (map Option ["none" "solid" "dotted" "etc."]))
```

See a suggested solution: "Solution 5-1" on page 88.

Étude 5-2: Reactive Programming with Reagent

To use Reagent, add `[reagent "0.5.0"]` to your project's dependencies and add this requirement to your namespace:

```
(:require [reagent.core :as reagent :refer [atom])
```

Note the `:refer [atom]` clause; Reagent has its own definition of `atom` that plays nicely with React; it is defined so that you can use it exactly the way you would use a normal ClojureScript atom.

As an example, let's define a simple component that displays an input area and some text that goes with the `w` field in the atom that was defined previously:

```
(defn example []
 [:div
  "Your input here:"
  [:input {:type "text"
           :value (:w @status)
           :size "5"}]
  [:br]
  "Your input, squared: "
  [:span (* (:w @status) (:w @status))]])
```

The general format for creating an HTML element inside a component is to create a vector whose first element is a keyword giving the HTML element name, a map of its attributes (if any), and the element content, which may contain other elements. The value of the input field and `span` are provided by the current value of the `:w` key in the `status` atom. Unlike Quiescent, you must dereference the atom.

The only thing remaining to do is to render the component. You don't have to request animation frames; Reagent handles that for you:

```
(defn run []
  (reagent/render [example]
                  (aget (.getElementsByTagName js/document "body") 0)))

(run)
```

Reagent's `render` function takes two arguments: a call to the component and the DOM node where you want the component rooted, in this case, the first (and, we hope, only) <body> element.

If you compile this code and then load the *index.html* file, you will see a zero in the input and output area—but you will also find that you cannot type into the field. That is because Reagent and React always keep the DOM value and the atom value synchronized, and since the value in the atom never changes, neither can the field. To fix that, add this code to the input element (it is in bold):

```
(d/input {:type "text"
        :value (:w status)
        :on-change update-value
        :size "5"})
```

Next, write the `update-value` function, which takes the value from the event target and puts it into the atom that keeps the page's state:

```
(defn update-value [evt]
  (swap! status assoc :w (.-value (.-target evt))))
```

Voilà—your page now updates properly.

Hints

1. You will have to initialize the values for the image's original width and height. To do this, you add an `:on-load` clause to the properties of the image component. Its value is a function that handles the event by setting the width, height, original width, and original height. Use the `naturalWidth` and `naturalHeight` properties of the image. Those properties do not work with Internet Explorer 8, but will work in Intenet Explorer 9+.

2. Handling the checkbox also requires some extra care. The value of the `checked` attribute isn't the checkbox's value, so you will have to directly change the checkbox status with code like this:

   ```
   (set! (.-checked (.getElementById js/document "prop"))
   ```

   Initializing the checkbox takes a bit more work in Reagent. You must define a symbol that adds meta-information to the `example` component. This information includes a function that does the initialization. Here is an example that initializes the example's input field to the current minute of the hour. You then render the new component:

   ```
   (def init-example
     (with-meta example
       {:component-will-mount
        (fn [this]
          (swap! status assoc :w (.getMinutes (js/Date.))))}))
   ```

3. If you want to use a list to initialize the drop-down menu, you will need to define a component for menu options and then use `for`. This took me a *long* time to get right, so I'm giving you the code for free with an abbreviated example. React is not happy if each `option` does not have a unique key, so this code adds it:

```
(defn option [item]
  [:option {:value item :key item} item])

;; then, in the component that builds the form:
[:select {:id "menu" :on-change change-border}
  (for [item ["none" "solid" "dotted" "etc."]]
     (option item))]])
```

See a suggested solution: "Solution 5-2" on page 90.

CHAPTER 6

Interlude: Room Usage Project

Once again, it's time to put together what you have learned into a somewhat open-ended project. Presume you are an administrator at a college and need to know how well the classroom buildings are utilized. The github repostiory for this book has a file named *roster.csv* in the *datafiles/chapter06/building_usage* directory. The roster file contains data for a list of class sections at a community college. This is real data, except the room numbers have been changed to "anonymize" the data. The file consists of a series of lines like this:

```
24414;201;ACCTG;022;Payroll Accounting;TTH;06:30 PM;08:20 PM;N190
22719;201;ART;012;Two Dimensional Design;MW;01:45 PM;02:35 PM;P204
22719;201;ART;012;Two Dimensional Design;MW;02:45 PM;04:35 PM;P204
```

The columns are the registration ID number, the section number, department, course number, course title, days of the week when the course meets, beginning and ending time, and room number. In the field for the days of the week, Thursday is represented as TH, Saturday as S, and Sunday as SU (yes, there are some Sunday classes).[1]

The ultimate goal of this chapter is to produce a program that will let you visualize the percentage use of each building at a particular time and day of week. (If you like, you can expand this étude to visualize usage on a room-by-room basis, but building usage is more generally useful. This is because not all rooms are interchangeable. For example, a chemistry lab may appear underutilized, but you can't put a history class in that room when it's not in use.)

[1] You may have noticed that the last two lines in the example have the same registration ID and section number. This is not an error. The first of the entries is the lecture part of the course and the second is the lab part. These are distinguished by an "instructional method" column that has not been included in the sample data.

Étude 6-1: Build the Data Structure

You have a lot of options in this étude. Phrasing them in the form of questions:

- Should you include the CSV text as a large string?
  - If so, do you include all the columns or just the ones you need for this project?
  - If you don't want to have a large string, you may end up writing a Node.js program that takes the data file and creates a ClojureScript source file.
- How will you index the data?
  - Day of week → time of day → building
  - Time of day → building → day of week
  - Building → day of week → time of day
  - Some other combination
- Should the data for time of day be an array, map, or some other data structure?
- Should you index days of the week by number or as a map?
- What is the granularity of time of day? Hourly, every 30 minutes, every 15 minutes, or some other unit?

Unless you decide on a single level map or vector, you will want to look at the `get-in` and `assoc-in` functions for accessing and modifying data in a nested associative structure.

In order to calculate the percentage of utilization, you will also need to know the number of distinct rooms in each building. Note that the utilization could be more than 100%. For example, there may be classes that are concurrent in different disciplines; an "introduction to computer technology" might be listed under both BIS (business information systems) and CIT (computer and information technology). Or, an open writing lab may be shared by several English classes at the same time.

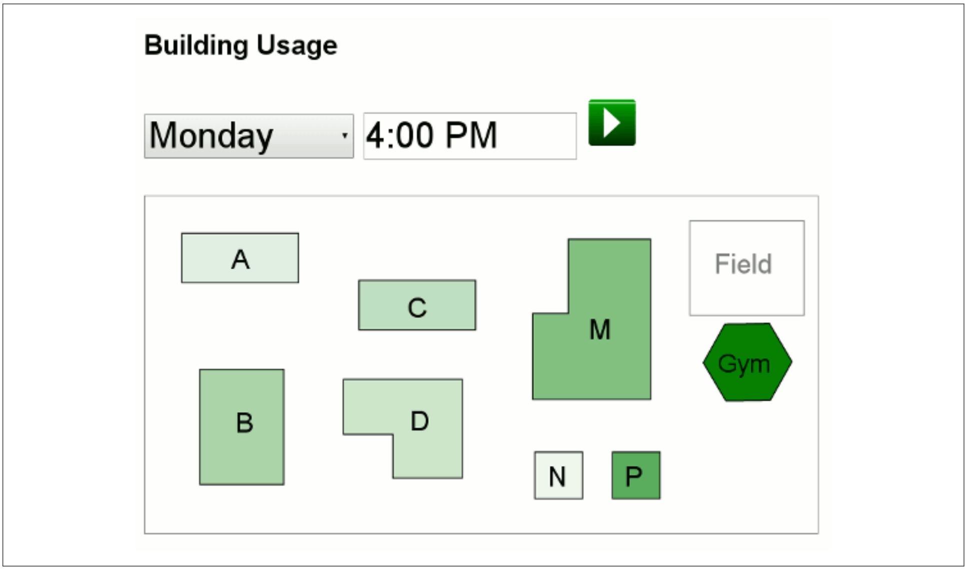
This is *your* implementation, so you get to make all these decisions. See what I came up with: "Solution 6-1" on page 93.

Étude 6-2: Visualizing the Data (Version 1)

Now that you have the data in a format that you like, choose a visualization. The one I decided on originally was to use a map of the campus, which is in a file named *campus_map.svg* in the *datafiles* folder in the github repository. The file has each building in a `<g>` element with an appropriate `id`; for example, the SVG for building B starts like this:

```
    <g>
      <title id="group_B">0%</title>
      <rect
        transform="matrix(0,1,-1,0,0,0)"
        y="-123.85256" x="906.50964" height="74.705124" width="102.70512"
        id="bldg_B"
        style="fill:green;fill-opacity:0;stroke:#000000;stroke-opacity:1" />
```

The program lets you choose a day and time of day; when either of those fields changes, the program calculates the percentage of usage of each building and adjusts the `fill-opacity` and `<title>` contents. (I used green for the fill color, because the more the building is in use, the better it is.) Figure 6-1 shows what the resulting page looks like. The “play” button will start advancing time 15 minutes every 1.5 seconds and updating the map automatically.



Building Usage

Monday

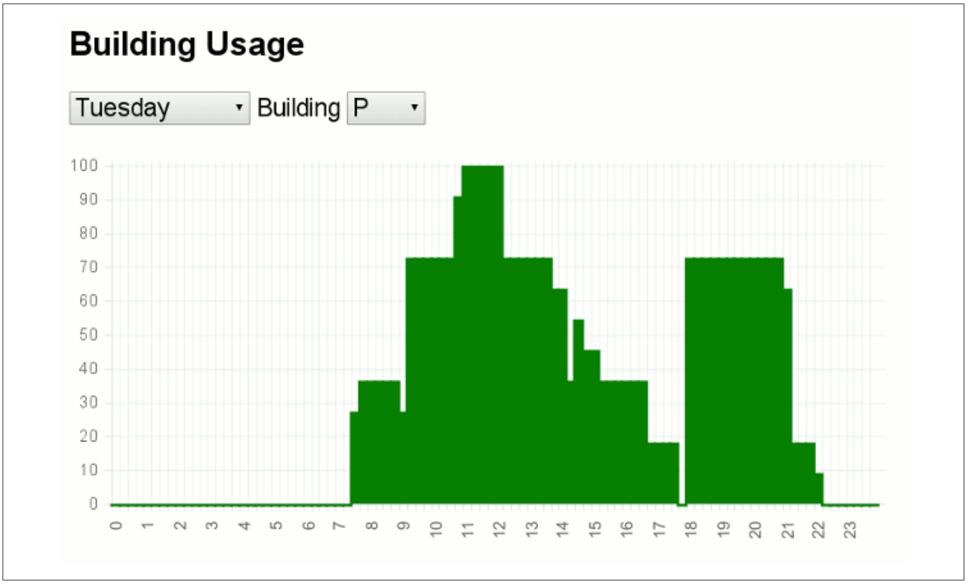
4:00 PM

Figure 6-1. Screenshot of building usage animation

See a suggested solution: “Solution 6-2” on page 95.

Étude 6-3: Visualizing the Data (Version 2)

I learned a lot of interesting things while writing the preceding étude, but, to be honest, it didn’t look anywhere near as exciting as I thought it would. A more traditional visualization—a bar chart—gives a lot more information in a very readable form, as you can see in Figure 6-2.



Building Usage

Tuesday ▾ Building P ▾

Figure 6-2. Screenshot of building usage bar chart

While it would be an interesting exercise to write a bar chart program, it is easier to use an existing library, so I downloaded Chart.js (version 1.0, not the alpha version 2.0 as of this writing) and installed the minimized JavaScript in the *public* directory. You may use any charting package you wish for your solution. If you feel tremendously ambitious, you may write your own.

See a suggested solution: "Solution 6-3" on page 98.

CHAPTER 7

Records and Protocols

In this chapter, you will write études that use `defprotocol` and `defrecord` to implement addition, subtraction, multiplication, and division of rational and complex numbers.

As an example, we will build a record that keeps track of a duration in terms of minutes and seconds, and implement a protocol that can add two durations and can convert a duration to a string. It is in a project named *proto*:

```
(defrecord Duration [min sec])
```

Once you have this record defined, you can use it as follows:

```
proto.core=> ;; Create a new duration of 2 minutes and 29 seconds
proto.core=> (def d (Duration. 2 29))
#proto.core.Duration{:min 2, :sec 29}
proto.core=> (:min d) ;; extract values
2
proto.core=> (:sec d)
29
```

Since a duration is a special kind of number, we will implement a protocol for handling special numbers. It has two methods: `plus` (to add two special numbers) and `canonical` (to convert the special number to "canonical form." For example, the canonical form of 2 minutes and 73 seconds is 3 minutes and 13 seconds:

```
(defprotocol SpecialNumber
    (plus [this other])
    (canonical [this]))
```

The `plus` method takes two parameters: `this` record and an `other` duration. When you define protocols, the first parameter of every method is the object you are interested in manipulating.

Now you can implement these methods by adding to `defrecord`. Here is the code for `canonical`:

```
(defrecord Duration [min sec]
    SpecialNumber

    (plus [this other]
        "Just add minutes and seconds part,
        and let canonical do the rest."
        (let [m (+ (:min this) (:min other))
              s (+ (:sec this) (:sec other))]
            (canonical (Duration. m s))))

    (canonical [this]
        (let [s (mod (:sec this) 60)
              m (+ (:min this) (quot (:sec this) 60))]
            (Duration. m s))))
```

And it works:

```
proto.core=> (canonical (Duration. 2 29))
#proto.core.Duration{:min 2, :sec 29}
proto.core=> (canonical (Duration. 2 135))
#proto.core.Duration{:min 4, :sec 15}
proto.core=> (plus (Duration. 2 29) (Duration. 3 40))
#proto.core.Duration{:min 6, :sec 9}
```

That's all very nice, but what if you want to display the duration in a form that looks nice, like `2:09`? You can do this by implementing the `toString` method of the `Object` protocol. Add this code to the `defrecord`:

```
    Object
    (toString [this]
        (let [s (:sec this)]
            (str (:min this) ":" (if (< s 10) "0" "") s)))
```

And voilà! `str` will now convert your durations properly:

```
proto.core=> (str (Duration. 4 45))
"4:45"
```

Étude 7-1: Rational Numbers

Clojure has rational numbers; if you enter `(/ 6 8)` in the REPL, you get back `3/4`. ClojureScript doesn't do that, so you will implement rational numbers by adding the `minus`, `mul`, and `div` methods to the `SpecialNumbers` protocol. You will then define a record named `Rational` for holding a rational number using its numerator and denominator. Implement all the methods of the protocol for rational numbers (including `canonical` and `toString`).

The canonical form of a rational number is the fraction reduced to lowest terms, with the denominator always positive; thus:

