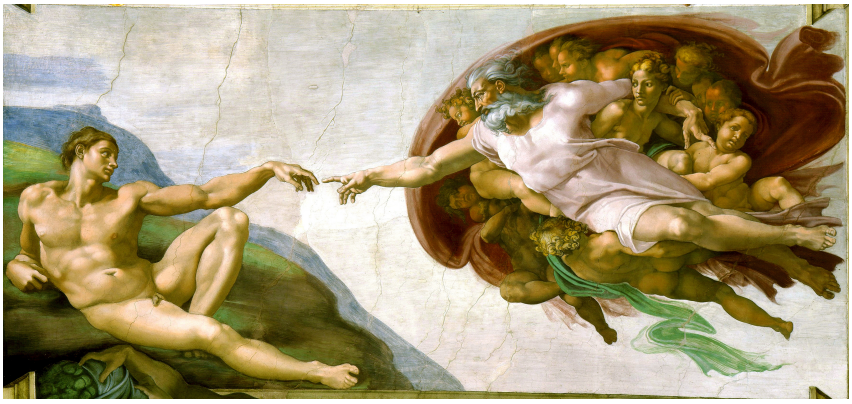
The GNU Java Training Wheels programming language for making it easier to learn Java



Part 1/3 of a Ph.D. Thesis

By Davin Pearson

Eleventh Edition

The GNU Java Training Wheels programming language for making it easier to learn Java

Part 1/3 of a A Ph.D. thesis

February 22, 2019

Abstract

This book is about how to add a preprocessor to the Java language to turbo-charge its performance and to create a new programming language called GNU Java Training Wheels *or* J.T.W. *for short. Both expressiveness and efficiency can be improved using preprocessor languages. J.T.W. has been created specifically for novice Java programmers who want to learn Java. In particular Pascal-style* **begin** *. . .* **end** *constructs are supported instead of Java's* { *. . .* } *construct, which makes J.T.W. code much more readable than the equivalent Java code. J.T.W. translates to Java in a natural and straightforward manner so it is easy for J.T.W. programmers to learn Java. J.T.W. is supported by easy to understand error messages so it is easy to debug J.T.W. code. For many reasons you might prefer to code in J.T.W. rather than Java. Experienced programmers will find J.T.W. useful too. Emacs Lisp is used as the preprocessor for the Java and C++ languages because it is powerful enough for my needs and it is free software. That is to say free as in free speech and not free beer. Lisp is a higher level language than Java and is powerful enough to render obsolete blocks of tiresome repetitive boilerplate code that dominates code written in Java. A small collection of* **d-defmacro***s have been provided for you to deploy in your client code. If you are especially clever, you can write your own Emacs Lisp* **d-defmacro***s to replace blocks of tiresome repetitive boilerplate code in Java. The idea for eliminating tiresome repetitive boilerplate code comes from Peter Seibel's 2005 book* [Sei05] Practical Common Lisp *which devotes an entire chapter (chapter 9) to eliminating tiresome repetitive boilerplate code from Common Lisp code.*

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[1] www.gnu.org/copyleft/fdl.html

For Dorothy

Contents

Preface

Preface to the eleventh edition

Split my book from one book into two separate books, *The Java Training Wheels programming language* and *Building C++ Preprocessors: Using Lisp++ for Efficient and Expressive Programing*

Preface to the tenth edition

Removed the C++ source code for the `libd` library because C++ is not supported by this version (and future versions) Added a new section §**??** called *A solution to the first problem.* Added a new section **??** called *Proof of concept 1: A small collection of d-defmacros for your use in your Lisp++ client code.* Also fontified all occurrences of private_foo in the face "`prvt`", short for *private.*

Preface to the ninth edition

Fixed numerous typographical errors. Changed the link of my large files links from

`davinpearson.com/binaries/large-files-links.html`

to

`davinpearson.com/binaries`

so that uploads to this website are displayed by default without the need to update the file `large-files-links.html`.

Preface to the eighth edition

Changed the save names for classes that begin with an initial capital letter. This overcomes Microsoft Windows' limitation in its filenames in how it cannot have two files with the same name, only different in case, e.g. `foo` and `Foo`. Therefore a **class** `X` will now reside in files called `_X.lisp++` and will be built into C++ source files `_X.h++`, `_X.ch++` and `_X.c++`. That way a **class** called `x` can reside in a file called `x.lisp++` and will be built into files called `x.h++`, `x.ch++` and `x.c++` and Windows won't complain about three pairs of files different only in case. Actually

instead of complaining, Windows silently overwrites one of each pair of files with the other, which is hardly ideal behaviour. This scheme of things works equally well in GNU/Linux but is superfluous in this case.

Preface to the seventh edition

Added syntax highlighting to the following textual elements:

NOTE: I am a note

COOL: I am a cool note

and similar textual elements. Added the following target to the manual's Makefile in §2.11.3 that was missing from earlier editions:

```
001 build-class-db:
002         @echo "* Stage 0 :  Building class database"
003         emacs --batch --eval "(setq dir \"$(PREFIX)/share/emacs/site-lisp/dlisp/\")" \
004 --load $(PREFIX)/share/emacs/site-lisp/dlisp/jtw-build-class-db.el --funcall doit
005
006 clean: build-class-db
```

Added section §?? on installing a C/C++ compiler.

Preface to the sixth edition

Put back sections §?? and §?? that were accidentally removed from the previous edition. In §2.16.4 removed the fontification of the word **main** → main. Also changed **begin**{**enumerate**} ... **end**{**enumerate**} → **begin**{**itemize**} ... **end**{**itemize**} in section §2.10. Centralised the diagrams in Figures ??, ?? and ??.

Preface to the fifth edition

Upped the number of lines of code written from 53,000 → 54,000. Moved *An idiom for* **constructor***s* from §?? to §2. Also updated the code to reflect this change. Expanded the section in §??. Removed the section *Debugging crappyness of Lisp++* since it no longer applies.

Preface to the fourth edition

Added a new section *Virtual Methods*, see §??. Added a new section *Run Time Type Inquiry*, see §??. Clipped extra long lines in the code listing in §2.7.2. Renamed **method**s in §?? from **x_method1** → **foo_method1** etc. Corrected the following hyperlink in §??

davinpearson.com/binaries/large-files-size.html

→

davinpearson.com/binaries/large-files-links.html

Improved the diagram in Figure 2.1.

Preface to the third edition

Added support for inline **function**s and **method**s and documentation of the `cinline` keyword. See §?? for more information. Fixed the following bug in the documentation. See §2.16.4.

A → pkg.inner.A

Upped the lines of Emacs Lisp source code written count from 41,000 → 53,000 lines of code. I now count experimental code as well as actively used code to get the higher value for the number of lines of code written. This bumped up the number of lines of code by over 6,000.

Preface to the second edition

Removed the extraneous large source code file: `Othello.lisp++` (1,000+ lines of code) from the first edition of my book. Updated the lines of Emacs Lisp source code written count from 38,000 → 41,000 lines of code.

Preface to the first edition

Wrote this book using the LaTeX document-markup system, specifically `pdfTex` Version 3.1415926-2.5-1.40.14 (TeX Live 2013/Debian). Also used the program `xfig` for drawing diagrams. Used the following Emacs Lisp code for syntax highlighting the various code language buffers, using LaTeX's **color**{*color name*}{*text to colourise*} and **colorbox**{*color name*}{*text to colourise*}.

davin.50webs.com/research/2010/d-latexize8.el.html

Executed `d-latexize.el` by issuing the following shell command:

```
emacs --batch --eval "(setq *target* \"/path/to/jtw11-ebook.tex\")" ↩
--load $(PREFIX)/share/emacs/site-lisp/dlisp/d-latexize8.el --funcall doit
```

where ***/path/to/jtw11-ebook.tex*** is the name of the file you want to include into your LaTeX sources. In the above printout, note the use of the symbol ↩ to refer to a line of code that has been clipped to fit onto the page. Note that `$(PREFIX)` is set by default to `/usr/` under GNU/Linux or `c:/java-training-wheels/` under M.S. Windows. Ran the LaTeX fontification engine on itself to print out the following printout. Note the use of GNU m4 to provide logic for the printout:

```
// BEGIN FILE: ../m4-emacs-pretty-print-latex2.m4
001  m4_changequote(,) m4_dnl
002  m4_changequote([,]) m4_dnl
003  m4_define([m4_emacs_pretty_print_latex],
004  \begin{raggedright}
005  \noindent{}\mbox{m4_ifelse(-1,m4_regexp($1,el),{\color{comm}{//}},{\color{comm}{;;}})
006  {\bf\colorbox{begin-code-bg}{\color{begin-code-fg}{{\bf B}EGIN FILE:}}}
007  {\bf\color{black}{{m4_patsubst(m4_patsubst($1,_,\_),~,\~{})}}}}
008  m4_syscmd(emacs --batch --eval  "(setq *target*a\"$1\")"  --load ~/dlisp/d-latexize9.el ↩
009  --debug-init --funcall doit)
010  m4_esyscmd(cat $1.tex)
011  m4_ifelse(-1,m4_regexp($1,el),{\color{comm}{//}},{\color{comm}{;;}}) m4_dnl
012  \mbox{{\bf\colorbox{begin-code-bg}{\color{begin-code-fg}{{\bf E}ND FILE:}}}\hspace{3.76mm} m4_dnl
013  {\bf\color{black}{{m4_patsubst(m4_patsubst($1,_,\_),~,\~{})}}}}
```

```
014  m4_syscmd(rm -f $1.tex)
015  \end{raggedright}
016  )
// END FILE:    ../m4-emacs-pretty-print-latex2.m4
```

This macro is called like so:

```
001 m4_begin_indent
002 m4_emacs_pretty_print_latex(/path1/to/File.java) m4_dnl java-mode file
003 m4_emacs_pretty_print_latex(/path2/to/File.jtw) m4_dnl jtw-mode file
004 m4_emacs_pretty_print_latex(/path3/to/file.cc) m4_dnl c++-mode file
005 m4_emacs_pretty_print_latex(/path4/to/file.c++) m4_dnl c++-mode file
006 m4_emacs_pretty_print_latex(/path5/to/file.el) m4_dnl emacs-lisp-mode file
007 m4_emacs_pretty_print_latex(/path6/to/file.lisp++) m4_dnl lisp++-mode file
008 m4_end_indent
```

Where `m4_begin_indent` and `m4_end_indent` are defined like so:

```
001 m4_define([m4_begin_indent],[m4_dnl
002 \begin{quote} m4_dnl
003 \begin{tt} m4_dnl
004 \begin{footnotesize} m4_dnl
005 m4_changequote(,) m4_dnl Turns m4 quotes off.
])
```

and like so:

```
001 m4_define([m4_end_indent],[m4_dnl
002 \end{footnotesize} m4_dnl
003 \end{tt} m4_dnl
004 \end{quote} m4_dnl
005 m4_changequote(,) m4_dnl Turns m4 quotes off
006 m4_changequote([,]) m4_dnl Changes m4 quotes back to [ ... ]
007 ])
```

Chapter 1

Introduction

This book is about how to add a preprocessor to the Java language to turbo-charge its performance. Both expressiveness and efficiency can be improved using preprocessor languages. The preprocessor language is *J.T.W.*. J.T.W stands for *Java Training Wheels*, and is intended for computer programming novices. The name Java Training Wheels was the outcome of an email conversation with Dr. Richard Stallman[1], the President of the *Free Software Foundation*[2] and founder of the *GNU Project*[3], creator of *GNU Emacs*[4], the *GCC compiler*[5], and the *GNU Debugger*[6] which ultimately resulted in the *GNU/Linux* [7] operating system.

Since August 2016, J.T.W. has been accepted by Richard Stallman for inclusion into the Free Software Foundation's repository of Free software, so it is now known by the slightly longer name *GNU Java Training Wheels*. Visit the following Web page on GNU's Website for more information:

www.gnu.org/software/jtw

J.T.W. for example allows programmers to learn programming within an environment that resembles *Pascal* and *BASIC*.

A small collection of **d-defmacros** have been written for you to deploy in your client code. If you are especially clever, then you can write your own **defmacros** to eliminate tiresome repetitive blocks of "boilerplate" code in Java. See §2.7.1 for how to add your own code to J.T.W.

As further proofs of concept for J.T.W. a **superfor** macro (see §2.7.2) is presented (much like the **for** loop construct in BASIC), as well as a file inclusion system (see §2.7.3).

When I first learned the C programming language I was impressed by the power of its preprocessor. Now in the twenty-first century, the C/C++ preprocessor seems like a remnant from the dinosaur age with its lack of support for `#define`s with multiple **template** arguments and the need for excessive backslashes to include blocks of code. Also I believe that the C/C++ preprocessor is not so-called *Turing complete*, which means that its computational power is severely limited. Emacs' suitability for both preprocessing and editing preprocessor code will soon be demonstrated to you the reader, if you will bare with me I will take you on a tour through some existing languages and show you how their performance can be turbo-charged.

After learning the C and C++ language, I learned the similar GNU m4 programming language[8] which is similar to the C/C++ preprocessor only more powerful, and used it to build a large (over 500 page) Website at

[1] stallman.org
[2] fsf.org
[3] gnu.org
[4] en.wikipedia.org/wiki/GNU_Emacs
[5] en.wikipedia.org/wiki/GNU_Compiler_Collection
[6] en.wikipedia.org/wiki/GNU_Debugger
[7] en.wikipedia.org/wiki/GNU/Linux
[8] en.wikipedia.org/wiki/GNU_m4

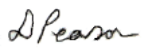
davin.50webs.com

Sometime in between learning C++ and m4 I learned Java and used my knowledge of it to tutor Stage I students in the language. Then I invented the J.T.W. programming language which is intended for novices to help them to learn the Java language. I originally used m4 to compile J.T.W. source code into Java code. It was then that I learned about m4's limitations, specifically how m4 operates on strings when it should leave them alone unchanged. More on this later.

I considered using Flex to compile J.T.W. into Java code but for simplicity I chose the slower but simpler and more powerful technique of using GNU Emacs as a preprocessor. Specifically, Emacs' *batch mode* is used to compile J.T.W. into Java code. The batch mode code is written in *Emacs Lisp* (or *Elisp* for short at the risk of confusion with an older unrelated language called Elisp), the extension language for the GNU Emacs editor. Emacs is available but not compulsory to be used as an editor. The main advantage of using Emacs as an editor as well as a preprocessor is that it allows for syntax **highlighting** of J.T.W. constructs or whatever constructs your language uses for the general case of adding a preprocessor language to your favourite language. Also Emacs provides correct automatic indentation of J.T.W. code.

The J.T.W. programming language is subject to the GNU General Public License for maximum freedom of extension. Therefore this program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See Chapter §3 for the license agreement.

Enjoy reading my book!



Davin Pearson
Christchurch
New Zealand
February 22, 2019

Chapter 2

The J.T.W. language

2.1 Why learn to use J.T.W.?

The first part of this book presents a new programming language called *J.T.W.*, short for *Java Training Wheels* for the sole purpose of making it easier to learn to program in Java. The J.T.W. language has a similar syntax to Delphi, Pascal, BASIC and JavaScript and therefore learning J.T.W. before or while learning Java provides a less steep learning curve than learning Java from scratch. For many reasons you might even prefer to program in J.T.W. rather than Java. Here is why you should learn J.T.W. before or while learning Java:

- The J.T.W. language is supported by a parser that troubleshoots problematic J.T.W. code with clear error messages.
- The J.T.W. language compiles to Java in a natural and straightforward way so it is easy to learn Java once you know J.T.W. See Figure 2.1 for a comparison of the J.T.W. and Java build processes.
- Pascal-style **begin** ... **end** constructs are supported instead of C-style { ... } constructs which is more sensible especially for novices.
- A simple syntax for the **main** **function**: **beginMain** ... **endMain** rather than the rather cumbersome: **public static** void **main** (String[] args) { ... }.
- Class **variable**s, **property**s, **function**s, **method**s and **constructor**s are declared as such much like Delphi which makes your code look clearer. In particular there are new keywords **classVar**, **property**, **function**, **method** and **constructor**.
- The Delphi/Pascal/JavaScript keyword **var** for clearer local **variable**s.
- The Pascal/BASIC keyword **then** for clearer **if** statements.
- The BASIC keywords **and** and **or** rather than Java's rather cumbersome: `&&` and `||`
- As proof of concept, a **superfor** macro is presented for enhanced BASIC-style **for** loops.
- As proof of concept, file inclusion is supported so that you can spread a **class** across several files. Natural divisions are **method**s. Different **method**s can be placed in different source files for those situations where **method**s become large and unwieldy.

NEW! J.T.W. Version 1.1 supports packages

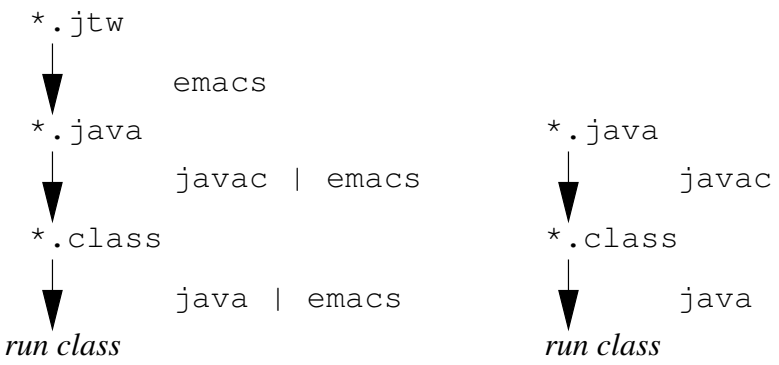


Figure 2.1: Above left is J.T.W.'s build process. Above right is Java's build process. **NOTE:** the vertical bar | represents a piping of the output of the first command into the input of the second command. In the case of Emacs, its *batch mode* rather than *interactive mode* is used in the build process. See §2.11.3 for the *GNU Makefile* for the details of this build process.

2.2 GNU Emacs as a development environment

2.2.1 Why use GNU Emacs as your development environment?

GNU Emacs is the most powerful editor in existence. Most of the Emacs source code is written in a high level language called *Emacs Lisp* or *Elisp* for short. Therefore it is much easier to add customizations than for any other program written in a lower level language such as C or C++. Code can be easily written so that Emacs can host any language you care to use. For J.T.W. the code has already been written for you in the form of `jtw-mode.el`. You can choose to use Emacs with Davin Pearson's customizations or Emacs with just Davin's `jtw-mode.el`. It is recommended that you use Emacs with all of Davin's customizations (also known as *Davin's Full Version of GNU Emacs*) for maximal editing effectiveness. See the following website `www.emacsrocks.com` for some cool stuff that Emacs can do.

2.2.2 Installing GNU Emacs

Installing GNU Emacs on Windows P.C.'s

1. First you need to download `emacs-25.2-i686.zip` or a later version from GNU's Website: `ftp://ftp.gnu.org/pub/gnu/emacs/windows`]. The file size is approximately 92 megabytes, about the size of twelve *MP3* songs. The download time should a few minutes on Broadband Internet.

2. Then you need to unzip the archive to your `c:/Program Files` folder.

3. Then you need to set the `HOME` environment variable to a sensible value for your system. If you have only one hard drive, then the most appropriate value for `HOME` is `c:/home`. If you do not set the `HOME` variable, it will default to `c:/` but the problem with this is that the **root** directory of your hard drive will be cluttered with a whole bunch of files beginning with the period character (.), eg. `.*`. Here is how you should go about achieving this:

   (a) Firstly minimise any open windows.

   (b) Press **Windows E** to open *Windows Explorer*.

   (c) Right click on *This P.C.* or *My Computer*, depending on what version of Windows you are running.

   (d) Click on *Properties* and then click on *Advanced*.

(e) Click on *Environment Variables*.

(f) In the *User variables* or *System variables* section, if there already is a value for the HOME variable, then either keep it or change it to a sensible valuesuch as `c:\home`.

(g) To change it, click on HOME and then click *Edit*.

(h) When you have finished editing it then click on *OK* Keep pressing *OK* until you have no windows left to close.

4. In Windows Explorer, click on the `c:` drive, then `Program Files` then `emacs-25.0.95` (or whatever version of Emacs that you have installed on your system), then `bin` then `addpm.exe` to add a button to copy the Start Emacs button to your Desktop.

5. In the folder pointed to by the `HOME` variable, create a file called `.emacs` and save it to disk. You can use *Notepad* to create such a file. To open Notepad, click on the *Start* button, then *All Programs*, then *Accessories*, then *Notepad*.

2.3 Installing the installer module for J.T.W.

To install J.T.W. and, optionally Davin's Full Version of GNU Emacs, follow the following instructions:

1. Untar the tarball `preprocessors-YYYYmmdd-HHMMSS.tar.gz`.

2. Change directory to the following directory: `~/preprocessors`, and run the following command under M.S. Windows

   ```
   bash install username ENTER
   ```

   Note that under GNU/Linux you will need to be logged in as the `root` user. To achieve this, simply wrap the above command with `su ...exit` like so:

   ```
   su
   bash install username ENTER
   exit ENTER
   ```

   Note that you will be prompted for the `root` password.

3. Note that under M.S. Windows you will need to have the program `bash.exe` installed on your system. You can install this program from Cygwin[1]. It should be already installed on GNU/Linux systems. When running the install script, you will be asked for the location of the prefix directory, the destination directory for your J.T.W. files, and whether or not to install Davin's Full Version of GNU Emacs.

4. If you have the program `yes` installed (as will be the case if you are running GNU/Linux or Cygwin[1]) then you can run the installer module with all of the default settings by issuing the following command. Note that the default setting is **not** to install Davin's Full Version of GNU Emacs. Use the following command under Windows:

   ```
   yes | bash install ENTER
   ```

   or the following command user GNU/Linux:

   ```
   su yes | bash install ENTER exit
   ```

[1] Visit the following Website: www.cygwin.com for the program `setup.exe` which will install this program (and others too).

Installing GNU Emacs on GNU/Linux systems

In *GNU/Linux* systems that derive from *Debian*,[2] all you need to do is to type the following command from your Bash prompt:

```
su
apt-get install emacs25 ENTER
exit ENTER
```

To execute this command, you will be prompted for the **root** password.

Installing `bash`, `grep`, `make` and `sed`

To run J.T.W. files you need to have `bash`, `grep`, `make` and `sed` installed on your system, which you can install yourself if you are using cygwin. If you are running a GNU/Linux system these commands will already be installed. If you are using Cygwin under M.S. Windows then you can download the executables using the already-mentioned command `setup.exe`

Under GNU/Linux systems that derive from Debian, execute the following command

```
su ENTER
apt-get install package ENTER
```

where ***package*** is a name of the package that you want to install. Note that you will be prompted for the **root** password.

2.3.1 Uninstalling J.T.W.

To uninstall J.T.W., you need to issue following command. Note that you will be prompted for the `root` password:

```
su ENTER
bash uninstall username ENTER
exit ENTER
```

Assuming you have untarred the tarball `preprocessors-YYYYmmdd-HHMMSS.tar.gz` to the following folder: `~/preprocessors`, then you need to issue the following command to remove the files: `rm -fr ~/preprocessors`.

2.4 Introducing J.T.W. keywords

In §2.1 I explained how the J.T.W. keywords **begin** ... **end** replaces { ... }, and how the J.T.W. keywords **beginMain** ... **endMain** replaces **public static void main** (String[] args) { ... }. This section explains the rest of the J.T.W. keywords.

1. The J.T.W. keyword **var** makes it clearer whenever a new local variable is introduced. For example: The following J.T.W. code: **var** int x = 123; compiles to the following Java code: int x = 123;.
2. The J.T.W. keyword **classVar** is used to denote **class variable**s, also known in Java as **static variable**s.

[2] See the following link: www.debian.org/misc/children-distros for a list of GNU/Linux distributions which derive from Debian. The list includes `Ubuntu` (see ubuntu.com) and `Lubuntu` (see lubuntu.net) the flavour of GNU/Linux that I choose to use.

3. The J.T.W. keyword **property** is used to denote **property**s, also known as instance **variable**s.
4. The J.T.W. keyword **function** is used to denote **class method**s, those which in Java have the **static** keyword.
5. The J.T.W. keyword **constructor** is used to denote **constructor**s.
6. The J.T.W. keyword **method** is used to denote **method**s, those which in Java lack the **static** keyword.
7. The J.T.W. keyword **then** is used to make **if** statements more clear. For example: **if** `(abc)` **then begin** `...` **end** in J.T.W. compiles to **if** `(abc)` { `...` } in Java.
8. The **elseif** keyword for replacing **else if**.
9. The J.T.W. keywords **and** and **or** serve to replace Java's cumbersome `&&` and `||` for, respectively *logical and* and *logical or*.

2.5 Your first program

Traditionally the first program you write in any language is a program that does nothing but prints out "`Hello, world!`". Here is such a program in J.T.W. which belongs in a file called `MyFirstProgram.jtw`:

```
001 class MyFirstProgram
002 begin
003     beginMain
004         System.out.println( "Hello, world!" );
005     endMain
006 end
```

Here is the same program as the above, after being compiled to Java. This code will reside in a file called **MyFirstProgram.java**.

```
001 class MyFirstProgram
002 {
003     public static void main (String[] args)
004     {
005         System.out.println( "Hello, world!" );
006     }
007 }
```

2.5.1 Building J.T.W. into Java and running class files

To build a single **class** file, you simply execute the command from your `~/jtw-tutorials` folder:

```
make build MyFirstProgram.run
```

which will build, in order, **MyFirstProgram.java**, `MyFirstProgram.class` before running

```
java -enableassertions MyFirstProgram
```

The purpose of the "`build`" target is to call the "`clean`" target which deletes all ***.java** and `*.class` files before building the target file. If you don't do this then `java` might run an old version of `*.class` files despite earlier errors in the build process. This is because the use of pipes in building and executing `*.class` files hides the return values of the programs `javac` and `java`. The `build` target is also useful also when compiling groups of `*.jtw` files.

2.6 J.T.W. Tutorials

These tutorials are also available on-line on my Website:

davin.50webs.com/J.T.W

The answers to the tutorials can be found at my Website above and are protected by passwords. For the passwords to the answers to the questions, see §2.17. To enter the passwords,scroll down to **Section 3: Answers to the tutorials**. and click on the hyperlink there.

- §2.6.1 Introducing **function***s*,*parameters*,*arguments*,*strings*,**System.out.println** and *comments* to give you enough basic J.T.W. to get you started.
- §2.6.2 **Tutorial 2: Introduction to programming in J.T.W.** Introducing chars,*the difference between* `==` *and* `=`,booleans,the **if** `(...)` **then** ... **elseif** `(...)` ... **elseif** `(...)` ... **else** ... construct,*local* **variable***s*,ints,the **superfor** construct and teaching you *how to call existing* **method***s of the string* **class** but not teaching you how to write your own **method**s until Tutorial 9.
- §2.6.3 **Tutorial 3: superfor loops and for loops.** Introducing **System.out.print** for printing without a trailing carriage return,revising loops that use the **superfor** construct,introducing doubles and revising ints and chars.
- §2.6.4 **Tutorial 4: Four looping constructs.** Other types of loops such as **while** and **do** ... **while**,and revising **if** (...) **then** ... **elseif** (...) ... **elseif** (...) ... **else** ... statements and **for** loops. Learning what is the best of these three looping constructs.
- §2.6.5 **Tutorial 5: A beer drinking song.** Using all of the J.T.W. constructs that you have learnt so far to rewrite a song to be more general-purpose.
- §2.6.6 **Tutorial 6: Class variables.** Introducing *class* **variable***s* which are different from **variable**s that are local to **function**s.
- §2.6.7 **Tutorial 7: Non-`Object` arrays.** Introducing *non-object arrays* that are either *single dimensional* or *multi dimensional* using *two different initialisation syntaxes* and introducing *function name overloading*.
- §2.6.8 **Tutorial 8: Accessing functions and class variables from another class.** Learning *how to access* **function***s and* **class variable***s from another* **class** and introducing *boolean arrays*.
- §2.6.9 **Tutorial 9: Mapping:**

  1. **class variable***s* → *instance* **variable***s* (which are better known as **property***s*),and
  2. **function***s* → **method***s*

  to allow for more than one object per **class**. This gives you the full power of O.O.P. *(Object Oriented Programming)* **class**es. Introducing *getter* **method***s* and *references* for accessing objects. Introducing the `null` keyword for representing *no object* and introducing the `toString` **method**,while explaining why this **method** is better than any other **method** or **property** for debugging your code.
- §2.6.10 **Tutorial 10: `Object` arrays.** Introducing *object arrays* that are either *single dimensional* or *multi dimensional*. Revising two different initialization syntaxes from Tutorial 7 on non-object arrays.
- §2.6.11 **Tutorial 11: References to another class.** When **class**es have references to objects of other classes in their **property**s then you can set up *relationships between different* **class***es*.

- §2.6.12 **Tutorial 12: Overloading methods.** *Overloading* **method***s,swapping the* **property***s* of two objects,and *converting* **method***s to* **function***s and vice-versa.*
- §2.6.13 **Tutorial 13: More about references.** More questions about references.
- §2.6.14 **Tutorial 14: Linked lists.** When a **class** has a *reference to itself* as a **property** then you can build *linked lists* out of objects of this class. **WARNING:** Linked lists are tricky for novice programmers to grasp.
- §2.6.15, **Tutorial 15: Introducing *inheritance*.** Introducing *polymorphism*, *getter* and *setter* **method**s, the **instanceof** keyword for run-time type enquiry, the `Object` class and explaining in more depth *why the* `toString` **method** *is useful for debugging.*
- §2.6.16 **Tutorial 16: Advanced inheritance.** Showing you *how inheritance can be used to reduce the amount of duplication of code.*
- §2.6.17 **Tutorial 17: Arrays, inheritance and polymorphism.** Also teaches why in most cases *it is better to use polymorphism rather than run-time type inquiry.*

2.6.1 Tutorial 1

Question 1.1: Some code to get you started. First, please visit §2.2.2 for the programs that you need to have installed before you can do any coding in J.T.W. You should then download a tarball (also known as a *compressed archive file*):

`davinpearson.com/binaries/preprocessor-YYYYmmdd-HHMMSS.tar.gz`

where `YYYY` is the year the file was last modified, `mm` is the month the file was last modified and `dd` is the day the file was modified and similarly for `HH`, `MM` and `SS`, containing the code you need to get started. Then unzip the tarball and change directory to `~/preprocessors` and issue the following command: `bash install <username>`. Note that you will need to be logged in as **root** to execute this command. If you want to run the installer module with all of the default settings, you need to execute the following command:

```
yes | bash install www
```

If you are using *M.S. Windows* and your `HOME` variable is unset, then you will need to set it to a sensible value. Examples of sensible values for your `HOME` variable include, `c:\` or `c:\home` or `d:\home` if your `d` drive is a hard drive. To set the `HOME` variable in windows, press **Windows E** and right click on *My Computer* (Windows XP) or *This Computer* (Windows 10) and click on *Properties*, then click on *Advanced system settings*, then click on *Advanced*, then click on *New* environment variable to set the `HOME` variable.

