

CSSE3100 Crib Sheet

Exam Format

The confirmed format of the exam is:

- Q1 weakest precondition reasoning.
 - Q2 method specification and loop invariants.
 - Q3 recursion and termination metrics.
 - Q4 classes and data structures.
 - Q5 lemmas and functional programming
- This section will be removed before the exam

Question 1

- book Default is two-sided.
- report No `\part` divisions.
- article No `\part` or `\chapter` divisions.
- letter Letter (?).
- slides Large sans-serif font.

Question 5

Lemmas

```
lemma name( $x_1 : T, x_2 : T, \dots, x_n : T$ )
  requires P
  ensures R
```

{ }

Lemmas can be called in a method to **prove** the lemmas property from that point onwards.

Weakest Precondition

$\text{wp}(M(E), Q) = P[x \in E] \ \&\& \ (R[x \in E] \implies Q)$

Calc

To prove a lemma by hand, you can add a **calc** section into the lemmas body, where γ is the default transitive operator between lines.

```
calc  $\gamma$  {
  5 * (x + 3);
  == 5 * x + 5 * 3;
  == 5x + 15;
}
```

You can use any transitive operator between lines (e.g. \implies). If no default operator is specific, the default is \implies . The **calc** statements can also be added inline within a method instead of creating and calling a lemma.

Induction

Lemmas can also be used to prove using induction by recursively calling the lemma in the body. E.g.

```
lemma SumLemma(a: array<int>, i: int, j: int)
  requires P
  ensures R
{
  if i == j { } // base case: Dafny can prove
  else {
    SumLemma(a, i+1, j); // inductive case
  }
}
```

Functional Programming

Key features:

- Program structures as mathematical functions
- Data is immutable (i.e. no heap, no side effects)

Match

Match is dafny's version of a switch statement, but it must cover all cases.

```
match x
case  $c_1$ 
case  $c_2$ 
...
case  $c_n$ 
```

Discriminators

Discriminators can be used to check if a variable is a given type. E.g. `xs.Nil?` checks if `xs` is type `Nil`.

Destructors

Destructors are used to access data in a composite datatype. E.g. for a variable `xs` of the datatype **datatype** `List<T> = Nil — Cons(head: T, tail: List<T>)`, `head` can be accessed using `xs.head`. Similarly `tail` can be accessed using `xs.tail`.

Intrinsic vs Extrinsic Property

- An intrinsic property is a property defined within a specification.
- An extrinsic property is a property defined externally using a lemma.
- Methods in Dafny are opaque, so all properties in the specification are intrinsic.
- Functions are transparent, so properties can be intrinsic or extrinsic.
- Intrinsic properties are available every time we apply a function, whereas extrinsic properties are only available if we call the lemma.
- Having all properties exposed intrinsically can lead to long verification times, so only define properties intrinsically if they will be required for all applications of the function.

Common documentclass options

10pt/11pt/12pt	Font size.
letterpaper/a4paper	Paper size.
twocolumn	Use two columns.
twoside	Set margins for two-sided.
landscape	Landscape orientation. Must use <code>dvips -t landscape</code> .
draft	Double-space lines.
Usage:	<code>\documentclass[opt,opt]{class}</code> .

Packages

fullpage Use 1 inch margins.
any size Set margins: `\margin size{l}{r}{t}{b}`.
multicol Use n columns: `\begin{multicols}{n}`.
latexp Use L^AT_EX symbol font.
graphicx Show image: `\includegraphics[width=x]{file}`.
url Insert URL: `\url{http://...}`.
Use before `\begin{document}`. Usage: `\usepackage{package}`

Title

`\author{text}` Author of document.
`\title{text}` Title of document.
`\date{text}` Date.
These commands go before `\begin{document}`. The declaration `\maketitle` goes at the top of the document.

Miscellaneous

`\pagestyle{empty}` Empty header, footer and no page numbers.
`\tableofcontents` Add a table of contents here.

Document structure

<code>\part{title}</code>	<code>\subsubsection{title}</code>
<code>\chapter{title}</code>	<code>\paragraph{title}</code>
<code>\section{title}</code>	<code>\subparagraph{title}</code>
<code>\subsection{title}</code>	

Use `\setcounter{secnumdepth}{x}` suppresses heading numbers of depth $> x$, where `chapter` has depth 0. Use a `*`, as in `\section*{title}`, to not number a particular item—these items will also not appear in the table of contents.

Text environments

`\begin{comment}` Comment (not printed). Requires `verbatim` package.
`\begin{quote}` Indented quotation block.
`\begin{quotation}` Like `quote` with indented paragraphs.
`\begin{verse}` Quotation block for verse.

Lists

`\begin{enumerate}` Numbered list.
`\begin{itemize}` Bulleted list.
`\begin{description}` Description list.
`\item text` Add an item.
`\item[x] text` Use x instead of normal bullet or number. Required for descriptions.

References

`\label{marker}` Set a marker for cross-reference, often of the form `\label{sec:item}`.
`\ref{marker}` Give section/body number of marker.
`\pageref{marker}` Give page number of marker.
`\footnote{text}` Print footnote at bottom of page.

Floating bodies

`\begin{table}[place]` Add numbered table.
`\begin{figure}[place]` Add numbered figure.
`\begin{equation}[place]` Add numbered equation.
`\caption{text}` Caption for the body.