```
proto.core=> (canonical (Rational. 6 8))
#proto.core.Rational{:num 3, :denom 4}
proto.core=> (canonical (Rational. 6 -9))
#proto.core.Rational{:num -2, :denom 3}
```

To reduce a fraction, you divide its numerator and denominator by the greatest common divisor (GCD) of the two numbers. The GCD is defined only for positive numbers. Here is Dijkstra's algorithm for the GCD of numbers *m* and *n*:

- If *m* equals *n*, return *m*.
- If *m* is greater than *n*, return the GCD of (*m* – *n*) and *n*.
- Otherwise, return the GCD of *m* and (*n* – *m*).

The cool thing about this algorithm for finding the greatest common divisor is that it doesn't do any division at all! Notice that it is recursively defined, so this is a wonderful place for you to learn to use `recur`. (Hint: `cond` is also quite useful here.)

When converting to canonical form, if you have a zero in the numerator, just keep the rational number exactly as it is.

See a suggested solution: "Solution 7-1" on page 101.

Étude 7-2: Complex Numbers

Extend this project further by adding a record and protocol for complex numbers. A complex number has the form *a* + *b*i, where *a* is the real part and *b* is the imaginary part. The letter "i" stands for the square root of negative 1.

Here are formulas for doing arithmetic on complex numbers:

$$(a + bi) + (c + di) = (a + c) + (b + d)i$$

$$(a + bi) - (c + di) = (a - c) + (b - d)i$$

$$(a + bi)(c + di) = (ac - bd) + (bc + ad)i$$

$$\frac{a + bi}{c + di} = \left(\frac{ac + bd}{c^2 + d^2}\right) + \left(\frac{bc - ad}{c^2 + d^2}\right)i$$

The canonical form of a complex number is just itself. Here is what conversion of complex numbers to strings should look like:

```
proto.core=> (str (Complex. 3 7))
"3+7i"
proto.core=> (str (Complex. 3 -7))
"3-7i"
proto.core=> (str (Complex. 3 0))
"3"
```

```
proto.core=> (str (Complex. 0 3))
"3i"
proto.core=> (str (Complex. 0 -3))
"-3i"
proto.core=> (str (Complex. 0 7))
"7i"
proto.core=> (str (Complex. 0 -7))
"-7i"
```

See a suggested solution: "Solution 7-2" on page 102.

Étude 7-3: Writing Tests

Through the book so far, I have been very lax in writing unit tests for my code. At least for this chapter, that changes.

Many projects put their tests in a separate *test* folder, so you should create one now, and, inside of it, make a file named *test_cases.cljs*. Then give it these contents (they presume that your project is named *proto*):

```
(ns ^:figwheel-always test.test-cases
  (:require-macros [cljs.test :refer [deftest is are]])
  (:require [cljs.test :as t]
            [proto.core :as p]))
```

Notice that the namespace is `test-cases`; the filename is translated to *test_cases*.

The `^:figwheel-always` is metadata that tells Figwheel to reload the code on every change to the file.

The `:require-macros` is something new; macros are like functions, except that they generate ClojureScript code. The three macros that you will use are `deftest`, `is`, and `are`. First, let's define a test that will check that the canonical form of 3 minutes and 84 seconds is 4 minutes and 24 seconds:

```
(deftest duration1
  (is (= (p/canonical (p/Duration. 3 84)) (p/Duration. 4 24))))
```

The `deftest` macro creates the test, and the `is` macro makes a testable assertion; the body of `is` should yield a Boolean value. You can run tests from the REPL:

```
cljs.user=> (in-ns 'proto.core)
nil
proto.core=> (require '[cljs.test :as t])
nil
proto.core=> (t/run-tests 'test.test-cases)

Testing test.test-cases

Ran 1 tests containing 1 assertions.
```

```
0 failures, 0 errors.
nil
```

If you want to test several additions, you could write several different `deftests`; but if they all follow the same model, you can use `are`, which is followed by a vector of parameter names, an expression to evaluate (which can contain `let`), and then a series of sets of arguments to be evaluated. In the following example, the parameter names vector is on the first line, the second and third line are the expression to evaluate, and the remaining lines are sets of arguments to assert. (Thus, the first set will plug in 1 for `m1`, 10 for `s1`, and `"1:10"` for `expected` and then test the expression with those values.)

```
(deftest duration-str
  (are [m1 s1 expected]
    (= (str (p/Duration. m1 s1) expected))
    1 10  "1:10"
    1 9 "1:09"
    1 60 "2:00"
    3 145 "5:25"
    0 0 "0:00")
```

You cannot use destructuring in the arguments to `are`, but you can use destructuring in a `let` within the expression you are testing. Also, when you save the test file, you may have to do the `(require '[cljs.test :as t])` in the REPL again in order to try your tests again.

In this étude, you will write a series of tests for the rational and complex numbers. As you will note, some of the tests I used for durations were designed to try “edge cases” in the hopes of making the algorithms fail. Here are some of the things you might consider testing:

Expression	Expected result
gcd(3, 5)	1
gcd(12, 14)	2
gcd(35, 55)	5
1/2 + 1/3	5/6
2/8 + 3/12	1/2
0/4 + 0/5	0/20
1/0 + 1/0	0/0
6/8 - 6/12	1/4
1/4 - 3/4	-1/2
1/3 * 1/4	1/12

Expression	Expected result
3/4 * 4/3	1/1
1/3 ÷ 1/4	4/3
3/4 ÷ 4/3	9/16
(str (Complex. 3 7))	“3+7i”
(str (Complex. 3 -7))	“3-7i”
(str (Complex. -3 7))	“-3+7i”
(str (Complex. -3 -7))	“-3-7i”
(str (Complex. 0 7))	“7i”
(str (Complex. 3 0))	“3”
(1 + 2i) + (3 + 4i)	4 + 6i
(1 - 2i) + (-3 + 4i)	-2 + 2i
(1 + 2i) - (3 + 4i)	-2 - 2i
(1 + 2i) * (3 + 4i)	-5 + 10i
2i * (3 - 4i)	8 + 6i
(3 + 4i) ÷ (1 + 2i)	2.2 - 0.4i
(1 - 2i) ÷ (3 - 4i)	0.44 -0.08i

See a suggested solution: “Solution 7-3” on page 103.

CHAPTER 8

Asynchronous Processing

In this chapter, you will write an étude that uses *core.async* to do asynchronous processing. Even though the JavaScript environment is single-threaded, *core.async* allows you to work with anything that needs to be handled asynchronously; this is a very nice feature indeed.

Here are two examples of using *core.async*. In the first example, Annie and Brian are going to send each other the numbers 5 down to zero, stopping at zero, in a project named *async1*. You will need to add some `:require` and `:require-macro` specifications to your namespace:

```
(ns ^:figwheel-always async1.core
  (:require-macros [cljs.core.async.macros :refer [go go-loop]])
    (:require [cljs.core.async
               :refer [<! >! timeout alts! chan close!]]))
```

Then, define a *channel* for both Annie and Brian:

```
(def annie (chan))
(def brian (chan))
```

Annie gets two processes: one for sending messages to Brian and another for receiving messages from him:

```
(defn annie-send []
  (go (loop [n 5]
          (println "Annie:" n "-> Brian")
          (>! brian n)
          (when (pos? n) (recur (dec n))))))

(defn annie-receive []
  (go-loop []
          (let [reply (<! brian)]
            (println "Annie:" reply "<- Brian")
            (if (pos? reply)
                  (recur)
                  (close! annie)))))
```

In the annie-send function, you see the go function, which asynchronously executes its body and immediately returns to the calling function. The >! function sends data to a channel. The loop continues until n equals zero, at which point the function returns nil.

Because go and loop occur together so often, ClojureScript has the go-loop construct, which you see in the annie-receive function. That function loops (but does not need the loop variable) until it has received the zero, at which point it performs a close! on the channel.

A similar pair of functions, brian-send and brian-receive, do Brian's sending and receiving tasks (they are not shown here). You may have noticed there's a lot of duplication here; we'll get rid of it in the next example.

All that remains to be done is to write a function that invokes these processes:

```
(defn async-test []
  (do
    (println "Starting...")
    (annie-send)
    (annie-receive)
    (brian-send)
    (brian-receive)))
```

Here is the console log output from invoking async-test. You can see that this is indeed asynchronous; the sends and receives are in no particular order:

```
Starting...
Annie: 5 -> Brian
Annie: 5 <- Brian
Brian: 5 -> Annie
Brian: 5 <- Annie
Annie: 4 -> Brian
Annie: 3 -> Brian
Brian: 4 -> Annie
Brian: 3 -> Annie
Annie: 4 <- Brian
Annie: 3 <- Brian
Brian: 4 <- Annie
Brian: 3 <- Annie
Annie: 2 -> Brian
Annie: 1 -> Brian
Brian: 2 -> Annie
Brian: 1 -> Annie
Annie: 2 <- Brian
Annie: 1 <- Brian
Brian: 2 <- Annie
Brian: 1 <- Annie
```

```
Annie: 0 -> Brian
Brian: 0 -> Annie
Annie: 0 <- Brian
Brian: 0 <- Annie
```

You can see the entire program here: "Sample core.async Program 1" on page 104.

The next example using *core.async*, in a project named *async2*, has processes that communicate with one another in a semi-synchronized manner. In this case, Annie will start off by sending Brian the number 8. He will send her a 7, she sends back 6, and so on, down to zero.

In this case, both people do the same thing: send the next lower number to their partner, then await the partner's reply. Here is the function to activate the process for the two partners. The `from-str` and `to-str` parameters are used for the debug output:

```
(defn decrement! [[from-str from-chan] [to-str to-chan] & [start-value]]
  (go-loop [n (or start-value (dec (<! from-chan)))]
           (println from-str ":" n "->" to-str)
           (>! to-chan n)
           (when-let [reply (<! from-chan)]
             (println from-str ":" reply "<-" to-str)
             (if (pos? reply)
               (recur (dec reply))
               (do
                 (close! from-chan)
                 (close! to-chan)
                 (println "Finished"))))))
```

There are several clever tricks going on in this function. The `& [start-value]` allows an optional starting value. There's an asymmetry in the processes; Annie starts the sending, and Brian starts by receiving her data. Thus, Annie will start with 8 as her `start-value`; Brian will omit that argument. The completion of this bit of kabuki is in `(or start-value (dec (<! from-chan)))`; if `start-value` is `nil` (which evaluates to false), you take one less than the received value as your starting value.

Similarly, the `when-let` clause is executed only when the reply from `from-chan` is true (i.e., not `nil`):

```
(defn async-test []
  (let [annie (chan)
        brian (chan)]
    (decrement! ["Annie" annie] ["Brian" brian] 8)
    (decrement! ["Brian" brian] ["Annie" annie])))
```

Here is the output from invoking `async-test`:

```
Annie : 8 -> Brian
Brian : 7 -> Annie
Annie : 7 <- Brian
Annie : 6 -> Brian
Brian : 6 <- Annie
Brian : 5 -> Annie
Annie : 5 <- Brian
Annie : 4 -> Brian
Brian : 4 <- Annie
Brian : 3 -> Annie
Annie : 3 <- Brian
Annie : 2 -> Brian
Brian : 2 <- Annie
Brian : 1 -> Annie
Annie : 1 <- Brian
Annie : 0 -> Brian
Brian : 0 <- Annie
Finished
```

You can see the entire program here: "Sample core.async Program 2" on page 106.

Étude 8-1: A Card Game

In this étude, you're going to write a program that lets the computer play the card game "War" against itself.

The Art of War

(Apologies to Sun Tzu.) These are the rules of the game as condensed from Wikipedia, adapted to two players, and simplified further.

Two players each take 26 cards from a shuffled deck. The players each put their top card face up on the table. Whoever has the higher value card wins that battle, takes both cards, and puts them at the bottom of her stack. What happens if the cards have the same value? Then the players go to "war." Each person puts the next two cards from their stack face down in the pile and a third card face up. High card wins, and the winner takes all the cards for the bottom of their stack. If the cards match again, the war continues with another set of three cards from each person. If a person has fewer than three cards when a war happens, they put in all their cards.

Repeat this entire procedure until one person has all the cards. That player wins the game. In this game, aces are considered to have the highest value, and king > queen > jack.

A game can go on for a *very* long time, so I have added a new rule: if the game goes more than a predetermined maximum number of rounds (50 in my program), stop playing. The person who has fewer cards wins. If the number of cards is equal, it's a tie.

War: What Is It Good For?

Absolutely nothing. Well, almost nothing. War is possibly the most incredibly inane card game ever invented. It is a great way for children to spend time, and it's perfect as an étude because:

- It is naturally implementable as channels (players) passing information (cards).
- There is no strategy involved in the play, thus allowing you to concentrate on the channels and messages.

Pay Now or Pay Later

When you purchase an item, if you pay cash on the spot, you often end up paying less than if you use credit. If you are cooking a meal, getting all of the ingredients collected before you start (pay now) is often less stressful than having to stop and go to the grocery store for items you found out you didn't have (pay later). In most cases, "pay now" ends up being less expensive than "pay later," and that certainly applies to most programming tasks.

So, before you rush off to start writing code, let me give you a word of advice: don't. Spend some time with paper and pencil, away from the computer, and *design* this program first. This is a nontrivial program, and the "extra" time you spend planning it (pay now) will save you a lot of time in debugging and rewriting (pay later). As someone once told me, "Hours of programming will save you minutes of planning."

Trust me, programs written at the keyboard look like it, and that is not meant as a compliment.

Note: this does not mean that you should never use the REPL or write anything at the keyboard. If you are wondering about how a specific part of ClojureScript works and need to write a small test program to find out, go ahead and do that right away.

Hint: do your design on paper. Don't try to keep the whole thing in your head. Draw diagrams. Sometimes a picture or a storyboard of how the messages should flow will clarify your thinking. (If your parents ever asked you, "Do I have to draw you a diagram?" you may now confidently answer "Yes. Please do that. It really helps.")

The Design

When I first started planning this, I was going to have just two processes communicating with each other, as it is in a real game. But let's think about that. There is a slight asymmetry between the players. One person usually brings the cards and suggests playing the game. He shuffles the deck and deals out the cards at the beginning. Once that's done, things even out. The game play itself proceeds almost automatically. Neither player is in control of the play, yet both of them are. It seems as if there is an implicit, almost telepathic communication between the players. Of course, there are no profound metaphysical issues here. Both players are simultaneously following the same set of rules. And that's the point that bothered me: who makes the "decisions" in the program? I decided to sidestep the issue by introducing a third agent, the *dealer*, who is responsible for giving the cards to each player at the start of the game. The dealer then can tell each player to turn over cards, make a decision as to who won, and then tell a particular player to take cards. This simplifies the message flow considerably.

In my code, the dealer has to keep track of:

- The players' channels
- The current state of play (see the following)
- Cards received from player 1 for this battle
- Cards received from player 2 for this battle
- The pile of cards in the middle of the table

The dealer initializes the players and then is in one of the following states. I'm going to anthropomorphize and use "me" to represent the dealer:

Pre-battle

Tell the players to send me cards. If the pile is empty, then it's a normal battle; give me one card each. If the pile isn't empty, then it's a war; give me three cards.

Battle

Wait to receive the cards from the players. If either player has sent me an empty list for their cards, then that player is out of cards, so the other player must be the winner. Send both players a message to quit looping `for` messages.

If I really have cards from both players, compare them. If one player has the high card, give that player the pile plus the cards currently in play, and go into "post-battle" state. Otherwise, the cards match. Add the cards currently in play to the pile, and go back to "pre-battle" state.

Post-battle

Wait for the person to pick up the cards sent by the dealer. If you've hit the maximum number of rounds, go to "long-game" state. Otherwise, go back to "pre-battle" state.

Long-game

The game has taken too many moves. Ask both players for the number of cards they have, and tell them both to quit looping. The winner is the player with the smaller number of cards (or a tie if they have the same number of cards).

Note that this is my implementation; you may find an entirely different and better way to write the program.

Messages Are Asynchronous

Remember that the order in which a process receives messages may not be the same order in which they were sent. For example, if players Annie and Brian have a battle, and Annie wins, you may be tempted to send these messages:

1. Tell Annie to pick up the two cards that were in the battle.
2. Tell Annie to send you a card for the next battle.
3. Tell Brian to send you a card for the next battle.

This works nicely unless Annie had just thrown her last card down for that battle and message two arrives *before* message one. Annie will report that she is out of cards, thus losing the game, even though she's really still in the game with the two cards that she hasn't picked up yet.

Representing the Deck

I decided to represent the deck as a vector of the numbers 0 through 51 (inclusive); 0 through 12 are the ace through king of clubs, 13 through 25 are diamonds, then hearts, then spades. (That is, the suits are in English alphabetical order.) You will find ClojureScript's `shuffle` function to be quite useful. I wrote a small module in a file named *utils.cljs* for functions such as converting a card number to its suit and name and finding a card's value.

If you want to make a web-based version of the game, you will find a set of SVG images of playing cards in the *datafiles/chapter08/images* directory, with names *0.svg* through *51.svg*. These filenames correspond to the numbering described in the preceding paragraph. The file *blue_grid_back.svg* contains the image of the back of a playing card.

Note: you may want to generate a small deck with, say, only four cards in two suits. If you try to play with a full deck, the game could go on for a very long time.

Here is output from a game:

```
Starting Player 1 with [2 0 16 13 14 18]
Starting Player 2 with [1 4 3 15 17 5]
** Starting round 1
Player 1 has [2 0 16 13 14 18] sending dealer (2)
Player 2 has [1 4 3 15 17 5] sending dealer (1)
3 of clubs vs. 2 of clubs
Player 2 receives [2 1] add to [4 3 15 17 5]
** Starting round 2
Player 1 has [0 16 13 14 18] sending dealer (0)
Player 2 has [4 3 15 17 5 2 1] sending dealer (4)
```

```
Ace of clubs vs. 5 of clubs
Player 2 receives [0 4] add to [3 15 17 5 2 1]
** Starting round 3
Player 1 has [16 13 14 18] sending dealer (16)
Player 2 has [3 15 17 5 2 1 0 4] sending dealer (3)
4 of diamonds vs. 4 of clubs
** Starting round 4
Player 2 has [15 17 5 2 1 0 4] sending dealer (15 17 5)
Player 1 has [13 14 18] sending dealer (13 14 18)
6 of diamonds vs. 6 of clubs
** Starting round 5
Player 1 has [] sending dealer ()
Player 2 has [2 1 0 4] sending dealer (2 1 0)
nil vs. Ace of clubs
Winner: Player 1
```

See a suggested solution: "Solution 8-1" on page 107.

APPENDIX A

Solutions

Here are suggested solutions for the études. Of course, your solutions may well be entirely different, and better.

Solution 1-2

```
(ns formulas.core
  (:require [clojure.browser.repl :as repl]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(enable-console-print!)

(defn distance
  "Calculate distance traveled by an object moving
  with a given acceleration for a given amount of time"
  [accel time]
  (* accel time time))

(defn kinetic-energy
  "Calculate kinetic energy given mass and velocity"
  [m v]
  (/ (* m v v) 2.0))

(defn centripetal
  "Calculate centripetal acceleration given velocity and radius"
  [v r]
  (/ (* v v) r))

(defn average
  "Calculate average of two numbers"
  [a b]
  (/ (+ a b) 2.0))
```

```
(defn variance
  "Calculate variance of two numbers"
  [a b]
  (- (* 2 (+ (* a a) (* b b))) (* (+ a b) (+ a b))))
```

Solution 1-3

```
(def G 6.6784e-11)

(defn gravitational-force
  "Calculate gravitational force of two objects of
  mass m1 and m2, with centers of gravity at a distance r"
  [m1 m2 r]
  (/ (* G m1 m2) (* r r)))
```

Solution 1-4

```
(defn monthly-payment
  "Calculate monthly payment on a loan of amount p,
  with annual percentage rate apr, and a given number of years"
  [p apr years]
  (let [r (/ (/ apr 100) 12.0)
        n (* years 12)
        factor (.pow js/Math (+ 1 r) n)]
    (* p (/ (* r factor) (- factor 1)))))
```

Solution 1-5

```
(defn radians
  "Convert degrees to radians"
  [degrees]
  (* (/ (.-PI js/Math) 180) degrees))

(defn daylight
  "Find minutes of daylight given latitude in degrees and day of year.
  Formula from http://mathforum.org/library/drmath/view/56478.html"
  [lat-degrees day]
  (let [lat (radians lat-degrees)
        part1 (* 0.9671396 (.tan js/Math (* 0.00860 (- day 186))))
        part2 (.cos js/Math (+ 0.2163108 (* 2 (.atan js/Math part1))))
        p (.asin js/Math (* 0.39795 part2))
        numerator (+ (.sin js/Math 0.01454) (* (.sin js/Math lat)
                                               (.sin js/Math p)))
        denominator (* (.cos js/Math lat) (.cos js/Math p))]
    (* 60 (- 24 (* 7.63944 (.acos js/Math (/ numerator denominator)))))))
```

Solution 2-1

```
(ns daylight-js.core
  (:require [clojure.browser.repl :as repl]))

(enable-console-print!)

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(defn radians
  "Convert degrees to radians"
  [degrees]
  (* (/ (.-PI js/Math) 180) degrees))

(defn daylight
  "Find minutes of daylight given day of year and latitude in degrees.
  Formula from http://mathforum.org/library/drmath/view/56478.html"
  [day lat-degrees]
  (let [lat (radians lat-degrees)
        part1 (* 0.9671396 (.tan js/Math (* 0.00860 (- day 186))))
        part2 (.cos js/Math (+ 0.2163108 (* 2 (.atan js/Math part1))))
        p (.asin js/Math (* 0.39795 part2))
        numerator (+ (.sin js/Math 0.01454) (* (.sin js/Math lat)
                                               (.sin js/Math p)))
        denominator (* (.cos js/Math lat) (.cos js/Math p))]
    (* 60 (- 24 (* 7.63944 (.acos js/Math (/ numerator denominator)))))))

(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (.-value (.getElementById js/document field))))

(defn calculate [evt]
  (let [lat-d (get-float-value "latitude")
        julian (get-float-value "julian")
        minutes (daylight lat-d julian)]
    (set! (.-innerHTML (.getElementById js/document "result")) minutes)))

(.addEventListener (.getElementById js/document "calculate") "click" calculate)
```

Solution 2-2

Much of the code is duplicated from the previous étude. Only new code is shown here, with ellipses to represent omitted code:

```
(ns daylight-gc.core
  (:require [clojure.browser.repl :as repl]
            [goog.dom :as dom]
            [goog.events :as events]))

...

(defn radians...)

(defn daylight...)

(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (.-value (dom/getElement field))))

(defn calculate [evt]
  (let [lat-d (get-float-value "latitude")
        julian (get-float-value "julian")
        minutes (daylight lat-d julian)]
    (dom/setTextContent (dom/getElement "result") minutes)))

(events/listen (dom/getElement "calculate") "click" calculate)
```

Solution 2-3

Much of the code is duplicated from the previous étude. Only new code is shown here, with ellipses to represent omitted code:

```
(ns daylight-dommy.core
  (:require [clojure.browser.repl :as repl]
            [dommy.core :as dommy :refer-macros [sel sel1]]))

...

(defn radians ... )

(defn daylight ... )

(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (dommy/value (sel1 field))))

(defn calculate [evt]
  (let [lat-d (get-float-value "#latitude")
        julian (get-float-value "#julian")
        minutes (daylight lat-d julian)]
    (dommy/set-text! (sel1 "#result") minutes)))

(dommy/listen! (sel1 "#calculate") :click calculate)
```

Solution 2-4

Much of the code is duplicated from the previous étude. Only new code is shown here, with ellipses to represent omitted code:

```
(ns daylight-domina.core
  (:require [clojure.browser.repl :as repl]
            [domina]
            [domina.events :as events]))
...

(defn radians ... )

(defn daylight ...)

(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (domina/value (domina/by-id field))))

(defn calculate [evt]
  (let [lat-d (get-float-value "latitude")
        julian (get-float-value "julian")
        minutes (daylight lat-d julian)]
    (domina/set-text! (domina/by-id "result") minutes)))

(events/listen! (domina/by-id "calculate") :click calculate)
```

Solution 2-5

Much of the code is duplicated from the previous étude. Only new code is shown here, with ellipses to represent omitted code:

```
(ns daylight-enfocus.core
  (:require [clojure.browser.repl :as repl]
            [enfocus.core :as ef]
            [enfocus.events :as ev]))

...

(defn daylight ... )

(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (ef/from field (ef/get-prop :value))))

(defn calculate [evt]
  (let [lat-d (get-float-value "#latitude")
        julian (get-float-value "#julian")
        minutes (daylight lat-d julian)]
    (ef/at "#result" (ef/content (.toString minutes)))))

(ef/at "#calculate" (ev/listen :click calculate))
```

Solution 3-1

```
(defn move-zeros
  "Move zeros to end of a list or vector of numbers"
  [numbers]
  (let [nonzero (filter (fn[x] (not= x 0)) numbers)]
    (concat nonzero
       (repeat (- (count numbers) (count nonzero)) 0))))
```

Solution 3-2

```
(ns daylight-by-date.core
  (:require [clojure.browser.repl :as repl]
            [clojure.string :as str]
            [domina]
            [domina.events :as events]))

(enable-console-print!)

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(defn radians
  "Convert degrees to radians"
  [degrees]
  (* (/ (.-PI js/Math) 180) degrees))

(defn daylight
  "Find minutes of daylight given latitude in degrees and day of year.
  Formula from http://mathforum.org/library/drmath/view/56478.html"
  [lat-degrees day]
  (let [lat (radians lat-degrees)
        part1 (* 0.9671396 (.tan js/Math (* 0.00860 (- day 186))))
        part2 (.cos js/Math (+ 0.2163108 (* 2 (.atan js/Math part1))))
        p (.asin js/Math (* 0.39795 part2))
        numerator (+ (.sin js/Math 0.01454) (* (.sin js/Math lat)
                                               (.sin js/Math p)))
        denominator (* (.cos js/Math lat) (.cos js/Math p))]
    (* 60 (- 24 (* 7.63944 (.acos js/Math (/ numerator denominator)))))))
```

```
(defn get-float-value
  "Get the floating point value of a field"
  [field]
  (.parseFloat js/window (domina/value (domina/by-id field))))

(defn leap-year?
  "Return true if given year is a leap year; false otherwise"
  [year]
  (or (and (= 0 (rem year 4)) (not= 0 (rem year 100)))
    (= 0 (rem year 400))))

(defn ordinal-day
  "Compute ordinal day given Gregorian day, month, and year"
  [day month year]
  (let [leap (leap-year? year)
        feb-days (if leap 29 28)
        days-per-month [0 31 feb-days 31 30 31 30 31 31 30 31 30 31]
        month-ok (and (> month 0) (< month 13))
        day-ok (and month-ok (> day 0) (<= day (+ (nth days-per-month month))))
        subtotal (reduce + (take month days-per-month))]
    (if day-ok (+ subtotal day) 0)))

(defn to-julian
  "Convert Gregorian date to Julian"
  []
  (let [greg (domina/value (domina/by-id "gregorian"))
        parts (str/split greg #"[-/]")
        [y m d] (map (fn [x] (.parseInt js/window x 10)) parts)]
    (ordinal-day d m y)))

(defn calculate [evt]
  (let [lat-d (get-float-value "latitude")
        julian (to-julian)
        minutes (daylight lat-d julian)]
    (domina/set-text! (domina/by-id "result") (str (quot minutes 60) "h "
                      (.toFixed (rem minutes 60) 2) "m"))))

(events/listen! (domina/by-id "calculate") :click calculate)
```

Solution 3-3

```
(defn mean
  "Compute mean of a sequence of numbers"
  [x]
  (let [n (count x)]
    (/ (apply + x) n)))

(defn median
  "Compute median of a sequence of numbers"
  [x]
  (let [n (count x)
        remainder (drop (- (int (/ n 2)) 1) (sort x))]
    (if (odd? n)
      (second remainder)
      (/ (+ (first remainder) (second remainder)) 2))))

(defn getsums
  "Reducing function for computing sum and sum of squares.
  The accumulator is a two-vector with the current sum and sum of squares.
  Could be made clearer with destructuring, but that's not in
  this chapter."
  [acc item]
  (vector (+ (first acc) item) (+ (last acc) (* item item))))

(defn stdev
  "Compute standard deviation of a sequence of numbers"
  [x]
  (let [[sum sumsq] (reduce getsums [0 0] x)
        n (count x)]
    (.sqrt js/Math (/ (- sumsq (/ (* sum sum) n)) (- n 1)))))
```

Solution 3-4

This solution uses the Domina library to interact with the web page. The ns special form needs to be updated to require the correct libraries:

```
(ns stats.core
  (:require [clojure.browser.repl :as repl]
            [clojure.string :as str]
            [domina :as dom]
            [domina.events :as ev]))
```

This is the additional code for interacting with the web page:

```
(defn calculate
  "Event handler"
  [evt]
  (let [numbers (map js/window.parseFloat
                  (str/split (domina/value (ev/target evt)) #"[, ]+"))]
     (domina/set-text! (domina/by-id "mean") (mean numbers))
     (domina/set-text! (domina/by-id "median") (median numbers))
     (domina/set-text! (domina/by-id "stdev") (stdev numbers))))

;; connect event handler
(ev/listen! (domina/by-id "numbers") :change calculate)
```

Solution 3-5

```
(ns teeth.core
  (:require [clojure.browser.repl :as repl]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(enable-console-print!)