When you run the `install` script using the command `bash install <username>` and you will be prompted for the location of prefix directory and the location of the place to keep your `*.jtw` files. You will also be asked if you want to install just *Davin's* `jtw-mode` or *Davin's Full Version of GNU Emacs*. The advantage of installing Davin's Full Version of GNU Emacs is that it has been extensively modified for optimum editing of code in many different languages. To install J.T.W. using the default settings, you need to issue the following command: `yes | bash configure`, assuming you have the command `yes` installed as will be the case if you are using GNU/Linux or Cygwin[3]. Note that under the default settings, Davin's Full Version of GNU Emacs is **not** extracted.

Question 1.2: Your first J.T.W. program. Traditionally in computer science the first program that you write in any programming language is a program that does nothing else but prints out `"Hello,World"`. The following code does just that. In order to compile and run the following program you will need use the *copy* feature of your web browser and the *paste* feature of your text

[3] `www.cygwin.com`

editor (which I hope for your sake is Davin's version of GNU Emacs or GNU Emacs with Davin's `jtw-mode`) to bring the following program code out of the J.T.W. web page and into your text editor for editing purposes. Once you have copied and pasted your code you can then compile and run it. Every other question in these tutorial requires you to be familiar with the copy and paste operation unless you are a masochist and like to type in your source code by hand. In the following code, note the use of the **class** construct. In J.T.W. and Java, every piece of program code that does some real computational work resides in a **class** of some description.

```
001  class MyFirstProgram
002  begin
003     beginMain
004        System.out.println( "Hello,World!" );
005     endMain
006  end
```

The code for any **class** X in these tutorials should reside in a file called `X.jtw`. Therefore the above code should be put into a file called `MyFirstProgram.jtw`. If two classes X and Y use each other and X contains the **main function** then it is convenient to place them both in a file called `X.jtw`. To build and run some code, you first need to be in the `/jtw-tutorials` folder and secondly you need to issue the following shell command: `make build X.run` where X is the name of the **class** that you want to run, so it is

```
make build MyFirstProgram.run
```

in this case. For all questions that follow this one, it will be assumed that you know how to do this. See §2.16.6 for more information about how to build collections of classes and entire packages.

Question 1.3: Multiple calls to `System.out.println`. Change the above code from printing the string `"Hello,World!"` to printing out the following messages. Please note that it will be easiest to use multiple calls to **System.out.println**() which sends text to the screen for the purpose of viewing.

```
Hello, Anne!  How are you doing?
Hello, Brian!  How are you doing?
Hello, Clare!  How are you doing?
```

Question 1.4: Functions, parameters and arguments. A **function** is a piece of code that does some computational work and optionally returns a value. Notice how the `hello` **function** below takes a value of whose name to say hello to. This value `who` is called a *parameter*. The values passed to the parameter by the call to the **function** is called an *argument*. For the purposes of this question, add two more calls to the `hello` **function** in the **main function** to get the same result as the code for the previous question. The keyword *void* indicates that this **function** does not return a value. See the next question for a **function** that does return a value.

```
001  class MySecondProgram
002  begin
003     function void hello (String who)
004     begin
005        System.out.println( "Hello " + who + ",how are you doing?" );
006     end
007     beginMain
008        hello( "Anne" );
009     endMain
010  end
```

Question 1.5: Return values. Notice how the following `hello` **function** returns a string rather than printing out the string. Add two more calls to the `hello` **function** below to get the same result as for Question 1.3.

```
001  class MyThirdProgram
002  begin
003     function String hello (String who)
004     begin
005        return "Hello " + who + ",how are you doing?";
006     end
007     beginMain
008        System.out.println(hello( "Anne" ));
009     endMain
010  end
```

Question 1.6: Ignoring return values. In J.T.W. and Java, it is not necessary to use a value that is returned by a **function**. Sometimes this wastes computational resources since the value that is computed by the **function** is not used but other times when the **function** whose value is to be ignored does some additional work by setting the value(s) of some variable(s) to different values then the **function** call is not a waste of resources. To ignore the value returned by the `hello` **function**, simply call the **function** without using the value like so: `hello( "Ignored" );` For the purposes of this question, try calling the `hello` **function** without using the return value by adding a line of code to the **main function**.

Question 1.7: Comments. Study the following code. Note the use of `dark green` and **red** comments. Comments are used to disable code for debugging purposes and also to help explain how a program works. The most useful comment in J.T.W. and Java is `/**` until the first `*/`. This type of comment is harvested by Javadoc to produce documentation on how a **class** works. The second and third most useful comments are (respectively) `//` until the end of the line and `/*` until the first `*/`. The third type of comment is not very useful because in J.T.W and Java you are not allowed to have one comment inside another, so if you use this type of comment you will constantly need to search for and remove `*/` closing comments. In the tutorials that follow you will see many comments, although mainly the first and second types of comments.

```
001  /** This comment is harvested by Javadoc
002         to document the MyFourthProgram class */
003  class MyFourthProgram
004  begin // I am a single line comment
005     /* I am
006           a multi-line
007                 comment */
008     /** This comment is harvested by Javadoc
009           to document the hello function */
010     function String hello (String who)
011     begin
012        return "Hello " + who + ",how are you doing?";
013     end
014     /** This comment is harvested by Javadoc
015           to document the main function */
016     beginMain
017        System.out.println(hello( "Anne" ));
018     endMain
019  end
```

2.6.2 Tutorial 2

Question 2.1: The following code returns whether or not the current parameter `ch` is a vowel. The parameter `ch` is of type char which is used to hold the components of a string. That is to say, strings are built out of sequences of chars. Also note the use of the `Character.toUpperCase` **function** to convert chars into uppercase chars so that the code works equally well for `isVowel( 'a' )` and `isVowel( 'A' )`. Study, compile and run the following code. Does it print what you expected it to? If not, then fix the bug.

```
001  class Scrabble
002  begin
003     function boolean isVowel (char ch)
004       begin
005        ch = Character.toUpperCase(ch);
006        if ((ch == 'A' ) or (ch == 'E' ) or (ch == 'I' ) or (ch == 'O' ) or (ch == 'U' ))
007        then return true;
008        else return false;
009       end
010     beginMain
011        System.out.println(isVowel( 'a' ));
012     endMain
013  end
```

In the above code, note the difference between `a = b` example: `ch = Character.toUpperCase(ch)` and `a == b` example: `ch == 'A'`. The first is an *assignment* that sets `a` to be whatever the value of `b` is, while the second is a *question* that says whether or not the two arguments `a` and `b` are equal.
Note that later on in this tutorial you will learn that this is *not* the way to compare two strings. Also note the use of the *boolean* return type. This means that the return value is either *true* or *false*.
Question 2.2: By copying the pattern established by the above code, write a **function** `isConsonant` which returns whether or not the given argument is not a vowel. The easiest way to do this is to write `isVowel(ch) == false` which means: *"ch is not a vowel"*. You will also need to ensure that the parameter `ch` is greater than or equal to `'A'` and less than or equal to `'Z'`. Then test your code by calling `isConsonant` from the **main function**.
Question 2.3: By copying the pattern established in the following code:

```
001  function int countVowels (String word)
002  begin
003     var int result = 0;
004     superfor (var int i=0 to word.length()-1;)
005     begin
006        var char ch = word.charAt(i);
007        if (isVowel(ch)) then result = result + 1;
008     end
009     return result;
010  end
```

write a **function** that counts the number of consonants in a word. Note the use of the **var** keyword for defining variables that are local to functions. Local variables are very much like parameters that were introduced in the previous tutorial. In the above code, note the use of `word.charAt(i)` and `word.length()`. The first of these results *the character at location in the string* `word` *given by the value of* `i` and the second of these returns *the length of the string* `word`. In Tutorial 11 you will

learn that these are called *methods* which are different from *functions* that currently know how to write. Until we get to this tutorial and we are ready to teach you how to write your own methods, you will only call existing methods such as the above methods of the String **class**. Then test your code by calling it from the **main function**.

Question 2.4: Write a **method** `simpleScoreWord` that calls `countVowels` and `countConsonants` to give a *Simple Score* of a word. The Simple Score of a word is the number of vowels in the word plus the number of consonants in the word times ten. Then test your code by calling it from the **main function**.

Question 2.5: Write a **method** `advancedScoreLetter` that returns the *Advanced Score* of a letter. Here is a breakdown of the distribution of letters for the purpose of the calculation of the Advanced Scores.

- 2 blank tiles (scoring 0 points)
- 1 point: E 12 tiles, A 9 tiles, I 9 tiles, O 8 tiles, N 6 tiles, R 6 tiles, T 6 tiles, L 4 tiles, S 4 tiles, U 4 tiles
- 2 points: D 4 tiles, G 3 tiles
- 3 points: B 2 tiles, C 2 tiles, M 2 tiles, P 2 tiles
- 4 points: F 2 tiles, H 2 tiles, V 2 tiles, W 2 tiles, Y 2 tiles
- 5 points: K 1 tiles
- 8 points: J 1 tiles, X 1 tiles
- 10 points: Q 1 tiles, Z 1 tiles

Then test your code by calling it from the **main function**.

Question 2.6: Write a **method** `advancedScoreWord` that returns the *Advanced Score* of a word. The Advanced Score of a word is the sum of the Advanced Scores of each letter in the word. If the word is eight letters long then you should add an extra, say, 50 points to the score. Then test your code by calling it from the **main function**.

Question 2.7: Comparing strings. Amend the `advancedScoreWord` **function** so that swear words get a score of zero. For the purposes of this question you only need to think of three swear-words to add to the code. In the interests of not offending anyone, please keep your choice of swear words very tame. When comparing strings it is a mistake to use `==` which you already know is how you compare the following types that you know of so far: booleans, chars and ints. Using `==` on strings compiles and runs but gives you the incorrect result. The correct **method** to compare strings is to use the `equals` **method** of the string **class** like so: `word.equals( "bugger" )` which returns true or false, depending on whether or not the string `word` currently holds the value `"bugger"`.

Question 2.8: Change the `advancedScoreWord` **function** so it works equally well with uppercase words and lowercase words. You will need write to call either `word.toUpperCase()` or `word.toLowerCase()` and store the result in `word`.

2.6.3 Tutorial 3

Question 3.1a: For loops that count up in steps of one. Study the following code and verify that it prints out "`2 3 4 5 6 7 8 9 10`" by compiling and running it. Notice that the **System.out.print**() **function** call doesn't print a carriage return after printing the argument value. That is why the **System.out.println**() **function** call is needed at the end of the **superfor** and **for** loop, to print a carriage return at the end of the line. Also note the use of the plus sign to concatenate a string and the number to produce another string.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var int i=2 to 10) System.out.print( " " + i);
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var int i=2 i<=10; i=i+1) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Question 3.1b: Change the **superfor** loop and the ordinary **for** looop to print out: "5 6 7 8 9 10".
Question 3.1c: Change the **superfor** loop and the ordinary **for** looop to print out: "234 235 236 237 238".
Question 3.1d: Change the **superfor** loop and the ordinary **for** looop to print out: the for loop to print out "48 49 50 ... 75 76".
Question 3.1e: Change the for loop to print out "-5 -4 -3 -2 -1 0 1 2 3".
Question 3.2a: For loops that count up in steps greater than one. Study the following code and verify that it prints out "10 15 20 25 30 35 40" by compiling and running it.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var int i=10 to 40 step 5) System.out.print( " " + i);
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var int i = 10; i<=40; i=i+5) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Question 3.2b: Change the for loop to print out "20 25 30 35 40".
Question 3.2c: Change the for loop to print out "100 105 110 115 120 125".
Question 3.2d: Change the for loop to print out "2 4 6 8 10 12 14".
Question 3.2e: Change the for loop to print out "10 13 16 19 22 25".
Question 3.3a: For loops that count down in steps of one. Study the following code and verify that it prints out "10 9 8 7 6 5 4 3 2 1" by compiling and running it.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var int i=10 downto 1) System.out.print( " " + i);
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var int i = 10; i>=1; i=i-1) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Question 3.3b: Change the for loop to print out "10 9 8 7 6 5 4".
Question 3.3c: Change the for loop to print out "20 19 18 17 16 15 14 13 12".
Question 3.3d: Change the for loop to print out "66 65 64 ... 47".
Question 3.3e: Change the for loop to print out "3 2 1 -1 -2 -3 -4 -5 -6 -7".
Question 3.4a: For loops that count down in steps greater than one. Study the following code and verify that it prints out "100 90 80 70 60 50 40 30 20" by compiling and running it.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var int i=100 downto 20 step -10) System.out.print( " " + i);
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var int i = 100; i>=20; i=i-10) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Question 3.4b: Change the for loop to print out "80 70 60 50 40 30 20".
Question 3.4c: Change the for loop to print out "500 490 480 470 460".
Question 3.4d: Change the for loop to print out "10 8 6 4 2 0".
Question 3.4e: Change the for loop to print out "33 28 23 18 13 8 3".
Question 3.5a: For loops that use floating point numbers to count. Study the following code and verify that it prints out "1.1 2.2 3.3 4.4" by compiling and running it. The type name *double* is short for *double precision floating point*. It is natural to ask: why not use single precision floating point? The answer to this question is that double precision floating point gives fewer compilation errors than single precision floating point does.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var double i=1.1 to 4.41 step 1.1) System.out.print( " " + i);
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var double i = 1.1; i<=4.41; i=i-1.1) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Note the extension of the **to** part of the superfor loop and the second part of the **for** loop. The number is 4.41 and this prevents round off errors in doubles from getting to the final value of 4.4.
Question 3.5b: Change the for loop to print out "0 2.2 4.4 6.6". Note that rounding errors may prevent you from getting this exact answer. Also note that the answer to this question is not what you would naively expect without running the code.
Question 3.5c: Change the for loop to print out "-30 -19.9 -9.8 0.3 10.4 20.5".
Question 3.5d: Change the for loop to print out "100 .0 96.7 93.4 90.1 86.8 83.5 80.2 76.9".
Question 3.5e: Change the for loop to print out "-100.0 -105.5 -111.0 -116.5".
Question 3.6a: For loops that use chars to count. Study the following code and verify that it prints out "a b c d e f g h i j k l m n o p q r s t u v w x y z" by and running it.

```
001 beginMain
002   /* Here is the superfor loop:  */
003   superfor (var char i = 'a' to 'z' )
004   System.out.println();
005
006   /* Here is the ordinary for loop:  */
007   for (var char i='a' ; i<='z' ; i=i+1) System.out.print( " " + i);
008   System.out.println();
009 endMain
```

Question 3.6b: Change the for loop to print out "`a b c d e f`".
Question 3.6c: Change the for loop to print out "`z y x w v u t s r q p o n m l k j i h g f e d c b a`".
Question 3.6d: Change the for loop to print out "`p o n m l k j i h`".
Question 3.6e: Change the for loop to print out "`A B C D E F G H I J K L M N O P Q R S T U V W X Y Z`".

2.6.4 Tutorial 4

Study the following code:

```
 class LoopTest
001 begin
002    function int powerOf2A (int n)
003    begin
004       var int counter = n;
005       var int result = 1;
006       while (counter != 0)
007       begin
008          result = 2 * result;
009          counter = counter - 1;
010       end
011       return result;
012    end
013
014    function int powerOf2B (int n)
015    begin
016       var int counter = n;
017       var int result = 1;
018       do
019       begin
020          result = 2 * result;
021          counter = counter - 1;
022       end while (counter != 0);
023       return result;
024    end
025
026    function int powerOf2C (int n)
027    begin
028       var int result = 1;
029       for (var int counter = n; counter != 0; counter = counter - 1)
030       begin
031          result = 2 * result;
032       end
033       return result;
034    end
035
036    function int powerOf2D (int n)
037    begin
038       var int result = 1;
039       superfor (var int counter = n downto 1)
040       begin
041          result = 2 * result;
042       end
```

```
043         return result;
044      end
045
046
047      /**
048      * Prints a row of stars of a given length.
049      */
050      function void printLineC (int length)
051      begin
052         for (var int i = 0; i<length; i=i+1)
053         begin
054            System.out.print( "#" );
055         end
056         System.out.println();
057      end
058
059      beginMain
060         // For question 4.1 add some code here...
061      endMain
062   end
```

Question 4.2: To the **main function** add some code to call the functions `powerOf2A`, `powerOf2B`, `powerOf2C` and `powerOf2D` to verify that they all return the same result. To inspect the result you will need to apply the **System.out.println**() statement to the values returned by those functions.
Question 4.3: There is a bug in the `powerOf2B` **method** because it does not behave correctly in the case when n is zero. Put an *if* statement at the top of this **method** to make it handle the case of zero properly.
Question 4.4: By copying the pattern of `powerOf2A`, `powerOf2B`, `powerOf2C` and `powerOf2D`, write methods `printLineA`, `printLineB` and `printLineD` that work identically to the **method** `printLineC`, except that they use *while* loops, *do* loops and **superfor** loops, respectively. Add some code to the **main function** to test them out.
Question 4.5: Based on the previous three questions, is there a best looping construct? Or does it depend on what the looping construct is going to be used for?

2.6.5 Tutorial 5

Question 5.1: Study the following code and then compile and run it to verify that it prints out the lyrics to a popular beer-drinking song:

```
001   class BeerSong
002   begin
003      beginMain
004         System.out.println( "Five bottles of beer on the wall." );
005         System.out.println( "Five bottles of beer on the wall." );
006         System.out.println( "If one bottle of beer should accidentally fall," );
007         System.out.println( "there'd be four bottles of beer on the wall." );
008         System.out.println();
009         System.out.println( "Four bottles of beer on the wall." );
010         System.out.println( "Four bottles of beer on the wall." );
011         System.out.println( "If one bottle of beer should accidentally fall," );
012         System.out.println( "there'd be three bottles of beer on the wall." );
013         System.out.println();
014         System.out.println( "Three bottles of beer on the wall." );
```

```
015         System.out.println( "Three bottles of beer on the wall." );
016         System.out.println( "If one bottle of beer should accidentally fall," );
017         System.out.println( "there'd be two bottles of beer on the wall." );
018         System.out.println();
019         System.out.println( "Two bottles of beer on the wall." );
020         System.out.println( "Two bottles of beer on the wall." );
021         System.out.println( "If one bottle of beer should accidentally fall," );
022         System.out.println( "There'd be one bottle of beer on the wall." );
023         System.out.println();
024         System.out.println( "One bottle of beer on the wall." );
025         System.out.println( "One bottle of beer on the wall." );
026         System.out.println( "If one bottle of beer should accidentally fall," );
027         System.out.println( "there'd be no bottles of beer on the wall." );
028         System.out.println();
029     endMain
030 end
```

Question 5.2: The following is the first attempt to make the code smaller but to keep the same output: If you compile and run the following code you will notice that it counts up from one rather than down from `n`. Change the *for* loop so that it runs down rather than up. For information about how to write the for loop, please consult Tutorial 2.

```
001  class BeerSong
002 begin
003     function song (int n)
004     begin
005         for (var int i=1; i<=n; i=i+1)
006         begin
007             System.out.println(i +  " bottles of beer on the wall" );
008             System.out.println(i +  " bottles of beer on the wall" );
009             System.out.println( "If one bottle of beer should accidentally fall," );
010             System.out.println( "there'd be "  + (i-1) +  " bottles of beer on the wall" );
011             System.out.println();
012         end
013     end
014
015     beginMain
016         song(5);
017     endMain
018 end
```

Question 5.3: Finish the `number2string` **function** below and add a new **function** call to this **function** in the song **function** so that it print textual numbers rather than digits.

```
001  function String number2string (int n)
002 begin
003     assert n>=0 :  n;
004     assert n<=10:  n;
005     if (n == 0) then return  "no" ;
006     if (n == 1) then return  "one" ;
007     if (n == 2) then return  "two" ;
008     /* rest of code goes here */
```

```
009     if (n == 9) then return "nine";
010     if (n == 10) then return "ten";
011     assert false;
012  end
```

Question 5.4: Add a new **function** String **capitalize** (int n) that capitalizes the first word in a `String` and call this **function** from the song **function** so that the first words in each sentence are capitalized. You should find the **function** Character.toUpperCase and the methods String and String helpful for writing this **function**. See the String **class** of the `java.lang` package in the following link:

docs.oracle.com/javase/1.5.0/docs/api

for more details.

Question 5.5: Add new **function** call String **plural** (int n) that returns the string `"s"` if `n` is not equal to 1 and the empty string `""` otherwise. Then call this **function** from the `song` **function** so that the phrase `"bottle"` is pluralized when it should be.

Question 5.6: Write a **function** called `number2string2` that can handle values up to but not including 100 . Note that you will need multiple **if** statements to achive this. Note that if `n` is a number then the following expressions are useful:

- **var** int `temp1 = n / 10 % 10` results in `temp1` holding the tens digit of `n` and is zero in the case that `n<10`.
- **var** int `temp2 = n % 10` results in `temp2` holding the ones digit of `n`.

Also make it print out `"one hundred or more"` in the case that `n>=100`

Question 5.7: Change the song **function** so that the following **function** call: `song(5, "rum");` in the **main** **function** results in the following printout:

```
Five bottles of rum on the wall.

...

there'd be no bottles of rum on the wall.
```

Question 5.8: Once all the code is working, add the following line to the **main** **function**: `song(100, "gin");` so that it prints out the following:

```
One hundred bottles of gin on the wall.

...

there'd be zero bottles of gin on the wall.
```

Question 5.9 Write a new **function** `number2string3` that works like `number2string2` and `number2string` except that it handles numbers up to 999 . Internally `number2string3` should call `number2string2`. You might find the following **function** useful:

```
001  function String textand (String a, String b)
002  begin
003     if (a.equals("") or b.equals("")) then return a + b;
004     else return a + " and " + b;
005  end
```

Question 5.10 † **Tricky** Write a new **function** `number2string4` that works like `number2string3` execpt that it handles numbers up to nine hundred and ninety-nine million nine hundred and ninety-nine thousand nine hundred and ninety-nine, i.e. 999, 999, 999. The **function** `number2string4` should internally call `number2string3` like so:

- `var String ones = number2string3(n % 1000);`
- `var String thousands = number2string3(n / 1000 % 1000);`
- `var String millions = number2string3(n / 1000 / 1000 % 1000);`

Note that the variables above will have values from 0 to 999 inclusive.

2.6.6 Tutorial 6

Question 6.1: Study, compile and run the following code. Note the use of the *class variable* `myMoney`. A **class** variable is different from a variable that is local to a **function** because the lifetime of the **class** variable is for the duration that the program is run, whereas the lifetime of a local variable is for the duration of the **function** call. In the code that follows, the variable `myMoney` is used to store a numerical value, for how much money you have.

```
001 class Money
002 begin
003    /** Property myMoney stores money value in dollars */
004    classVar int myMoney;
005
006    function void spend (String item, int value)
007    begin
008       myMoney = myMoney - value;
009       System.out.println( "*** spent $" +
010                           value +
011                           " on " + item +
012                           ",leaving you with $" + myMoney);
013       end
014    end
015    beginMain
016       myMoney = 100 ;
017       spend( "aquarium" ,50);
018       spend( "shoes" ,100 );
019       spend( "lipstick" ,20);
020    endMain
021 end
```

Question 6.2: Change the `myMoney` **class** variable so that it is a *double* (short for double-precision floating point) rather than an *int*. You will need to add a new **function** `money2string` that converts double values into strings. For example the floating point number 1.2345 should be printed out as $1.23. If `x` is a double then the following expression converts `x` from a double into a number of dollars `(int)x` and the following expression converts `x` into a number of cents `(int)(money * 100) - 100 * dollars`. Note that you will need to make it so that $1.03 prints out as this value.

Question 6.3: Add an *if* statement to the `spend` **function** so that it uses **System.out.println**() to print out an error message if the person does not have enough funds in their bank account to pay for the item parameter.

Question 6.4: Add a new **class** variable `double governmentsMoney` and make it so that 12.5goes to the government in the form of G.S.T. (¡u¿G¡/u¿oods and ¡u¿S¡/u¿ervices ¡u¿T¡/u¿ax a value-added tax)
Question 6.5: Add a new **class** variable `numBattleships` that records how many batteships are owned by the government. Write a **function** `buyBattleShips` that causes the government to buy as many battleships as it can afford. Make it so that the `buyBattleShips` **function** prints out how many battleships were purchased. Let the cost of each battleship be one million dollars and store this value in a variable called `costOfShip`. Please note that if the government's money is less the one million dollars then no battleships will be purchased.
Question 6.6: Set the initial value for `governmentsMoney` to be two millions dollars, then call the `buyBattleShips` **function** and verify that two battleships were purchased.

2.6.7 Tutorial 7

This tutorial teaches you how to create single dimensional and multi-dimensional arrays of non-objects. The non-object types in Java are those which aren't declared inside a **class**, so it includes the following types: *boolean*, *char*, *int*, *float* and *double*. A helpful convention in Java is that the non-object types start with a lowercase letter, while object types start with an uppercase letter, such as for example the `String` **class** as an example of an object type. In addition to this, two different array initialization syntaxes are presented.

Single dimensional arrays

Question 7.1: Here is an example of a convenient one dimensional array initialization syntax. Study, compile and run the following code. The code `int[]` should be read out loud as *int array* indicating that the variable `a` is an int array, also known as an array of ints. Note that the first value of the for loop below is zero. This is because in J.T.W. and Java, the first index of an array is zero not one. This convention harks back to the old days of the *C Programming Language* and is used because it is more efficient in the low level of machine language than counting arrays from one. Also note that parenthesis are used to delimit arrays. I use this practice because this is the only place in Java where a semicolon follows a closing parenthesis. If you don't know what I am talking about, simply ignore that remark!

```
001  var int[] a = { 1,2,3 };
002  for (var int i=0; i<3; i=i+1)
003  begin
004     System.out.println( "a[" + i + "]=" + a[i]);
005  end
```

Due to a design oversight by the creators of Java you cannot use this syntax to re-initialize an array like so:

```
a = { 4,5,6 }; // Compilation error
```

Luckily there is a way array around this oversight and that is to use a design pattern where you introduce a temporary variable like so:

```
001  var int[] temp = { 4,5,6 };
002  a = temp; // Array "a" now holds 4 5 6
```

Later you will learn why this design pattern is useful for re-initializing multi-dimensional arrays.
Question 7.2: Write a **function** `print` that takes an int array argument and prints out the array. You will need to use the `length` property of the array parameter so your **function** works

with arbitrary sized arrays. Change the **main** **function** to what follows so that it contains a call to the `print` **function**.

```
001  var int[] a = { 1,2,3 };
002  print(a);
```

Question 7.3: Write a **function** with same name as the previous `print` **function**, except that this one should take an argument that is a `double[]`, also known as a double array. Two functions with the same name in the same **class** is allowed in Java and the practice of using has a special name that is: **function** *name overloading*. Overloading is only allowed when the two functions with the same name have different parameters. When you call an overloaded **function** J.T.W. and Java looks at the number and types of the arguments a determines from this which of the overloaded functions to call. Change the **main** **function** to what follows so that it initializes an array of double-precision floating point variables and then calls the second `print` **function**.

```
001  var double[] b = { 1.1,2.2,3.3 };
002  print(b);
```

Here is an example of a second initialisation syntax. For this particular example it is better to use the simpler, earlier initialisation syntax, but when the size of the array to be created is to be determined at run-time, then the second syntax should used. The next question will show you an example of this.

```
001  beginMain
002    var int[] a = new int[3];
003    // at this point the array is all zeroes
004    for (var int i=0; i<3; i=i+1)
005    begin
006       a[i] = i;
007    end
008    print(a);
009  endMain
```

Question 7.4: Write a **function** `create` takes one int argument, the size of the array to create and returns an int array of that size. Make it so the $\texttt{i}^{th}$ element of the array is initialized to `i`. Call this **function** from the **main** **function** like so:

```
001  beginMain
002    var int[] a = create(3);
003    print(a);
004  endMain
```

Question 7.5: Write a **function** `create2` takes one int argument, the size of the array to create and returns a double array of that size. Make it so the $\texttt{i}^{th}$ element of the array is initialized to `i.i`, given that `i<10`. Why is it not possible to overload that `create` **function**? Try it and see what the compiler says. Call `create2` from the **main** **function** like so:

```
001  beginMain
002    var double[] a = create2(3);
003    print(a);
004  endMain
```

Question 7.6: Write a **function** `doubler` that takes an int array `x` and returns a new int array `result` that is twice as big as `x`. Copy `x` into `result` before you return it. The extra elements in the `result` should all be zero.
Question 7.7: Change the `doubler` **function** so that every zero in the array `result` is set to the value 13.