(def pocket-depths
  [[0], [2 2 1 2 2 1], [3 1 2 3 2 3],
  [3 1 3 2 1 2], [3 2 3 2 2 1], [2 3 1 2 1 1],
  [3 1 3 2 3 2], [3 3 2 1 3 1], [4 3 3 2 3 3],
  [3 1 1 3 2 2], [4 3 4 3 2 3], [2 3 1 3 2 2],
  [1 2 1 1 3 2], [1 2 2 3 2 3], [1 3 2 1 3 3], [0],
  [3 2 3 1 1 2], [2 2 1 1 3 2], [2 1 1 1 1 2],
  [3 3 2 1 1 3], [3 1 3 2 3 2], [3 3 1 2 3 3],
  [1 2 2 3 3 3], [2 2 3 2 3 3], [2 2 2 4 3 4],
  [3 4 3 3 3 4], [1 1 2 3 1 2], [2 2 3 2 1 3],
  [3 4 2 4 4 3], [3 3 2 1 2 3], [2 2 2 2 3 3],
  [3 2 3 2 3 2]])

(defn bad-tooth
  "Accumulator: vector of bad tooth numbers
  and current index"
  [[bad-list index] tooth]
  (if (some (fn[x] (>= x 4)) tooth)
    (vector (conj bad-list index) (inc index))
    (vector bad-list (inc index))))

(defn alert
  "Display tooth numbers where any of the
  pocket depths is 4 or greater."
  [depths]
  (first (reduce bad-tooth [[] 1] depths)))
```

Solution 3-6

```
(ns make_teeth.core
  (:require [clojure.browser.repl :as repl]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(defn one-tooth
  "Generate one tooth"
  [present probability]
  (if (= present "F") []
    (let [base-depth (if (< (rand) probability) 2 3)]
      (loop [n 6
             result []]
         (if (= n 0) result
           (recur (dec n) (conj result (+ base-depth (- 1 (rand-int 3))))))))))

(defn generate-list
  "Take list of teeth, probability, and current vector of vectors.
  Add pockets for each tooth."
  [teeth-present probability result]
  (if (empty? teeth-present) result
    (recur (rest teeth-present) probability
    (conj result (one-tooth (first teeth-present) probability)))))

(defn generate-pockets
  "Take list of teeth present and probability of a good tooth,
  and create a list of pocket depths."
  [teeth-present probability]
  (generate-list teeth-present probability []))
```

Solution 3-7

This suggested solution uses the Enfocus library to interact with the web page:

```
(ns daylight-summary.core
  (:require [clojure.browser.repl :as repl]
            [enfocus.core :as ef]
            [enfocus.events :as ev]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(enable-console-print!)

(defn radians
  "Convert degrees to radians"
  [degrees]
  (* (/ (.-PI js/Math) 180) degrees))

(defn daylight
  "Find minutes of daylight given day of year and latitude in degrees.
  Formula from http://mathforum.org/library/drmath/view/56478.html"
  [lat-degrees day]
  (let [lat (radians lat-degrees)
        part1 (* 0.9671396 (.tan js/Math (* 0.00860 (- day 186))))
        part2 (.cos js/Math (+ 0.2163108 (* 2 (.atan js/Math part1))))
        p (.asin js/Math (* 0.39795 part2))
        numerator (+ (.sin js/Math 0.01454) (* (.sin js/Math lat)
                                               (.sin js/Math p)))
        denominator (* (.cos js/Math lat) (.cos js/Math p))]
    (* 60 (- 24 (* 7.63944 (.acos js/Math (/ numerator denominator)))))))

(defn make-ranges
  "Return vector of begin-end ordinal dates for a list of days per month"
  [mlist]
  (reduce (fn [acc x] (conj acc (+ x (last acc)))) [1] (rest mlist)))

(def month-ranges
  "Days per month for non-leap years"
  (make-ranges '(0 31 28 31 30 31 30 31 31 30 31 30 31)))

(defn to-hours-minutes
  "Convert minutes to hours and minutes"
  [m]
  (str (quot m 60) "h "  (.toFixed (mod m 60) 0) "m"))

(defn get-value
  "Get the value from a field"
  [field]
  (ef/from field (ef/get-prop :value)))

(defn mean
  "Compute mean of a sequence of numbers"
  [x]
  (/ (apply + x) (count x)))

(defn mean-daylight
  "Get mean daylight for a range of days"
  [start finish latitude]
  (let [f (fn [x] (daylight latitude x))]
    (mean (map f (range start finish)))))

(defn generate-averages
  "Generate monthly averages for a given latitude"
  [latitude]
  (loop [ranges month-ranges
         result []]
    (if (< (count ranges) 2)
        result
        (recur (rest ranges)
               (conj result (mean-daylight (first ranges)
                                           (second ranges) latitude))))))

(defn calculate [evt]
  (let [fromMenu (first (ef/from "input[name='locationType']"
                                 (ef/get-prop :checked)))
        lat-d (if fromMenu (.parseFloat js/window (get-value "#cityMenu"))
                           (.parseFloat js/window (get-value "#latitude")))
        averages (generate-averages lat-d)]
    (doall (map-indexed
             (fn [n item] (ef/at (str "#m" (inc n))
                                 (ef/content (to-hours-minutes item))))
             averages))))

(ef/at "#calculate" (ev/listen :click calculate))
```

Solution 4-1

```
(ns condiments.core
  (:require [cljs.nodejs :as nodejs]))

(nodejs/enable-util-print!)

(def xml (js/require "node-xml-lite"))

;; forward reference
(declare process-child)

(defn process-children
  "Process an array of child nodes, given a current food name
  and an accumulated result"
  [[food result] children]
  (let [[final-food final-map] (reduce process-child [food result] children)]
    [final-food final-map]))

(defn add-condiment
  "Add food to the vector of foods that go with this condiment"
  [result food condiment]
  (let [food-list (get result condiment)
        new-list (if food-list (conj food-list food) [food])]
    (assoc result condiment new-list)))

(defn process-child
  "Given a current food and result map, and an item,
  return the new food name and result map"
  [[food result] item]

  ;; The first child of an element is text - either a food name
  ;; or a condiment name, depending on the element name.
  (let [firstchild (first (.-childs item))]
    (cond
      (= (.-name item) "display_name") (vector firstchild result)
      (.test #"cond_._name" (.-name item))
        (vector food (add-condiment result food firstchild))
      (and (.-childs item) (.-name firstchild))
        (process-children [food result] (.-childs item))
      :else [food result])))

(defn -main []
  (let [docmap (.parseFileSync xml (nth (.-argv js/process) 2))]
    (println (last (process-children ["" {}] (.-childs docmap))))))

(set! *main-cli-fn* -main)
```

Solution 4-2A

This is a sample web server that simply echoes back the user's input. Use this as a guide for the remainder of the étude:

```
(ns servertest.core
  (:require-macros [hiccups.core :as hiccups])
  (:require [cljs.nodejs :as nodejs]
            [hiccups.runtime :as hiccupsrt]))

(nodejs/enable-util-print!)

(def express (nodejs/require "express"))

(defn generate-page! [request response]
  (let [query (.-query request)
        user-name (if query (.-userName query) "")]
    (.send response
           (hiccups/html
             [:html
              [:head [:title "Server Example"]
               [:meta {:http-equiv "Content-type" :content "text/html"
                       :charset "utf-8"}]]
              [:body
               [:p "Enter your name:"]
               [:form {:action "/"
                       :method "get"}
                [:input {:name "userName" :value user-name}]
                [:input {:type "submit" :value "Send Data"}]]
               [:p (if (and user-name (not= user-name ""))
                     (str "Pleased to meet you, " user-name ".") "")]]]))))

(defn -main []
  (let [app (express)]
    (.get app "/" generate-page!)
    (.listen app 3000
             (fn []
               (println "Server started on port 3000")))))

(set! *main-cli-fn* -main)
```

Solution 4-2B

This is a solution for the condiment matcher web page. It has separated the code for creating the condiment map from the XML page into a separate file to keep the code cleaner:

```
(ns foodserver.mapmaker)

(def xml (js/require "node-xml-lite"))

;; forward reference
(declare process-child)

(defn process-children
  "Process an array of child nodes, given a current food name
  and an accumulated result"
  [[food result] children]
  (let [[final-food final-map] (reduce process-child [food result] children)]
    [final-food final-map]))

(defn add-condiment
  "Add food to the vector of foods that go with this condiment"
  [result food condiment]
  (let [food-list (get result condiment)
        new-list (if food-list (conj food-list food) [food])]
    (assoc result condiment new-list)))

(defn process-child
  "Given a current food and result map, and an item,
  return the new food name and result map"
  [[food result] item]

  ;; The first child of an element is text - either a food name
  ;; or a condiment name, depending on the element name.
  (let [firstchild (first (.-childs item))]
    (cond
      (= (.-name item) "display_name") (vector firstchild result)
      (.test #"cond_._name" (.-name item))
      (vector food (add-condiment result food firstchild))
      (and (.-childs item) (.-name firstchild))
      (process-children [food result] (.-childs item))
      :else [food result])))

(defn foodmap [filename]
  (let [docmap (.parseFileSync xml filename)]
    (last (process-children ["" {}] (.-childs docmap)))))
```

Here is the main file:

```
(ns foodserver.core
  (:require-macros [hiccups.core :as hiccups])
  (:require [cljs.nodejs :as nodejs]
            [hiccups.runtime :as hiccupsrt]
            [foodserver.mapmaker :as mapmaker]
            [clojure.string :as str]))

(nodejs/enable-util-print!)

(def express (nodejs/require "express"))

(def foodmap (mapmaker/foodmap "food.xml"))

(defn case-insensitive [a b]
  (compare (str/upper-case a) (str/upper-case b)))

(defn condiment-menu
  "Create HTML menu with the given selection
  as the 'selected' item"
  [selection]
  (map (fn [item] [:option
                 (if (= item selection)
                   {:value item :selected "selected"}
                   {:value item})
                 item])
       (sort case-insensitive (keys foodmap))))

(defn compatible-foods
  "Create unordered list of foods compatible with selected condiment"
  [selection]
  (if selection
    (map (fn [item] [:li item]) (sort case-insensitive (foodmap selection)))
    nil))

(defn generate-page! [request response]
  (let [query (.-query request)
        chosen-condiment (if query (.-condiment query) "")]
    (.send response
           (hiccups/html
             [:html
              [:head
               [:title "Condiment Matcher"]
               [:meta {:http-equiv "Content-type"
                       :content "text/html; charset=utf-8"}]]
              [:body
               [:h1 "Condiment Matcher"]
               [:form {:action "http://localhost:3000"
                       :method "get"}
                [:select {:name "condiment"}
                 [:option {:value ""} "Choose a condiment"]
                 (condiment-menu chosen-condiment)]
                [:input {:type "submit" :value "Find Compatible Foods"}]]
               [:ul (compatible-foods chosen-condiment)]
               [:p "Source data: "
               ;; URL split across two lines for book width
                [:a {:href (str
                    "http://catalog.data.gov/dataset/"
                                          "mypyramid-food-raw-data-f9ed6")}
                 "MyPyramid Food Raw Data"]
                " from the Food and Nutrition Service of the "
                " United States Department of Agriculture."]]]))))

(defn -main []
  (let [app (express)]
    (.get app "/" generate-page!)
    (.listen app 3000 (fn []
                        (println "Server started on port 3000")))))

(set! *main-cli-fn* -main)
```

Solution 4-3

Here is the code for reading a file line by line:

File cljs_made_easy/line_seq.clj

```
 ;; This is a macro, and must be in Clojure.
;; Its name and location is the same as
;; the cljs file, except with a .clj extension.
(ns cljs-made-easy.line-seq
  (:refer-clojure :exclude [with-open]))

(defmacro with-open [bindings & body]
  (assert (= 2 (count bindings)) "Incorrect with-open bindings")
  `(let ~bindings
     (try
       (do ~@body)
       (finally
         (.closeSync cljs-made-easy.line-seq/fs ~(bindings 0))))))
```

File cljs_made_easy/line_seq.cljs

```
(ns cljs-made-easy.line-seq
  (:require clojure.string)
  (:require-macros [cljs-made-easy.line-seq :refer [with-open]]))

(def fs (js/require "fs"))

(defn- read-chunk [fd]
  (let [length 128
        b (js/Buffer. length)
        bytes-read (.readSync fs fd b 0 length nil)]
    (if (> bytes-read 0)
      (.toString b "utf8" 0 bytes-read))))
```

```
(defn line-seq
  ([fd]
   (line-seq fd nil))
  ([fd line]
   (if-let [chunk (read-chunk fd)]
     (if (re-find #"\n" (str line chunk))
       (let [lines (clojure.string/split (str line chunk) #"\n")]
         (if (= 1 (count lines))
           (lazy-cat lines (line-seq fd))
           (lazy-cat (butlast lines) (line-seq fd (last lines)))))
       (recur fd (str line chunk)))
     (if line
       (list line)
       ()))))
```

File frequency/core.cljs

This is the code to create the frequency table:

```
(ns frequency.core
  (:require [cljs.nodejs :as nodejs]
            [clojure.string :as str]
            [cljs-made-easy.line-seq :as cme]))

(nodejs/enable-util-print!)

(def filesystem (js/require "fs")) ;;require nodejs lib

;; These keywords are the "column headers" from the spreadsheet.
;; An entry of nil means that I am ignoring that column.
(def headers [:date :time nil :accident :injury :property-damage
              :fatal nil :vehicle :year :make :model :color
              :type nil :race :gender :driver-state nil])

(defn zipmap-omit-nil
  "Does the same as zipmap, except when there's a nil in the
  first vector, it doesn't put anything into the map.
  I wrote it this way just to prove to myself that I could do it.
  It's easier to just say (dissoc (zipmap a-vec b-vec) nil)"
  [a-vec b-vec]
  (loop [result {}
         a a-vec
         b b-vec]
    (if (or (empty? a) (empty? b))
      result
      (recur (if-not (nil? (first a))
               (assoc result (first a) (first b))
               result)
             (rest a) (rest b)))))

(defn add-row
  "Convenience function that adds a row from the CSV file
  to the data map."
  [line]
  (zipmap-omit-nil headers (str/split line #"\t")))

(defn create-data-structure
  "Create a vector of maps from a tab-separated value file
  and a list of header keywords."
  [filename headers]
  (cme/with-open [file-descriptor (.openSync filesystem filename "r")]
             (reduce (fn [result line] (conj result (add-row line))) []
                     (rest (cme/line-seq file-descriptor)))))

(def traffic (create-data-structure "traffic_july_2014_edited.csv" headers))

(defn frequency-table
  "Accumulate frequencies for specifier (a heading keyword
   or a function that returns a value) in data-map,
   optionally returning a total."
  [data-map specifier]
  (let [result-map (reduce
                    (fn [acc item]
                      (let [v (if specifier (specifier item) nil)]
                        (assoc acc v (+ 1 (get acc v)))))
                    {} data-map)
        result-seq (sort (seq result-map))
        freq (map last result-seq)]
    [(vec (map first result-seq)) (vec freq) (reduce + freq)]))

(defn -main []
  (println "Hello world!"))

(set! *main-cli-fn* -main)
```

Solution 4-4

The code for reading the CSV file is unchanged from the previous étude, so I won't repeat it here:

```
(ns crosstab.core
  (:require [cljs.nodejs :as nodejs]
            [clojure.string :as str]
            [cljs-made-easy.line-seq :as cme]))

(nodejs/enable-util-print!)