Two dimensional arrays

Question 7.8: Here is an example of a convenient two dimensional array initialization syntax. Study, compile and run the following code. The code `int[][]` should be read out loud as *int array array* indicating the variable `a` is an *int array array*, also known as a *two-dimensional array of ints*.

```
001  beginMain
002    var int[][] a = { { 1,2,3 } { 4,5 } { 6 } }
003
004    for (var int y=0; y<a.length; y=y+1)
005    begin
006       for (var int x=0; x<a[y].length; x=x+1)
007       begin
008          System.out.print( " " + a[y][x]);
009       end
010       System.out.println();
011    end
012  endMain
```

Question 7.9: By copying the pattern of the code above, do some more overloading of the `print` **function** by writing two new `print` functions, one taking a two-dimensional array of ints, the other taken a two-dimensional array of doubles. The call both of these functions from the **main function**.
Note that if `x` is a two-dimensional array of ints, then `x[i]` is a one dimensional array of ints for each in the range `0 ... x.length-1`. Note that in the above code, `a[0]` is an array of three ints, `a[1]` is an array of two ints and `a[2]` is an array of one int. The reason these sub-arrays are all of different sizes is to save your computer's precious memory. For example you can have one sub-array much longer than all of the others without needing to allocate a whole bunch of memory that will go unused. Since `a[0]` is an int array, you would naively expect it to be able to be re-initialized like so:

```
001  a[0] = { 4,5,6,7};
```

so that after this code `a[0]` holds the four element long array 4,5,6 and 7. But as mentioned above in Section §7.1, this doesn't work because of a design oversight by the creators of Java. Luckily as mentioned above there is a way around this oversight and that is to use a temporary variable like so:

```
001  var int[] temp = { 4,5,6,7};
002  a[0] = temp; // Array "a[0]" now holds 4 5 6 7
```

Like with one dimensional arrays, there is a second initialisation syntax for two-dimensional arrays and here it is. Unlike the above code the sub-arrays `a[0]`, `a[1]` and `a[2]` are all of equal size, namely three.

```
001  var int[][] a = new int[3][3];
002  a[0][0] = 1; a[1][0] = 2; a[2][0] = 3;
003  a[0][1] = 4; a[1][1] = 5;
004  a[0][2] = 6;
```

Question 7.10: Write a **function** `create3` and `create4` that takes on int argument `size` and returns a two dimensional array of ints or doubles, respectively. Make is so that if `a` is the name of the returned array, then `a[y][x]` is set to the value of `x+y`.

Three dimensional arrays

Question 7.11: Using the knowledge you have gained so far about arrays, create, initialize and print a three dimensional array of ints.

2.6.8 Tutorial 8

Question 8.1: Study, compile and run the following code which resides in a file called `Box.jtw`. Notice the use of **System.out.print**() to print without a trailing newline and **System.out.println**() to print with a trailing newline. The **ln** part tells you this.

```
001  class Box
002  begin
003     function void square (int n)
004     begin
005        for (var int y=0; y<n; y=y+1)
006        begin
007           for (var int x=0; x<n; x=x+1)
008           begin
009              if ((x == 0) or (x == n-1) or (y == 0) or (y == n-1))
010              then System.out.print( "#" );
011              else System.out.print( " " );
012           end
013           System.out.println();
014        end
015     end
016     beginMain
017        square(5);
018     endMain
019  end
```

Notice that here is the output of the above code for different values of the `n` parameter:

n = 1	#
n = 2	## ##
n = 3	### # # ###
n = 4	#### # # # # ####
n = 5	##### # # # # # # #####

Question 8.2: By copying the pattern established in the above code, write a new **function** `square2` that generates the following output. Note that you will need to remove some of the *or* clauses in the `square` **method** above to get the following output:

n = 1	#
n = 2	## ##
n = 3	### ###
n = 4	#### ####
n = 5	##### #####

Question 8.3: By copying the pattern established in the above code, write a now **function** `square3` that generates the following output:

n = 1	#
n = 2	## ##
n = 3	# # # # # #
n = 4	# # # # # # # #
n = 5	# # # # # # # # # #

Question 8.4: Study, compile and run the following code which resides in a file called `Box.java`:

```
001  class Box
002  begin
003     function void x (int n)
004     begin
005        for (var int y=0; y<n; y=y+1)
006        begin
007           for (var int x=0; x<n; x=x+1)
008           begin
009              if ((x == y) or (x == n-1-y)) then System.out.print( "#" );
010              else System.out.print( " " );
011           end
012           System.out.println();
013        end
014     end
015     beginMain
016        x(5);
017     end
018  end
```

Notice that here is the output of the above code for different values of the `n` parameter:

n = 1	#
n = 2	## ##
n = 3	# # # # #
n = 4	# # ## ## # #
n = 5	# # # # # # # # #

Question 8.5: By copying the pattern established in the above code, write a now **function** `x2` that generates the following output. Note that you will need to remove one of the *or* clauses in the **`x` method** above to get the following output:

n = 1	#
n = 2	# #

n = 3	#
	  #
	  #

n = 4	#
	  #
	  #
	  #

n = 5	#
	  #
	  #
	  #
	  #

Question 8.6: By copying the pattern established in the above code, write a now **function** `x3` that generates the following output. Note that you will need to remove one of the *or* clauses in the `x` **method** above to get the following output:

n = 1	#
n = 2	# #
n = 3	# # #
n = 4	# # # #

n = 5	#
	   #
	  #
	 #
	#

Question 8.7: Study, compile and run the following code which resides in a file called `Box.java`:

```
001  class Box
002  begin
003     function void triangle (int n)
004     begin
005        for (var int y=0; y<n; y=y+1)
006        begin
007           for (var int x=0; x<n; x=x+1)
008           begin
009              if (x<y)
010              then System.out.print( "#" );
011              else System.out.print( " " );
012           end
013           System.out.println();
014        end
015     end
016     beginMain
017        triangle(5);
```

```
018     endMain
019 end
```

Notice that here is the output of the above code for different values of the `n` parameter:

n = 1	#
n = 2	# ##
n = 3	# ## ###
n = 4	# ## ### ####
n = 5	# ## ### #### #####

Question 8.8: By copying the pattern established in the above code, write a now **function** `triangle2` that generates the following output. Note that you will need to change the if clause in the `triangle` **method** above to get the following output:

n = 1	#
n = 2	## #
n = 3	### ## #
n = 4	#### ### ## #
n = 5	##### #### ### ## #

Question 8.9: Write a now **function** called `box` that generates the following output. Note that you will need to modify the `triangle` **method** above to get the following output:

n = 1	#
n = 2	## ##
n = 3	### ### ###
n = 4	#### #### #### ####
n = 5	##### ##### ##### ##### #####

Question 8.10: Add the following code to `Box.java`:

```
001  class Grid
002  begin
003     /** The dimensions of the array named: array. */
004     classVar int size = 20;
005
006     /* NOTE: the array below is a two-dimensional array */
007     classVar boolean[][] array = new boolean[SIZE][SIZE];
008
009     function void set (int x, int y, boolean v)
010     begin
011        if (x>=0 and x<size and y>=0 and y<size) then
012        begin
013           array[x][y] = v;
014        end
015     end
016
017     function void print (int size)
018     begin
019        for (var int y=0; y<size; y=y+1)
020        begin
021           for (var int x=0; x<size; x=x+1)
022           begin
023              if (array[x][y])
024              then System.out.print( "#" );
025              else System.out.print( " " );
026           end
027           System.out.println();
028        end
029        System.out.println(); // prints an empty line between shapes
030     end
031  end
```

Question 8.11: The following question will guide you through the process of making the drawing algorithm more powerful. Instead of printing the shapes directly to the screen, they will be stored in an array to be printed out only when the array has been completely set. You don't need to know a great deal about arrays to answer the remaining questions of this section as the array

code has been written for you in the Grid **class** above. For every call to **System.out.println**() in `Box.java`, replace it with a call to the set **method** of the Grid **class**. Note that the third parameter in the `set` **method** is of type *boolean*, that is to say it can be either `true` or `false`. To call a **function** of another **class** you need to prefix the name of the **class** like so: `Grid.set(/* argument values */)`. Finally at the end of all of the functions in the Box **class** except for the **main function** you will need to call the `print(int)` **method** of the Grid **class** to actually print out the array.

Question 8.12: Re-initialize the boolean array array named `array` from the **main function** of the `Box` **class**. **HINT:** to access a **class** variable from another **class**, you need to prefix it with the name of its **class** name, in this case it is `Grid`. Re-initialize the `array` variable to a two-dimensional array of dimensions 100 x 100. Also set the `size` variable to 100 so that the functions of the `Grid` **class** still work.

2.6.9 Tutorial 9

Elementary classes: using a single class for everything

For the purpose of the text that follows, O.O.P. stands for *Object Oriented Programming*.

Question 9.1: Study, compile and run the following code:

```
// BEGIN FILE: jtw-tutorials/Person-1.jtw.m4
001  class PersonDriver1
002  begin
003     classVar String homersName = "Homer Simpson" ;
004     classVar int    homersAge  = 40; // Homer's age in years
005
006     classVar String fredsName  = "Fred Flintstone" ;
007     classVar int    fredsAge   = 45; // Fred's age in years
008
009     classVar String darthsName = "Darth Vader" ;
010     classVar int    darthsAge  = 55; // Darth's age in years
011
012     function void growHomer ()
013     begin
014        homersAge = homersAge + 1;
015     end
016     function void growFred ()
017     begin
018        fredsAge = fredsAge + 1;
019     end
020     function void growDarth ()
021     begin
022        darthsAge = darthsAge + 1;
023     end
024
025     function void knightHomer ()
026     begin
027        homersName = "Sir " + homersName;
028     end
029     function void knightFred ()
030     begin
031        fredsName = "Sir " + fredsName;
032     end
033     function void knightDarth ()
034     begin
035        darthsName = "Sir " + darthsName;
036     end
```

```
037
038     function void printHomer ()
039     begin
040        System.out.println( "I am " + homersName + ", my age is " + homersAge);
041     end
042     function void printFred ()
043     begin
044        System.out.println( "I am " + fredsName + ", my age is " + fredsAge);
045     end
046     function void printDarth ()
047     begin
048        System.out.println( "I am " + darthsName + ", my age is " + darthsAge);
049     end
050
051     beginMain
052        growHomer();
053        knightHomer();
054        printHomer();
055        printFred();
056        printDarth();
057     endMain
058  end
// END FILE:     jtw-tutorials/Person-1.jtw.m4
```

Question 9.2: By copying the pattern established in the existing code write a some new **class** variables to represent a new person called Barack Obama. Note that he was born in 1945 so at the time of writing this manual he is 67 years old.
Question 9.3: Then write some functions to work with this new person.
Question 9.4: Finally call those functions from the **main** **function**.

Improved classes: one object per class

As your program gets large (say over 1000 lines) then it becomes no longer practical to put all of your code in the same **class**. So it is natural to put each piece of related code in its own **class**.
Question 9.5: Study, compile and run the following code: Each of these classes can be put in their own file. For each **class** X, this **class** can be put into a file called `X.jtw`. However for the purposes of this tutorial you will probably find it easier to merge all of the classes into the same file into a file called `PersonDriver2.jtw`

```
// BEGIN FILE: jtw-tutorials/Person-2.jtw.m4
001  class Homer
002  begin
003     classVar String name = "Homer Simpson" ;
004     classVar int    age  = 40; // Homer's age in years
005
006     function void grow ()
007     begin
008        age = age + 1;
009     end
010     function void knight ()
011     begin
012        name = "Sir " + name;
013     end
014     function void print ()
015     begin
016        System.out.println( "I am " + name + ", my age is " + age);
017     end
018  end
```

```
019
020 class Fred
021 begin
022    classVar String name =  "Fred Flintstone" ;
023    classVar int    age  = 45; // Fred's age in years
024
025    function void grow ()
026    begin
027       age = age + 1;
028    end
029    function void knight ()
030    begin
031       name =  "Sir "  + name;
032    end
033    function void print ()
034    begin
035       System.out.println( "I am "  + name +  ", my age is "  + age);
036    end
037 end
038
039 class Darth
040 begin
041    classVar String name =  "Darth Vader" ;
042    classVar int    age  = 55; // Darth's age in years
043
044    function void grow ()
045    begin
046       age = age + 1;
047    end
048    function void knight ()
049    begin
050       name =  "Sir "  + name;
051    end
052    function void print ()
053    begin
054       System.out.println( "I am "  + name +  ", my age is "  + age);
055    end
056 end
057
058 class PersonDriver2
059 begin
060    beginMain
061       Homer.grow();
062       Fred.knight();
063       Homer.print();
064       Fred.print();
065       Darth.print();
066    endMain
067 end
// END FILE:    jtw-tutorials/Person-2.jtw.m4
```

Question 9.6: By copying the pattern established in the existing code write a new **class** to represent Barack Obama.
Question 9.7: Call the functions from the **main function** of the driver **class**.

True O.O.P.: more than one object per class

To allow for more than one object per **class**, most if not all **class** variables needs to be made into what are called *instance variables* (or more simply and more commonly known as *properties*) and

most if not all functions need to be made into what are called *methods*.

Question 9.8: Study, compile and run the following code:

```
// BEGIN FILE: jtw-tutorials/Person-3.jtw.m4
001  class Person
002  begin
003     //
004     // NOTE: the use of the "property" keyword here instead of the "classVar" keyword
005     //
006     property String name; // Person's full name
007     property int    age;  // Person's age in years
008
009     //
010     // NOTE: the use of the "method" keyword here instead of the "function" keyword
011     //
012     method void grow ()
013     begin
014        age = age + 1;
015     end
016
017     method void knight ()
018     begin
019        name = "Sir " + name;
020     end
021
022     method void print ()
023     begin
024        System.out.println( "I am " + name + ", my age is " + age);
025     end
026
027     beginMain
028
029        var Person h = new Person();
030        h.name = "Homer Simpson" ;
031        h.age  = 40;
032
033        var Person f = new Person();
034        f.name = "Fred Flintstone" ;
035        f.age  = 45;
036
037        var Person d = new Person();
038        d.name = "Darth Vader" ;
039        d.age  = 55;
040
041        h.grow();
042        h.knight();
043        h.print();
044        f.print();
045        d.print();
046
047     endMain
048  end
// END FILE:    jtw-tutorials/Person-3.jtw.m4
```

In the above code, note the use of three references `h`, `f` and

Question 9.9: By copying the pattern established in the existing code add some code to the **main function** add some code to create a new person for Barack Obama.

A common design pattern: private properties, public constructor and public getters

A common design pattern in Java and one that I present for you in the following code is to make all of the properties of a **class** effectively read-only to all client classes by making all of the properties *private* and providing *non-private getter* methods for getting the values of the properties. It is possible for the original **class** to change the values of the properties but other classes (such as PersonTest below) are not capable of doing this, without calling a **method** of the original **class** such the `grow` and `knight` methods of the Person **class**. Finally an additional thing known as a **constructor** is used to ensure that objects are initialized with meaningful values for their properties.

Question 9.10: Study, compile and run the following code:

```
// BEGIN FILE: jtw-tutorials/Person-4.jtw.m4
001  class Person
002  begin
003
004     private property String name;
005     private property int    age; // Age in years
006
007     //
008     // NOTE: Getter methods
009     //
010     public method String getName()
011     begin
012        return name;
013     end
014
015     public method int getAge()
016     begin
017        return age;
018     end
019
020     public constructor Person(String aName, int anAge)
021     begin
022        this.name = aName;
023        this.age  = anAge;
024     end
025
026     public method void grow()
027     begin
028        age = age + 1;
029     end
030
031     public method void knight()
032     begin
033        name = "Sir " + name;
034     end
035
036     public method void print()
037     begin
038        System.out.println( "I am " + name + ", my age is " + age);
039     end
040  end
041
042  class PersonDriver3
043  begin
044     beginMain
045
046        //
047        // NOTE: In the following constructor calls the age and name are set by the constructor
048        //
```

```
049         var Person h = new Person( "Homer Simpson" ,40);
050         var Person f = new Person( "Fred Flintstone" ,45);
051         var Person d = new Person( "Darth Vader" ,55);
052
053         h.grow();
054         h.knight();
055         h.print();
056         f.print();
057         d.print();
058
059         h.name = "Luke Skywalker" ;                 // ERROR: name is private
060         h.age = h.age + 1;                          // ERROR: age is private
061
062         System.out.println( "name=" + h.name);      // ERROR: name is private
063         System.out.println( "age=" + h.age);        // ERROR: age is private
064
065         System.out.println( "name=" + h.getName()); // OK: getter is non-private
066         System.out.println( "age=" + h.getAge());   // OK: getter is non-private
067
068     endMain
069 end
// END FILE:    jtw-tutorials/Person-4.jtw.m4
```

Question 9.11: By copying the pattern established in the existing code add some code to the **main function** add some code to create a new person called Barack Obama.

Comparing strings

Question 9.12: Add a **method** `unknight()` which removes the `"Sir "` title if he has one. One trap for young players in J.T.W. or Java is to use the operator `==` to compare strings like so:

```
001 function boolean myCompare (String a, String b)
002 begin
003     return a == b; // Works but not as expected!
004 end
```

It compiles without error, but doesn't give you the result you were expecting. Instead you need to use the `equals` **method** of the String **class** like so:

```
001 function boolean myCompare (String a, String b)
002 begin
003     return a.equals(b);
004 end
```

More generally, if `x` and `y` are a references to objects, then `x == y` returns whether or not x and y are pointing to the same object, whereas `x.equals(y)` returns whether or not the *contents* of the objects referred to by `x` and `y` are equal. The meaning of the word *contents* varies from **class** to **class**, but in the case of strings it means that the strings contain the same data.

You will also find the String **class**' `substring` and (`toUpperCase` or `toLowerCase`) methods useful here too. See the String **class** of the `java.lang` package in the following link:

docs.oracle.com/javase/1.5.0/docs/api

for more details of these two methods.

The `null` value for references

As soon as you learn how to use references you need to know that all reference variables could conceivably hold the value *null*, meaning *no value*. In particular when properties are themselves references as you will discover in Tutorial 11, then those properties are initialized to `null` by default. Object arrays that you will learn about in Tutorial 10 using the second of two initialization syntaxes are also initialized to `null` by default.

Why the `toString` method is better than any other method or property for debugging

If `x` is a reference to a **class** X (including `this`) and if `m` is a **method** of X and `p` is a property of X, and if `x` is currently `null`, then the following lines result in a `NullPointerException` being thrown when executed:

```
001  x.p;
002  x.m();
```

whereas if `x` is `null` then

- **System.out.println**`(x);` and
- **System.out.println**`( "x=" + x);`

prints out, respectively:

- `null`, and
- `x=null`.

If `x` is not `null`, it calls

- **System.out.println**`(x.toString());`
- **System.out.println**`( "x=" + x.toString());`

so these expressions are safer to use than any other **method** or property in situations where `x` might be `null`. The syntax of the `toString` **method** is as follows:

```
001  public method String toString()
002  begin
003     // Code goes here...
004  end
```

Importantly for reasons which will be explained later the `toString` **method** must be declared with `public` visibility. For other properties and methods to be used safely with `null` references you need to wrap a conditional *if* construct around the calling of the **method** or property like so for properties:

```
001  if (x != null)
002  then begin
003     System.out.println(x.p);
004  end
```

or like so for methods:

```
001  if (x != null)
002  then begin
003     System.out.println(x.m());
004  end
```

Therefore the `toString` **method** is more convenient than any other **method** or property. Note that its use is without the explicit call to the `toString` **method** and only used with a variable name, including `this` for the current **class**. Most of the time the `this` keyword is optional which is why novices don't bother to learn it, but in the case of the `toString` **method** it is essential, as can be seen in the following example code:

```
001  System.out.println( "x.toString()=" + x);
002  System.out.println( "this.toString()=" + this);
```

Question 9.13: Change the `print` **method** above from a **method** that prints out to the screen to a **method** called `toString` that returns a string.
Question 9.14: Call the `toString` **method** instead of the `print` methods in the **main function**.

2.6.10 Tutorial 10

This tutorial teaches you how to create single dimensional and multi-dimensional arrays of objects. The object types are all types execpt for *boolean*, *char*, *int*, *float* and *double*. A helpful convention in Java is that the Object types start with an uppercase letter, while non-object types start with a lowercase letter, such as for example the String **class** as an example of an object type. In addition to this, two different array initialization syntaxes are presented.

Single dimensional arrays

Question 10.1: Here is an example of a convenient one dimensional array initialization syntax. Study, compile and run the following code. The code `Person[]` should be read out loud as *person array* indicating the variable `a` is a *person array*, also known as an *array of persons*.

```
001  class Person
002  begin
003     private property String name;
004
005     public constructor Person(String aName)
006     begin
007        name = aName;
008     end
009
010     public String toString()
011     begin
012        return name;
013     end
014  end
015
016  class PersonTest
017  begin
018     beginMain
019        var Person[] a = { new Person( "P # 1" ), new Person( "P # 2" ), new Per-
son( "P # 3" ) };
```

```
020
021         for (var int i=0; i<3; i=i+1)
022         begin
023             System.out.println( "a[" + i + "]=" + a[i]);
024         end
025     endMain
026 end
```

Due to a design oversight by the creators of Java you cannot use this syntax to re-initialize an array like so:

```
001 // Compilation error
002 a = { new Person( "P # 4" ), new Person( "P # 5" ), new Person( "P # 6" ), new Person( "P # 7" ) };
```

Luckily there is a way array around this oversight and that is to use a design pattern where you introduce a temporary variable like so:

```
001 // No error
002 var Person[] temp = { new Person( "P # 4" ), new Person( "P # 5" ), new Person( "P # 6" ), new Person( "P # 7" ) };
003 a = temp; // Array "a" now holds P # 4,P # 5,P # 6,P # 7
```

Later you will learn why this design pattern is useful for re-initialising multi-dimensional arrays.
Question 10.2: Write a **function** in the **class** PersonTest called `print` that takes a Person array argument and prints out the array. You will need to use the `length` property of the array parameter so your **function** works with arbitrary sized arrays. Change the **main function** to what follows so that it contains a call to the `print` **function**.

```
001 var Person[] a = { new Person( "P # 1" ), new Person( "P # 2" ), new Person( "P # 3" )};
002 print(a);
```

Question 10.3: Write your own **class** called Mine similar to the Person **class** with a one int parameter **constructor**, a private int property `p` and a `toString` **method** that converts `p` to a string. Then write a **function** in the PersonTest **class** with same name as the previous `print` **function**, except that this one takes a Mine[], also known as a Mine array. You might recall from Tutorial 7 that this practice of having two functions with the same name is called **function** *name overloading*. Change the **main function** to what follows so that it initializes an array of Mine point variables and then calls the second `print` **function**.

```
001 var Mine[] b = { new Mine(1), new Mine(2), new Mine(3) };
002 print(b);
```

Here is an example of a second initialization syntax. For this particular example it is better to use the simpler, earlier initialization syntax, but when the size of the array to be created is to be determined at run-time, then the second syntax should used. The next question will show you an example of this.

```
001 beginMain
002     var Person[] a = new Person[3];
003     // at this point the array is all nulls
```

```
004     for (var int i=0; i<3; i=i+1)
005     begin
006        a[i] = new Person( "P # " + (i+1));
007     end
008     print(a);
009  endMain
```

Question 10.4: Write a **function** `create` takes one `int` argument, the size of the array to create and returns a `Person` array of that size. Make it so the i^{th} element of the array is initialized to `"P # " + i`. Call this **function** from the **main function** like so:

```
001  beginMain
002     var Person[] a = create(3);
003     print(a);
004  endMain
```

Question 10.5: Write a **function** `create2` takes one int argument, the size of the array to create and returns a `Mine` array of that size. Make it so the i^{th} element of the array's `toString` **method** prints out `"Mine # " + i`. Why is it not possible to overload that `create` **function**? Try it and see what the compiler says. Call `create2` from the **main function** like so:

```
001  beginMain
002     var Mine[] a = create2(3);
003     print(a);
004  endMain
```

Question 10.6: Write a **function** `doubler` that takes a `Person` array `x` and returns a new `Person` array called `result` twice as big as `x`. Copy `x` into the `result` before you return it. The extra elements in `result` should all be `null`.
Question 10.7: Change the `doubler` **function** so that every `null` in the array `result` is set to a new `Person` make it so that every new `Person` object has a different `name` property.

Two dimensional arrays

Question 10.8: Here is an example of a convenient two dimensional array initialization syntax. Study, compile and run the following code. The code `Person[][]` should be read out loud as *person array array* indicating the variable `a` is a *person array array*, also known as a *two-dimensional array of persons*.

```
001  beginMain
002     var Person[][] a = { { new Person( "P # 1" ), new Person( "P # 2" ), new Per-
son( "P # 3" ) },
003                          { new Person( "P # 4" ), new Person( "P # 5" ) },
004                          { new Person( "P # 6" ) } };
005
006     for (var int y=0; y<a.length; y=y+1)
007     begin
008        for (var int x=0; x<a[y].length; x=x+1)
009        begin
010           System.out.print( " " + a[y][x]);
011        end
012        System.out.println();
```

```
013     end
014  endMain
```

Question 10.9: By copying the pattern of the code above, do some more overloading of the `print` **function** by writing two new `print` functions, one taking a two dimensional array of Person, the other taken a two dimensional array of Mine. The call both of these functions from the **main function**.
Since `a[0]` is a Person array,you would naively expect it to be able to be re-initialized like so:

```
001  a[0] = { new Person( "P # 4" ),
002           new Person( "P # 5" ),
003           new Person( "P # 6" ) };
```

so that after this code `a0` holds the four element long array `Person # 4`,`Person # 5` and `Person # 6`,but it does't work owing to a design oversight by the creators of Java. Luckily as mentioned above there is a way around this oversight and that is to use a temporary variable like so:

```
001  var Person[] temp = { new Person( "P # 4" ),
002                        new Person( "P # 5" ),
003                        new Person( "P # 6" ) };
004  a[0] = temp; // Array "a[0]" now holds P # 4,P # 5,P # 6
```

Like with one dimensional arrays,there is a second initialisation syntax for two dimensional arrays and here it is. Unlike the above code the sub-arrays `a[0]`,`a[1]` and `a[2]` are all of equal size,namely three.

```
001  var Person[][] a = new Person[3][3];
002  a[0][0] = new Person( "P # 1" );
003  a[0][1] = new Person( "P # 2" );
004  a[0][2] = new Person( "P # 3" );
005  a[1][0] = new Person( "P # 4" );
006  a[1][1] = new Person( "P # 5" );
007  a[1][2] = new Person( "P # 6" );
008  a[2][0] = new Person( "P # 7" );
009  a[2][1] = new Person( "P # 8" );
010  a[2][2] = new Person( "P # 9" );
```

Question 10.10: Write a **function** `create3` and `create4` that takes an int argument `size` and returns a two dimensional array of Person or Mine, respectively. Make is so that each Person or Mine object has its own number, using a separate counter variable int `count`.

Three dimensional arrays

Question 10.11: Using the knowledge you have gained so far about arrays, create, initialize and print a three dimensional array of Person. Make it so that each Person object is given its own number using a separate counter variable int `count`.

2.6.11 Tutorial 11

The following code presents example involving three classes Flea, Dog and DogOwner to represent the idea that a *dog* has a *flea* and a *dog-owner* has a *dog*. The **class** DogTest is the driver

class. The key concept of this tutorial is that classes can have references of objects of another **class** in order to set up a relationship between the two classes.

Question 11.1 Study the following code and find the two bugs in it. Fix the bugs and then compile and run it to verify that it prints out `"p=I am a flea called Pop"`.

```
// BEGIN FILE: jtw-tutorials/DogTest.jtw
001  class Flea
002  begin
003     property String name;
004
005     constructorFlea(String aName)
006     begin
007        aName = name;
008     end
009
010     public method String toString()
011     begin
012        return "(I am a flea called " + name + ")";
013     end
014  end
015
016  class Dog
017  begin
018     property String name;
019     property int    age;      // Age in years
020     property Flea   dogsFlea;
021
022     constructorTurtle(String aName, int anAge, Flea aFlea)
023     begin
024        name     = aName;
025        age      = anAge;
026        dogsFlea = aFlea;
027     end
028  end
029
030  class DogTest
031  begin
032     beginMain
033        var Flea p = new Flea( "Pop" );
034        var Flea s = new Flea( "Squeak" );
035        var Flea z = new Flea( "Zip" );
036        System.out.println( "p=" + p);
037     endMain
038  end
// END FILE:    jtw-tutorials/DogTest.jtw
```

Question 11.2: In the **main function** of the DogTest **class**, write code to call the `toString` **method** for the fleas referenced by `s` and `z`.

Question 11.3: In the **main method** of the DogTest **class**, write code to construct three dogs called `"Fido"`, `"Jimbo"` and `"Rex"`. For the purposes of the rest of these questions, let the name of the references for Fido, Jimbo and Rex be `f` `j` and `r`. Note that the third parameter to the Dog **class** is of type Flea. Therefore you will need to supply a Flea reference for each dog. Make it so that Fido has a flea called Pop, Jimbo has a flea called Squeak, and Rex has a flea called Zip.

HINT: If the flea called Pop is referenced by the variable name `p`, then this reference should appear as the third argument in one of the calls to the Dog **constructor**.

Question 11.4: Write a `toString` **method** in the Dog **class** that works like the `toString` **method** in the Flea **class**. Then call this **method** from the **main function** to print out the full statistics of the three dogs that you have just created in Question 11.3.

Question 11.5: By copying the pattern of the Flea and Dog classes, write a **class** DogOwner that has three non-**private** properties: `name`, `salary` and `ownersDog`. Also write a three-parameter **constructor** for the DogOwner **class** that sets these properties.
Question 11.6: Add some code into the **main function** to construct three dog owners called `Angus`, `Brian` and `Charles`. Make it so that Angus has a dog called Rex, Brian has a dog called Jimbo, and Charles has a dog called Fido. For the purposes of the rest of these questions, let the name of the references for Angus, Brian and Charles be (respectively) `a`, `b` and `c`. Use the Dog references that you created in Question 11.3 to achieve this. Make it so that Angus, Brian and Charles have initial salaries of 10,000, 20,000 and 30,000.
Question 11.7: Without changing the call to the DogOwner **constructor**, change the value of the `salary` property of object referenced by `a` to 1,000,000. Note that since the `salary` property of the DogOwner **class** is non-**private** you should be able to set the value of the `salary` property from the **main function** of DogTest.
Question 11.8: Write a `toString` **method** for the **class** DogOwner and add some code to the **main function** to call it for Angus, Brian and Charles.
Question 11.9: What is the value of: `a.ownersDog.dogsFlea.toString()`? Add some code to the **main function** to find out if it does what you think it should do.