(def filesystem (js/require "fs")) ;;require nodejs lib

;; These keywords are the "column headers" from the spreadsheet.
;; An entry of nil means that I am ignoring that column.
(def headers [:date :time nil :accident :injury :property-damage
              :fatal nil :vehicle :year :make :model :color
              :type nil :race :gender :driver-state nil])
```

```
(defn zipmap-omit-nil
  "Does the same as zipmap, except when there's a nil in the
  first vector, it doesn't put anything into the map.
  I wrote it this way just to prove to myself that I could do it.
  It's easier to just say (dissoc (zipmap a-vec b-vec) nil)"
  [a-vec b-vec]
  (loop [result {}
         a a-vec
         b b-vec]
    (if (or (empty? a) (empty? b))
      result
      (recur (if-not (nil? (first a))
               (assoc result (first a) (first b))
               result)
             (rest a) (rest b)))))

(defn add-row
  "Convenience function that adds a row from the CSV file
  to the data map."
  [line]
  (zipmap-omit-nil headers (str/split line #"\t")))

(defn create-data-structure
  "Create a vector of maps from a tab-separated value file
  and a list of header keywords."
  [filename headers]
  (cme/with-open [file-descriptor (.openSync filesystem filename "r")]
             (reduce (fn [result line] (conj result (add-row line))) []
               (rest (cme/line-seq file-descriptor)))))

(def traffic (create-data-structure "traffic_july_2014_edited.csv" headers))

(defn marginal
  "Get marginal totals for a frequency map. (Utility function)"
  [freq]
  (vec (map last (sort (seq freq)))))

(defn cross-tab
  "Accumulate frequencies for given row and column in data-map,
  returning row and column totals, plus grand total."
  [data-map row-spec col-spec]

  ; In the following call to reduce, the accumulator is a
  ; vector of three maps.
  ; The first maps row values => frequency
  ; The second maps column values => frequency
  ; The third is a map of maps, mapping
  ; row values => column values => frequency

  (let [[row-freq  col-freq cross-freq] (reduce
                   (fn [acc item]
                     (let [r (if row-spec (row-spec item) nil)
                             c (if col-spec (col-spec item) nil)]
                         [(assoc (first acc) r (+ 1 (get (first acc) r)))
                          (assoc (second acc) c (+ 1 (get (second acc) c)))
                          (assoc-in (last acc) [r c]
                                    (+ 1 (get-in (last acc) [r c])))]))
                     [{} {} {}] data-map)
        ; I need row totals as part of the return, and I also
        ; add them to get grand total - don't want to re-calculate
        row-totals (marginal row-freq)]
        [(vec (sort (keys row-freq)))
         (vec (sort (keys col-freq)))
         (vec (for [r (sort (keys row-freq))]
                (vec (for [c (sort (keys col-freq))]
                       (if-let [n (get-in cross-freq (list r c))] n 0)))))
         row-totals
         (marginal col-freq)
         (reduce + row-totals)]))

(defn frequency-table
  "Accumulate frequencies for specifier in data-map,
  optionally returning a total. Use a call to cross-tab
  to re-use code."
  [data-map specifier]
  (let [[row-labels _ row-totals _ grand-total]
        (cross-tab data-map specifier nil)]
    [row-labels (vec (map first row-totals)) grand-total]))

(defn -main []
  (println "Hello world!"))

(set! *main-cli-fn* -main)
```

Solution 4-5

The cross-tabulation functions from "Solution 4-4" on page 82 are moved to a file named *crosstab.cljs* and the initial `(ns...)` changed accordingly:

```
(ns traffic.core
  (:require-macros [hiccups.core :as hiccups])
  (:require [cljs.nodejs :as nodejs]
            [clojure.string :as str]
            [cljs-made-easy.line-seq :as cme]
            [hiccups.runtime :as hiccupsrt]
            [traffic.crosstab :as ct]))

(nodejs/enable-util-print!)

(def express (nodejs/require "express"))

(def filesystem (js/require "fs")) ;;require nodejs lib

;; These keywords are the "column headers" from the spreadsheet.
;; An entry of nil means that I am ignoring that column.
(def headers [:date :time nil :accident :injury :property-damage
              :fatal nil :vehicle :year :make :model :color
              :type nil :race :gender :driver-state nil])

(defn zipmap-omit-nil
  "Does the same as zipmap, except when there's a nil in the
  first vector, it doesn't put anything into the map.
  I wrote it this way just to prove to myself that I could do it.
  It's easier to just say (dissoc (zipmap a-vec b-vec) nil)"
  [a-vec b-vec]
  (loop [result {}
         a a-vec
         b b-vec]
    (if (or (empty? a) (empty? b))
      result
      (recur (if-not (nil? (first a))
               (assoc result (first a) (first b))
               result)
             (rest a) (rest b)))))

(defn add-row
  "Convenience function that adds a row from the CSV file
  to the data map."
  [line]
  (zipmap-omit-nil headers (str/split line #"\t")))

(defn create-data-structure
  "Create a vector of maps from a tab-separated value file
  and a list of header keywords."
  [filename headers]
  (cme/with-open [file-descriptor (.openSync filesystem filename "r")]
             (reduce (fn [result line] (conj result (add-row line))) []
                      (rest (cme/line-seq file-descriptor)))))

(def traffic (create-data-structure "traffic_july_2014_edited.csv" headers))

(defn day [entry] (.substr (:date entry) 3 2))
(defn hour [entry] (.substr (:time entry) 0 2))

(def field-list [
               ["Choose a field" nil]
               ["Day" day]
               ["Hour" hour]
               ["Accident" :accident]
               ["Injury" :injury]
               ["Property Damage" :property-damage]
               ["Fatal" :fatal]
               ["Vehicle Year" :year]
               ["Vehicle Color" :color]
               ["Driver's Race" :race]
               ["Driver's Gender" :gender]
               ["Driver's State" :driver-state]])

(defn traffic-menu
  "Create a <select> menu with the given choice selected"
  [option-list selection]
  (map-indexed (fn [n item]
                 (let [menu-text (first item)]
                   [:option
                    (if (= n selection){:value n :selected "selected"}
                       {:value n})
                    menu-text]))
                 option-list))

(defn field-name [n] (first (get field-list n)))
(defn field-code [n] (last (get field-list n)))

(defn add-table-row
  [row-label counts row-total result]
    (conj result (reduce (fn [acc item] (conj acc [:td item]))
                         [:tr [:th row-label]] (conj counts row-total))))

(defn html-table
  [[row-labels col-labels counts row-totals col-totals grand-total]]
  [:div
   [:table
    (if (not (nil? (first col-labels)))
      [:thead (reduce (fn [acc item] (conj acc [:th item])) [:tr [:th "\u00a0"]]
                      (conj col-labels "Total"))]
      [:thead [:tr [:th "\u00a0"] [:th "Total"]]])
    (if (not (nil? (first col-labels)))
        (vec (loop [rl row-labels
                    freq counts
                    rt row-totals
                    result [:tbody]]
               (if-not (empty? rl)
                 (recur (rest rl) (rest freq) (rest rt)
                        (add-table-row (first rl) (first freq)
                                       (first rt) result))
                 (add-table-row "Total" col-totals grand-total result))))
        (vec (loop [rl row-labels
                    rt row-totals
                    result [:tbody]]
               (if-not (empty? rl)
                 (recur (rest rl) (rest rt)
                        (conj result [:tr [:th (first rl)] [:td (first rt)]]))
                 (conj result [:tr [:th "Total"] [:td grand-total]])))))]
   ])

(defn show-table
  [row-spec col-spec]
  (cond
    (and (not= 0 row-spec) (not= 0 col-spec))
```

```
      [:div [:h2 (str (field-name row-spec) " vs. " (field-name col-spec))]
      (html-table (ct/cross-tab traffic (field-code row-spec)
                                (field-code col-spec)))]
    (not= 0 row-spec)
      [:div [:h2 (field-name row-spec)]
       (html-table (ct/cross-tab traffic (field-code row-spec) nil))]
    :else
      nil))

(defn generate-page! [request response]
  (let [query (.-query request)
        col-spec (if query (js/parseInt (.-column query)) nil)
        row-spec (if query (js/parseInt (.-row query)) nil)]
    (.send response
           (hiccups/html
             [:html
              [:head
               [:title "Traffic Violations"]
               [:meta {:http-equiv "Content-type"
                       :content "text/html; charset=utf-8"}]
               [:link {:rel "stylesheet" :type "text/css" :href "style.css"}]]
              [:body
               [:h1 "Traffic Violations"]
               [:form {:action "http://localhost:3000"
                       :method "get"}
                "Row: "
                [:select {:name "row"}
                 (traffic-menu field-list row-spec)]
                "Column: "[:select {:name "column"}
                 (traffic-menu field-list col-spec)]
                [:input {:type "submit" :value "Calculate"}]]
               (show-table row-spec col-spec)
               [:hr]
               [:p "Source data: "
                [:a
                {:href "http://catalog.data.gov/dataset/traffic-violations-56dda"}
                 "Montgomery County Traffic Violation Database"]]]]))))

(defn -main []
  (let [app (express)]
    (.use app (.static express "."))
    (.get app "/" generate-page!)
    (.listen app 3000 (fn []
                        (println "Server started on port 3000")))))

(set! *main-cli-fn* -main)
```

Solution 5-1

```
(ns react_q.core
  (:require [clojure.browser.repl :as repl]
            [quiescent.core :as q]
            [quiescent.dom :as d]
            [quiescent.dom.uncontrolled :as du]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(defonce status
         (atom {:w 0 :h 0 :proportional true
                :border-width "3" :border-style "none"
                :orig-w 0 :orig-h 0 :src "clock.jpg"}))

(enable-console-print!)

(defonce border-style-list '("none" "solid" "dotted" "dashed"
                              "double" "groove" "ridge"
                              "inset" "outset"))
(defn resize
  "Resize the image; if proportional, determine which field
  has changed and change the other accordingly."
  [evt]
  (let [{:keys [w h proportional orig-w orig-h]} @status
        target (.-target evt)
        id (.-id target)
        val (.-value target)]
    (if proportional
      (cond
        (= id "w") (swap! status assoc :w val :h (int (* (/ val orig-w) orig-h)))
        (= id "h") (swap! status assoc :h val :w (int (* (/ val orig-h) orig-w)))
        :else (swap! status assoc :h orig-h :w orig-w))
      (swap! status assoc (keyword id) (.-value target)))))

(defn recheck
  "Handle the checkbox. Since the checked property isn't the
  value of the checkbox, I had to set the property by hand"
  [evt]
  (let [new-checked (not (:proportional @status))]
    (swap! status assoc :proportional new-checked)
    (set! (.-checked (.-target evt)) new-checked)))

(defn change-border [evt]
  (let [{:keys [border-width border-style]} @status
        target (.-target evt)
        id (.-id target)
        val (.-value target)]
    (cond
      (= id "menu") (swap! status assoc :border-style val)
      (= id "bw") (swap! status assoc :border-width val))))

(defn set-dimensions
  "Set dimensions of the image once it loads"
  [evt]
  (let [node (.getElementById js/document "image")
        id (.-id node)]
    (swap! status assoc :orig-w (.-naturalWidth node)
           :orig-h (.-naturalHeight node)
           :w (.-naturalWidth node) :h (.-naturalHeight node))))

(q/defcomponent Image
                "A component that displays an image"
                :name "ImageWidget"
                [status]
                (d/img {:id "image"
                        :src (:src status)
                        :width (:w status)
                        :height (:h status)
                        :style {:float "right"
                                :borderWidth (:border-width status)
                                :borderColor "red"
                                :borderStyle (:border-style status)}
                        :onLoad set-dimensions
                        }))

(q/defcomponent Option
                [item]
                (d/option {:value item} item))

(q/defcomponent Form
                "Input form"
                :name "FormWidget"
                :on-mount (fn [node val]
                            (set! (.-checked
                                    (.getElementById js/document "prop"))
                                  (:proportional val)))
                [status]
                (d/form {:id "params"}
                        "Width: "
                        (d/input {:type "text" :size "5"
                                  :value (:w status)
                                  :id "w"
                                  :onChange resize})
                        "Height: "
                        (d/input {:type "text" :size "5"
                                  :value (:h status)
                                  :id "h"
                                  :onChange resize})
                        (d/br)
                        (du/input {:type "checkbox"
                                   :id "prop"
```

```
                                    :onChange recheck
                                    :value "proportional"})
                          "Preserve Proportions"
                          (d/br)
                          "Border: "
                          (d/input {:type "text" :size "5"
                                    :value (:border-width status)
                                    :id "bw"
                                    :onChange change-border})
                          "px "
                          (apply d/select {:id "menu" :onChange change-border}
                                 (map Option border-style-list))))

(q/defcomponent Interface
                "User Interface"
                :name "Interface"
                [status]
                (d/div {}
                  (Image status)
                  (Form status)))

(defn render
  "Render the current state atom, and schedule a render on the next
  frame"
  []
  (q/render (Interface @status) (.getElementById js/document "interface"))
  (.requestAnimationFrame js/window render))

(render)
```

Solution 5-2

```
(ns react_r.core
  (:require [clojure.browser.repl :as repl]
            [reagent.core :as reagent :refer [atom]]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(defonce status
         (atom {:w 0 :h 0 :proportional true
                :border-width "3" :border-style "none"
                :orig-w 0 :orig-h 0 :src "clock.jpg"}))

(enable-console-print!)