2.6.12 Tutorial 12

Question 12.1: Write **constructor**s for the classes SportsShoe and Runner below, by looking at the **main function** to see how many arguments each **constructor** has.

```
// BEGIN FILE: jtw-tutorials/RunnerTest.jtw
001  class SportsShoe
002  begin
003
004     property String model;        // what kind of shoe it is
005     property double speedBoost;   // the boosting factor of the shoe
006
007     // constructor goes here:
008
009     // Useful method for debugging
010     method String toString()
011     begin
012        return "(I am a shoe called " + model + " and my boosting factor is " + speedBoost + ")";
013     end
014
015  end
016
017  class Runner
018  begin
019     private property String     name;     // Runner's name.
020     private property int        speed;    // speed of runner in km/hr.
021     private property SportsShoe shoes;    // which shoe they are wearing
022
023     // constructor goes here:
024
025     // Useful method for debugging
026     method String toString()
027     begin
028        return "(I am a runner and my name is " + name + " and my shoes are " + shoes + ")";
029     end
030
031     /*
032     ** This private method computeSpeed works out the runners speed,
033     ** based on their basic speed and the speed boost due to the
034     ** SportsShoe that they are currently wearing.
035     */
036
```

```
037     // method goes here:
038
039
040     /**
041      ** Prints the result of racing two runners against each other.
042      */
043     function void race (Runner r1, Runner r2)
044     begin
045        if (r1.computeSpeed() > r2.computeSpeed()) then
046        begin
047           System.out.println( "Runner " + r1.name + " beats " + r2.name);
048        end
049        else
050        begin
051           System.out.println( "Runner " + r2.name + " beats " + r1.name);
052        end
053     end
054
055
056     /**
057      ** Swaps the shoes of two runners.
058      */
059     function void swapShoes (Runner r1, Runner r2)
060     begin
061       var SportsShoe tempShoe = r1.shoes;
062       r1.shoes = r2.shoes;
063       r2.shoes = tempShoe;
064    end
065  end
066
067  class RunnerTest
068  begin
069     beginMain
070        var SportsShoe nike    = new SportsShoe( "Nike NX-71" ,   2.0);
071        var SportsShoe reebock = new SportsShoe( "Reebock R20" ,  2.3);
072        var SportsShoe puma    = new SportsShoe( "Puma P200-MMX" ,4.8);
073
074        var Runner sg = new Runner( "Speedy Gonzalez" , 55, nike);
075        var Runner sw = new Runner( "Slick Willy" ,     49, reebock);
076        var Runner fa = new Runner( "Fat Albert" ,      15, puma);
077
078        Runner.race(sg,sw);
079        // Runner.race(sg,sw,fa);
080        // sg.raceAgainst(sw);
081     endMain
082  end
083
// END FILE:    jtw-tutorials/RunnerTest.jtw
```

Question 12.2: In the Runner **class**, write the private **method** `computeSpeed` that has no arguments and returns a double-precision floating point value that equals the runner's running speed. Note that the speed of a runner is determined by multiplying their `speed` property with the `speedBoost` property of the shoes that they are wearing. For example, Speedy Gonzalez's running speed = 55 * 2.0 = 110.0.

Question 12.3: Fix the `race` **method** so that it checks for a draw.

Question 12.4: By copying the `race` **method**, write a three-parameter `race` **method** for racing three runners against each other. Two methods in the same **class** with the same name is called *overloading* in Java. Add a call to this **method** from the **main function**.

Question 12.5: What is the difference between a **method** and a **function**? Write a one parameter **method** `raceAginst` that behaves exactly like two-parameter **function** `race`. There are two ways of doing this, one is to optionally use the **this** keyword rather than one of the parameters

r1 or r2. The second way is for race to simply call race using **this** as one of the arguments to the **function**.

Question 12.6: Is it true that any **method** can be re-worked into a **function** and vice versa?

Question 12.7: The swapShoes **method** in the Runner **class** swaps the shoes of two runners. Add some code to the **main function** to swap the shoes of two runners and verify that the shoes do indeed get swapped.

Question 12.8: Write a **method** called swapNames that swaps the names of two runners. You can put this **function** into any **class** but it makes the most sense to put it into the Runner **class** since it has two Runner parameters.

Question 12.9: Write a **method** swapSpeeds that swaps the speed properties of two runners.

2.6.13 Tutorial 13

Question 13.1: Study, compile and run the following code:

```
// BEGIN FILE: jtw-tutorials/CarTest.jtw
001  class Car
002  begin
003
004     property String      model;
005     property int         value; // Car's value in dollars
006     property int         serialNumber;
007     private classVar int serialCounter = 1000;
008
009     constructorCar(String aModel, int aValue)
010     begin
011        model         = aModel;
012        value         = aValue;
013        serialNumber  = serialCounter;
014        serialCounter = serialCounter + 1;
015     end
016
017     public method String toString ()
018     begin
019        return "(I am a car, model=" + model + ", value=" + value +
020               ", serial number=" + serialNumber + ")";
021     end
022  end
023
024  class Owner
025  begin
026
027     property String name;
028     property int    money; // Owner's money in dollars
029     property Car    ownersCar;
030
031     constructorOwner(String aName, int aMoney, Car aCar)
032     begin
033        name      = aName;
034        money     = aMoney;
035        ownersCar = aCar;
036     end
037
038     public method String toString ()
039     begin
040        return "(I am a car owner, name=" + name + ", money=" + money +
041               ", car=(" ) + ownersCar + "))";
042     end
043  end
044
045  /**
```

```
046   *     Code goes here
047   *
048   */
049  class CarTest
050  begin
051     beginMain
052        var Car   ford   = new Car( "Ford Escort" ,1000);
053        var Car   nissan = new Car( "Nissan Nivara" ,2000);
054        var Owner joe    = new Owner( "Joe Bloggs" ,500,ford);
055        var Owner mary   = new Owner( "Mary Smith" ,600,null); // Mary has no car to start with.
056        joe.describe();
057     endMain
058  end
//  END FILE:    jtw-tutorials/CarTest.jtw
```

Question 13.2: What is the purpose of the **class** variable `serialCounter`?
Question 13.3: Write a **method** `sellCar` that increases the owner's money by half the value of their car and the owner's car reference gets set to `null`, for no car. If the owner owns no car (`null`) simply do nothing.
Question 13.4: Write a **method** in the Owner **class** called `purchase` so that:

```
001  Car newCar = new Car( "Mini Cooper" ,100 0);
002  joe.purchase(newCar);
```

results in Joe's money going down by `newCar.value` and Joe's car being set to `newCar`. Call the `sellCar` method before Joe purchases his new car
Question 13.5: Write a **function** in the Owner **class** called `netWorth` so that:

```
System.out.println( "Joe's net worth = " + joe.netWorth());
```

prints out Joes' money plus the value of his car, if he has a car. You will need to use an **if** (...) **then** ... statement to test whether or not a reference is pointing to a valid object or `null` for no object like so:

```
001  if (ownersCar == null)
002  then begin
003     // do not access ownersCar.value as ownersCar points to no object
004  end
005  else begin
006     // do access ownersCar.value
007  end
```

Question 13.6: Write a **method** in the Owner **class** called `smashCar` so that:

```
mary.smashCar();
```

halves the value of Mary's car.
Question 13.7: Write a **method** in the Owner **class** called `stealCarFrom` so that:

```
mary.stealCarFrom(joe);
```

results in Mary selling his current car (if he has one) for its market value and Mary acquiring ownership of Joe's car. Also make Joe invoke his `sellCar` method to relinquish ownership of his car if he has one.
Question 13.8: Write a **function** in the Owner **class** called `swapMoney` so that:

```
Owner.swapMoney(joe,mary);
```

swaps the money of Joe and Mary.
Question 13.9: Write a **function** in the Owner **class** called `swapCars` so that:

```
Owner.swapCars(joe,mary);
```

swaps the cars of Joe and Mary.
Question 13.10: Write a **function** in the Car **class** called `swapSerialNumbers` so that:

```
Car.swapSerialNumbers(ford,nissan);
```

swaps the serial numbers of `ford` and `nissan`.
Question 13.11: Write a **function** in the Owner **class** called `sellCarTo` so that

```
joe.sellCarTo(mary);
```

results in Joe's money going up by the value of his car and Mary's money going down by the value of his car, and the ownership of Mary's car gets transferred to Joe.

2.6.14 Tutorial 14

Dr Seuss' story [*Yertle the Turtle*] describes how a turtle called Yertle sits at the top of a pile of other turtles. In this example, the pile of turtles is represented by a linked list of Turtle objects, with the `down` property serving to connect one Turtle object to another. If a Turtle object has a non-`null` `down` property, then this represents a turtle that is sitting below the current one. The last turtle in the linked list is the turtle that is at the bottom of the pile, which has a `null` value for its `down` property.
Question 14.1: Study, compile and run the following code:

```
// BEGIN FILE: jtw-tutorials/TurtleTest.jtw
001  package files;
002
003  class Turtle
004  begin
005
006     private property String  name;
007     private property int     age;    // Turtle's age in years
008     private property double  weight; // Turtle's weight in kg
009
010     // NOTE: this property allows for linked lists
011     property Turtle down;
012
013     constructorTurtle(String aName, int anAge, double aWeight)
014     begin
015        name   = aName;
016        age    = anAge;
017        weight = aWeight;
018     end
019
020     /** Getter method for name property */
021     method String getName()
022     begin
023        return name;
024     end
```

```
025
026     /** Getter method for weight property */
027     method double getWeight()
028     begin
029        return weight;
030     end
031
032     /** Useful method for debugging */
033     public method String toString()
034     begin
035        return name;
036     end
037
038     /** Inserts the turtle t below the current one */
039     method void insert(Turtle t)
040     begin
041        var Turtle temp = this.down;
042        this.down = t;
043        t.down = temp;
044     end
045  end
046
047  public class TurtleTest
048  begin
049     beginMain
050
051        var Turtle yurtle = new Turtle("Yurtle", 103, 20);
052        var Turtle zippy  = new Turtle("Zippy",  102, 30);
053        var Turtle bungle = new Turtle("Bungle", 101, 40);
054
055        // *** see later
056        yurtle.down = zippy;
057        zippy.down  = bungle;
058        bungle.down = null; // NOTE: not needed as bungle.down is null by default
059
060        var int totalWeight = 0;
061        for (var Turtle current = yurtle; current != null; current=current.down)
062        begin
063           totalWeight = totalWeight + current.getWeight();
064        end
065        System.out.println("The total weight is " + totalWeight);
066     endMain
067  end
// END FILE:    jtw-tutorials/TurtleTest.jtw
```

The code in the **main function** after the *** sets up the following relationships between the three Turtle objects (Bungle, Zippy and Yertle). Figure 2.2 shows the relationship between the different turtles. When you traverse the list of turtles you must always start at the top turtle (known as the *head of the linked list*). If you give a different value for the top turtle, your code will think that the given turtle is the one at the top of the pile and you will get the wrong result.

Question 14.2: Move the code for calculating the total weight of the turtles from the **main function** to a **function** called **function** void **printTotalWeight**(Turtle top) in the Turtle **class** that prints out the total weight of the turtles. Then call that **function** from the **main function** to get the same result as before. Note that that if `printTotalWeight` was a **method** then calling that **method** using `null` (representing an empty list) like so: `null.printTotalWeight()` would be an error, whereas `Turtle.printTotalWeight(null)` wouldn't be and therefore is better. This is one example of how methods and functions differ.

Question 14.3: Revision question for getters. By copying the pattern established by the `getName` **method**, add two getter methods to the Turtle **class**: `getAge` which returns the current

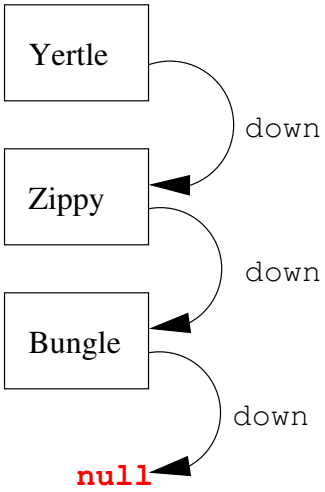


Figure 2.2: A linked list of `Turtle` objects

turtle's age and `getWeight` which returns the current turtle's weight. Then call these methods on the Yertle object in the **main function**. Note that the `toString` **method** would be more appropriate as it handles nulls better but you known that the `yurtle` reference is not `null` so you know it is safe to call the `getAge` and `getWeight` methods on the `yurtle` reference.
Question 14.4: Write a **function** Turtle **findBottomTurtle** (Turtle top) that returns the Turtle object that is at the top of the pile, and returns `null` if there isn't one.
Question 14.5: Then call this **function** from the **main function** using **System.out.println**() and the top turtle `yertle`.
Question 14.6: Write a **function** Turtle **findOldestTurtle** (Turtle top) that returns the oldest turtle or `null` if there isn't one.
Question 14.7: Then call this **function** from the **main function** using **System.out.println**() and the top turtle `yurtle`.
Question 14.8: Write a **function** Turtle **findHeaviestTurtle** (Turtle top) returns the heaviest turtle, or `null` if there isn't one.
Question 14.9: Then call this **function** from the **main function** using **System.out.println**() and the top turtle `yurtle`.
Question 14.10: Write a **function** void **sayPile** (Turtle top) that prints the names of the turtles in the pile starting from the top turtle and finishing at the bottom turtle. Then call this **function** from the **main function**.
Question 14.11: Under what circumstances would it be okay to change the visibility of the `down` property to private, like the `name`, `age` and `weight` properties?
Question 14.11: Add an extra parameter to the **constructor** which is a reference the to the turtle below of the current one. Then remove all occurrences of the `down` property from the **main function**. The advantage of this is that it enables you to change the visibility of the `down` property to **private**.

2.6.15 Tutorial 15

Basic Inheritance

When you see the following code: **class** X **extends** Y, it means that **class** X *inherits* from the **class** Y. Class X is called the *subclass* and the **class** Y is called the *super-class* or sometimes the *parent* **class**. When the **class** X extends from Y, it pulls in all of the non-**private methods** and **propertys** from the super-**class** Y. Inherited **methods** can override the behaviour of that same **method** in the super-**class** to give behaviour that is specific to the sub-**class**. The concept of

methods overriding other **methods** is called *dynamic* **method** *binding* or more commonly the more impressive-sounding name: *polymorphism*. The main thing that this tutorial shows is the idea that inheritance is a non-symmetrical relationship. For example: in the code that follows, the Bird **class** inherits from the Animal **class**, which corresponds to the idea that *every bird is an animal*. The reverse, *every animal is a bird* is plainly not true! Inheritance forces you to recognize this.

Question 15.1: Study, compile and run the following code. The following code shows how inheritance works. In the following code, the Bird **class** inherits from the Animal **class**. The Bird **class** pulls in the Animal **class**'s `age` property and the `canFly` and `talk` **methods**. Importantly the `canFly` property overrides the behaviour of the `canFly` **method** of the parent Animal **class**, which reflects that fact that generally speaking, birds can fly. In the code that follows, note that *int* properties are initialized to zero by default and the *super* **method** (also known as the **constructor** of the super-class) is called by default if there is a zero parameter **constructor** in the super-class, which there is by default, even if you don't write one!

```
001  class Animal
002  begin
003
004     property int age; // Animal's age in years
005     property int health; // Animal's health in hit points
006
007     constructor Animal()
008     begin
009        age = 0; // NOTE: not needed as set by default
010        health = 100 ;
011     end
012
013     method boolean canFly()
014     begin
015        return false;
016     end
017
018     method void talk()
019     begin
020        System.out.println( "Hello" );
021     end
022  end
023
024  class Bird extends Animal
025  begin
026
027     property double flySpeed; // Bird's speed in km/h
028
029     constructor Bird()
030     begin
031        super();       // NOTE: not needed as called by default
032        flySpeed = 0; // NOTE: not needed as set by default
033     end
034
035     method boolean canFly()
036     begin
037        return true;
038     end
039
```

```
040     method void peck()
041     begin
042         System.out.println( "peck" );
043     end
044 end
045
046 class InheriTest
047 begin
048     beginMain
049         var Bird eagle = new Bird();
050         eagle.talk();
051         eagle.peck();
052     endMain
053 end
```

Question 15.2: Override the `talk` **method** of the Animal **class** in the Bird **class** to print out `"Tweet Tweet!"` rather than `"hello"` to give more accurate talking of bird objects.
Question 15.3: By copying the pattern established in the Bird **class**, change the eagle from an instance of the Bird **class** to its own **class** in its own right and then create an instance of that **class** in the **main** **function** of InheriTest. Your Eagle **class** should have one **property**: `int numberOfKills` and one **method**: `void attack()` that internally increments the value of `numberOfKills`. In the **main** **function** you should call every **method** of the Eagle **class** and its super-classes.
Question 15.4: What is the advantage of using a new separate **class** to represent a new object rather than using an instance of an existing **class**?
Question 15.5: Create a new **class** Kiwi that inherits from the Bird **class**. Your Kiwi **class** should override the `canFly` **method** to return false, which reflects the fact that generally speaking birds can fly, but the kiwi bird in particular does not fly. Your Kiwi **class** have a property `numberOfWorms`. Once you have written the Kiwi **class** you should create an instance of the Kiwi **class** in the **main** **function**.

Question 15.6: Why does the following line of code in the **main** **function** print out 100 but there is no setting of that variable to that value in the Kiwi **class**?

```
System.out.println(k.health);
```

Question 15.7: In the classes Animal, Bird, Eagle and Kiwi, remove all of the `canFly` **method**s and replace it with a single `canFly` property of the Animal **class**. In the **constructor**s you will need to set the value of the `canFly` **property** to a value that is appropriate for that **class**. For example in the Bird **class**'s **constructor** you should set the `canFly` property to true, while in the Kiwi **class**'s **constructor** you should set the `canFly` **property** to false.
Question 15.8: What is the advantage of having a `canFly` **property** over a bunch of `canFly` **method**s?
There is an equally valid alternative to having a **public property** in the Animal **class** and that is to have in the Animal **class** a **private property** `canFly` and a pair of **method**s for getting and setting the value of the `canFly` property like so. These **method**s in J.T.W. and Java are called *getter* **method**s and *setter* **method**s since, as their names suggest, getters are used for getting the value of something and setters are used for setting the value of something. Note that the `canFly` **method** of the code above corresponds to `getCanFly` **method** in the code below.

```
001 private property boolean canFly;
002
003 method boolean getCanFly()
```

```
004  begin
005     return canFly;
006  end
007
008  method void setCanFly (boolean aCanFly)
009  begin
010     canFly = aCanFly;
011  end
```

You might think that it is simpler to have one thing (a single non-**private property**) rather than three things (a **private** property and a non-**private** getter **method** and a non-**private** setter **method**) and you would be right. However from the point of view of the client code that uses the Animal **class**, the two approaches are identical. Later on when you learn more you will understand under what circumstances the second getter and setter approach is better.

Question 15.9: Change the **main function** to what follows:

```
001  var Bird b = new Bird(10);
002  var Animal a = b;
003  a.talk();
004  a.peck();
```

When you compile this code it gives a compilation error. What line gives the error and what is the reason for the error?

Question 15.10: Change the **main function** to what follows:

```
001  var Animal a = new Animal();
002  var Bird b = a;
003  b.talk();
004  b.peck();
```

When you compile this code it gives a compilation error. What line gives the error and what is the reason for the error?

Run-time type inquiry

In J.T.W. and Java there is a keyword called *instanceof* that does a run-time check on the type of an object. The following **function**:

```
001  function void say (Animal a)
002  begin
003     System.out.println(a instanceof Bird);
004  end
```

uses the **instanceof** keyword to determine the run-time type of the reference `a` and prints out whether or not the reference is referring to a Bird object. Some examples should clarify the situation:

- `say(new Bird())` prints `true`, Since the parameter `a` is pointing to a bird object at run-time,
- `say(new Animal())` prints `false` since not every animal is a bird,
- `say(new Eagle())` prints `true`, since every eagle is a bird, and

- `say(new Kiwi())` prints `true`, since every kiwi is a bird.
- **var** `Animal a = new Animal(); say(a);` prints `false` since at run-time `a` is not pointing to a bird object
- **var** `Animal a = new Bird(); say(a);` prints `true` since at run-time `a` is pointing to a bird object.

In Tutorial 17 you will learn why in most cases it is better to use polymorphism instead of the **instanceof** keyword for run-time type enquiry.

The super-class of all objects

Every **class** in Java inherits either directly or indirectly from a **class** called *Object*. That is to say if `x` is a reference variable, then the run-time expression `x instanceof Object` is always true except for the pathological case where `x` is `null` (i.e. is currently pointing to *no object*). The `Object` **class** contains a **method** called `toString` that returns a string containing the run-time **class** name of the object concatenated with the something like the memory address of the object in base 16 (also known as *hexadecimal*) format. Since every **class** inherits from `Object`, every object can have `toString` invoked upon it. Even better, every **class** `X` can override `toString` to provide debugging information that is tailored to `X`. Therefore the `toString` **method** is convenient for debugging. Since the `toString` **method** is a **public method** of the `Object` **class** it must be overridden as a **public method**, since your overridden **function** cannot have weaker access privileges.

2.6.16 Tutorial 16

This tutorial shows you a practical example of inheritance. The file `StarWars.jtw` is comprised of three classes: `XWing`, `TieFighter` and `StarWars`. The first two represent spacecraft from the two sides of the Star Wars films. The **class** `StarWars` is the driver **class** and contains code for executing a battle between the X-Wings and the Tie Fighters.
Question 16.1: Study, compile and run the following code:

```
001  class XWing
002  begin
003
004     private property int shields;
005     private property int weapon;
006     private property boolean dead;
007
008     constructor XWing()
009     begin
010        shields = 100 0;
011        weapon = 10;
012     end
013
014     method int getWeapon()
015     begin
016        return weapon;
017     end
018     method boolean isDead()
019     begin
020        return dead;
021     end
```

```
022     method void hit (int damage)
023     begin
024        shields = shields - damage;
025        if (shields<0)
026        then begin
027           System.out.println( "BOOM!!!" );
028           dead = true;
029        end
030     end
031  end
032
033  class TieFighter
034  begin
035
036     private property int shields;
037     private property int weapon;
038     private property boolean dead;
039
040     constructor TieFighter()
041     begin
042        shields = 500 ;
043        weapon = 20;
044     end
045
046     method int getWeapon ()
047     begin
048        return weapon;
049     end
050     method boolean isDead ()
051     begin
052        return dead;
053     end
054     method void hit (int damage)
055     begin
056        shields = shields - damage;
057        if (shields<0)
058        then begin
059           System.out.println( "BOOM!!!" );
060           dead = true;
061        end
062     end
063  end
064
065  class StarWars
066  begin
067
068     private function void duel (XWing x, TieFighter t)
069     begin
070
071        for (;;)
072        begin
073           x.hit(t.getWeapon());
074           if (x.isDead())
075           then begin
```

```
076             System.out.println( "X-Wing is dead" );
077             break;
078          end
079          t.hit(x.getWeapon());
080          if (t.isDead())
081          then begin
082             System.out.println( "Tie Fighter is dead" );
083             break;
084          end
085       end
086
087    end
088
089    private function void battle (XWing[] good, TieFighter[] evil)
090    begin
091
092       var int g         = 0;
093       var int e         = 0;
094       var int goodDeaths = 0;
095       var int evilDeaths = 0;
096
097       while (g<good.length and e<evil.length)
098       begin
099          System.out.println( "battling X-Wing #" + g + " versus Tie Fighter #" + e);
100          duel(good[g],evil[e]);
101          if (good[g].isDead())
102          then begin
103             g = g + 1;
104             goodDeaths = goodDeaths + 1;
105          end
106          if (evil[e].isDead())
107          then begin
108             e = e + 1;
109             evilDeaths = evilDeaths + 1;
110          end
111       end
112
113       var int finalGood = good.length - goodDeaths;
114       var int finalEvil = evil.length - evilDeaths;
115
116       System.out.println();
117       System.out.println( "Battle Report:  X-Wings Tie Fighters" );
118       System.out.println( "-----------------------------------------" );
119       System.out.println();
120       System.out.println( "Initial ships:" + good.length + " " + evil.length);
121       System.out.println();
122       System.out.println( "Killed ships:" + goodDeaths + " " + evilDeaths);
123       System.out.println();
124       System.out.println( "Final ships:"   + finalGood + " " + finalEvil);
125       System.out.println();
126       if (finalGood>finalEvil)
127       then begin
128          System.out.println( "The rebel alliance is victorious!" );
```

```
129         end
130         else begin
131            System.out.println( "The dark side has conquered!" );
132         end
133         System.out.println();
134      end
135
136      beginMain
137
138         // defines the goodies array
139         var XWing[] goodies = new XWing[3];
140
141         // initializes the elements of the goodies array
142         for (var int i=0; i<goodies.length; i = i + 1)
143         begin
144            goodies[i] = new XWing();
145         end
146
147         // defines the baddies array
148         var TieFighter[] baddies = new TieFighter[3];
149
150         // initializes the elements of the baddies array
151         for (var int i=0; i<baddies.length; i=i+1)
152         begin
153            baddies[i] = new TieFighter();
154         end
155
156         battle(goodies,baddies);
157
158      endMain
159   end
```

Question 16.2: Compile and run this file to see the battle between the X-Wings and the Tie Fighters unfold.
Question 16.3: If you look at the Java code for the XWing and TieFighter classes you will notice that they are almost identical: They have the same methods and properties, the only difference is that the XWing objects are initialized with a different value for their shields and weapon properties to the TieFighter objects.
The next few questions will guide you through the process of using inheritance to eliminate this unnecessary duplication of code. A new **class** called SpaceShip will be created and all of the code that is common to XWing and TieFighter will be moved into this **class**. The XWing and TieFighter classes will then be modified so that they both inherit from SpaceShip.
Question 16.4: The first step in this process is to create the outer shell of the SpaceShip **class**, which you should now type in:

```
001  class SpaceShip
002  begin
003  end
```

Question 16.5: Move the properties `shields`, `weapon` and `dead` out of the XWing and TieFighter classes and into the SpaceShip **class**. You must change the privacy status of the properties from *private* to *protected*. The protected modifier was invented as an intermediate level of privacy between public and private. Like **private**, it allows visibility to the same **class** in which the **method**

or **property** was defined, but unlike **private** it also allows visibility to sub-classes of the **class** in which the **method** or **property** was defined.
Question 16.6: Move the three methods `getWeapon`, `isDead` and `hit` out of the XWing and TieFighter classses and into the SpaceShip **class**. At this point, the XWing and TieFighter classes should contain nothing but a **constructor**.
Question 16.7: Finally, add the *extends* keyword to the first line of the XWing and TieFighter classes:

```
class XWing extends SpaceShip
```

and

```
class TieFighter extends SpaceShip
```

Question 16.8: Compile and run your program again, making sure that it produces the same results now that it is using inheritance.
Question 16.9: The SpaceShip **class** is a superclass of both XWing and TieFighter containing everything that X-Wings and Tie Fighters contain in common. Because the role of the SpaceShip **class** is simply to hold these commonalities, we might choose to label the **class** with the **abstract** keyword:

```
abstract class SpaceShip
```

This prevents us from creating instances of the SpaceShip **class**. Without the **abstract** modifier, we could happily create a **new** SpaceShip(), which would be an object that is not an X-Wing, nor a Tie Fighter, but just a vague "space ship". If we consider this to be a logical mistake then we can use **abstract** to prevent such calls to the SpaceShip **constructor**. Change the **class** SpaceShip to be **abstract** and observe how the compiler will not accept any lines of the form:

```
var SpaceShip s = new SpaceShip(); // compiler error
```

Remove the **abstract** keyword and notice how the compiler will then allow this line to compile.

2.6.17 Tutorial 17

Question 17.1: Study the following code:

```
001  class AnimalTest
002  begin
003     private function void chatter(Animal[] a)
004     begin
005        for (var int i=0; i<a.length; i=i+1)
006        begin
007           a[i].talk();
008        end
009     end
010     beginMain
011        var Animal[] farm = { new Dog(),new Cow(),new Fish() };
012        var Animal[] ark = { new Dog(),new Dog(),new Cow(),new Cow(),new Fish(), new Fish() };
013        var Cow[]   herd = { new Cow(),new Cow(),new Cow() };
014        chatter(farm);
015        chatter(ark);
```

```
016         chatter(herd);
017      endMain
018   end
019
020   class Animal
021   begin
022      method boolean breathesUnderwater()
023      begin
024         return false;
025      end
026
027      method boolean isPredator()
028      begin
029         return false;
030      end
031
032      method void talk()
033      begin
034      end
035   end
036
037   class Dog extends Animal
038   begin
039      method boolean isPredator()
040      begin
041         return true;
042      end
043
044      method void talk()
045      begin
046         System.out.println("Woof woof!");
047      end
048   end
```

Question 17.2: Write the following classes that sub-**class** the Animal **class** above: Cow, Cat, Fish, and Whale.

Question 17.3: Write the Shark **class** which extends Fish **class**. Override all necessary **method**s. For the sake of this example and the code that follows, suppose that shark's `talk` **method** prints out `"Chomp Chomp!"`.

Question 17.4: Run the AnimalTest **class** to make sure that all the **method**s work correctly.

Question 17.5: Rewrite the `chatter` **method** so that it never calls the `talk` **method**s and instead uses a series of *if* statements and the *instanceof* operator to test the run-time type of each object in the `a` array. Here is some code to get you started:

```
001   private function void chatter(Animal[] a)
002   begin
003      for (var int i=0; i<a.length; i=i+1)
004      begin
005         if (a[i] instanceof Cow) then
006         begin
007            System.out.println("Moo!");
008         end
009         else if (a[i] instanceof Cat) then
```

```
010         begin
011            System.out.println( "Meow!" );
012         end
013         /* other code goes here */
014      end
015   end
```

Note that the sub-**class**es must appear before super-classes in the above code, otherwise the wrong message will be printed out for sub-**class**es.
Question 17.6: Why is the code from the last question not as good as calling each animal's `talk` **method**?

2.7 Proofs of concept for the J.T.W language

2.7.1 Proof of concept #1: A small collection of d-defmacros for your use in client code

Study the following Elisp code which creates a pair of macros `getter` and `setter`, a macro for implementing the *singleton design pattern* called `singleton_design_pattern` and a macro `foreach` for implementing the iterator design pattern.

```
;; BEGIN FILE: ~/dlisp/d-defmacro.el
001  ;;; d-defmacro.el
002
003  ;; Copyright (C) 2017 Davin Pearson
004
005  ;; Emacs Lisp Archive Entry
006  ;; Filename: d-defmacro.el
007  ;; Author/Maintainer: Davin Max Pearson <http://davin.50webs.com>
008  ;; Keywords: defmacros for defining macros in J.T.W.
009  ;; Version: 1.0
010
011  ;;; Commentary:
012
013  ;; This file is part of GNU Java Training Wheels.
014  ;;
015  ;;; m4_limitation_of_warranty
016
017  ;;; m4_install_instructions(d-defmacro)
018
019  ;;; Known Bugs:
020
021  ;; None so far!
022
023  ;;; Code:
024
025  ;;(load-file "~/lisp++-projects/c++2lisp++-stage-1-purge-comments.el")
026  ;;(load-file (concat (car load-path) "lisp++-mode.el"))
027  ;;(load-file "~/lisp++-projects/lisp++2c++-cclass.el")
028
029  (safe-require 'd-flm)
030
031  (setq d-macro-list nil)
032
033  (defmacro d-defmacro (name &rest macro-form)
034    `(progn
035       (setq d-macro-list (cons (quote , name) d-macro-list))
036       (defmacro , name (&rest rest)
037         ,@ macro-form
```

```
038           )
039       ))
040
041  ;;(setq type "int")
042  ;;(setq vari "v")
043  ;;(setter int i)
044
045  (d-defmacro
046   getter
047   (setq type (nth 0 rest))
048   (setq vari (nth 1 rest))
049   (d-assert (cdr rest))
050   (d-assert (not (cdddr rest)))
051   (if (not (stringp type))
052       (setq type (prin1-to-string type)))
053   (if (not (stringp vari))
054       (setq vari (prin1-to-string vari)))
055   (setq prop nil)
056   (setq var (d-read-str (concat "getter-setter-prop--" type "--" vari)))
057   (when (not (and (boundp var) var))
058     (set var t)
059     (setq prop (concat "private " type " private_" vari ";")))
060   (concat "public " type " get" (d-string-capitalise vari) "()"
061           "{ return private_" vari "; }" prop "\n"))
062
063  (d-defmacro
064   setter
065   (setq type (nth 0 rest))
066   (setq vari (nth 1 rest))
067   (d-assert (cdr rest))
068   (d-assert (not (cdddr rest)))
069   (if (not (stringp type))
070       (setq type (prin1-to-string type)))
071   (if (not (stringp vari))
072       (setq vari (prin1-to-string vari)))
073   (setq prop nil)
074   (setq var (d-read-str (concat "getter-setter-prop--" type "--" vari)))
075   (when (not (and (boundp var) var))
076     (set var t)
077     (setq prop (concat "private " type " private_" vari ";")))
078   (concat "public void set" (d-string-capitalise vari) "(" type " " vari ")"
079           "{this.private" vari "=" vari ";}" prop "\n"))
080
081  ;; (d-compress-args '("100" "200" "300" ")"))
082  (defun d-compress-args (rest)
083    (let ((ptr    rest)
084          (result "(")
085          (count  0)) ;; (setq count 0)
086      (while ptr
087        (when (not (string= (car ptr) ")"))
088          (setq result (concat result (if (/= count 0) "," ) (car ptr)))
089          (incf count))
090        (setq ptr (cdr ptr)))
091      (setq result (concat result ")"))
092      (cons result count)
093      ) ;; end LET!
094    )   ;; end DEFUN! d-compress-args
095
096  (defun d-get-class-list ()
097    (interactive)
098    (save-excursion
099      (save-match-data
```

```
100       (let (indent-str class-or-interface class-name p1 p2 list)
101         (goto-char (point-min)) ;;           1
102         (while (re-search-forward (concat "\\(^[ \t]*\\)"
103                                           "\\(public[ \t]+\\|abstract[ \t]+\\|"
104                                           "final[ \t]+\\|\\)*"
105                                           "\\(class\\|interface\\)[ \t]+"
106                                           "\\([A-Z][a-zA-Z0-9_]*\\)" ) nil t)
107           ;;                              3                       4
108           (setq indent-str         (buffer-substring-no-properties (match-beginning 1)
109                                                                    (match-end 1)))
110           (setq class-or-interface (buffer-substring-no-properties (match-beginning 3)
111                                                                    (match-end 3)))
112           (setq class-name         (buffer-substring-no-properties (match-beginning 4)
113                                                                    (match-end 4)))
114           (save-excursion
115             (beginning-of-line)
116             (setq p1 (point))
117             (cond
118              ((save-excursion
119                 (forward-line 1)
120                 (beginning-of-line)
121                 (looking-at "^[ \t]*{" ))
122               (forward-line)
123               (beginning-of-line)
124               (forward-sexp)
125               ;;(if (string= class-name "Singleton")
126               ;;    (d-debug "Public Enemy / Mind Terrorist"))
127               (setq p2 (point)))
128              ((save-excursion
129                 (forward-line 1)
130                 (beginning-of-line)
131                 (looking-at "^[ \t]*begin\\>" ))
132               (re-search-forward (concat "^" indent-str "end[ \t]*$" ) nil t)
133               (setq p2 (point)))
134              )
135             (setq list (cons (list class-or-interface class-name p1 p2) list))))
136         list))))
137
138 (defun d-are-we-inside-class (class)
139   (d-assert (stringp (nth 0 class)))
140   (d-assert (stringp (nth 1 class)))
141   (and (>= (point) (nth 2 class))
142        (<= (point) (nth 3 class))))
143
144 (defun d-find-matching-class (class-list)
145   (block nil
146     (let ((ptr class-list)) ;; (setq ptr class-list)
147       (while ptr
148         (when (d-are-we-inside-class (car ptr))
149           ;;(message "* found d-are-we-inside-class class-list=%s (car ptr)=%s" ptr (car ptr))
150           ;;(d-error "Foomatic")
151           (return (car ptr)))
152         (setq ptr (cdr ptr))))))
153
154 (defun d-get-enclosing-class ()
155   (let (class-list)
156     (setq class-list (d-find-matching-class (d-get-class-list)))
157     ;;(d-error "Alien Syndrome / class-list=%s" class-list)
158     class-list))
159
160 ;; (setq compress-args (d-compress-args '("100" "200" "300")))
161 (d-defmacro
162  singleton_design_pattern
```

```
(let (ctor compress-args compressed-args compressed-count
          list-of-classes matching-class count location)
  (setq class (nth 1 (d-get-enclosing-class)))
  (d-error (and "Public Enemy / How to Kill a Radio Consultant" class))
  (with-temp-buffer
    ;;(when (get-buffer "*singleton*")
    ;;  (kill-buffer "*singleton*"))
    ;;(switch-to-buffer (generate-new-buffer "*singleton*"))
    (setq b2 (current-buffer))
    ;;(message "* rest=%s" rest)
    (setq ctor (nth 0 rest))
    (insert ctor)
    (goto-char (point-min))
    (while (re-search-forward "^\\([ \t]*\\)constructor[ \t]*(" nil t)
      (replace-match (concat "\\1constructor " class "(") 'fixedcase))
    (goto-char (point-min))
    (d-assert (flm-re-search-forward--no-comments-no-strings "(" nil t))
    (setq begy (point))
    (setq compress-args (d-compress-args (cdr rest)))
    (setq compressed-args (car compress-args))
    (setq compressed-count (cdr compress-args))
    (setq location (flm-re-search-forward--no-comments-no-strings "(" nil t))
    (forward-char -1)
    (forward-sexp)
    (setq endy (point))
    (goto-char begy)
    (setq count 0)
    (condition-case err
        (while (<= (point) endy)
          (cond
           ;; ------------------------------------------------------
           ((looking-at "[a-zA-Z0-9_]")
            (skip-chars-forward "a-zA-Z0-9_")
            ;;(message "* [a-zA-Z0-9_] (point)=%s line=(%s) count=%s"
            ;;  (point) (d-current-line-as-string) count)
            )
           ;; ------------------------------------------------------
           ((looking-at "[ \t\r\n]")
            (skip-chars-forward " \t\r\n")
            ;;(message "skip-chars-forward  \\t\\r\\n (point)=%s" (point))
            ;;(d-debug "Public Enemy / Don't Believe the Hype")
            )
           ;; ------------------------------------------------------
           ((looking-at ",")
            (incf count)
            ;;(message "* (point)=%s line=(%s) incf count=%s" (point)
            ;;  (d-current-line-as-string) count)
            (forward-char)
            ;;(d-debug "Cold Lampin' with Flavor")
            )
           ;; ------------------------------------------------------
           ((looking-at "/\\*")
            (forward-sexp))
           ;; ------------------------------------------------------
           ((looking-at "\"")
            ;;(error "* inside string")
            (forward-sexp))
           ;; ------------------------------------------------------
           ((looking-at "//")
            (forward-line)
            (beginning-of-line))
           ;; ------------------------------------------------------
```

```
225             ((looking-at "(")
226              (forward-sexp))
227             ;; ------------------------------------------------------
228             ((looking-at ")")
229              (forward-char)
230              )
231             ;; ------------------------------------------------------
232             ((looking-at "<")
233              (forward-sexp))
234             ;; ------------------------------------------------------
235             ((looking-at "{")
236              (let ((debug-on-error nil))
237                (error "{ found in arg list")))
238             ;; ------------------------------------------------------
239             (t
240              (message "Misc case (point)=%s" (point))
241              (forward-char))))
242       (error
243        (message "Error err=%s" (prin1-to-string err))))
244     (incf count) ;; NOTE: one more than the number of commas
245     (let ((debug-on-error nil))
246       (when (/= count compressed-count)
247         (d-debug "(/= count compressed-count): count=%s compressed-count=%s" count compressed-count)))
248     ;;(d-debug "Public Enemy / Raise the Roof (point)=%s" (point))
249     (setq ctor (buffer-substring-no-properties (point-min) (point-max)))
250     (setq str (concat "private " ctor
251                       "private classVar " class " private_instance;"
252                       "public function " class "getInstance()"
253                       "{"
254                       "if (private_instance != null) then"
255                       "{"
256                       "return private_instance;"
257                       "}"
258                       "else"
259                       "{"
260                       "return private_instance = new " class compressed-args ";"
261                       "}"
262                       "}"))
263     ;;(message "str=%s" str)
264     str
265     ) ;; end WITH-TEMP-BUFFER!
266   )   ;; end LET!
267 )     ;; end D-DEFMARO! singleton_design_pattern
268
269 (defun split-string-into-csv (str)
270   "Note: csv stands for Comma Separated Values"
271   (with-temp-buffer
272     ;;(when (get-buffer "*csv*")
273     ;;  (kill-buffer "*csv*"))
274                                       ;(set-buffer (generate-new-buffer "*csv*"))
275     ;;(switch-to-buffer (current-buffer))
276     (setq b3 (current-buffer))
277     ;;(switch-to-buffer b3)
278     (d-assert (stringp str))
279     (insert str)
280     (jtw-mode)
281     ;;(d-debug "Public Enemy / Public Enemy No. 1")
```

```
282       ;;(let ((debug-on-error nil))
283       ;;  (error "Prince / Forever in my life"))
284       (let ((done  nil)
285             (endy  nil)
286             (p0    (goto-char (1+ (point-min))))
287             (p1    nil)
288             (list  nil)
289             (depth 0))
290         (while (not endy)
291           (while (not done)
292             (message "* schmu depth=%s looking-at=\"%s\""
293                      depth
294                      (buffer-substring-no-properties (point) (jtw--clamp-
point (+ (point) 10))))
295             (condition-case err
296                 (cond
297                  ((looking-at "{")
298                   (condition-case err
299                       (forward-sexp)
300                     (error
301                      (forward-char)
302                      (incf depth))))
303                  ((looking-at ",")
304                   (forward-char 1)
305                   (when (= depth 0)
306                     (setq done t)))
307                  ((looking-at "<")
308                   (condition-case err
309                       (progn
310                         (forward-sexp)
311                         (cond
312                          ((save-excursion
313                             (backward-char)
314                             (looking-at ">"))
315                           ;; DOaNOTHING!
316                           )
317                          ((save-excursion
318                             (backward-char)
319                             (looking-at ")"))
320                           (decf depth)
321                           )))
322                     (error
323                      (forward-char)
324                      (incf depth))))
325                  ((looking-at "[a-zA-Z0-9_]+")
326                   (skip-chars-forward "a-zA-Z0-9_"))
327                  ((looking-at "[ \t\r\n]+")
328                   (skip-chars-forward " \t\r\n"))
329                  ((eobp)
330                   (setq done t)
331                   (setq endy t))
332                  ((and (looking-at ")") (> depth 0))
333                   (decf depth)
334                   (when (= depth 0)
335                     (setq done t)
336                     (setq endy t)
337                     ))
338                  ((looking-at "(")
339                   (condition-case err
340                       (forward-sexp)
341                     (error
342                      (forward-char)
343                      (incf depth))))
```

```
344                ((looking-at "[" )
345                 (condition-case err
346                     (forward-sexp)
347                   (error
348                    (forward-char 1)
349                    (incf depth))))
350                ((looking-at "\\]" )
351                 (forward-char)
352                 (decf depth))
353                ((looking-at "//" )
354                 (forward-sexp))
355                ((looking-at "/\\*" )
356                 (forward-sexp))
357                ((looking-at "\"" )
358                 (forward-sexp))
359                (t
360                 (forward-char)
361                 ))
362              (error
363               ;;(message "Error err=%s" (prin1-to-string err))
364               (cond
365                ((eq (car err) 'invalid-regexp)
366                 ;;(d-debug "invalid-regexp %s" (prin1-to-string err))
367                 (forward-char)
368                 (setq done t))
369                ((eq (car err) 'end-of-buffer)
370                 ;;(d-debug "end-of-buffer %s" (prin1-to-string err))
371                 (setq done t)
372                 (setq endy t))
373                ((eq (car err) 'scan-error)
374                 (let ((debug-on-error nil))
375                   (error "scan error %s" (prin1-to-string err)))
376                 (setq done t)
377                 (setq endy t))
378                (t
379                 (let ((debug-on-error nil))
380                   (error "Misc error: %s" err)))
381                ))))
382          (setq done nil)
383          (setq p1 (point))
384          (setq str (buffer-substring-no-properties p0 (1- p1)))
385          (setq p0 p1)
386          ;;(d-debug "foomatic")
387          ;;(d-assert (null list))
388          (setq list (cons str list))
389          ;;(sit-and-message 3 "list=%s" list)
390          )
391        ;;(d-debug "Prince / It's Gonna Be a beautiful night")
392        (setq list (nreverse list)))))
393
394  (defun splat-list (list)
395    ;;(setq args (eval args))
396    (let ((done   nil)
397          (i      0)
398          (result nil))
399      (while (not done)
400        (if (nth i list)
401            (setq result (cons (nth i list) result))
402          (setq done t))
403        (incf i)
404        )
405      (setq list (mapcar (function (lambda (x) `(quote ,x))) list))
406      list))
407
408  (defun fcall (func &rest args)
```

```
409     (eval `(,func ,@args))
410     )
411
412   (d-defmacro
413    foreach
414    (setq vrbl (nth 0 rest))
415    (setq list (nth 1 rest))
416    (message "vrbl=%s" vrbl)
417    (message "list=%s" list)
418    (d-assert (null (cdddr rest)))
419    ;;(d-assert (null (nth 3 rest)))
420    (concat "for(Iterator " vrbl "= " list ".getIterator(); "
421            "!" vrbl ".isDone();"
422            vrbl ".next())" )
423    )
424
425   (d-defmacro
426    null_macro
427    (message "(nth 0 rest)=%s" (nth 0 rest))
428    (concat "public property String s = " (prin1-to-string (nth 0 rest)) ";" ))
429
430   (provide 'd-defmacro)
;; END FILE:    ~/dlisp/d-defmacro.el
```

Study the following fragment of `jtw-build-java.el` (see 2.13.1) which deals with macros:

```
;; BEGIN FILE: el/d-defmacro.el
001   (progn
002     (setq ptr d-macro-list)
003     (while ptr
004       (while (re-search-forward (prin1-to-string (car ptr)) nil t)
005         (when (not (warn-inside-comment-or-string))
006           (beginning-of-line)
007           (setq p0 (point))
008           (skip-chars-forward "a-zA-Z0-9_ \t\r\n" )
009           (setq p1 (point))
010           (if (not (looking-at "(" ))
011               (let ((debug-on-error nil))
012                 (error "*** Not looking at \"(\" expression" )))
013           (forward-sexp 1)
014           (setq p2 (point))
015           (setq str (buffer-substring-no-properties p1 p2))
016           (delete-region p0 p2)
017           (setq args (split-string-into-csv str))
018           (insert (eval `(fcall (car ptr) ,@ (splat-list args))))
019           ))
020       (setq ptr (cdr ptr))))
;; END FILE:    el/d-defmacro.el
```

Here is some J.T.W. code that uses the `getter` and `setter` macros:

```
// BEGIN FILE: jtw-tutorials/Foo.jtw
001   class Foo
002   begin
003       getter (int,foo)
004       setter (int,foo)
005       getter (int,bar)
006       setter (int,bar)
007   end
// END FILE:    jtw-tutorials/Foo.jtw
```

Here is the resulting Java code:

```
// BEGIN FILE: jtw-tutorials/Foo.java
001  class Foo
002  {
003     public  int   getFoo() { return private_foo; }
004     public  void  setFoo(int foo) { private_foo = foo; }
005     private int   private_foo;
006
007     public int   getBar() { return private_bar; }
008     public void  setBar(int bar) { private_bar = bar; }
009     private int  private_bar;
010  }
// END FILE:    jtw-tutorials/Foo.java
```

Note that the properties private_foo and private_bar are automatically created when you call one of `getter` or `setter` macros. This is not the case for the Lisp++ version of the `getter` and `setter` macros.

```
001  (class X 002  private property int i; 003  private property int j; 004  singleton_design_pattern(constructor
(int i, int j, /* rest of args */)
005  { this.i = i; this.j = j; /* rest of ctor code */},100 ,200 ,/* rests of ctor parameters
*/)
006  )
```

which generates the following Java code:

```
 001  class X
002  {
003     private property int i;
004     private property int j;
005     private X(int i, int j)
006     {
007        this.i = i;
008        this.j = j;
009     }
010     private X private_instance;
011     public static X getInstance()
012     {
013        if (private_instance != null)
014        {
015           return private_instance;
016        }
017        else
018        {
019           return private_instance = new X(100 ,200 );
020        }
021     }
022  }
```

The `foreach` macro is called like so:

```
// BEGIN FILE: jtw-tutorials/IteratorTest.jtw
```

```
001
002 class Node
003 begin
004    property Object current;
005    property Node   next;
006
007    constructorNode(Object current)
008    begin
009       this.current = current;
010    end
011 end
012
013 interface Iterator
014 begin
015    public method Iterator first ();
016    public method void     next ();
017    public method boolean  isDone ();
018    public method Object   currentItem ();
019 end
020
021 class SinglyLinkedListIterator implements Iterator
022 begin
023    property Node first;
024    property Node current;
025
026    constructorSinglyLinkedListIterator(Node first)
027    begin
028       this.first   = first;
029       this.current = first;
030    end
031
032    public method SinglyLinkedListIterator first ()
033    begin
034       return new SinglyLinkedListIterator(first);
035    end
036
037    public method void next ()
038    begin
039       if (current != null) then
040       begin
041          current = current.next;
042       end
043    end
044
045    public method boolean isDone ()
046    begin
047       return current == null;
048    end
049
050    public method Object currentItem ()
051    begin
052       return current.current;
053    end
054 end
055
056 class SinglyLinkedList
057 begin
058    property Node first;
059
060    public method Iterator getIterator ()
061    begin
062       return new SinglyLinkedListIterator(first);
063    end
064
065    public method void addElement (Object o)
```

```
066     begin
067        var Node n = new Node(o);
068        n.next = first;
069        first  = n;
070     end
071  end
072
073  class IteratorTest
074  begin
075     beginMain
076        System.out.println( "Welcome to IteratorTest" );
077        var SinglyLinkedList list = new SinglyLinkedList();
078        list.addElement(123);
079        list.addElement(456);
080        list.addElement(789);
081        list.addElement( "apple" );
082        list.addElement( "banana" );
083        list.addElement( "carrot" );
084        var int i = 0;
085        foreach (n,list)
086        begin
087           System.out.println( "i=" + i + ", " + n.currentItem());
088           i++;
089        end
090        System.out.println();
091     endMain
092  end
// END FILE:     jtw-tutorials/IteratorTest.jtw
```

The above code results in the following print out:

```
Welcome to file:  IteratorTest
i=0, carrot
i=1, banana
i=2, apple
i=3, 789
i=4, 456
i=5, 123
```

2.7.2 Proof of concept #2: A superfor macro

One application of the Java preprocessor is the **superfor** macro, which is an enhanced BASIC-style **for** loop. Here is how to invoke the **superfor** macro in your `*.jtw` file:

```
// BEGIN FILE: jtw-tutorials/SuperFor.jtw
001  class SuperFor
002  begin
003     beginMain
004        System.out.println( "Welcome to SuperFor.jtw" )
005        superfor (var int i = 0 to 10)
006        begin
007           System.out.println( "i=" + i);
008        end
009     endMain
010  end
// END FILE:     jtw-tutorials/SuperFor.jtw
```

The above code results in the following printout:

```
Welcome to file:  SuperFor.jtw
i=0
```

```
i=1
i=2
i=3
i=4
i=5
i=6
i=7
i=8
i=9
i=10
```

The step size argument is optional, here is an example with an explicit step size announced:

```
// BEGIN FILE: jtw-tutorials/SuperFor2.jtw
001  class SuperFor2
002  begin
003      beginMain
004          System.out.println( "Welcome to SuperFor2.jtw" )
005          superfor (var int i = 0 to 10 step 2)
006          begin
007              System.out.println( "i=" + i);
008          end
009      endMain
010  end
// END FILE:     jtw-tutorials/SuperFor2.jtw
```

The above code results in the following printout:

```
Welcome to file:  SuperFor2.jtw
i=0
i=2
i=4
i=6
i=8
i=10
```

If the **downto** keyword is given instead of the **to** keywords then the loop will count downwards from the first given number to the second, even if a positive **step** size is given. Here is an example with a negative step size:

```
// BEGIN FILE: jtw-tutorials/SuperFor3.jtw
001  class SuperFor3
002  begin
003      beginMain
004          System.out.println( "Welcome to SuperFor3.jtw" )
005          superfor (var int i = 10 downto 0 step 2)
006          begin
007              System.out.println( "i=" + i);
008          end
009      endMain
010  end
// END FILE:     jtw-tutorials/SuperFor3.jtw
```

The above code results in the following printout:

```
Welcome to file:  SuperFor3.jtw
i=10
```

```
i=8
i=6
i=4
i=2
i=0
```

Note that the specification of the **superfor** macro doesn't need constants as the values of `start`, `stop` and `step-size`. They can be any variable or more generally any Java expression, and those expressions will be evaluated only once, should your code have side effects, i.e. changes the value of a variable in your code. In the following code, the expression `++x` has the side effect of incrementing the value of `x` before returning the value of `x`. Similarly for `fooVariable`. See the following code:

```
// BEGIN FILE: jtw-tutorials/SuperFor4.jtw
001  class SuperFor4
002  begin
003     classVar int fooVariable = 22;
004
005     function int foo ()
006     begin
007        return ++fooVariable;
008     end
009
010     function int bar ()
011     begin
012        return 2;
013     end
014
015     beginMain
016        System.out.println( "Welcome to SuperFor4.jtw" )
017        var int x = 15;
018        superfor (var int i = foo() - bar() to (2 * ++x))
019        begin
020           System.out.println( "i=" + i);
021        end
022     endMain
023  end
// END FILE:    jtw-tutorials/SuperFor4.jtw
```

The above code results in the following printout:

```
Welcome to file:  SuperFor4.jtw
i=21
i=22
i=23
i=24
i=25
i=26
i=27
i=28
i=29
i=30
i=31
i=32
```

Elisp source code for the superfor macro

The following code belongs in the file `jtw-build-java.el` which in itself is too large for inclusion in this book (2,900+ lines of code). You can find this code by visiting the following Website:

davin.50webs.com/J.T.W/tutorial-01-HelloWorld.html

and clicking on the tarball in Question 1.1. Alternatively, you can study this fragment of the file `jtw-build-java.el` which deals with the **superfor** macro.

```
;; BEGIN FILE: el/superfor.el
(let (p1 p2 str form type variable T var start stop
          step-size step-size-2 this_start this_stop this_step
          this_step_size file line p-prior beg0 end0
          (case-fold-search nil) from to step keyword-to
          keyword-step-size)
  (setq strobe nil)
  (checkpoint "2")
  (save-excursion
    (goto-char (point-min))
    (setq *superfor* 0)
    (while (re-search-forward "\\<superfor\\>" nil t)
      (checkpoint "found superfor...")
      (setq beg0 (match-beginning 0))
      (setq end0 (match-end 0))
      ;;(checkpoint "sitting for 1 seconds...")
      (font-lock-fontify-buffer)
      (when (save-excursion
              (save-match-data
                (re-search-forward "(" (point-at-eol) t)
                (forward-char -1)
                (re-search-forward "\\<var\\>" (point-at-eol) t)
                (not (warn-inside-comment-or-string))))
        ;;superfor (var int i = 0 to 10)
        ;;(error "Smelly cat")
        (setq *current-buffer* (current-buffer))
        (setq p1 beg0)
        (skip-chars-forward " \t\r\n")
        (when (not
               (save-match-data
                 (looking-at "{")))
          ;; EVAL HERE! vvv

          (setq p2 ;; EVAL HERE! nnn
                (save-excursion
                  (forward-sexp 1)
                  (point)))
          (setq str (buffer-substring-no-properties end0 p2))
          (checkpoint "str=%s" str)
          (setq form (read-str str))
          (checkpoint "form=%s" form)
          ;;(d-debug "form")
          ;;(d-assert (consp form))
          (message "*** form=%s" form)
          ;;(setq debug-on-error nil)
          ;;(error "The Rolling Stones / Rolling Stones plays Cuba")
          (message "(deleted-region=%s)" (buffer-substring-no-properties p1 p2))
          (delete-region p1 p2)
          (incf *superfor*)
          (setq this (format "superfor_%d_" *superfor*))
          (when (not (eq (nth 0 form) 'var))
            (warn-log-
message "Error 35: Keyword var missing from superfor construct")
            )
          (when (eq (nth 0 form) 'var)
            (if (and (not (eq (nth 1 form) 'char))
                     (not (eq (nth 1 form) 'short))
```

```
056                     (not (eq (nth 1 form) 'int))
057                     (not (eq (nth 1 form) 'long))
058                     (not (eq (nth 1 form) 'float))
059                     (not (eq (nth 1 form) 'double)))
060                 (warn-log-message (concat
061                                    "Error 37:#2 argument type to superfor macro must be"
062                                    " one of char/short/int/long/float/double" )))
063             ;; (setq form '(var int i=0 to stop))
064             ;; (setq form '(var int i =0 to stop))
065             ;; (setq form '(var int i = 0 to stop))
066             (progn
067               (setq form-str (aref (eval `(d-prin1-to-string-java ,form sexy)) 0))
068               (when (string-match "^var[ \t]*" form-str)
069                 (setq form-str (substring form-str (match-end 0))))
070               (when (string-match "^\\(char\\|short\\|int\\|long\\|float\\|double\\)\\>" form-str)
071                 (setq T                    (substring form-str (match-beginning 0) (match-end 0)))
072                 (setq form-str (d-trim-string (substring form-str (match-end 0))))
073                 (when (string-match "[^<>]=" form-str)
074                   (setq var (substring form-str 0 (1+ (match-beginning 0))))
075                   (setq form-str (substring form-str (1+ (length var))))
076                   ))
077               (cond
078                ((string-match "\\<to\\>" form-str)
079                 (message "found to" )
080                 (setq keyword-to 'to)
081                 (setq start      (d-trim-
string (substring form-str 0 (match-beginning 0))))
082                 (setq form-str   (d-trim-
string (substring form-str (match-end 0))))
083                 )
084                ((string-match "\\<downto\\>" form-str)
085                 (message "found downto" )
086                 (setq keyword-to 'downto)
087                 (setq start    (d-trim-
string (substring form-str 0 (match-beginning 0))))
088                 (setq form-str (d-trim-string (substring form-str (match-end 0))))
089                 )
090                ) ;; ENDaCOND!
091               )
092             ;;(d-debug "Duran Duran / Girls on Film")
093             ;;(setq form '(var int i = 0 to 10 step 2))
094             (progn
095               (if (string-match "\\<step\\>" form-str)
096                   (progn
097                     (setq keyword-step-size t)
098                     (setq stop (d-trim-
string (substring form-str 0 (match-beginning 0))))
099                     (setq step (d-trim-string (substring form-str (match-end 0))))
100                     )
101                 (setq keyword-step-size nil)
102                 (setq stop (d-trim-string form-str))
103                 (setq step nil)
104                 )
105               ;;(setq start form)
106               ;;(when (string-match "=" start)
107               ;;  (setq start (substring start (match-end 0))))
108               ;;(when (string-match "\\<to\\>" start)
109               ;;  (setq start (d-trim-string (substring start 0 (match-beginning 0)))))
110               ;;(setq rest1 (eval `(d-prin1-to-string-java , form step)))
111               ;;(setq stop (aref rest1 0))
112               ;;(when (string-match "\\<to\\>" stop)
113               ;;  (setq stop (d-trim-string (substring stop (match-end 0)))))
114               ;;(setq keyword-step (car (aref rest1 1)))
```

```
115                ;;(when keyword-step
116                ;;  (setq step (aref rest1 1))
117                ;;  (when (eq keyword-step 'step)
118                ;;    (setq step (cadr (aref rest1 1)))
119                ;;    (if step (setq keyword-step-size 'step))))
120                )            ;; ENDaPROGN!
121              ;;(d-debug "Art Blakey / Lou's Blues")
122              (progn ;; (warn--cull-quotes)
123                ;;(setq var         eq)
124                (setq start-2     (warn-splat-quest start))
125                (setq stop-2      (warn-splat-quest stop ))
126                (setq step-size-2 (warn-splat-quest step ))
127                ) ;; ENDaPROGN!
128              ;; ---------------------------------------------
129              ;;(d-debug "The Pretenders / Precious")
130              (setq this_start     (concat this "start" ))
131              (setq this_stop      (concat this "stop" ))
132              (setq this_step      (concat this "step" ))
133              (setq this_step_size (concat this "step_size" ))
134              ;;(d-debug "Dire Straits / My Parties")
135              (insert (concat (concat "var " T " " this_start " = " start-2 ";a" )
136                              (concat "var" T "a" this_stop  " = " stop-2  ";a" )
137                              (if keyword-step-size
138                                  (concat "var" T "a" this_step "= " step-size-2 "; "
139                                          "var" T "a" this_step_size "= "
140                                          (cond
141                                           ((eq keyword-to 'to)
142                                            (concat "Math.abs(" this_step ")" ))
143                                           ((eq keyword-to 'downto)
144                                            (concat "-Math.abs(" this_step ")" ))
145                                           (t
146                                            (d-debug "Dire Straits / Heavy Fuel" )))
147                                          ";\n"
148                                          )
149                                (concat "var" T "a" this_step_size "=a"
150                                        (cond
151                                         ((eq keyword-to 'to)
152                                          "1" )
153                                         ((eq keyword-to 'downto)
154                                          "-1" )
155                                         (t
156                                          (d-debug "Dire Straits / Ticket to Heaven" )))
157                                        ";\n"
158                                        ) ;; ENDaCONCAT!
159                                )         ;; ENDaif!
160                              )           ;; ENDaCONCAT!
161                      )                   ;; ENDaINSERT!
162              )                           ;; ENDaPROGN!
163            ;;(d-debug "Rod Stewart / Hot Legs")
164            (setq line 0)
165            (setq p-prior
166                  (save-excursion
167                    (beginning-of-line)
168                    (setq str (concat "^[ \t]*//+a" *pp-
namespace* "#location[0-9]"
169                                      "a(\\(" *drive-
spec* "[-a-zA-Z0-9_./]+\\):\\([0-9]+\\))" ))
```

```
170                     (if (or (looking-at str) (re-search-backward str nil t))
171                         (progn
172                           ;;(d-debug "Antonio Vivaldi")
173                           (setq file (buffer-substring-no-properties          (match-beginning 1)
174                                                                              (match-end 1)))
175                           (d-assert (stringp file))
176                           (setq line (read-str (buffer-substring-no-properties (match-beginning 3)
177                                                                              (match-end 3))))
178                           (d-assert (integerp line))
179                           (point)
180                           )
181                       (setq file (concat *def-dir* *stump* ".jtw" ))
182                       (setq line 1)
183                       (goto-char (point-min))
184                       (forward-line 2)
185                       (point)
186                       )))
187             (setq line (+ line (count-lines p-prior (point))))
188             (decf line)
189             (decf line)
190             (insert (format "// %s '%s\n"                    *list-
namespace* (prin1-to-string file-stack)))
191             (insert (format "// %s#location3 (%s:%d)\n"      *pp-
namespace*   file line))
192             (insert (concat "for (var " T " " var "=" this_start ";"
193                             "((" this_step_size "> 0) ?" var "<= "
194                             this_stop ":" var ">=" this_stop ");"
195                             var " += " this_step_size ")" ))
196             (if strobe (d-debug "Pretenders / The Wait" ))
197             ;;(d-debug "Yehudi Menuhin")
198             ) ;; ENDaWHEN!
199           )   ;; ENDaWHEN!
200         )     ;; ENDaWHILE!
201       )       ;; ENDaSAVE-EXCURSION!
202     )         ;; ENDaLET!
203
204
205
;; END FILE:    el/superfor.el
```