(defonce border-style-list '("none" "solid" "dotted" "dashed"
                              "double" "groove" "ridge"
                              "inset" "outset"))
(defn resize
  "Resize the image; if proportional, determine which field
  has changed and change the other accordingly."
  [evt]
  (let [{:keys [w h proportional orig-w orig-h]} @status
        target (.-target evt)
        id (.-id target)
        val (.-value target)]
    (if proportional
      (cond
        (= id "w") (swap! status assoc :w val :h (int (* (/ val orig-w) orig-h)))
        (= id "h") (swap! status assoc :h val :w (int (* (/ val orig-h) orig-w)))
        :else (swap! status assoc :h orig-h :w orig-w))
      (swap! status assoc (keyword id) (.-value target)))))

(defn recheck
  "Handle the checkbox. Since the checked property isn't the
  value of the checkbox, I had to set the property by hand"
  [evt]
  (let [new-checked (not (:proportional @status))]
    (swap! status assoc :proportional new-checked)
    (set! (.-checked (.-target evt)) new-checked)))

(defn change-border [evt]
  (let [{:keys [border-width border-style]} @status
        target (.-target evt)
        id (.-id target)
        val (.-value target)]
    (cond
      (= id "menu") (swap! status assoc :border-style val)
      (= id "bw") (swap! status assoc :border-width val))))

(defn set-dimensions
  "Set dimensions of the image once it loads"
  [evt]
  (let [node (.getElementById js/document "image")
        id (.-id node)]
    (swap! status assoc :orig-w (.-naturalWidth node)
           :orig-h (.-naturalHeight node)
           :w (.-naturalWidth node) :h (.-naturalHeight node))))

(defn image
  "A component that displays an image"
  []
  [:img {:id "image"
  :src (:src @status)
  :width (:w @status)
  :height (:h @status)
  :style {:float "right"
      :borderWidth (:border-width @status)
      :borderColor "red"
      :borderStyle (:border-style @status)}
  :on-load set-dimensions}])

(defn option [item]
  [:option {:value item :key item} item])

(defn cbox []
 (do
    [:input {:type "checkbox"
             :id "prop"
             :on-change recheck
             :value "proportional"}]))

(defn form
  "Input form"
  []
  [:form {:id "params"}
    "Width: "
    [:input {:type "text" :size "5" :value (:w @status)
             :id "w"
             :on-change resize}]
    "Height: "
    [:input {:type "text" :size "5":value (:h @status)
             :id "h"
             :on-change resize}]
    [:br]
    (cbox)
    "Preserve Proportions"
    [:br]
    "Border: "
    [:input {:type "text" :size "5"
          :value (:border-width @status)
          :id "bw"
          :on-change change-border}]
    "px "

    [:select {:id "menu" :on-change change-border}
      (for [item border-style-list]
         (option item))]])

(defn interface-without-init []
  [:div
    (image)
    (form)])

(def interface
  (with-meta interface-without-init
    {:component-did-mount
      (fn [this]
       (set! (.-checked (.getElementById js/document "prop"))
             (:proportional @status))
        )}))


(defn render
  "Render the current state atom"
  []
  (reagent/render [interface] (.getElementById js/document "interface")))

(render)
```

Solution 6-1

In this étude, I named the project *building_usage* and had a module named *roster.cljs* to create the data structures. I also had a module named *utils.cljs* to handle conversion of time of day to number of minutes past midnight, which makes it easy to calculate durations. There is also a utility routine to convert that format to 24-hour time.

The *roster.cljs* file includes the raw CSV as a gigantic string (well, if you consider 72K bytes to be gigantic), including columns I am not using. The `build-data-structure` function creates:

- A map with a day name as a key…
  - whose value is a map with a building name as a key…
    - whose value is a map with time (number of 15-minute intervals since midnight) as a key
      - whose value is the number of rooms occupied

For this very small subset of the data:

```
(def roster-string "W;01:00 PM;03:25 PM;C283
TH;06:30 PM;09:35 PM;D207
W;02:45 PM;05:35 PM;C244
TH;06:00 PM;09:05 PM;D208")
```

The resulting map:

```
{"Wednesday"
  {"C" {64 1, 65 1, 66 1, 67 1, 68 1, 69 1, 70 1, 52 1, 53 1, 54 1, 55 1, 56 1,
        57 1, 58 1, 59 2, 60 2, 61 2, 62 1, 63 1}},
"Thursday"
  {"D" {72 1, 73 1, 74 2, 75 2, 76 2, 77 2, 78 2, 79 2, 80 2, 81 2, 82 2, 83 2,
        84 2, 85 1, 86 1}}}
```

File building_usage/src/roster.cljs

```
(ns building_usage.roster
  (:require [clojure.string :as str]
            [building_usage.utils :as utils]))

;; many lines omitted
(def roster-string "MW;01:00 PM;03:25 PM;C283
TH;06:30 PM;09:35 PM;D207
W;02:45 PM;05:35 PM;C244
TH;06:00 PM;09:05 PM;D208")
```

```
(def day-map {"M" "Monday", "T" "Tuesday",
  "W" "Wednesday", "R" "Thursday"
  "F" "Friday", "S" "Saturday", "N" "Sunday"})

(defn add-entries
  "Increment the usage count for the building on the given days and times.
  If there is not an entry yet, created 96 zeros (24 hours
  at 15-minute intervals)"
  [acc day building intervals]
  (let [current (get-in acc [(day-map day) building])
        before (if (nil? current) (into [] (repeat 96 0)) current)
        after (reduce (fn [acc item] (assoc acc item (inc (get acc item))))
                      before intervals)]
     (assoc-in acc [(day-map day) building] after)))

(defn building-map-entry
  "Split incoming line into parts, then add entries into the count vector
   for each day and time interval for the appropriate building."
  [acc line]
  (let [[days start-time end-time room] (str/split line #";")
        day-list (rest (str/split
                         (str/replace
                          (str/replace days #"TH" "R") #"SU" "N") #""))
        start-interval (quot (utils/to-minutes start-time) 15)
        end-interval (quot (+ 14 (utils/to-minutes end-time)) 15)
        building (str/replace room #"([A-Z]+).*$" "$1")]
    (loop [d day-list
           result acc]
      (if (empty? d)
          result
          (recur (rest d)
                 (add-entries result (first d) building
                              (range start-interval end-interval)))))))

(defn building-usage-map []
  (let [lines (str/split-lines roster-string)]
    (reduce building-map-entry {} lines)))

(defn room-list
  "Create a map building -> set of rooms in building"
  [acc line]
  (let [[_ _ _ room] (str/split line #";")
        building (str/replace room #"([A-Z]+).*$" "$1")
        current (acc building)]
    (assoc acc building (if (nil? current) #{room} (conj current room)))))

(defn total-rooms []
  "Create map with building as key and number of rooms in building as value."
  (let [lines (str/split-lines roster-string)
        room-list (reduce room-list {} lines)]
    (into {} (map (fn [[k v]] [k (count (room-list k))]) room-list))))
```

File building_usage/src/utils.cljs

```
(ns building_usage.utils)

(defn to-minutes [time-string]
  (let [[_ hr minute am-pm] (re-matches
                              #"(?i)(\d\d?):(\d\d)\s*([AP])\.?M\.?"
                              time-string)
        hour (+ (mod (js/parseInt hr) 12)
                (if (= (.toUpperCase am-pm) "A") 0 12))]
    (+ (* hour 60) (js/parseInt minute))))

(defn pad [n] (if (< n 10) (str "0" n) (.toString n)))

(defn to-am-pm [total-minutes]
  (let [h (quot total-minutes 60)
        m (mod total-minutes 60)
        hour (if (= (mod h 12) 0) 12 (mod h 12))
        suffix (if (< h 12) "AM" "PM")]
    (str hour ":" (pad m) " " suffix)))

(defn to-24-hr [total-minutes]
  (str (pad (quot total-minutes 60)) (pad (mod total-minutes 60))))
```

Solution 6-2

In this solution, I am using `setInterval` to advance the animation rather than `requestAnimationFrame`. This is because I don't need smooth animation; I really want one "frame" every 1.5 seconds.

File core.cljs

```
(ns ^:figwheel-always building_usage.core
    (:require [building_usage.roster :as roster]
              [building_usage.utils :as utils]
              [goog.dom :as dom]
              [goog.events :as events]))

(enable-console-print!)

(def days ["Monday" "Tuesday" "Wednesday" "Thursday"
           "Friday" "Saturday" "Sunday"])

(def buildings ["A" "B" "C" "D" "FLD" "GYM"
                "M" "N" "P"])
(def svg (.-contentDocument (dom/getElement "campus_map")))

;; define your app data so that it doesn't get overwritten on reload
(defonce app-state (atom {:day "Monday" :interval 24
                          :usage (roster/building-usage-map)
                          :room-count (roster/room-count)
                          :running false
                          :interval-id nil}))

(defn update-map []
  (let [{:keys [day interval usage room-count]} @app-state]
    (doseq [b buildings]
      (let [n (get-in usage [day b interval])
            percent (/ n (room-count b))]
        (set! (.-fillOpacity
                (.-style (.getElementById svg (str "bldg_" b)))) percent)
        (set! (.-textContent(.getElementById svg (str "group_" b)))
              (str (int (* 100 (min 1.0 percent))) "%"))
        ))))

(defn update-atom [evt]
  (do
    (swap! app-state assoc :day (.-value (dom/getElement "day"))
           :interval (quot (utils/to-minutes
                             (.-value (dom/getElement "time"))) 15))
    (update-map)))

(defn display-day-time [day interval]
  (set! (.-innerHTML (dom/getElement "show"))
                     (str day " " (utils/to-am-pm (* 15 interval)))))

(declare advance-time)

(defn play-button [evt]
  (if (@app-state :running)
    (do
      (.clearInterval js/window (@app-state :interval-id))
      (swap! app-state assoc :running false :interval-id nil)
      (set! (.-value (dom/getElement "time"))
            (utils/to-am-pm (* 15 (@app-state :interval))))
      (set! (.-className (dom/getElement "edit")) "visible")
      (set! (.-className (dom/getElement "show")) "hidden")
      (set! (.-src (dom/getElement "play")) "images/play.svg"))
    (do
      (swap! app-state assoc :running true :interval-id
             (.setInterval js/window advance-time 1500))
      (display-day-time (@app-state :day) (@app-state :interval))
      (set! (.-className (dom/getElement "edit")) "hidden")
      (set! (.-className (dom/getElement "show")) "visible")
      (set! (.-src (dom/getElement "play")) "images/pause.svg"))))

(defn advance-time [dom-time-stamp]
  (let [{:keys [day lastUpdate interval]} @app-state
        next-interval (inc interval)]
    (if (>= next-interval 96)
      (play-button nil)
      (do
        (update-map)
        (swap! app-state assoc :interval next-interval)
        (display-day-time day next-interval)))))

(do
  (events/listen (dom/getElement "time") "change" update-atom)
  (events/listen (dom/getElement "day") "change" update-atom)
  (events/listen (dom/getElement "play") "click" play-button))


(defn on-js-reload []
  ;; optionally touch your app-state to force rerendering depending on
  ;; your application
  ;; (swap! app-state update-in [:__figwheel_counter] inc)
)
```

File index.html

```
<!DOCTYPE html>
<html>
  <head>
    <link href="css/style.css" rel="stylesheet" type="text/css">
    <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
  </head>
  <body>
    <div id="app">
      <h2>Building Usage</h2>
      <p class="bigLabel">
      <span id="edit" class="visible">
      <select id="day" class="bigLabel">
        <option value="Monday">Monday</option>
        <option value="Tuesday">Tuesday</option>
        <option value="Wednesday">Wednesday</option>
        <option value="Thursday">Thursday</option>
        <option value="Friday">Friday</option>
        <option value="Saturday">Saturday</option>
        <option value="Sunday">Sunday</option>
      </select>

      <input class="bigLabel" id="time" value="6:00 AM" size="8"/>
      </span>

      <span id="show" class="hidden">
      </span>

      <img src="images/play.svg" width="45" height="45" alt="play" id="play"/>
     </p>

     <div>
      <object id="campus_map" data="images/campus_map.svg"
        type="image/svg+xml" style="border: 1px solid gray">
        <p>Alas, your browser can not load this SVG file.</p>
      </object>
     </div>
    <script src="js/compiled/building_usage.js" type="text/javascript"></script>
  </body>
</html>
```

Solution 6-3

File core.cljs

```
(ns ^:figwheel-always building_usage2.core
    (:require [building_usage2.roster :as roster]
              [building_usage2.utils :as utils]
              [goog.dom :as dom]
              [goog.events :as events]))

(enable-console-print!)

(def days ["Monday" "Tuesday" "Wednesday" "Thursday"
           "Friday" "Saturday" "Sunday"])

(def buildings ["A" "B" "C" "D" "FLD" "GYM"
                "M" "N" "P"])

(def building-totals (roster/room-count))

(def usage (roster/building-usage-map))

(defn make-labels [items]
  "Intersperse blank labels between the labels for the hours so that
  the number of labels equals the number of data points."
  (let [result (reduce (fn [acc item] (apply conj acc [item "" "" ""])) []
                      items)]
    result))

(defn create-chart [data]
  (let [ctx (.getContext (dom/getElement "chart") "2d")
        chart (js/Chart. ctx)
        ;; Note: everything needs to be converted to JavaScript
        ;; objects and arrays to make Chart.js happy.
        graph-info #js {:labels (clj->js (make-labels (range 0 24)))
                        :datasets #js [ #js {:label "Usage"
                                             :fillColor "rgb(0, 128, 0)"
                                             :strokeColor "rgb(0, 128, 0)"
                                              :highlightStroke "rgb(255, 0,0)"
                                             :data (clj->js data)}]}

        ;; Override default animation, and set scale
        ;; of y-axis to go from 0-100 in all cases.
        options #js {:animation false
                     :scaleBeginAtZero true
                     :scaleShowGridLines true
```

```
                      :scaleGridLineColor "rgba(0,0,0,.05)"
                      :scaleGridLineWidth 1
                      :scaleShowVerticalLines true
                      :scaleOverride true
                      :scaleSteps 10
                      :scaleStepWidth 10
                      :scaleStartValue 0}]
    (.Bar chart graph-info options)))

(defn to-percent [counts building]
  "Convert counts of rooms occupied to a percentage;
  max out at 100%"
  (let [total (get building-totals building)]
    (map (fn [item] (min 100 (* 100 (/ item total)))) counts)))

(defn update-graph [evt]
  (let [day (.-value (dom/getElement "day"))
        building (.-value (dom/getElement "building"))
        data (if (and (not= "" day) (not= "" building))
               (to-percent (get-in usage [day building]) building)
               nil)]
    (if (not (nil? data)) (create-chart data) nil)))

(do
  (events/listen (dom/getElement "day") "change" update-graph)
  (events/listen (dom/getElement "building") "change" update-graph))

(defn on-js-reload []
  ;; optionally touch your app-state to force rerendering depending on
  ;; your application
  ;; (swap! app-state update-in [:__figwheel_counter] inc)
)
```

File index.html

```
<!DOCTYPE html>
<html>
  <head>
    <link href="css/style.css" rel="stylesheet" type="text/css"/>
    <script type="text/javascript" src="Chart.min.js"></script>
    <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
  </head>
  <body>
    <div id="app">
      <h2>Building Usage</h2>
      <p class="bigLabel">
        <select id="day" class="bigLabel">
          <option value="">Choose a day</option>
          <option value="Monday">Monday</option>
          <option value="Tuesday">Tuesday</option>
          <option value="Wednesday">Wednesday</option>
          <option value="Thursday">Thursday</option>
          <option value="Friday">Friday</option>
          <option value="Saturday">Saturday</option>
          <option value="Sunday">Sunday</option>
        </select>

        Building
        <select id="building" class="bigLabel">
          <option value="">--</option>
          <option value="A">A</option>
          <option value="B">B</option>
          <option value="C">C</option>
          <option value="D">D</option>
          <option value="FLD">FLD</option>
          <option value="GYM">Gym</option>
          <option value="M">M</option>
          <option value="N">N</option>
          <option value="P">P</option>
        </select>
      </p>

      <canvas id="chart" width="600" height="300"></canvas>

      <script src="js/compiled/building_usage2.js"
              type="text/javascript"></script>
    </div>
  </body>
</html>
```

Solution 7-1

```
(ns ^:figwheel-always proto.core
    (:require))

(enable-console-print!)