A bug in J.T.W. superfor

The question mark **operator** `a ? b : c` which expands to

```
001  type result;
002  if (a) then
003  begin
004     result = b;
005  end
006  else
007  begin
008     result = c;
009  end
```

where `type` can be any Java type directly supported by the arguments to the **superfor** macro in J.T.W., namely char, short, int, long, float and double. Elsewhere the question mark is supported. Instead in the **superfor** macro you have to write the following code to get a question mark **operator** online:

```
// BEGIN FILE: jtw-tutorials/SuperFor5.jtw
001  class SuperFor5
002  begin
003     beginMain
004        System.out.println( "Welcome to SuperFor5.jtw" );
005        foo(1,2);
006     endMain
007     function void foo (int x, int y)
008     begin
009        superfor (var int i=0 to (x < y) QUEST 10 : 20))
010        begin
011           System.out.println( "i=" + i);
012        end
013        System.out.println();
014     end
015  end
016
// END FILE:    jtw-tutorials/SuperFor5.jtw
```

where the symbol QUIST compiles into a question mark: `?` When built, the program prints out the following:

```
Welcome to file:  SuperFor5.jtw
i=0
i=1
i=2
i=3
i=4
i=5
i=6
i=7
i=8
i=9
i=10
```

2.7.3 Proof of concept #3: File inclusion

When your classes become large and unwieldy, it becomes useful to split a source file into several compilation units. The most natural division into compilation units is at the level of **method**s. With each method in a separate file you can manage **method**s that are excessively large. Here is how to use file inclusion in the J.T.W. language. First comes the `*.jtw` file with all bodies of **method**s harvested from them:

```
001  class Foo
002  begin
003     include "apple.method"
004     include "banana.method"
005     include "carrot.method"
006  end
```

Here are the files that get included. The first file is `apple.method`:

```
001  property int prop; /* property for use with apple method */
002
003  method void apple(/* parameters */)
004  begin
```

```
005     prop = prop + 1;
006     /* rest of body of apple method */
007  end
```

The second file is `banana.method`:

```
001  method void banana (/* parameters */)
002  begin
003     /* body of banana method */
004  end
```

The third file is `carrot.method`:

```
001  method void carrot (/* parameters */)
002  begin
003     /* body of carrot method */
004  end
```

When all of the file inclusions have been carried out by the J.T.W. to Java compiler, the code that `javac` sees will be something like this:

```
001  /** Automatically generated file. Do not edit! */
002  // #foomatic #location (Foo.jtw:1)
003  class Foo
004  {
005     // #foomatic #location (apple.method:1)
006     int prop;
007
008     void apple (/* parameters */)
009     {
010        prop = prop + 1;
011        /* rest of body of apple method */
012     }
013     // #foomatic #location (banana.method:1)
014     void banana (/* parameters */)
015     {
016        /* body of banana method */
017     }
018     // #foomatic #location (carrot.method:1)
019     void carrot (/* parameters */)
020     {
021        /* body of carrot method */
022     }
023     // #foomatic #location (Foo.jtw:6)
024  }
```

Note the use of the value `#foomatic` of the string `*pp-namespace*` (where *pp* stands for pre-processor) that is a long arbitrarily defined string to prevent accidental aliasing with the rest of the commented code that the user of the system might write. The `#location` directives are used to keep track of the original line number in the source file. Using Emacs batch mode executing the Elisp code: `jtw-build-java.el` (see 2.13.1), error messages in `Foo.java` now point back to the

original `Foo.jtw` file, or one of the files that get **#include**d like so: `apple.method`, `banana.method` or `carrot.method`.

NOTE: Version 1.0 of J.T.W. used the C Pre-Processor (C.P.P.) to manage the `#location` directives but unfortunately C.P.P. destroys comments in the target file, and Java uses `/** ... */` comments to document the program's behaviour so C.P.P. cannot be used.

2.8 Java/J.T.W./C++ coding preferences

Many a religious war has been fought over coding preferences, how code should be named and indented. I started programming when I was 5 years old in 1978 so over my years as a computer programmer I have gravitated to the following coding preferences. Here I present them to you now, and I also explain their rationale so that their use is not mindlessly following my own religious ideas but rather practical conventions for improving the readability of program code. The recommended preferences for indenting J.T.W. code is as follows:

```
001 begin
002    /* code goes here */
003    begin
004       /* code goes here */
005       begin
006          /* code goes here */
007       end
008       /* code goes here */
009    end
010    /* code goes here */
011 end
```

In Emacs you can get the above indentation online by putting the following command in your `~/.emacs` file, where ~ is an abbreviation for the contents of your `HOME` environment variable.

```
(setq c-basic-offset 3)
```

instead of:

```
begin begin /* code goes here */ end begin /* code goes here */ end end
```

or similar coding styles. The rationale for placing ends in equal alignment with begins is so that even on long lines, the **begin** and **end** symbol are not truncated away from view, unless you are not looking at column zero, which is a rare event, or you have a pathologically deep level of nesting of your squigglies (curly braces) i.e. more than screen width divided by tab width = 80 / 3 = 26 on my system. Note that in Emacs, `screen-width` is a **function** and `tab-width` is a variable so you can calculate this value in your version of Emacs by evaluating the following code:

```
(/ (screen-width) tab-width).
```

In Emacs activate **Control-x Control-e** at the end of the above Lisp form to execute that code. The only place where this falls down is where you have excessively long lines which are ugly no matter how your editor chooses to display them. In Emacs the variable `truncate-lines` can either be set to `t` in which long lines keep the screen scrolling to the right hand side of the screen. When `nil` the lines wrap around inside the visible window of the screen. Both approaches look ugly in my opinion. Luckily the programmer is able to reformat their code so that excessively long lines do not occur. This coding preference for J.T.W. code translates into the following preference for Java and C/C++ code:

```
001 {
002    /* code goes here */
003    {
004       /* code goes here */
005       {
006          /* code goes here */
007       }
008       /* code goes here */
009    }
010    /* code goes here */
011 }
```

The much maligned *Hungarian Notation* is recommended so that syntax highlighting can be applied to keywords. The term "Hungarian Notation" comes from the fact that under the worst instances of Hungarian notation such as `m_piMax` your code looks as indecipherable as the Hungarian language is to Westerners. In Hungarian notation, **private property**s and **method**s should be named with a preceding underscore like so: `_foo` or something similar like `private_foo`. The famous book *Design Patterns* by [GRHV95] uses an underscore at the beginning of a word to indicate that that variable is **private**. The following Elisp code can allow **private property**s to be highlighted in a different color from the rest of your code:

```
;; BEGIN FILE: ~/dlisp/d-flock-private.el;; END FILE:     ~/dlisp/d-flock-private.el
```

Simply place this code into your file `.emacs` in your `HOME` directory and run Emacs to activate this syntax highlighting feature. If such a file does not exist, it will be necessary to create one.
Java and J.T.W. conventionally name **variable**s in "caMeL" case, i.e. component words concatenated together and using uppercase letters to delimit the sub-words of a given expression. Examples are like so: `setFoo()` and `getFoo()`. In C and C++ symbols are conventionally named with underscores like so: `set_foo()` and `get_foo()`. If you follow these conventions, your code will be easier to read by the large number of other programmers who follow these conventions.

2.9 Parenthesis and squigglies { ... } instead of begin ... end

It is sometimes said that Lisp stands for *Lots of Irritating Superfluous Parentheses*. But in reality Lisp is for the expert coder who prefers their programming to be deeply nested. In the same vein, going from BASIC to Java involves getting used to squigglies { ... } all over the place. The Basic coder will soon find that { ... } operators are a useful tool for managing the complexity of a program. While learning a program language for the first time however, the programmer will like as much help as the compiler can give you, which includes supporting the **begin** and **end** constructs.

2.10 Troubleshooting J.T.W. code

The Elisp file `jtw-build-java.el` (see 2.13.1) contains code for GNU Emacs to parse and troubleshoot problematic J.T.W. code. The following errors produce a diagnostic:

- Error 1: **method** needs a return type.
- Error 2: **function** needs a return type.
- Error 3: **constructor**s need the correct **class** name.

- Errors 5-13: Cannot have more than one of **property**, **classVar**, **function**, **method** or **constructor** on the same line.
- Error 14: This line needs one of the following keywords: **function**, **method**, **classVar**, **property** or **constructor**.
- Error 15: Functions cannot reside inside **function**s/**method**s/**constructor**s.
- Error 16: Function must have **begin** on the following line.
- Error 17: Constructors cannot reside inside **function**s/**method**s/**constructor**s.
- Error 18: **constructor** must have **begin** on the following line.
- Error 19: Methods cannot reside inside **function**s/**method**s/**constructor**s.
- Error 20: Method must have **begin** on the following line.
- Error 21: Property must not have **begin** on the following line.
- Error 22: Class variable must not have **begin** on the following line.
- Error 23: Expecting (after **if** statement.
- Error 24: Unbalanced parentheses after **if** statement.
- Error 25: Expecting **then** keyword after **if** statement.
- Error 26: More **end**s than **begin**s.
- Error 27: Missing **end**s at the end of the file.
- Error 28: Spurious semicolon at the end of the line.
- Error 29: Cannot call a **method** without an object from the **main** **function**.
- Error 30: Cannot call a **method** with a **class** name prefix from the **main** **function**.
- Error 31: Cannot call a **method** without an object from a **function**.
- Error 32: Cannot call a **method** with a **class** name prefix from a **function**.
- Error 33: Cannot call a **method** without an object from a **method**.
- Error 34: Cannot call a **method** without an object from a **constructor**.
- Error 35: Keyword **var** missing.
- Error 36: Keyword **var** does not belong here.
- Error 37: argument type to **superfor** macro must be one of char/short/int/long/float/double.
- Error 38: **function** outside of a **class**.
- Error 39: **method** outside of a **class**.
- Error 40: **property** outside of a **class**.
- Error 41: Class variable outside of a **class**.
- Error 42: Cannot have a **function** inside an **interface**.
- Error 44: Class `X` has no **function** named `foo`.

- Error 45: Class `X` has no **classVar** named `foo`.
- Error 46: Function `Foo.bar()` not found.
- Error 47: ClassVar `Foo.classVar` not found.
- Error 48: Infinite loop in include directives.
- Error 49: **class** `X` has multiple instances.

2.11 Mapping from J.T.W. to Java

The J.T.W. language maps to the Java language in a natural and straightforward way, making it easy to learn Java, once you know the J.T.W.language. Here is the actual mapping of keywords from J.T.W. to Java:

```
function    → static
var         → nothing
classVar    → static
property    → nothing
method      → nothing
constructor → nothing
begin       → {
end         → }
beginMain   → public static void main(String args) {
endMain     → }
and         → &&
or          → ||
then        → nothing
elseif      → else if
```

2.11.1 Choosing a preprocessor language for J.T.W.

Note that these J.T.W. keywords on the left hand side of the above diagram should not map to their Java equivalents inside strings and comments. The transformation was originally written to use the m4 language to map J.T.W. onto Java but this approach had the disadvantage that keywords like **begin** and **end** inside strings were mapped to their Java equivalents like so:

```
001 System.out.println( "function" ); → System.out.println( "static" );
002 System.out.println( "var" ); → System.out.println( "" );
003 System.out.println( "classVar" ); → System.out.println( "static" );
004 System.out.println( "property" ); → System.out.println( "" );
005 System.out.println( "method" ); → System.out.println( "" );
006 System.out.println( "constructor" ); → System.out.println( "" );
007 System.out.println( "begin" ); → System.out.println( "{" );
008 System.out.println( "end" ); → System.out.println( "}" );
009 System.out.println( "beginMain" ); → System.out.println( "public static void main(String[] args) {" );
010 System.out.println( "endMain" ); → System.out.println( "}" );
011 System.out.println( "and" ); → System.out.println( "&&" );
012 System.out.println( "or" ); → System.out.println( "||" );
013 System.out.println( "then" ); → System.out.println( "" );
014 System.out.println( "elseif" ); → System.out.println( "else if" );
```

which is of course the wrong behaviour. A hack to get around this limitation is to break apart the J.T.W. keywords like so:

```
System.out.println( "be" + "gin" );
```

This problem can be fixed for good either by using *Flex* to compile J.T.W. into Java or to use Emacs to do the same thing, only a little slower than what Flex can do. In the end I chose GNU Emacs as the host for the preprocessor language J.T.W. because it is free software and is adequate for my programming needs and is more powerful than Flex or m4. To remedy this deficiency Emacs' batch mode is used to do the transformation from J.T.W. to Java. This implies that GNU Emacs must be present on the client's system to do the J.T.W. to Java mapping. Of course, there is no compulsion to use Emacs as an editor, although there are a couple of advantages in doing this. Number one is that J.T.W. keywords, comments and strings have **syntax highlighting**. And number two is that Emacs can do correct automatic indentation of J.T.W. code.

2.11.2 Piping the output of `javac` and `java`

Output from the executables `javac` and `java` have their standard output stream and error stream piped into Emacs' batch mode so that error messages like `Foo.java:123` point back to the correct file even if file inclusion (see §2.7.3) has been used. The programs `grep` and `sed` are also used as pipes in the transformation process so they must be present on the client's system.

2.11.3 The *GNU Makefile* for building *.java files and `*.class` files

Here is the `Makefile` that is used to build ***.java** files from `*.jtw` files and `*.class` files from ***.java** files and finally executing `*.class` files:

```
.PRECIOUS:
.PRECIOUS: %.java %.class

JAVAC_FLAGS = -source 1.5 -Xlint:unchecked -Xlint:deprecation -Xlint:-options
JAVA_FLAGS = -enableassertions
SHELL = /bin/bash
PREFIX = /usr/
TELEPHONE = telephone-1800-NEW-FUNK

build-class-db:
        @echo "* Stage 0 :  Building class database"
        emacs --batch --eval "(setq dir \"$(PREFIX)/share/emacs/site-lisp/dlisp/\")" \
--load $(PREFIX)/share/emacs/site-lisp/dlisp/jtw-build-class-db.el --funcall doit

%.java : %.jtw
        @echo "* Stage 1 :  Debugging $*.jtw and building $*.java file" \
        emacs --batch --eval "(setq *stump* \"$*\")" \
--load $(PREFIX)/share/emacs/site-lisp/dlisp/jtw-build-java.el \
--funcall doit

%.class: %.java
        @echo "* Stage 2 :  Debugging *.java file(s) and building *.class file(s)"
        javac $(JAVAC_FLAGS) $$(find .  -name "*.java" ) |& emacs --batch \
--load $(PREFIX)/share/emacs/site-lisp/dlisp/jtw-javac.el --funcall doit |& \
grep "#$(TELEPHONE) input[0-9]:" - |& sed -e "s/\#$(TELEPHONE) input[0-9]://g" -

%.run: %.class
        @echo "* Stage 3 :  Running $*.class file"
        java $(JAVA_FLAGS) $* |& emacs --batch \
--load $(PREFIX)/share/emacs/site-lisp/dlisp/jtw-java.el --funcall doit \
|& grep "#$(TELEPHONE) input[0-9]*:" - |& sed -e "s/\#$(TELEPHONE) input[0-9]*://g" -

clean: build-class-db
```

```
        rm -fv $$(find .  -name "*.java" )
        rm -fv $$(find .  -name "*.class" )

build: clean
```

The first line **.PRECIOUS** without any arguments clears the list of precious files, the list of files not to delete during the build process.

2.12 Elisp code for editing `*.jtw` files

This following Elisp file `$(PREFIX)/share/emacs/site-lisp/dlisp/jtw-mode.el` gives you syntax **highlighting** of J.T.W. constructs and correct indentation of J.T.W. code.

```
;; BEGIN FILE: ~/dlisp/d-make-face.book.el
001  ;; (d-make-face 'red-face (setq bgcolor bg-colour) "red" :bold)
002  (defmacro d-make-face (font bgcolor fgcolor &rest rest)
003    ;;(d-debug "Queen / Another one bites the dust")
004    (d-assert (symbolp 'font))
005    (d-assert (if (boundp 'font)
006                  (symbolp 'font)
007                t))
008    ;;(d-debug "Calamansi")
009    (let (p was-error
010          bold unbold
011          italic unitalic
012          underline ununderline)
013      ;;(d-debug "The Shape of Jazz to Come / Chronology")
014      ;;(d-debug "Queen / Fat Bottomed Girls")
015      (setq bgcolor (eval bgcolor))
016      (setq fgcolor (eval fgcolor))
017      ;;(message "bgcolor=%s fgcolor=%s" bgcolor fgcolor)
018      ;;(progn (setq bgcolor "#ffffff") (setq fgcolor "#000") (setq font 'fg:white))
019      (setq p `(progn
020                 (if (not (eq 'font 'default))
021                     (kill-local-variable (quote , font)))
022                 (setq , font (quote , font))
023                 (make-face (quote , font))
024                 (set-face-background (quote , font) , bgcolor)
025                 (set-face-foreground (quote , font) , fgcolor)))
026      (setq ptr rest)
027      ;;(d-debug "The Shape of Jazz to Come / Congeniality")
028      (while ptr
029        (cond
030         ((or (null    (car ptr))
031              (stringp (car ptr)))
032          )
033         ;; ------------------------------------------------------------
034         ((or (eq (car ptr) :bold) (eq (car ptr) :unbold))
035          (if (eq (car ptr) :bold)
036              (setq bold t))
037          (if (eq (car ptr) :unbold)
038              (setq unbold t))
039          (when (and bold unbold)
040            (setq was-error (concat
041                             was-error
042                             "Both symbols should not be defined: :bold and :unbold," )))
043          (if bold
044              (setq p `(progn
045                         , p
046                           (make-face-bold (quote , font)))))
047          (if unbold
048              (setq p `(progn
```

```
049                         , p
050                           (make-face-unbold (quote , font))))
051           ))
052         ;; ------------------------------------------------------------
053         ((or (eq (car ptr) :italic) (eq (car ptr) :unitalic))
054          (if (eq (car ptr) :italic)
055              (setq italic t))
056          (if (eq (car ptr) :unitalic)
057              (setq unitalic t))
058          (when (and italic unitalic)
059            (setq was-error (concat
060                             was-error
061                             "Both symbols should not be defined: :italic and :unitalic," )))
062          (if italic
063              (setq p `(progn
064                         , p
065                           (make-face-italic (quote , font)))))
066          (if unitalic
067              (setq p `(progn
068                         , p
069                           (make-face-unitalic (quote , font))))
070            ))
071         ;; ------------------------------------------------------------
072         ((or (eq (car ptr) :underline) (eq (car ptr) :ununderline))
073          (when (eq (car ptr) :underline)
074            (setq u-or-uu   t)
075            (setq underline t))
076          (when (eq (car ptr) :ununderline)
077            (setq u-or-uu nil)
078            (setq ununderline t))
079          (when (and underline ununderline)
080            (setq was-error (concat
081                             was-error
082                             "Both symbols should not be defined: :underline and :ununderline," )))
083          (setq p `(progn
084                     , p
085                       (set-face-underline (quote , font) u-or-uu))))
086         ;; ------------------------------------------------------------
087         (t ;; (setq was-error "Schmu")
088          ;;(d-debug "Calamansi")
089          (if (not (car ptr))
090              (debug))
091          (setq was-error (format "%s, FOO! unrecognised symbol: %s"
092                                  was-error
093                                  (car ptr)))
094          (error (format "%s Unrecognised keyword %s" was-error (car ptr))))
095         )
096        (setq ptr (cdr ptr))) ;; end WHILE! ptr
097      ;; ------------------------------------------------------------
098      (if was-error
099          (d-error (concat was-error " in macro d-make-face." ))
100        )
101      p)
102    )
103  ;; (d-amiga-color (setq rgb-components "#fff"))
104  (defun d-amiga-color (rgb-components)
105    "Allows for entry into the Amiga colour-space with 12 bits of
106    colour for a total of 4096 different colours."
107    (cond
108     ((= (length rgb-components) 7)
109      rgb-components)
110     ((= (length rgb-components) 4)
111      (let (r g b)
112        (setq r (substring rgb-components 1 2))
113        (setq g (substring rgb-components 2 3))
114        (setq b (substring rgb-components 3 4))
```

```
115       (setq rgb-components (concat "#" r r g g b b))
116       ))))
117
118  (defun d-font-lock-add-begin (keywords)
119    (if (fboundp 'font-lock-add-keywords)
120        (font-lock-add-keywords nil keywords nil)
121      (setq font-lock-keywords
122            (append
123             keywords
124             font-lock-keywords))))
125
126  (defun d-font-lock-add-end (keywords)
127    (if (fboundp 'font-lock-add-keywords)
128        (font-lock-add-keywords nil keywords 'end)
129      (setq font-lock-keywords
130            (append
131             font-lock-keywords
132             keywords))))
133
134  (progn
135    (kill-local-variable 'nil)
136    (kill-local-variable 'prefs-bg-black-p)
137    (kill-local-variable 'bg-colour-inverted)
138    (setq bg-colour       "#000" )
139    (setq prefs-bg-black-p   t)
140    (safe-require 'rgb-inverted)
141    (setq bg-colour-inverted (rgb-inverted bg-colour))
142    )
143
144  ;; ordinary comment
145  ;;; super comment
146    ;;(d-beeps "Inside d-make-face-1")
147  (d-make-face font-lock-comment-face ;; TRUCKaME!
148               nil
149               (if prefs-bg-black-p "#88ff88"  "#070" )
150               :italic)
151  (d-make-face bold nil bg-colour-inverted :bold)
152  (d-make-face d-face-el-d-stuff-2
153               nil
154               (if prefs-bg-black-p
155                   "#fff"  "#88c" )
156               :bold)
157  (d-make-face font-lock-keyword-face
158               nil
159               (if prefs-bg-black-p "#fff"  "#000" )
160               :bold)
161  (d-make-face d-face-super-comment
162               nil
163               (if prefs-bg-black-p "#e44"  "#f00" )
164               :italic :bold)
165      ;;; adksajdjk
166    (d-make-face font-lock-constant-face nil "#f00"  :bold)
167
168  ;;(if abc)
169  ;;      apple is in the comment face
170  "I am in string face..."
171  "aaaaaapple aaaaa"
172  (d-make-face font-lock-type-face nil "#88f"  :bold)
173  (d-make-face font-lock-variable-name-face
174               nil
175               (if prefs-bg-black-p "#f8f"  "#8800ff" )
176               :unbold
177               :unitalic)
178  (d-make-face font-lock-function-name-face
```

```
179              (if prefs-bg-black-p
180                   "#000000"  "#ffff00" )
181              (if prefs-bg-black-p
182                   "#ffff00"  "#000000" )
183              :bold)
184 (d-make-face font-lock-doc-face nil  "#ff0000"  :bold :italic)
185 ;;(message "*** d-make-face-1 font-lock-doc-face bg-colour=%s" bg-colour)
186 (d-make-face dd-face nil  "#00f" )
187
188 (progn
189   (d-make-face dired-marked   "#9999ff"  "#ffffff" )
190   (d-make-face dired-flagged  "#ff9999"  "#ffffff" )
191   )
192
193 (progn
194   (d-make-face d-face-cc-digits nil  "#f0f"  :bold)
195   (d-make-face d-face-defmacro nil  "#f80"   :bold)
196   )
197
198 (progn
199   (d-make-face redb-face nil  "#f00"  :bold)
200   (d-make-face grnb-face nil  "#0c0"  :bold)
201   (d-make-face blub-face nil  "#00f"  :bold)
202   )
203 (progn
204   (d-make-face red-face nil  "#f00"  :bold)
205   (d-make-face grn-face nil  "#0c0"  :bold)
206   (d-make-face blu-face nil  "#66f"  :bold)
207   )
208 (d-make-face font-lock-string-face
209              (if prefs-bg-black-p  "#88f"  (d-amiga-color  "#ddf" ))
210              (if prefs-bg-black-p  "#fff"  "#000" )
211              )
212 "a I am a string in font-lock-string-face...a"
213 (d-make-face d-face-el-d-stuff    nil (if prefs-bg-black-p  "#66f"  "#00f" ) :bold)
214 (d-make-face d-face-el-quote      nil (if prefs-bg-black-p  "#8f8"  "#0a0" ) :bold)
215 (d-make-face bg:yellow
216              (if prefs-bg-black-p nil  "#ffff00" )
217              (if prefs-bg-black-p  "#ffff00"  "#000" )
218              :bold)
219 (d-make-face d-face-path       nil  "#0c0" )
220 (d-make-face d-face-makefile-space  "#f0f"  "#fff" )
221 (d-make-face d-face-cc-global nil (if prefs-bg-black-p  "#0c0"  "#0c0" ) :bold)
222 (d-make-face fg:lightgreen nil  "#080" )
223 (d-make-face d-face-cc-debugging  "#f0f"  "white" )
224 (d-make-face fg:white bg-colour-lighter bg-colour-inverted :bold)
225 (d-make-face d-face-path nil  "#080" )
226 (d-make-face d-face-cc-digits nil  "#f0f" )
227 (d-make-face d-face-property nil  "#f80" )
228 (d-make-face d-face-property-inverse  "#f80"  nil)
229 (d-make-face d-face-m4  "#f44"  "#fff" )
230 (d-make-face d-face-makefile-space nil  "#f00" )
231 (d-make-face bg:yellow nil (d-amiga-color  "#ff0" ))
232 (d-make-face bg:lightmagenta  "#f0f"  "white"  :bold)
233 (d-make-face bg:lightred      "#f00"  "white"  :bold)
```

```
234 (d-make-face bg:lightgreen    "#0f0" "white"  :bold)
235 (d-make-face bg:lightblue     "#00f" "lightblue" :bold)
236 ;;(d-make-face fg:white "white" "black" :bold)
237 (d-make-face fg:red nil "#f00" :bold)
238 ;;(d-make-face fg:red nil (rgb-invert nil) :bold)
239 (d-make-face d-face-m5 "#080" "#fff" :bold)
240 (d-make-face d-face-cc-debug "#080" "#fff" :bold)
241 (d-make-face blu-face nil "#00f" :bold)
242 (d-make-face lisp++-face-keywords nil "#00f" :bold)
243 (d-make-face d-debug-face      nil "#f0f" :bold)
244 (d-make_face d-checkpoint-face nil "#404" :bold)
245 (d-make-face lisp++-face-illegal-type "#0ff" "#f0f" :bold)
;; END FILE:    ~/dlisp/d-make-face.book.el

;; BEGIN FILE: ~/dlisp/jtw-mode.el
001
002 ;;; jtw-mode.el — A new major mode for editing *.jtw files
003
004 ;; Copyright (C) 2016 Davin Pearson
005
006 ;; Maintainer: Davin Max Pearson <http://davin.50webs.com>
007 ;; Keywords: Java Training Wheels major mode
008 ;; Version: 2.0
009
010 ;;; Commentary:
011
012 ;; This program is part of GNU Java Training Wheels.
013
014 ;;; m4_limitation_of_warranty
015
016 ;;; Code:
017
018 (message "Welcome to file: jtw-mode.el")
019
020 (require 'cl)
021
022 (setq *prefix* default-directory)
023
024 (when (not (fboundp 'd-emergency-set-load-path))
025   (defun d-emergency-set-load-path ()
026     (d-assert (boundp '*prefix*))
027     (d-assert *prefix*)
028     (setq load-path (cons (expand-file-name (concat *prefix* "/../dlisp/"))
029                           load-path))
030     (message "** jtw-mode.el (car load-path)=%s" (car load-path))))
031
032 (d-emergency-set-load-path)
033
034 (require 'early-bindings)
035
036 (defvar jtw-mode-syntax-table)
037
038 (defvar jtw-mode-map (make-keymap))
039
040 (setq auto-mode-alist (cons '("\\.jtw$" . jtw-mode) auto-mode-alist))
041
042 (add-hook 'font-lock-mode-hook 'd-jtw-font-lock-mode-hook-post 'APPEND)
043
044 (defun cull-from-list (cull-me list)
045   (let (ptr)
046     (setq ptr list)
047     (while ptr
```

```
048       (when (equal cull-me (car ptr))
049         (setq list (cdr ptr))
050         (setq ptr  nil)
051         )
052       (setq ptr (cdr ptr)))
053     list))
054
055 (defun d-jtw-font-lock-mode-hook-post ()
056   (if (eq major-mode 'jtw-mode)
057       (d-font-lock-add-end
058        '(
059          ( "^[ \t]*\\(//.*$\\)" 1 'font-lock-comment-face t)))))
060
061 (defvar *elaborate-jtw* t
062   "Whether or not to turn on buggy java-mode syntax highlighting" )
063
064 (defun jtw-mode ()
065   (interactive)
066   ;;(html-mode)
067   ;;(if *elaborate-jtw*
068   (java-mode)
069   (setq major-mode 'jtw-mode)
070   (setq mode-name "JTW" )
071   (set (make-local-variable 'jtw-mode-syntax-table)
072        (copy-syntax-table java-mode-syntax-table))
073   (set-syntax-table jtw-mode-syntax-table)
074   (progn
075     (modify-syntax-entry ?_ "w" )
076     (modify-syntax-entry ?< "(>" )
077     (modify-syntax-entry ?> ")<" )
078     )
079   (use-local-map jtw-mode-map)
080   (local-set-key "\t"                 'jtw-indent-line)
081   (progn
082     (local-set-key "\C-m"               'd-indent-new-comment-line)
083     (local-set-key "\C-r"               'd-indent-new-comment-line)
084     )
085   (local-set-key [(meta control \\)] 'jtw-meta-control-backslash)
086   (local-set-key "\C-c\C-c"           'd-cc-comment-region)
087   (abbrev-mode 1)
088   (setq local-abbrev-table java-mode-abbrev-table)
089   (make-local-variable 'font-lock-keywords)
090   (make-local-variable 'c-basic-offset)
091   (setq c-basic-offset 3)
092   (font-lock-mode 1)
093   (font-lock-fontify-buffer)
094   ;;(setq font-lock-keywords nil)
095   ;;; NOTE: the following code adds syntax highlighting of /** ... */ javadoc comments
096    (when *elaborate-jtw*
097     (setq font-lock-keywords (cull-from-list
098                               '( "\\<\\(@[a-zA-Z0-9]+\\)\\>" (1 c-annotation-face))
099                               font-lock-keywords))
100     (set (kill-local-variable 'global-font-lock-keywords) font-lock-keywords)
101     (with-temp-buffer
102       (emacs-lisp-mode)
103       (kill-local-variable 'global-font-lock-keywords)
104       (insert-prin1 '(setq global-font-lock-keywords
105                             (append global-font-lock-keywords
106                                     '(c-font-lock-complex-decl-prepare
107                                       (#[(limit)
108                                          sexy-string
109                                          [limit javadoc-font-lock-doc-comments c-font-lock-doc-comments "/\\*\\*
```

```
                                        4])))))
    (goto-char (point-min))
    (d-assert (re-search-forward "\\<sexy-string\\>" nil t))
    (replace-match (format "\"\302\303%c%c#\207\"" 8 ?\t) 'FIXEDCASE 'LITERAL)
    (eval-buffer)
    (setq font-lock-keywords global-font-lock-keywords)
    ))
;; NOTE: the following code adds fontication of J.T.W. keywords
(when *elaborate-jtw*
  (d-font-lock-add-begin
   '(
    ("\\(class\\) \\([A-Z][a-zA-Z0-9_]*\\)"
     (1 'font-lock-keyword-face nil)
     (2 'font-lock-type-face    t))

    (,(concat "\\<\\([A-Z]+[a-z][A-Za-z0-9]*\\|[A-Z]\\|void\\|boolean\\|"
              "char\\|int\\|long\\|short\\|float\\|double\\)"
              "[][]*[ \t]+\\([a-z][A-Za-z0-9_]*\\)(")
     (1 'font-lock-type-face          nil)
     (2 'font-lock-function-name-face nil))

    (,(concat "\\<\\([A-Z]+[a-z][A-Za-z0-9]*\\|[A-Z]\\|void\\|boolean\\|"
              "char\\|int\\|long\\|short\\|float\\|double\\)"
              "[][]*[ \t]+\\([a-z][A-Za-z0-9_]*\\) *[;=,)]")
     (1 'font-lock-type-face          nil)
     (2 'font-lock-variable-name-face nil))

    (,(concat "\\<\\(d-assert\\|function\\|var\\|classVar\\|"
              "property\\|method\\|constructor\\|"
              "until\\|then\\|and\\|or\\|include\\)\\>")
     (1 font-lock-keyword-face nil))

    ("^\\(package\\)[ \t]+\\([a-z.]+\\);"
     (1 'bold nil)
     (2 'fg:lightred t))

    ("^\\(import\\)[ \t]+\\([a-z.]+\\)\\.\\*;"
     (1 'bold nil)
     (2 'fg:lightred t))

    ("\\<\\(begin\\)\\>"                          0 font-lock-keyword-face nil)
    ("\\<\\(end\\)\\>"                            0 font-lock-keyword-face nil)
    ("\\<\\(beginMain\\)\\>"                      0 font-lock-keyword-face nil)
    ("\\<\\(endMain\\)\\>"                        0 font-lock-keyword-face nil)

    ("\\<\\(System.out.print\\(ln\\)?\\)("        1 d-face-cc-global nil)
    ("\\<\\(System.exit\\)("                      1 d-face-cc-global nil)
    ("\\<\\([a-z][A-Za-z0-9]*\\.printStackTrace\\)(" 1 d-face-cc-global nil)
    ("\\<\\(null\\|true\\|false\\)\\>"            1 font-lock-constant-face nil)

    (,(concat "\\<\\(abstract\\|break\\|byte\\|case\\|catch\\|"
              "const\\|continue\\|default\\|do\\|else\\|elseif\\|"
              "extends\\|final\\|finally\\|for\\|goto\\|if\\|"
              "implements\\|instanceof\\|interface\\|"
              "native\\|new\\|package\\|private\\|protected\\|"
```

```
165                   "public\\|return\\|static\\|super\\|switch\\|"
166                   "synchronized\\|this\\|throw\\|throws\\|transient\\|"
167                   "superfor\\|downto\\|to\\|step\\|"
168                   "try\\|volatile\\|while\\)\\>" )
169          1 font-lock-keyword-face nil)
170
171         ( "\\(\\<\\|-\\)\\([0-9]+[.]\\)?[0-9]+\\([eE]-?[0-9]+\\)?"
172          0 d-face-cc-digits nil)
173
174         ( "\\<b\\>"  0 'bold nil)
175
176         ( "\\<function [^ \t]* \\([a-z][A-Za-z0-9_]*\\)("
177          1 font-lock-function-name-face nil)
178         ( "\\<method [^ \t]* \\([a-z][A-Za-z0-9_]*\\)("
179          1 font-lock-function-name-face nil)
180
181         ( "\\<\\(method\\|function\\) \\([a-z][a-zA-Z0-9_]*\\)("
182          2 font-lock-function-name-face nil)
183
184         ( "\\<[A-Z]+[a-z][A-Za-z0-9_<,>]*"    0 'font-lock-type-face nil)
185         ( "\\<[A-Z]\\>"                        0 'font-lock-type-face nil)
186         (,(concat  "\\<\\(void\\|boolean\\|char\\|int\\|long\\|short\\|"
187                    "float\\|double\\)\\>" )   0 'font-lock-type-face nil t)
188
189         ( "\\<m4_[a-zA-Z0-9]*"              0 d-face-m4 t)
190         (,(concat  "\\(\\<m4_"  "dnl\\>\\)\\([^\r\n]*\\)$" )
191          (1 d-face-m4-dnl t)
192          (2 font-lock-comment-face t))
193         ( "\\<\\(\\([a-z]+\\.\\)*\\)[A-Z][a-zA-Z0-9_]*"  1 'fg:lightred nil)
194
195         ( "\\<\\(getter\\|setter\\)\\>"                              1 'd-face-
defmacro t)
196         ( "\\<\\([a-zA-Z0-9_]*[\\\\]?_design[\\\\]?_pattern\\)\\>"  1 'd-face-
defmacro t)
197         ( "\\<\\(foreach\\)\\>"                                      1 'd-face-
defmacro t)
198
199         )))
200    ;;(font-lock-fontify-buffer)
201    )
202
203  (defun jtw-clamp-point (newpoint)
204    (max (point-min) (min (point-max) newpoint)))
205
206  (defun jtw-inside-comment-or-string ()
207    (save-match-data
208      (let ((p (get-char-property (jtw-clamp-point (1- (point))) 'face)))
209        (or (eq p 'font-lock-string-face)
210            (eq p 'font-lock-comment-face)
211            (eq p 'font-lock-doc-face)
212            (eq p 'font-lock-doc-string-face)
213            (eq p 'd-face-super-comment)
214            )))
215    )
216
217  (defun jtw-count-string (string)
218    (save-excursion
219      (save-match-data
220        (let ((max (point-at-eol))
```

```
221             (count 0))
222         (beginning-of-line)
223         (while (re-search-forward string max t)
224           (if (not (jtw-inside-comment-or-string))
225               (incf count)))
226         count))))
227
228 (defun jtw-count ()
229   (let (r)
230     (save-excursion
231       (beginning-of-line)
232       (setq r (- (+ (jtw-count-string "\\<begin\\>")
233                     (jtw-count-string "\\<beginMain\\>")
234                     (* 2 (jtw-count-string "(" ))
235                     (* 2 (jtw-count-string "{" )))
236                  (+ (jtw-count-string "\\<end\\>")
237                     (jtw-count-string "\\<endMain\\>")
238                     (* 2 (jtw-count-string ")" ))
239                     (* 2 (jtw-count-string "}" )))))
240       ;;(message "r=%s" r)
241       r)))
242
243 (defun jtw-get-indent ()
244   (save-excursion
245     (beginning-of-line)
246     (while (looking-at "a")
247       (forward-char))
248     (- (point) (point-at-bol))))
249
250 (defun jtw-set-indent (should-be)
251   (if (>= should-be 0)
252       (save-excursion
253         (beginning-of-line)
254         (d-assert (looking-at "^[a\t]*" ))
255         (setq i (- (match-end 0) (match-beginning 0)))
256         (when (/= i should-be)
257           ;;(d-foo)
258           (delete-region (point-at-bol)
259                          (save-excursion
260                            (beginning-of-line)
261                            (skip-chars-forward "a") (point)))
262           (beginning-of-line)
263           (insert (make-string should-be ? ))))))
264
265 (defvar jtw-basic-offset 3)
266
267 (defun jtw-line-1 ()
268   (interactive)
269   ;;(d-foo)
270   (save-excursion
271     (beginning-of-line)
272     ;;(d-foo)
273     (cond
274      ((= (point) (point-min))
275       ;;(d-foo)
276       (jtw-set-indent 0))
277      ((looking-at "^[a-z ]*\\(class\\|interface\\)\\>")
278       (when (not (flm-inside-comment-or-string))
279         (jtw-set-indent 0)))
280      (t
281       (forward-line -1)
```

```
282         (setq rel (jtw--count))
283         (setq i (jtw--get-indent))
284         (forward-line 1)
285         ;;(if (/= rel 0) (beep))
286         ;;(set-buffer-modified-p t))
287         (jtw--set-indent (+ i (* rel jtw--basic-offset)))))))
288
289   (defun jtw--line-2 ()
290     ;;(d-foo)
291     (save-excursion
292       (when (looking-at "^[ \t]*end")
293         (setq i (jtw--get-indent))
294         (jtw--set-indent (- i jtw--basic-offset)))))
295
296   ;;(eval '(setq f 123))
297   ;;(setq func 'jtw--line-1)
298   ;;(eval (cons 'jtw--line-1 nil))
299
300   (defun jtw--a (func)
301     (save-excursion
302       (let (m)
303         (setq m (make-marker))
304         (forward-line)
305         (set-marker m (point))
306         (if (not (re-search-backward "^\\([a-z].*\\)?\\(class\\|interface\\)" nil t))
307             (goto-char (point-min)))
308         ;;(d-foo)
309         ;;(goto-char (point-min))
310         (while (< (point) (marker-position m))
311           (eval (cons func nil))
312           (forward-line 1))
313         (set-marker m nil))))
314
315   (defun jtw--meta-control-backslash ()
316     (interactive)
317     (let (m)
318       (setq m (make-marker))
319       (set-marker m (point))
320       (if (and (fboundp 'd-movement--unpad-buffer) (d-movement--is-correct-
mode))
321           (d-movement--unpad-buffer))
322       (goto-char (point-min))
323       (while (< (point) (point-max))
324         (jtw--line-1)
325         (forward-line 1))
326       (goto-char (point-min))
327       (while (< (point) (point-max))
328         (jtw--line-2)
329         (forward-line 1))
330       (if (and (fboundp 'd-movement--pad-buffer) (d-movement--is-correct-mode))
331           (d-movement--pad-buffer))
332       (goto-char m)
333       (set-marker m nil)
334       (message "Ran jtw--meta-control-backslash")
335       ))
336
337   (defun jtw--all ()
338     ;;(d-beeps "line1")
339     (jtw--a 'jtw--line-1)
340     ;;(d-beeps "line2")
341     (jtw--a 'jtw--line-2)
342     ;;(d-beeps "line3")
343     )
344
345   (defun jtw--get-indents ()
346     (save-excursion
```

```
347     (let (list)
348       (goto-char (point-max))
349       (beginning-of-line)
350       (setq list nil)
351       (while (not (bobp))
352         (forward-line -1)
353         (beginning-of-line)
354         (setq i (jtw--get-indent))
355         (setq list (cons i list)))
356       list)))
357
358 (defun jtw--newline ()
359   (interactive)
360   (let (c)
361     (when (save-excursion (beginning-of-line) (looking-at "^.*//"))
362       (setq c t))
363     ;;(d-foo)
364     (insert "\n")
365     (jtw--indent-line)
366     (if c (insert "// "))))
367
368 (defun jtw--delete-line ()
369   (delete-region (point-at-bol) (point-at-eol))
370   (if (looking-at "\n")
371       (delete-char 1))
372   )
373
374 (defun jtw--get-current-indentation ()
375   (save-excursion
376     (beginning-of-line)
377     (d-assert (looking-at "^\\([ \t]*\\)[^ \t\r\n]"))
378     (/ (length (buffer-substring-no-properties (match-beginning 1) (match-end 1)))
379        c-basic-offset)))
380
381 (defun jtw--current-line-as-string ()
382   (buffer-substring-no-properties (point-at-bol)
383                                   (point-at-eol)))
384
385 (defun jtw--get-prev-and-this-line ()
386   (beginning-of-line)
387   (let (line)
388     (list (if (save-excursion
389                 (beginning-of-line)
390                 (bobp))
391               ""
392             (save-excursion
393               (forward-line -1)
394               (beginning-of-line)
395               (while (and (not (bobp)) (looking-at "^[ \t]*$"))
396                 (forward-line -1)
397                 (beginning-of-line))
398               (setq line (d-what-line))
399               ;;(message "*** jtw--current-line-as-string=%s" (jtw--current-line-as-string))
400               (jtw--current-line-as-string)))
401           (jtw--current-line-as-string)
402           line)))
403
404 (defun jtw--indent-line ()
405   (interactive)
406   (font-lock-fontify-buffer)
407   (let (pair prev-line this-line i triple)
408     (save-match-data
409       (save-excursion
410         (beginning-of-line)
```

```
411         (setq i (if (save-excursion
412                       (beginning-of-line)
413                       (bobp))
414                     0
415                   (save-excursion
416                     (forward-line -1)
417                     (beginning-of-line)
418                     (while (and (not (bobp)) (looking-at "^[ \t]*$" ))
419                       (forward-line -1)
420                       (beginning-of-line))
421                     (jtw-get-current-indentation)
422                     ;;(debug "bar")
423                     )))
424         (setq triple (jtw-get-prev-and-this-line))
425         ;;(debug "John Coltrane")
426         (setq prev-line (nth 0 triple))
427         (setq this-line (nth 1 triple))
428         (setq previous-nontrivial-line (nth 2 triple))
429         (if (and (string-match "begin" prev-line)
430                  (save-excursion
431                    (goto-line previous-nontrivial-line)
432                    (or (looking-at "^[ \t]*begin" )
433                        (re-search-forward "begin" (point-at-eol) t)))
434                  (not (memq (cadr (text-properties-at (save-excursion
435                                                         (goto-line previous-nontrivial-line)
436                                                         (beginning-of-line)
437                                                         (re-search-forward "begin" (point-at-eol) t))))
438                             '(font-lock-string-face
439                               font-lock-comment-face
440                               font-lock-doc-face
441                               font-lock-doc-string-face
442                               d-face-super-comment))))
443             (incf i))
444         (if (and (string-match "end" this-line)
445                  (save-excursion
446                    (beginning-of-line)
447                    (or (looking-at "^[ \t]*end" )
448                        (re-search-forward "end" (point-at-eol) t)))
449                  (not (memq (cadr (text-properties-at (save-excursion
450                                                         (beginning-of-line)
451                                                         (re-search-forward "end" (point-at-eol) t))))
452                             '(font-lock-string-face
453                               font-lock-comment-face
454                               font-lock-doc-string-face
455                               font-lock-doc-face
456                               d-face-super-comment))))
457             (decf i))
458         (setq i (max 0 i))
459         ;;(message "indenting line %d to %d" (d-what-line) i)
460         ;;(sit-for 1)
461         (beginning-of-line)
462         ;;(indent-line-to i)
463         (indent-line-to (* c-basic-offset i))
464         ;;(debug "Halloway")
465         )
466       (beginning-of-line)
467       (skip-chars-forward " \t" )
468       ;;(debug "antelope")
469       )))
470
471 ;; I am a normal comment
472 ;;; I am a super comment
473
474 (setq bg-colour "#f0f0f0" )
```

```
475
476  (require 'd-make-face)
477
478  (provide 'jtw-mode)
;; END FILE:    ~/dlisp/jtw-mode.el
```

2.13 Translator `*.jtw` to `*.class` Elisp source code

2.13.1 `jtw-build-java.el` Elisp source code

The file `jtw-build-java.el` saves to disk a ***.java** file corresponding to the `*.jtw` file given as an argument. It gives error diagnostics on problematic J.T.W. constructs. This file respects file line numbers in the case that **include** statements are present in your code. The large size of the file (2,900+ lines of code) makes it unsuitable for inclusion in this book, so instead for the Elisp source code, see the file `jtw-build-java.el` by visiting the following Website:

davin.50webs.com/J.T.W/tutorial-01-HelloWorld.html

and clicking on the tarball in Question 1.1. If you use the default setting of the installer module, the file `jtw-build-java.el` will be located at `/usr/share/emacs/site-lisp/dlisp/` for GNU/Linux and `c:/java-training-wheels/share/emacs/site-lisp/dlisp/` for M.S. Windows.

2.13.2 `jtw-javac.el` Elisp source code

The file `jtw-javac.el` is used to convert ***.java** files to `*.class`, again respecting line numbers in the case that **include** statements are present in your source code. The location of `jtw-javac.el` will be the same as the location of `jtw-build-java.el`. The output of the `javac` command has its standard output and standard error piped into Emacs' batch mode running the file `jtw-javac` and invoking the **method**: `doit`. Here is the file `jtw-javac.el`. This file is included in the tarball mentioned in the last subsection §2.13.1.

```
;; BEGIN FILE:  ~/dlisp/jtw-javac.el
001
002  ;;; jtw-javac.el --- A program for receiving the output of the program: javac
003
004  ;; Copyright (C) 2006-2016 Davin Pearson
005
006  ;; Author/Maintainer: Davin Max Pearson <http://davin.50webs.com>
007  ;; Keywords: javac backend
008  ;; Version: 2.0
009
010  ;; This program is part of GNU Java Training Wheels.
011
012  ;;; m4_limitation_of_warranty
013
014  ;;; Commentary:
015
016  ;; A program for receiving the output of the program: javac in the form
017  ;; of a pipe.
018
019  ;;; Known Bugs:
020
021  ;; None so far!
022
023  ;;; Code:
024
025  (message "*** Welcome to file: jtw-java.el" )
026
027  (require 'cl)
028
029  (when (not (fboundp 'd-emergency-set-load-path))
```

```
030   (defun d-emergency-set-load-path ()
031     (assert (and 'king-kong (boundp '*prefix*)))
032     (assert *prefix*)
033     (setq load-path (cons (expand-file-name (concat *prefix* "/../dlisp/" ))
034                           load-path))
035     (message "** jtw-javac.el (car load-path)=%s" (car load-path))))
036
037 (d-emergency-set-load-path)
038
039 (require 'early-bindings)
040
041 (message "file: jtw-javac.el %s %s" (print-symbol *prefix*) (print-symbol *stump*))
042
043 (defun checkpoint (msg &rest rest)
044   (apply 'message msg rest)
045   ;; do nothing
046   )
047
048 (if (not (boundp 'file-comes-from))
049     (setq file-comes-from nil))
050
051 (if (not file-comes-from)
052     (setq file-comes-from (cons "jtw-javac.el" file-comes-from)))
053
054 (require 'early-bindings)
055 (require 'jtw-build-java)
056
057 (message "*** Welcome to file: jtw-javac.el %s %s"
058          (print-symbol *prefix*)
059          (print-symbol *stump*)
060          )
061
062 (d-assert (find "jtw-javac.el" file-comes-from :test 'string=))
063 ;;(d-assert (string= file-comes-from "jtw-javac.el"))
064
065 ;;(message "*** Symbol value... %s" (print-symbol *stump*))
066
067 (defun doit ()
068   (interactive)
069   ;;(read-line-pre)
070   ;;(message "input8: jtw-javac: *stump*=%s" *stump*)
071   (message "*** Called defun: doit file: jtw-javac.el %s"
072            (print-symbol *stump*))
073   (let (numb said-message red-line numb file-less-suffix old-suffix new-suffix
074             line-left line-right file-plus-suffix location
075             (case-fold-search t) p)
076     (condition-case err
077         ;;(while (setq red-line (d-read-line))
078         (while (setq red-line (read-from-minibuffer "" ))
079           (setq said-message nil)
080           ;;(message "input0: red-line=%s" red-line)
081           ;;(if (not (string-match "^Loading " red-line))
082           (cond
083            ((or (string-match (regexp-quote "Loading 00debian-vars..." ) red-line)
084                 (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50autoconf.el" ) red-line)
085                 (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50dictionaries-common.el" ) red-lin
086                 (string-match (regexp-quote "Loading debian-ispell..." ) red-line)
087                 (string-match (regexp-quote "Loading /var/cache/dictionaries-common/emacsen-ispell-default.el...
088                 (string-match (regexp-quote "Loading /var/cache/dictionaries-common/emacsen-ispell-dicts.el..."
089                 (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50git-core.el" ) red-line)
090                 )
091             ;; do nothing
```

```
092             )
093            ((string-match (concat "\\(\\([a-zA-Z]:/\\|"
094                                   "~/\\|/\\|\\.\\./\\|\\)"
095                                   "[a-zA-Z0-9_/]+\\)"
096                                   "\\(\\.java\\):\\([0-9]+\\)" )
097                           red-line)
098             (progn
099               (setq file (substring red-line (match-beginning 0) (match-end 3)))
100               ;;(message "input6: jtw11-ebook.tex=%s" file)
101               (save-match-data
102                 (if (string-match "^/" file)
103                     (setq file (substring file 1))))
104               ;;(message "input7: jtw11-ebook.tex=%s" file)
105               ;;(setq said-message t)
106               (setq numb             (1- (d-read-str (substring red-line
107                                                                 (match-beginning 4)
108                                                                 (match-end 4)))))
109               (setq file-less-suffix (substring red-line
110                                                 (match-beginning 1)
111                                                 (match-end 1)))
112               ;;(message "input3: red-line=%s" red-line)
113               ;;(message "input3: file-less-suffix=%s" file-less-suffix)
114               (setq old-suffix ".java" )
115               (setq new-suffix ".jtw" )
116               (setq line-left        (substring red-line 0 (match-end 1)))
117               (setq line-right       (substring red-line (match-end 4)))
118               (setq file-plus-suffix (concat file-less-suffix new-suffix))
119               (setq file             (concat file-less-suffix old-suffix))
120               (if (string-match "./" file)
121                   (setq file (substring file (match-end 0))))
122               ;;(setq default-directory (file-name-directory default-directory))
123               ;;(setq file (concat default-directory file))
124               ;;(error "Maria Callas")
125               ;;(message "input8: (file-name-directory file)=%s" (file-name-directory file))
126               ;;(message "input7: file=%s" file)
127               ;;(message "input7: default-directory pre=%s" default-directory)
128               (d-assert (stringp file))
129               ;;(message "input7: file=%s" file)
130               ;;(message "input9: (file-name-directory file)=%s" (file-name-directory file))
131               (when (file-name-directory file)
132                 (d-assert (stringp (file-name-directory file)))
133                 (d-assert (stringp default-directory))
134                 (if (string-match (file-name-directory file) default-directory)
135                     (setq default-directory (substring default-directory 0 (match-beginning 0))))
136                 ;;(message "input7: default-directory post=%s" default-directory)
137                 ;;(message "input7: (file-name-nondirectory)=%s" (file-name-nondirectory file))
138                 )
139               (d-assert (stringp file))
140               (d-assert (stringp default-directory))
141               ;;(message "input8: (concat default-directory file)=%s" (concat default-directory file))
142               ;;(message "input8: numb=%s" numb)
143               (find-file (concat default-directory file))
144               ;;(message "input2: finding file=%s" file)
145               ;;(debug "Desolation Row")
146               (goto-line numb)
147               ;;(debug "Tiger Woods")
148               ;;(message "input2: Amber Dempsey")
149               ;;(message "input2: (buffer-file-name)=%s" (buffer-file-name))
150               (setq location (warn-get-location))
151               ;;(message "input2: (cdr location)=%d" (cdr location))
152               ;;(message "input2: setq location")
153               (setq red-line (concat line-left new-suffix ":" (prin1-to-string (cdr location)) line-right))
154               ;;(message "input2: setq red-line")
155               ;;(debug "J.S. Bach / Mass in B Minor")
```

```
156               (message "%s input1: %s" *java-namespace* red-line)))
157             (t
158              (message "%s input2: %s" *java-namespace* red-line))))
159        (error
160         (setq p (prin1-to-string (cdr err)))
161         (if (and (not (string-match "Error reading from stdin" p))
162                  (not (string-match "End of file"              p))
163                  (not (string-match "Eobp"                     p)))
164             (message "%s input4: Error=%s" *java-namespace* (cdr err)))
165         )))
166    ;;(message "*** end defun: doit file: jtw-javac.el %s %s"
167    ;;         (print-symbol *stump*)
168    ;;         (print-symbol *prefix*))
169    )
170
171  ;;(message "*** Scanner reached end file: jtw-javac.el")
172  ;; (round (/ (d-what-line) 58.0)) 2 pages
173  (provide 'jtw-javac)
;; END FILE:    ~/dlisp/jtw-javac.el
```