(defprotocol SpecialNumber
    (plus [this b])
    (minus [this b])
    (mul [this b])
    (div [this b])
    (canonical [this]))

(defn gcd [mm nn]
  (let [m (js/Math.abs mm)
        n (js/Math.abs nn)]
    (cond
      (= m n) m
      (> m n) (recur (- m n) n)
      :else (recur m (- n m)))))

(defrecord Rational [num denom]

  Object
  (toString [r] (str (:num r) "/" (:denom r)))

  SpecialNumber

  (canonical [r]
    (let [d (if (>= (:denom r) 0) (:denom r) (- (:denom r)))
          n (if (>= (:denom r) 0) (:num r) (- (:num r)))
          g (if (or (zero? n) (zero? d)) 1 (gcd n d))]
      (if-not (= g 0)
        (Rational. (/ n g) (/ d g))
        r)))

  (plus [this r2]
    (let [{n1 :num d1 :denom} this
          {n2 :num d2 :denom} r2
          n (+ (* n1 d2) (* n2 d1))
          d (* d1 d2)]
      (if (= d1 d2)
        (canonical (Rational. (+ n1 n2) d1))
        (canonical (Rational. n d)))))

  (minus [r1 r2] (plus r1 (Rational. (- (:num r2)) (:denom r2))))

  (mul [r1 r2] (canonical (Rational. (* (:num r1) (:num r2))
                                     (* (:denom r1) (:denom r2)))))
  (div [r1 r2] (canonical (Rational. (* (:num r1) (:denom r2))
                                     (* (:denom r1) (:num r2))))))
```

Solution 7-2

```
(ns ^:figwheel-always proto.core)

(enable-console-print!)

(defprotocol SpecialNumber
  (plus [this b])
  (minus [this b])
  (mul [this b])
  (div [this b])
  (canonical [this]))

;; code for duration and rational not duplicated

(defrecord Complex [re im]
    Object
    (toString [c]
        (let [{:keys [re im]} c]
            (str (if (zero? re) "" re)
                 (if-not (zero? im)
                     ; note: the order of the conditions here
                     ; is absoutely crucial in order to get the
                     ; leading minus sign
                     (str (cond
                              (< im 0) "-"
                              (zero? re) ""
                              :else "+")
                          (js/Math.abs im) "i")))))

    SpecialNumber
    (canonical [c] c)

    (plus [this other]
        (Complex. (+ (:re this) (:re other)) (+ (:im this) (:im other))))

    (minus [this other]
        (Complex. (- (:re this) (:re other)) (- (:im this) (:im other))))

    (mul [this other]
        ; better living through destructuring
        (let [{a :re b :im} this
              {c :re d :im} other]
          (Complex. (- (* a c) (* b d)) (+ (* b c) (* a d)))))

    (div [this other]
        (let [{a :re b :im} this
              {c :re d :im} other
              denom (+ (* c c) (* d d))]
              denom (+ (* c c) (* d d))]
          (Complex. (/ (+ (* a c) (* b d)) denom)
                    (/ (- (* b c) (* a d)) denom)))))
```

Solution 7-3

```
(ns ^ :figwheel-always test.test-cases
  (:require-macros [cljs.test :refer [deftest is are]])
  (:require [cljs.test :as t]
            [proto.core :as p]))

(deftest duration1
  (is (= (p/canonical (p/Duration. 3 84)) (p/Duration. 4 24))))

(deftest duration-str
  (are [m1 s1 expected]
    (= (str (p/Duration. m1 s1) expected))
    1 10  "1  10"
    1 9 "1  09"
    1 60 "2  00"
    3 145 "5  25"
    0 0 "0  00"))

(deftest gcd-test
  (are [x y] (= x y)
             (p/gcd 3 5) 1
             (p/gcd 12 14) 2
             (p/gcd 35 55) 5))

(deftest rational-plus
  (are [x y z]
    (let [[a b] x
          [c d] y
          [rn rd] z]
      (= (p/plus (p/Rational. a b) (p/Rational. c d)) (p/Rational. rn rd)))
    [1 2] [1 3] [5 6]
    [2 8] [3 12] [1 2]
    [0 4] [0 5] [0 20]
    [1 0] [1 0] [2 0]))

(deftest rational-minus
  (are [x y z]
    (let [[a b] x
          [c d] y
          [rn rd] z]
      (= (p/minus (p/Rational. a b) (p/Rational. c d)) (p/Rational. rn rd)))
    [6 8] [6 12] [1 4]
    [1 4] [3 4] [-1 2]
    [1 4] [1 4] [0 4]))

(deftest rational-multiply
  (are [x y z]
    (let [[a b] x
          [c d] y
          [rn rd] z]
      (= (p/mul (p/Rational. a b) (p/Rational. c d)) (p/Rational. rn rd)))
    [1 3] [1 4] [1 12]
    [3 4] [4 3] [1 1]))

(deftest rational-divide
  (are [x y z]
    (let [[a b] x
          [c d] y
          [rn rd] z]
      (= (p/div (p/Rational. a b) (p/Rational. c d)) (p/Rational. rn rd)))
    [1 3] [1 4] [4 3]
    [3 4] [4 3] [9 16]))

(deftest complex-str
  (are [r i result]
    (= (str (p/Complex. r i)) result)
  3 7 "3+7i"
  3 -7 "3-7i"
  -3 7 "-3+7i"
  -3 -7 "-3-7i"
  0 7 "7i"
  3 0 "3"))

(deftest complex-math
  (are [r1 i1 f r2 i2 r3 i3]
    (= (f (p/Complex. r1 i1) (p/Complex. r2 i2)) (p/Complex. r3 i3))
     1 2  p/plus  3 4  4 6
     1 -2  p/plus  -3 4 -2 2
     1 2  p/minus  3 4  -2 -2
     1 2  p/mul  3 4  -5 10
     0 2  p/mul  3 -4  8 6
     3 4  p/div  1 2  2.2 -0.4
     1 -2  p/div  3 -4  0.44 -0.08))
```

Sample core.async Program 1

```
(ns ^:figwheel-always async1.core
  (:require-macros [cljs.core.async.macros :refer [go go-loop]])
    (:require [cljs.core.async
               :refer  [<! >! timeout alts! chan close!]]))

(enable-console-print!)

(defn on-js-reload [])

(def annie (chan))
(def brian (chan))

(defn annie-send []
  (go (loop [n 5]
           (println "Annie:" n "-> Brian")
           (>! brian n)
           (if (pos? n) (recur (dec n)) nil))))

(defn annie-send []
  (go (loop [n 5]
           (println "Annie:" n "-> Brian")
           (>! brian n)
           (when (pos? n) (recur (dec n))))))

(defn annie-receive []
  (go-loop []
           (let [reply (<! brian)]
             (println "Annie:" reply "<- Brian")
             (if (pos? reply)
               (recur)
               (close! annie)))))

(defn brian-send []
  (go-loop [n 5]
           (println "Brian:" n "-> Annie")
           (>! annie n)
           (when (pos? n) (recur (dec n)))))

(defn brian-receive []
  (go-loop []
           (let [reply (<! annie)]
             (println "Brian:" reply "<- Annie")
             (if (pos? reply)
               (recur)
               (close! brian)))))

(defn async-test []
  (do
    (println "Starting...")
    (annie-send)
    (annie-receive)
    (brian-send)
    (brian-receive)))
```

Sample core.async Program 2

```
(ns ^:figwheel-always async2.core
  (:require-macros [cljs.core.async.macros :refer [go go-loop]])
    (:require [cljs.core.async :as a
               :refer  [<! >! timeout alts! chan close!]]))

(enable-console-print!)

(defn on-js-reload [])

(defn decrement! [[from-str from-chan] [to-str to-chan] & [start-value]]
  (go-loop [n (or start-value (dec (<! from-chan)))]
           (println from-str ":" n "->" to-str)
           (>! to-chan n)
           (when-let [reply (<! from-chan)]
             (println from-str ":" reply "<-" to-str)
             (if (pos? reply)
               (recur (dec reply))
               (do
                 (close! from-chan)
                 (close! to-chan)
                 (println "Finished"))))))

(defn async-test []
  (let [annie (chan)
        brian (chan)]
    (decrement! ["Annie" annie] ["Brian" brian] 8)
    (decrement! ["Brian" brian] ["Annie" annie])))
```

Solution 8-1

This solution is split into two files: *core.cljs* and *utils.cljs*.

File core.cljs

```
(ns ^:figwheel-always cardgame.core
  (:require-macros [cljs.core.async.macros :refer [go go-loop]])
  (:require [cljs.core.async
             :refer  [<! >! timeout alts! chan close! put!]]
            [cardgame.utils :as utils]))

(enable-console-print!)

(def max-rounds 50) ;; max # of rounds per game

;; create a channel for each player and the dealer

(def player1 (chan))
(def player2 (chan))
(def dealer (chan))

(defn on-js-reload [])

;; I have added a player-name for debug output;
;; it's not needed for the program to work.

(defn player-process
  "Arguments are channel, channel name, and initial
  set of cards. Players either give the dealer cards
  or receive cards from her. They send their player
  number back to the dealer so that she can distinguish
  the inputs. The :show command is for debugging;
  the :card-count is for stopping a game after a
  given number of rounds, and the :quit command finishes the loop."
  [player player-name init-cards]
  (do
    (println "Starting"  player-name "with" init-cards)
    (go (loop [my-cards init-cards]
          (let [[message args] (<! player)]
            (condp = message
              :give (do
                      (println player-name
                               "has" my-cards
                               "sending dealer" (take args my-cards))
                      (>! dealer [player-name (take args my-cards)])
                      (recur (vec (drop args my-cards))))
              :receive (do
                         (println player-name "receives" args
                                  "add to" my-cards)
```

```
                            (>! dealer "Received cards")
                            (recur (apply conj my-cards args)))
                 :show (do (println my-cards) (recur my-cards))
                 :card-count (do
                               (>! dealer [player-name (count my-cards)])
                               (recur my-cards))
                 :quit nil))))))

(defn determine-game-winner
  "If either of the players is out of cards, the other player wins."
  [card1 card2]
  (cond
    (empty? card1) "Player 1"
    (empty? card2) "Player 2"
    :else nil))

(defn make-new-pile
  "Convenience function to join the current pile
  plus the players' cards into a new pile."
  [pile card1 card2]
  (apply conj (apply conj pile card1) card2))

(defn put-all!
  "Convenience function to send same message to
  all players. The (doall) is necessary to force
  evaluation."
  [info]
  (doall (map (fn [p] (put! p info)) [player1 player2])))

(defn arrange
  "Since we can't guarantee which order the cards come in,
  we arrange the dealer's messages so that player 1's card(s)
  always precede player 2's card(s)."
  [[pa ca] [pb cb]]
  (if (= pa "Player 1") [ca cb] [cb ca]))

(defn do-battle
  "Returns a vector giving the winner (if any) and the
  new pile of cards, given the current pile, the players' cards,
  and the number of rounds played.
  If someone's card is empty, the other person is the winner.
  If the number of rounds is at the maximum, the person with
     the smaller number of cards wins.
  If one player has a higher card, the other player has
  to take all the cards (returning an empty pile); if they
  match, the result is the pile plus the cards"
  [pile card1 card2 n-rounds]
  (let [c1 (utils/value (last card1))
        c2 (utils/value (last card2))
        game-winner (determine-game-winner card1 card2)
        new-pile (make-new-pile pile card1 card2)]
    (println (utils/text (last card1)) "vs." (utils/text (last card2)))
    (when-not game-winner
        (cond
        (> c1 c2) (put! player2 [:receive new-pile])
        (< c1 c2) (put! player1 [:receive new-pile])))
      [game-winner (if (= c1 c2) new-pile (vector))]))

(defn play-game
  "The game starts by dividing the shuffled deck and
  gives each player half.
  Pre-battle state: ask each player to give a card
    (or 3 cards if the pile isn't empty)
  Battle state: wait for each player to send cards and evalute.
  Post-battle: wait for person who lost hand (if not a tie)
    to receive cards
  Long-game: too many rounds. Winner is person with most cards"
  []
  (let [deck (utils/short-deck)
        half (/ (count deck) 2)]
    (player-process player1 "Player 1" (vec (take half deck)))
    (player-process player2 "Player 2" (vec (drop half deck)))
    (go (loop [pile []
               state :pre-battle
               n-rounds 1]
             (condp = state
               :pre-battle (do
                             (println "** Starting round" n-rounds)
                             (put-all! [:give (if (empty? pile) 1 3)])
                             (recur pile :battle n-rounds))

               :battle (let [d1 (<! dealer) ;; block until
                             d2 (<! dealer) ;; both players send cards
                             [card1 card2] (arrange d1 d2)
                             [game-winner
                              new-pile] (do-battle pile card1 card2 n-rounds)]
                         (<! (timeout 300))
                         (if-not game-winner
                           (recur new-pile :post-battle n-rounds)
                           (do
                             (put-all! [:quit nil])
                             (println "Winner:" game-winner))))

               :post-battle (do
                              ;; wait until player picks up cards
                              (when (empty? pile) (<! dealer))
                              (if (< n-rounds max-rounds)
                                (recur pile :pre-battle (inc n-rounds))
                                (do
                                  (put-all! [:card-count nil])
                                  (recur pile :long-game 0))))
               :long-game (let [[pa na] (<! dealer)
                                [pb nb] (<! dealer)]
                            (put-all! [:quit nil])
```

```
                                 (println pa "has" na "cards.")
                                 (println pb "has" nb "cards.")
                                 (println "Winner:" (cond
                                                      (< na nb) pa
                                                      (> na nb) pb
                                                      :else "tied"))))))))
```

File utils.cljs

```
(ns ^:figwheel-always cardgame.utils
  (:require))

(def suits ["clubs" "diamonds" "hearts" "spades"])
(def names ["Ace" "2" "3" "4" "5" "6" "7" "8" "9" "10"
            "Jack" "Queen" "King"])

;; If there was no card at all (nil)
;; return nil, otherwise aces are high.
(defn value [card]
  (let [v (when-not (nil? card) (mod card 13))]
    (if (= v 0) 13 v)))

(defn text [card]
  (let [suit (quot card 13)
        base (mod card 13)]
    (if (nil? card)
      "nil"
      (str (get names base) " of " (get suits suit)))))

(defn full-deck []
  (shuffle (range 0 52)))

;; Give a short deck of Ace to 4 in clubs and diamonds only
;; for testing purposes.