2.13.3 `jtw-java.el` Elisp source code

The file `jtw-java.el` reads the output of `java`'s standard output and standard error piped into this file and generates correct line numbers of `java` error messages, even if file inclusion is used. The location of `jtw-java.el` will be the same as the location of `jtw-build-java.el`. Here is the file `jtw-java.el`. This file in included in the tarball mentioned two subsections ago, in §2.13.1.

```
;; BEGIN FILE: ~/dlisp/jtw-java.el
001  ;;; jtw-java.el — A program for receiving the output of the program: java
002
003  ;; Copyright (C) 2006-2016 Davin Pearson
004
005  ;; Author/Maintainer: Davin Max Pearson <http://davin.50webs.com>
006  ;; Keywords: java backend
007  ;; Version: 2.0
008
009  ;; This file is part of GNU Java Training Wheels.
010
011  ;;; m4_limitation_of_warranty
012
013  ;;; Commentary:
014
015  ;; A program for receiving the output of the program: java in the form
016  ;; of a pipe.
017
018  ;;; Known Bugs:
019
020  ;; None so far!
021
022  ;;; Code:
023
024  (message "*** Welcome to file: jtw-java.el" )
025
026  (setq debug-on-error t)
027
028  (require 'cl)
029
030  (message "Watties Baked Beans make you fart" )
031
032  (progn
033    (assert (and 'rocket-man   (boundp '*prefix*)))
034    (assert (and 'wonder-woman *prefix*))
035    )
```

```
036
037 (message "**** Trisquel Linux")
038
039 (when (not (fboundp 'd-emergency-set-load-path))
040   (defun d-emergency-set-load-path ()
041     (message "Inside d-emergency-set-load-path")
042     (assert (and 'foxy-lady (boundp '*prefix*)))
043     (assert *prefix*)
044     (setq load-path (cons (expand-file-name (concat *prefix* "/../dlisp/"))
045                           load-path))
046     (message "** jtw-java.el (car load-path)=%s" (car load-path))))
047
048 (d-emergency-set-load-path)
049
050 (require 'early-bindings)
051
052 (progn
053   (assert (and 'cattymouse (boundp '*prefix*)))
054   (assert (and 'doggydoggy *prefix*))
055   )
056
057 (message "*** file: jtw-java.el %s %s" (print-symbol *prefix*) (print-symbol *stump*))
058
059 (if (not (boundp 'file-comes-from))
060     (setq file-comes-from nil))
061
062 (setq file-comes-from (cons "jtw-java.el" file-comes-from))
063
064 (message "* begin (require 'early-bindings)")
065
066 (require 'early-bindings)
067
068 (message "* end (require 'early-bindings)")
069
070 (require 'jtw-build-java)
071
072 (d-assert (find "jtw-java.el" file-comes-from :test 'string=))
073
074 (defun checkpoint (msg &rest rest)
075   ;;(apply 'message msg rest)
076   ;; do nothing
077   )
078
079 (defun doit ()
080   (interactive)
081   (message "Welcome to defun: doit file: jtw-java.el DOUGHNUTS")
082   (let (red-line said-message numb file-less-suffix old-suffix
083                  new-suffix line-left line-right file-plus-suffix
084                  cdr-err)
085     (condition-case err
086         (while (setq red-line (read-from-minibuffer ""))
087           ;;(while (setq red-line (d-read-line))
088           ;;(message "input0: red-line=%s" red-line)
089           ;;(message "1")
090           (d-assert red-line)
091           ;;(message "2")
092           (d-assert (stringp red-line))
093           ;;(message "3")
094           (d-assert (sequencep red-line))
095           ;;(message "4")
096           (setq said-message nil)
097           ;;(message "5")
098           (cond
099            ((or
```

```
100               (string-match (regexp-quote "Loading 00debian-vars...") red-line)
101               (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50aut(string (regexp-quote oconf.el")
102               (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50dictionaries-common.el") red-line)
103               (string-match (regexp-quote "Loading debian-ispell...") red-line)
104               (string-match (regexp-quote "Loading /var/cache/dictionaries-common/emacsen-ispell-default.el") re
105               (string-match (regexp-quote "Loading /var/cache/dictionaries-common/emacsen-ispell-dicts.el") red-
106               (string-match (regexp-quote "Loading /etc/emacs/site-start.d/50git-core.el") red-line)
107               )
108              ;; do nothing
109              )
110             ((string-match "\\([A-Z][a-zA-Z0-9_]*\\)\\(\\.java\\):\\([0-9]+\\)" red-line)
111              ;;(message "6")
112              (setq said-message t)
113              ;;(message "7")
114              (setq numb (substring red-line (match-beginning 3) (match-end 3)))
115              ;;(message "8")
116              (d-assert (d-read-ready numb))
117              ;;(message "9")
118              ;;(d-assert (sequencep (count-locations)))
119              ;;(setq numb (- (d-read-str numb) (count-locations)))
120              ;;(message "10")
121              (d-assert (sequencep numb))
122              ;;(message "11")
123              (d-assert (stringp numb))
124              (setq numb (d-read-str numb))
125              ;;(message "12")
126              (d-assert (integerp numb))
127              ;;(d-assert (sequencep numb))
128              ;;(message "13")
129              (d-assert (stringp red-line))
130              (d-assert (sequencep red-line))
131              (d-assert (and 1 (match-beginning 1)))
132              (d-assert (and 2 (match-end 1)))
133              (d-assert (and 3 (match-beginning 2)))
134              (d-assert (and 4 (match-end 2)))
135              (d-assert (and 5 (match-beginning 3)))
136              (d-assert (and 6 (match-end 3)))
137              ;;(message "14")
138              (setq file-less-suffix (substring red-line (match-beginning 1) (match-end 1)))
139              ;;(message "15")
140              (d-assert file-less-suffix)
141              (d-assert (stringp file-less-suffix))
142              ;;(message "16")
143              (setq old-suffix ".java")
144              ;;(message "17")
145              (d-assert old-suffix)
146              (d-assert (stringp old-suffix))
147              ;;(message "18")
148              (setq new-suffix ".jtw")
149              ;;(message "19")
150              (d-assert new-suffix)
151              (d-assert (stringp new-suffix))
152              ;;(message "20")
153              (setq line-left        (substring red-line 0 (match-beginning 1)))
154              (setq line-right       (substring red-line (match-end 3)))
155              (setq file-plus-suffix (concat file-less-suffix new-suffix))
156              (setq file             (concat file-less-suffix old-suffix))
157              ;;(message "21")
158              (d-assert (stringp line-left))
159              (d-assert (stringp line-right))
160              (d-assert (stringp file-plus-suffix))
161              (d-assert (stringp file))
162              ;;(message "22")
```

```
163             (find-file file)
164             ;;(message "23")
165             (d-assert (integerp numb))
166             (goto-line numb)
167             ;;(message "(warn--get-location)=%s" (warn--get-location))
168             ;;(message "24")
169             ;;(debug "Tiger Woods")
170             (setq location (warn-get-location))
171             ;;(setq location (cons file numb))
172             ;;(message "24b")
173             ;;(message "location=%s" location)
174             (d-assert (not (eq location t)))
175             (d-assert (not (eq location nil)))
176             (d-assert (sequencep location))
177             (d-assert (consp location))
178             (d-assert (stringp (car location)))
179             (d-assert (numberp (cdr location)))
180             ;;(message "25")
181             (when location
182               ;;(message "26")
183               (setq red-line (concat line-left (car location) ":" (prin1-to-string (cdr location)) line-right))
184               ;;(message "27")
185               )
186             ;;(message "28")
187             (d-assert (sequencep red-line))
188             )
189           )  ;; endaCOND!
190           (when said-message
191             (message "%s input1: %s" *java-namespace* red-line))
192           (when (not said-message)
193             (message "%s input2: %s" *java-namespace* red-line))
194           ;;(message "Jean Jarre's Equinoxe")
195           )
196       (error
197        (setq cdr-err (prin1-to-string (cdr err)))
198        (if (or (string-match "Error reading from stdin"          cdr-err)
199                (string-match "Eobp"                              cdr-err)
200                (string-match "Could not find or load main class" cdr-err))
201            (message "Known error err=%s" cdr-err)
202          (message "%s input3: Unknown error (%s)" *java-namespace* cdr-err)
203          ) ;; endaif!
204        )   ;; endaERROR!
205       )    ;; end CONDITION-CASE! err
206     )      ;; end LET! red-line said-message numb file-less-suffix old-suffix
207   ;;(message "Reached end of defun: doit file: jtw-java.el DOUGHNUTS")
208   )
209
210 ;; My Fair Lady / Rex Harrison & Julie Andrews
211 ;;(message "Scanner at end of file: jtw-java.el")
212
213 ;; (round (/ (d-what-line) 50.0)) 3 pages
214 (provide 'jtw-java)
;; END FILE:    ~/dlisp/jtw-java.el
```

2.14 An idiom for constructors in Java and C++

When a **constructor**'s purpose is to set one or many **property variable**s, it seems natural to name the parameters with the same names as the **property**s. The problem with this approach is that you need to distinguish between the names of the **property**s with the names of the parameters. Luckily there is a way to do this. The **this** keyword is not learned by novice programmers because it is implicit in every mention of a **property** in the same **class** and every call to a **method**

of the same **class**. Here is some J.T.W. code to show you what I mean:

```
001  class A
002  begin
003     property int data;
004     method void foo()
005     begin
006        System.out.println( "data=" + data);
007        bar(); PRINTS OUT: bar!
008     end
009     method void bar()
010     begin
011        System.out.println( "bar!" );
012     end
013  end
```

The `foo` **method** can be identically rewritten as follows:

```
001  class A
002  begin
003     property int data;
004     method void foo()
005     begin
006        System.out.println( "data=" + this.data);
007        this.bar(); PRINTS OUT: bar!
008     end
009     method void bar()
010     begin
011        System.out.println( "bar!" );
012     end
013  end
```

Therefore `this.data` inside the `A` **class** is the same as `data` and `this.bar()` inside the `A` **class** is the same as `bar()`. A difference occurs when there is a parameter called `data`, in which case `this.data` and `data` refer to different **variable**s, the former to the **property** `data` and the latter to the parameter `data`. You can exploit this difference by writing your **constructor** like so:

```
001  class A
002  begin
003
004     property int data;
005
006     constructor A(int data)
007     begin
008        this.data = data;
009     end
010  end
```

or for more parameters, like so:

```
001  class A
002  begin
```

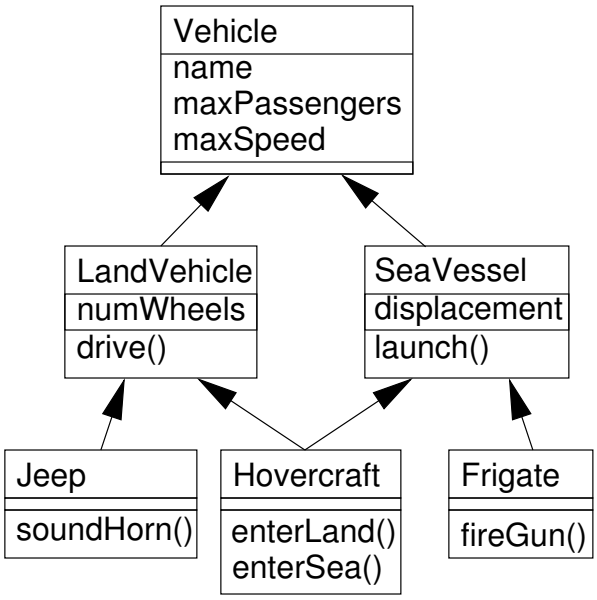


Figure 2.3: A U.M.L diagram for C++

```
003
004     property int data1;
005     property int data2;
006     property int data3;
007
008     constructor A(int data1, int data2, int data3)
009     begin
010        this.data1 = data1;
011        this.data2 = data2;
012        this.data3 = data3;
013     end
014  end
```

The only difference between the Java code and C++ code is that **this** in C++ is a pointer to the current object rather than a reference to the current object like it is in Java. Therefore in C++ and Lisp++ you write **this->**`data` rather than **this.**`data` in Java and J.T.W.

2.15 Interfaces in Java and J.T.W.

This section explains how **interface**s in Java and J.T.W. are a solution to C++'s problematic multiple inheritance. Consider Figure 2.3 for an example. The `Hovercraft` **class** shown in the diagram inherits from both `LandVehicle` and `SeaVessel` since the hover-craft is in the rather unique position of being able to travel on land and sea. The `Hovercraft` **class** cannot be expressed in Java since Java does not have the facility for *multiple inheritance*. All other **class**es in the diagram use *single inheritance* and so they can be expressed in Java.

One of the problems with multiple inheritance is in deciding what to do with **property**s in a **class** like `Vehicle` that is an indirect superclass of `Hovercraft` in two different ways, via `LandVehicle` and via `SeaVessel`. The hover-craft in being able to drive on land and sea might have two different maximum speeds, one for land travel and the other for sea travel. This leads

to a problem of what should be the appropriate value for the `maxSpeed` **property** of `Hovercraft` objects? We could set `maxSpeed` to be the maximum of the two speed values but then this might badly affect the behaviour of the `drive` **method** which, because it is defined in the `LandVehicle` **class**, might assume that the value of `maxSpeed` is the maximum speed attainable on land. A similar problem arises with the `launch` **method**.

Another approach would be for the `Hovercraft` **class** to possess two separate `maxSpeed` **property**s, one for the maximum speed on land and the other for the maximum speed on the sea. The C++ language gives the programmer a choice between having one or two copies of `maxSpeed` with the option of using **virtual** base **class**es rather than normal inheritance, whereas Java avoids this extra complexity by not allowing multiple inheritance.

So that the Java programmer is not disadvantaged by the lack of multiple inheritance, Java has the **interface** feature, which allows for a kind of multiple inheritance involving **interface**s, without the complexity of multiple inheritance of **class**es that is present in languages like C++. Figure 2.4 shows on the left a diagram showing how **interface**s in Java relate to the Java concepts of **class**es and objects. On the right is a diagram showing the equivalent concepts in C++.

The diagram shows that in a sense **interface**s are a "higher level concept" than **class**es, since you can never create an instance of an **interface**, only instances of **class**es that implement that **interface**. Interfaces have no **constructor**s.

The most important feature of **interface**s is that a **class** can implement more than one interface. Interfaces are limited in two respects. Firstly, they are not allowed to have any **property**s except **static** constants, and secondly the **method**s of an **interface** must be defined without bodies, like **abstract method**s. These two limitations prevent **interface**s from suffering from the problem that occurred with the `maxSpeed` **property** in the previous U.M.L. diagram.

We can re-work the previous U.M.L. diagram into something that can be expressed within the Java language by replacing the **class**es `Vehicle`, `LandVehicle` and `SeaVessel` with **interface**s `IsVehicle`, `IsLandVehicle` and `IsSeaVessel`, respectively. The dotted arrows in Figure 2.5 indicate **interface**s extending from **interface**s. Note that the `Hovercraft` **class** implements both the `IsLandVehicle` and `IsSeaVessel` **interface**s, rather than inheriting from two **class**es which is not allowed in Java.

Since an **interface** is not allowed to have any **property**s except **static** constants, we have replaced the **property**s that existed in the **class**es `Vehicle`, `LandVehicle` and `SeaVessel` with "getter" and "setter" **method**s. That is to say that, for each **property** `X`, there is now a pair of **method**s `getX` and `setX`. A `getX`, `setX` pair of **public method**s in a **class** is logically equivalent for users of the **class** to a **public property** called `X`. Since the **method**s of the **interface**s are defined without bodies, they are defined in the **class**es `Jeep`, `Hovercraft` and `Frigate` that implement the three **interface**s. The `getMaxSpeed()` **method** could return the maximum speed depending on whether or not the vehicle is currently on the land or on the sea, and similarly for the `setMaxSpeed()` **method**.

2.16 Packages in Java and J.T.W.

2.16.1 Package visibility

In Java and J.T.W. when an object is declared with package visibility it gains a level of protection between **protected** and **private**.

	public visibility	**protected** visibility	**package** visibility	**private** visibility
In the same **class** as `X`	✔	✔	✔	✔
In the same **package** as `X`	✔	✔	✔	✖
In a subclass of `X` but a different **package**	✔	✔	✖	✖
Anywhere else	✔	✖	✖	✖

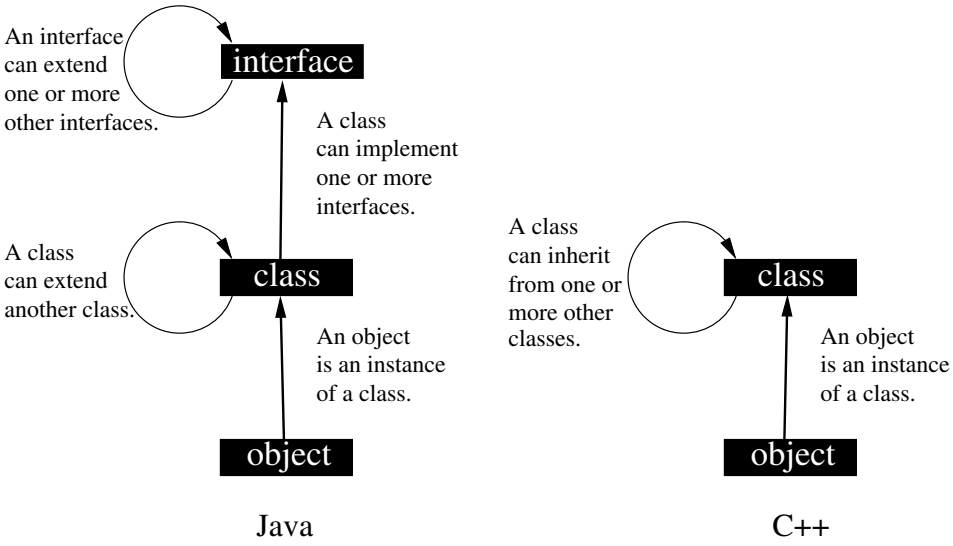


Figure 2.4: Comparision of Java's objects, **class**es and **interface**s with C++'s objects and **class**es. Note that to simulate Java's **interface**s in C++ it is sufficient to use **abstract class**es, that is to say: **class**es with at least one pure **virtual method**.

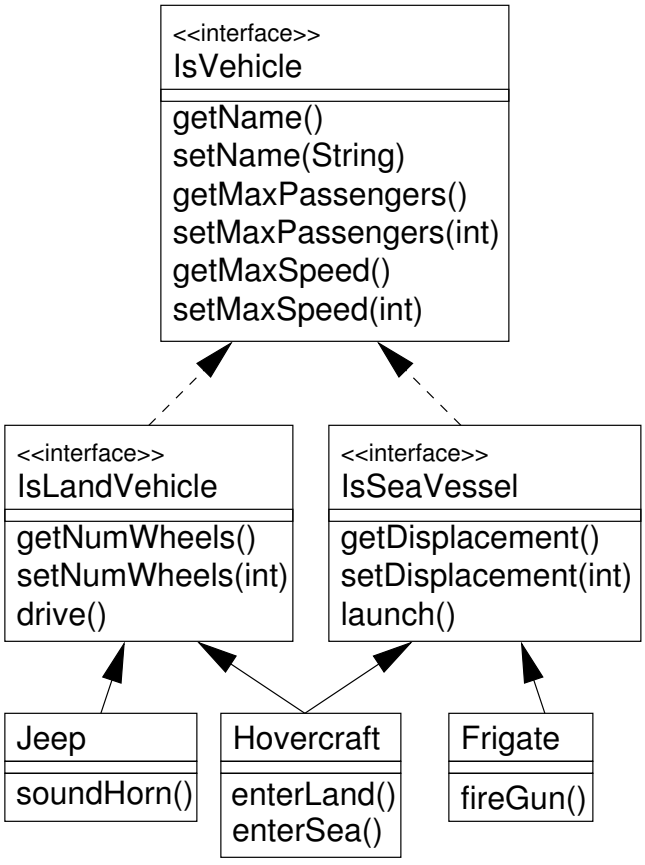


Figure 2.5: A U.M.L diagram for Java. Note that dotted lines represent **interface**s extending from one another.

To get **package** visibility, simply omit **public**, **private** and **protected** from the **method**, **property** or **constructor** spec, e.g. like so in J.T.W.:

```
// BEGIN FILE: A.jtw
001  class A
002  begin
003      function void package_visible_function()
004      begin
005          // NOTE: code goes here
006      end
007      method void package_visible_method()
008      begin
009          // NOTE: code goes here
010      end
011      property int package_visible_property;
012
013      classVar int package_visible_class_variable;
014  end
// END FILE:     A.jtw
```

and like so in Java:

```
// BEGIN FILE: A.java
001  class A
002  {
003      static void package_visible_function()
004      {
005          // NOTE: code goes here
006      }
007      void package_visible_method()
008      {
009          // NOTE: code goes here
010      }
011      int package_visible_property;
012
013      static int package_visible_class_variable;
014  }
// END FILE:     A.java
```

2.16.2 Moving a class into a package

Consider a typical **class**:

```
// BEGIN FILE: jtw-tutorials/A.jtw// END FILE:     jtw-tutorials/A.jtw
```

To move this **class** into a **package** called (for argument's sake) `pkg`, you need to set the **class**'s visibility status from none (i.e. **package** visibility) to **public**. Also each **package** visible (i.e. no **private** or **public** or **protected** specification) **class** variable, **function**, **method** and **property** needs to have its visibility status changed from **package** to **public** if you want to be able to access these items from outside of the **package**. If you have more than one **class** in the same file, they will have to be separated into separate files as you can only have one **public class** per file. Also the name of the package must be declared via a **package** specification like so **package** `pkg`; Here is the same source file, ready to be put into a **package**:

```
// BEGIN FILE: jtw-tutorials/pkg/A.jtw
001  package pkg;
002
003  public class A
004  begin
005      public property int data;
```

```
006
007     public classVar int data2 = 666;
008
009     public constructorA(int data)
010     begin
011        this.data = data;
012     end
013
014     public method void meth1()
015     begin
016        System.out.println( "meth1:" + data);
017     end
018
019     public method void meth2()
020     begin
021        System.out.println( "meth2:" + data);
022     end
023
024     public function void func()
025     begin
026        System.out.println( "func:" + data2);
027     end
028
029     beginMain
030        var A a1 = new A(123);
031        a1.meth1(); // PRINTSaOUT: meth1:123
032        var A a2 = new A(456);
033        a2.meth2(); // PRINTSaOUT: meth2:456
034        A.func(); // PRINTSaOUT: func:666
035     endMain
036  end
// END FILE:    jtw-tutorials/pkg/A.jtw
```

Also the source file for the **class** needs to be moved into the folder `~/jtw-tutorials/pkg`. To run the **class**, you will need to invoke the `Makefile` command:

```
make build pkg/A.run
```

2.16.3 Moving a class into a sub-package

Suppose you want to move a **class** A from no package (the folder `~/jtw-tutorials`) to a package called for argument's sake `pkg.inner`, the steps from the §2.16.2 needs to be followed, the only difference being that the package spec needs to be changed to **package** `pkg.inner;` and the file needs to be moved into the folder `pkg/inner`. To run the **class** file you need to invoke the following Make command:

```
make build pkg/inner/A.run.
```

Here is the **class** definition for the file `~/jtw-tutorials/pkg/inner/A.jtw`:

```
// BEGIN FILE: jtw-tutorials/pkg/inner/A.jtw
001  package pkg.inner;
002
003  public class A
004  begin
005     public property int data;
006
007     public classVar int data2 = 666;
008
009     public constructorA(int data)
010     begin
011        this.data = data;
```

```
012     end
013
014     public method void meth1()
015     begin
016        System.out.println("meth1:" + data);
017     end
018
019     public method void meth2()
020     begin
021        System.out.println("meth2:" + data);
022     end
023
024     public function void func()
025     begin
026        System.out.println("func:" + data2);
027     end
028
029     beginMain
030        var A a1 = new A(123);
031        a1.meth1(); // PRINTSaOUT: meth1:123
032        var A a2 = new A(456);
033        a2.meth2(); // PRINTSaOUT: meth2:456
034        A.func(); // PRINTSaOUT: func:666
035     endMain
036  end
// END FILE:    jtw-tutorials/pkg/inner/A.jtw
```

2.16.4 Importing a package

When referring to a **class** or **interface** in a package you need to specify the package name in front of every **class** name and **interface** name in the package you want to access, like so, in the main folder `~/jtw-tutorials` (outside of any package):

```
// BEGIN FILE: jtw-tutorials/B.jtw
001  class B
002  begin
003     beginMain
004        var pkg.A a1 = new pkg.A(123);
005        a1.meth1(); // PRINTSaOUT: meth1:123
006        var pkg.A a2 = new pkg.A(456);
007        a2.meth2(); // PRINTSaOUT: meth2:456
008        pkg.A.func(); // PRINTSaOUT: func:666
009     endMain
010  end
// END FILE:    jtw-tutorials/B.jtw
```

To avoid having to qualify each **class** name and **interface** name with it's package, you need to use the **import** directive like so before the definition of the **class** like so:

```
// BEGIN FILE: jtw-tutorials/B2.jtw
001  import pkg.*;
002
003  class B2
004  begin
005     beginMain
006        var A a1 = new A(123);
007        a1.meth1(); // PRINTSaOUT: meth1:123
008        var A a2 = new A(456);
009        a2.meth2(); // PRINTSaOUT: meth2:456
010        A.func();   // PRINTSaOUT: func:666
011     endMain
```

```
012 end
// END FILE: jtw-tutorials/B2.jtw
```

2.16.5 Importing a package from another package

When referring to a **class** or **interface** in a package you need to specify the package name: **package** pkg; at the top of the file before any actual code. Where the pkg package lives in a folder called ~/jtw-tutorials/pkg.

```
// BEGIN FILE: jtw-tutorials/pkg/C.jtw
001 package pkg;
002
003 public class C
004 begin
005     beginMain
006         var pkg.inner.A a1 = new pkg.inner.A(123);
007         a1.meth1(); // PRINTSaOUT: meth1:123
008         var pkg.inner.A a2 = new pkg.inner.A(456);
009         a2.meth2(); // PRINTSaOUT: meth2:456
010         pkg.inner.A.func(); // PRINTSaOUT: func:666
011     endMain
012 end
// END FILE: jtw-tutorials/pkg/C.jtw
```

To avoid having to qualify each **class** name or **interface** name with it's package, you need to use the **import** directive like so after the **package** declaration but before the definition of the **class** like so:

```
// BEGIN FILE: jtw-tutorials/pkg/C2.jtw
001 package pkg;
002
003 import pkg.inner.*;
004
005 public class C2
006 begin
007     beginMain
008         var A a1 = new A(123);
009         a1.meth1(); // PRINTSaOUT: meth1:123
010         var A a2 = new A(456);
011         a2.meth2(); // PRINTSaOUT: meth2:456
012         A.func(); // PRINTSaOUT: func:666
013     endMain
014 end
// END FILE: jtw-tutorials/pkg/C2.jtw
```

2.16.6 Modifying the Makefile to build a class that calls other class(es)

When your **class** X uses another **class** Y then you need to add to the build target which is initially like so:

```
build: clean
```

to what follows:

```
build: clean Y.java
```

If your **class** Y is in another **package** such as the **class** ~/jtw-tutorials/path/to/dir/Y.class i.e. in the **package** path.to.dir then you need to add to the build target like so:

```
build: clean path/to/dir/Y.java
```

This process should be repeated for every **class** that is called, directly or indirectly from your **main** **class** X. This process can be applied to build an entire package when you simply issue the command `make build`. To actually build and run the X **class**, let `~/jtw-tutorials/path2/to/dir/X.class` be the location of the X **class**. Then you need to invoke the following `Makefile` target:

```
make build path2/to/dir/X.run
```

The "`build`" target calls the "`clean`" target which deletes all ***.java** and `*.class` files directly or indirectly in the folder `~/jtw-tutorials`. If you don't do this then **java** might run an old version of `*.class` files despite earlier errors in the build process. This is because the use of pipes in building and executing `*.class` files hides the return values of the programs **javac** and **java**.

2.16.7 Running javadoc on a package

To invoke `javadoc`, you need to issue the following command from the folder `~/jtw-tutorials`:

```
make build
```

See §2.16.6 for more information about setting up the `build` target. Then you need to issue the following command from the folder `~/jtw-tutorials`:

```
javadoc path3/to/pkg -d /path4/to/dir
```

where `path3.to.pkg` is the name of the package that you want to build and `/path4/to/dir` is the desired location for your documentation files in `*.html` format.

2.17 Passwords for the J.T.W. tutorial answers

Here are the passwords for the tutorials, which are located at the following Website:

davin.50webs.com/J.T.W

The place to enter your passwords is Section 3 of the above Web page.

No.	Password
1	policefish
2	chessweta
3	tallpencil
4	freshwhale
5	sneakermagic
6	kingpump
7	lakemarmite
8	nutriciouslamps
9	sadbutter
10	skyfresh
11	fivemagpies
12	phonesheds
13	dawnsweet
14	nightroads
15	blackscrews
16	snowfrog
17	tenflower

Chapter 3

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Praise for my book: *"Davin is bright and has a deep understanding of programming matters."*, Dr Andy Cockburn, email: andy<*at*>cosc<*dot*>canterbury<*dot*>canterbury<*dot*>ac<*dot*>nz Associate Professor of the Department of Computer Science, the University of Canterbury, Christchurch, New Zealand.

Michael Pagan, email: michael<*at*>pagan<*at*>member<*dot*>fsf<*dot*>org, said of it: *"I must say, his book is very well organised and easy to understand for a beginner like me ... Once I get deep into this book, I'd like to send him my comments. Java is such a great language and to have a book that covers it in such an eloquent way while involving Emacs in the process is too much of a rarity and a delight for me to ignore."*

This book is about how to add a preprocessor to the Java language to turbo charge its performance. Both expressiveness and efficiency can be improved using a preprocessor. The preprocessor language is called *J.T.W.* which stands for *Java Training Wheels* and is intended to make it easier for novices to program in Java. The suitability of Richard Stallman's *GNU Emacs* text editor for hosting this preprocessor language is demonstrated by examples. If you are especially clever, you can write your own Emacs Lisp **d-defmacro**s to replace blocks of tiresome repetitive "boilerplate" code in Java. A small collection of **d-defmacro**s have been written for you to deploy in your client code.

Davin Pearson was born in 1973 and is an ex-Computer Science tutor from the University of Canterbury, Christchurch, New Zealand. He has three and a half years of experience tutoring Stage I Computer Science programming courses to computer programming novices. He is probably New Zealand's foremost exponent of GNU Emacs having used it for 20 years (Happy Anniversary Emacs!) and having written over 55,000 lines of Emacs Lisp customisation code some of which he has published. While on his beloved computer he enjoys listening to music of all genres and while not on his computer he enjoys reading literature of all genres. For more information please visit his personal Website at davin.50webs.com. Photograph ©2017 Simone Pearson.

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