(defn short-deck []
  (shuffle (list 0 1 2 3 4 5 13 14 15 16 17 18)))
```

APPENDIX B

Setting Up Your ClojureScript Environment

Setting Up ClojureScript

ClojureScript is a dialect of Clojure that compiles to JavaScript. Clojure is a Lisp dialect that runs on the Java Virtual Machine. So, in order to use JavaScript, you need Java and Clojure.

Getting Java

You can test to see if Java is already installed on your computer by opening a command window (on Windows) or a terminal window (on Mac OS X or Linux) and typing `java -version` at the command line. If you get some output describing a version of Java, such as the following, you have Java installed:

```
java version "1.8.0_40"
    Java(TM) SE Runtime Environment (build 1.8.0_40-b26)
    Java HotSpot(TM) 64-Bit Server VM (build 25.40-b25, mixed mode)
```

If you get an error message, then you need to install Java. You may either use OpenJDK or Oracle's Java Development Kit. Follow the download and installation instructons you find there.

Getting Clojure and ClojureScript

If you want to get started quickly with ClojureScript, I recommend that you follow the instructions at the aptly named ClojureScript Quick Start page. From that page, you can download a *JAR* file that has "the ClojureScript compiler and the bundled REPLs without an overly complicated command line interface."

Creating a ClojureScript Project

Again, using the instructions at the Quick Start page, I created a project named *sample-project*. (I am sick and tired of "Hello, world!" so I did something slightly different.)

Here is the file structure of the directory, with files organized by category rather than alphabetical order. Notice that the project name *sample-project* has a hyphen in it, but when used in a directory name, you replace the hyphen with an underscore: *sample_project*:

```
sample_project
├── cljs.jar
├── src
│   └── sample_project
│       └── core.cljs
├── index.html
├── build.clj
├── release.clj
├── repl.clj
└── watch.clj
```

The *cljs.jar* file contains ClojureScript, downloaded from the link at the Quick Start page.

ClojureScript File src/sample_project/core.cljs

This is the ClojureScript file for the project; it simply prints to the console:

```
;; remove the :require and defonce when building the release version

(ns sample-project.core
  (:require [clojure.browser.repl :as repl]))

(defonce conn
  (repl/connect "http://localhost:9000/repl"))

(enable-console-print!)

(println "It works!")
```

File index.html

This file has a bit more than the Quick Start file: the addition of the `<meta>` element avoids a warning in the web console, and the `<title>` element lets you distinguish projects from one another if you have multiple browser tabs open:

```
<!DOCTYPE html>
<html>
    <head>
        <title>sample-project</title>
        <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
    </head>
    <body>
        <script type="text/javascript" src="out/main.js"></script>
    </body>
</html>
```

File build.clj

Builds an unoptimized version of the project. Run with the command:

```
(require 'cljs.build.api)

(cljs.build.api/build "src"
  {:main 'sample-project.core
   :output-to "out/main.js"})
```

File release.clj

Builds an optimized version of the project:

```
((require 'cljs.build.api)

(cljs.build.api/build "src"
  {:output-to "out/main.js"
   :optimizations :advanced})

(System/exit 0)
```

File repl.clj

Builds an unoptimized version of the project and launches a browser REPL. On Linux and MacOSX, make sure you have `rlwrap` installed:

```
(require 'cljs.repl)
(require 'cljs.build.api)
(require 'cljs.repl.browser)

(cljs.build.api/build "src"
  {:main 'sample-project.core
   :output-to "out/main.js"
   :verbose true})

(cljs.repl/repl (cljs.repl.browser/repl-env)
  :watch "src"
  :output-dir "out")
```

File watch.clj

This program watches the *src* directory and recompiles when any file in that directory changes:

```
(require 'cljs.build.api)

(cljs.build.api/watch "src"
  {:main 'sample-project.core
   :output-to "out/main.js"})
```

Getting a Text Editor

You can use any text editor you like to create your ClojureScript programs. The Emacs editor seems to be quite popular, with Vim another popular choice. Yes, both have plug-ins for support of Clojure (CIDER for Emacs; Fireplace for Vim). No, I will not get involved in the theological battle between these two editors. If you are in search of an IDE (integrated development environment), you have a number of choices there as well:

- IntelliJ IDEA with the Cursive plug-in
- Light Table
- Nightcode
- Eclipse with the Counterclockwise plug-in for Clojure

APPENDIX C

Creating a ClojureScript Project with Leiningen

Another way to get Clojure is to use Leiningen, a tool (as the website puts it) “for automating Clojure projects without setting your hair on fire.” Follow the download instructions at the Leiningen website, and then, as it says, type `lein`. Leiningen will download the self-install package, and you will then be ready to create ClojureScript (and Clojure) projects.

Leiningen lets you create projects based on *templates*. You create a new project with a command of the form `lein new` *`template-name project-name`*. There are plenty of templates out there, but the two I’m going to use in this book are the minimal *mies* template and the more advanced *figwheel* template.

The mies Template

Use the `git` utility to download the latest version and install it:

```
[etudes@localhost ~]$ git clone https://github.com/swannodette/mies.git
Cloning into 'mies'...
remote: Counting objects: 524, done.
remote: Total 524 (delta 0), reused 0 (delta 0), pack-reused 524
Receiving objects: 100% (524/524), 48.61 KiB | 0 bytes/s, done.
Resolving deltas: 100% (217/217), done.
Checking connectivity... done.
[etudes@localhost ~]$ cd mies
[etudes@localhost mies]$ lein install
Created /home/etudes/mies/target/lein-template-0.6.0.jar
Wrote /home/etudes/mies/pom.xml
Installed jar and pom into local repo.
```

Here is the file structure that came from the command `lein new mies example`:

```
example
├── index.html
├── index_release.html
├── project.clj
├── README.md
├── scripts
│   ├── brepl
│   ├── build
│   ├── compile_cljsc
│   ├── release
│   ├── repl
│   └── watch
└── src
    └── example
        └── core.cljs
```

The *project.clj* file contains information about your project's requirements and dependencies. The *scripts* directory contains scripts that:

- Open a browser REPL (*brepl*)
- Build the development version of the project (*build*)
- Compile parts of the ClojureScript system so you don't have to recompile them every time you rebuild the project (*compile_cljsc*)
- Build the relase version of the project, which optimizes the compiled JavaScript code (*release*)
- Open a Node.js REPL (*repl*)
- Monitor the source directory and rebuild the project whenever a source file changes (*watch*)

The *core.cljs* file will contain your code. For a new project, it looks like this:

```
(ns example.core
  (:require [clojure.browser.repl :as repl]))

;; (defonce conn
;;   (repl/connect "http://localhost:9000/repl"))

(enable-console-print!)

(println "Hello world!")
```

The lines beginning with the two semicolons are ClojureScript comments. The commented-out lines enable the browser REPL. You will almost certainly want to uncomment those lines by removing the semicolons. Then you can, from the main *example* folder, invoke *scripts/compile_cljsc*—which you need to do only once—then build the project with *scripts/build*, and start the browser REPL with *scripts/brepl*. All these scripts use Leiningen, which will automatically retrieve any dependencies that your project needs. You will eventually see something like this:

```
[etudes@localhost example]$ scripts/brepl
Compiling client js ...
Waiting for browser to connect ...
Watch compilation log available at: out/watch.log
To quit, type: :cljs/quit
cljs.user=>
```

Automatic Compilation

As set up in the *mies* template, the *brepl* script keeps track of your *src* directory, and the project is recompiled whenever a file changes. The results are placed in the file *out/watch.log*. You can open a separate terminal window and use the command `tail out/watch.log` to continuously monitor that file. If you do not want to automatically rebuild, go to the *scripts/brepl.clj* file and change this line:

```
{:watch "src"
```

to this, making sure that you put the semicolons *after* the opening brace:

```
{ ;; :watch "src"
```

If you do this, then you must manually recompile files, and compile errors will appear in the REPL window.

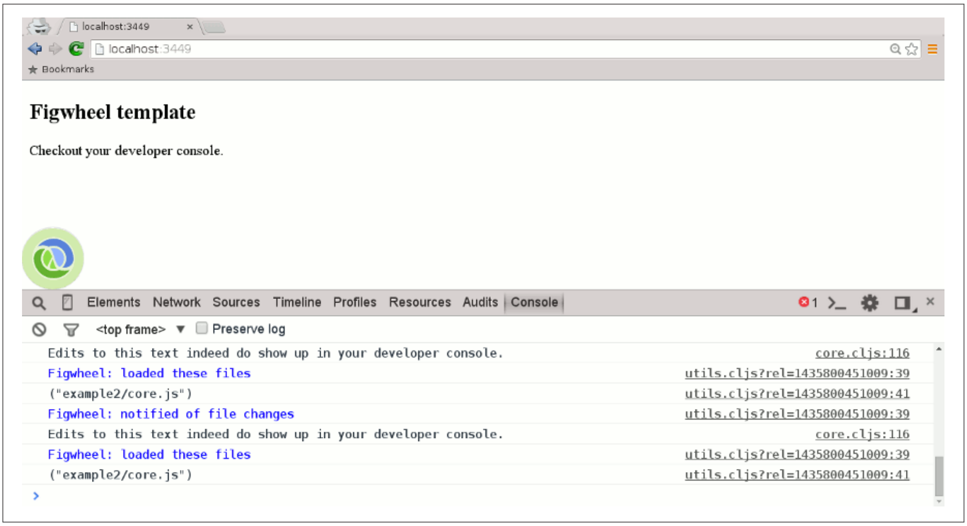
The figwheel Template

The *figwheel* template is designed to make interactive development easy. Here is the file structure that you get from the command `lein new figwheel example2`:

```
example2
├── .gitignore
├── project.clj
├── README.md
├── resources
│   └── public
│       ├── css
│       │   └── style.css
│       └── index.html
└── src
    └── example2
        └── core.cljs
```

The *project.clj* file contains the information about your project's requirements and dependencies. Your code goes in the *core.cljs* file. To compile and run the code, open a terminal window and type `lein figwheel`, then go to *http://localhost:3449* in your browser. You will have a REPL prompt in the terminal window, and figwheel will monitor your source directory for changes.

Figure C-1 shows the result of a good compile after making a change to the *core.cljs* file; Figure C-2 shows the result of a compile error. Notice that figwheel points out the line in the ClojureScript file where the error occurred.

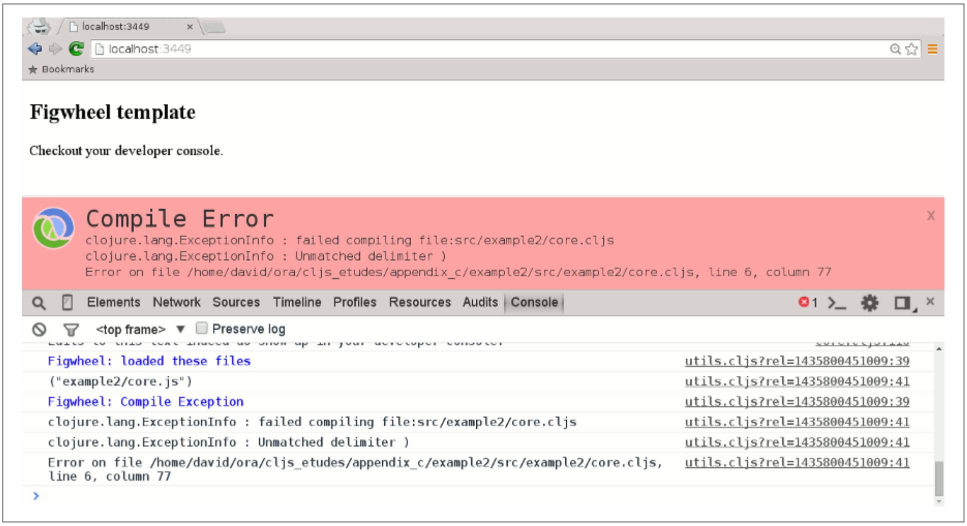


Figwheel template

Checkout your developer console.

```
Edits to this text indeed do show up in your developer console.          core.cljs:116
Figwheel: loaded these files                          utils.cljs?rel=1435800451009:39
("example2/core.js")                                  utils.cljs?rel=1435800451009:41
Figwheel: notified of file changes                    utils.cljs?rel=1435800451009:39
Edits to this text indeed do show up in your developer console.          core.cljs:116
Figwheel: loaded these files                          utils.cljs?rel=1435800451009:39
("example2/core.js")                                  utils.cljs?rel=1435800451009:41
>
```

Figure C-1. Screenshot of result of good compilation



Figwheel template

Checkout your developer console.

```
Compile Error
clojure.lang.ExceptionInfo : failed compiling file:src/example2/core.cljs
clojure.lang.ExceptionInfo : Unmatched delimiter )
Error on file /home/david/ora/cljs_etudes/appendix_c/example2/src/example2/core.cljs, line 6, column 77
```

```
Figwheel: loaded these files                          utils.cljs?rel=1435800451009:39
("example2/core.js")                                  utils.cljs?rel=1435800451009:41
Figwheel: Compile Exception                           utils.cljs?rel=1435800451009:39
clojure.lang.ExceptionInfo : failed compiling file:src/example2/core.cljs   utils.cljs?rel=1435800451009:41
clojure.lang.ExceptionInfo : Unmatched delimiter )    utils.cljs?rel=1435800451009:41
Error on file /home/david/ora/cljs_etudes/appendix_c/example2/src/example2/core.cljs,   utils.cljs?rel=1435800451009:41
line 6, column 77
>
```

Figure C-2. Screenshot of result of error in compilation

This is not to say that *mies* and *figwheel* are the only templates you can use; a search for *clojurescript template* at https://clojars.org/ will produce a whole list of templates with varying purposes. Choose whichever works best for you.

APPENDIX D
ClojureScript on the Server

ClojureScript on the Server

Just as JavaScript works in the browser and on the server, via a library like Node.js, so does ClojureScript. In this book, I'm using Node.js for the server side.

Getting Node.js

You can get Node.js from the download page. This will also give you *npm*, Node's package manager.

Creating a ClojureScript/Node.js Project

I created a project named *node-project* by following the instructions at the ClojureScript Quick Start page. (I am sick and tired of "Hello, world!" so I did something slightly different.)

Here is the file structure of the directory, with files organized by category rather than alphabetical order. Notice that the project name *node-project* has a hyphen in it, but when used in a directory name, you replace the hyphen with an underscore, *node_project*:

```
node_project
├── cljs.jar
├── src
│   └── node_project
│       └── core.cljs
└── node.clj
```

The *cljs.jar* file contains ClojureScript, downloaded from the link at the Quick Start page.

ClojureScript File src/node_project/core.cljs

This is the ClojureScript file for the project; it simply prints to the console:

```
(ns node-project.core
  (:require [cljs.nodejs :as nodejs]))

(nodejs/enable-util-print!)

(defn -main [& args]
  (println "It works!"))

(set! *main-cli-fn* -main)
```

File node.clj

This file builds the unoptimized project:

```
(require 'cljs.build.api)

(cljs.build.api/build "src"
  {:main 'node-project.core
   :output-to "main.js"
   :target :nodejs})
```

File node_repl.clj

This file will build the project and start a REPL:

```
(require 'cljs.repl)
(require 'cljs.build.api)
(require 'cljs.repl.node)

(cljs.build.api/build "src"
  {:main 'hello-world.core
   :output-to "out/main.js"
   :verbose true})

(cljs.repl/repl (cljs.repl.node/repl-env)
  :watch "src"
  :output-dir "out")
```

Using Node.js Modules

To use a Node.js module, you need to define a binding for the library via the `js/require` function. You can then use that binding's methods and properties in your ClojureScript code. The following is a REPL session that shows the use of the built-in `os` module:

```
cljs.user=> (in-ns 'node-project.core)
node-project.core=> (def os (js/require "os"))
```

```
;; much output omitted
node-project.core=> (.hostname os)
"localhost.localdomain"
node-project.core=> (.platform os)
"linux"
example.core=> (.-EOL os) ;; this is a property
"\n"
```