The *place* is a list valid placements for the body. `t=top`, `h=here`, `b=bottom`, `p=separate page`, `!=place even if ugly`. Captions and label markers should be within the environment.

Text properties

Font face

Command	Declaration	Effect
<code>\textrm{text}</code>	<code>{\rmfamily text}</code>	Roman family
<code>\textsf{text}</code>	<code>{\sffamily text}</code>	Sans serif family
<code>\texttt{text}</code>	<code>{\ttfamily text}</code>	Typewriter family
<code>\textmd{text}</code>	<code>{\mdseries text}</code>	Medium series
<code>\textbf{text}</code>	<code>{\bfseries text}</code>	Bold series
<code>\textup{text}</code>	<code>{\upshape text}</code>	Upright shape
<code>\textit{text}</code>	<code>{\itshape text}</code>	<i>Italic shape</i>
<code>\textsl{text}</code>	<code>{\slshape text}</code>	<i>Slanted shape</i>
<code>\textsc{text}</code>	<code>{\scshape text}</code>	SMALL CAPS SHAPE
<code>\emph{text}</code>	<code>{\em text}</code>	<i>Emphasized</i>
<code>\textnormal{text}</code>	<code>{\normalfont text}</code>	Document font
<code>\underline{text}</code>		<u>Underline</u>

The command (`tttt`) form handles spacing better than the declaration (`tttt`) form.

Font size

<code>\tiny</code>	<code>tiny</code>	<code>\Large</code>	Large
<code>\scriptsize</code>	<code>scriptsize</code>	<code>\LARGE</code>	LARGE
<code>\footnotesize</code>	<code>footnotesize</code>		
<code>\small</code>	<code>small</code>	<code>\huge</code>	huge
<code>\normalsize</code>	<code>normalsize</code>		
<code>\large</code>	<code>large</code>	<code>\Huge</code>	Huge

These are declarations and should be used in the form `{\small ...}`, or without braces to affect the entire document.

Verbatim text

<code>\begin{verbatim}</code>	Verbatim environment.
<code>\begin{verbatim*}</code>	Spaces are shown as <code>␣</code> .
<code>\verb!text!</code>	Text between the delimiting characters (in this case ‘!’) is verbatim.

Justification

Environment	Declaration
<code>\begin{center}</code>	<code>\centering</code>
<code>\begin{flushleft}</code>	<code>\raggedright</code>
<code>\begin{flushright}</code>	<code>\raggedleft</code>

Miscellaneous

`\linespread{x}` changes the line spacing by the multiplier *x*.

Text-mode symbols

Symbols

<code>&</code>	<code>\&</code>	<code>_</code>	<code>_</code>	<code>...</code>	<code>\ldots</code>	<code>•</code>	<code>\textbullet</code>
<code>\$</code>	<code>\\$</code>	<code>^</code>	<code>\^{}{}</code>	<code> </code>	<code>\textbar</code>	<code>\</code>	<code>\textbackslash</code>
<code>%</code>	<code>\%</code>	<code>~</code>	<code>\~{}{}</code>	<code>#</code>	<code>\#</code>	<code>§</code>	<code>\S</code>

Accents

<code>ò \’o</code>	<code>ó \’o</code>	<code>ô \’o</code>	<code>õ \’o</code>	<code>ō \=o</code>
<code>ô \.o</code>	<code>ö \”o</code>	<code>q \c o</code>	<code>õ \v o</code>	<code>ó \H o</code>
<code>ç \c c</code>	<code>ø \d o</code>	<code>ø \b o</code>	<code>öo \t oo</code>	<code>œ \oe</code>
<code>Œ \OE</code>	<code>æ \ae</code>	<code>Æ \AE</code>	<code>â \aa</code>	<code>Å \AA</code>
<code>ø \o</code>	<code>Ø \O</code>	<code>ı \l</code>	<code>L \L</code>	<code>ı \i</code>
<code>j \j</code>	<code>i \i</code>	<code>ı \i</code>	<code>ı \i</code>	

Delimiters

<code>‘ ‘ ‘ ‘</code>	<code>{ \{</code>	<code>[[((</code>	<code>< \textless</code>
<code>, , ” ”</code>	<code>} \}</code>	<code>]]))</code>	<code>> \textgreater</code>

Dashes

Name	Source	Example	Usage
hyphen	-	X-ray	In words.
en-dash	--	1–5	Between numbers.
em-dash	---	Yes—or no?	Punctuation.

Line and page breaks

<code>\</code>	Begin new line without new paragraph.
<code>*</code>	Prohibit pagebreak after linebreak.
<code>\kill</code>	Don’t print current line.

`\pagebreak` Start new page.
`\noindent` Do not indent current line.

Miscellaneous

<code>\today</code>	May 27, 2024.
<code>\sim\$</code>	Prints <code>~</code> instead of <code>\~{}</code> , which makes <code>~</code> .
<code>~</code>	Space, disallow linebreak (W.J.~Clinton).
<code>\@.</code>	Indicate that the <code>.</code> ends a sentence when following an uppercase letter.
<code>\hspace{l}</code>	Horizontal space of length <i>l</i> (Ex: <i>l</i> = 20pt).
<code>\vspace{l}</code>	Vertical space of length <i>l</i> .
<code>\rule{w}{h}</code>	Line of width <i>w</i> and height <i>h</i> .

Tabular environments

tabbing environment

`\=` Set tab stop. `\>` Go to tab stop.
Tab stops can be set on “invisible” lines with `\kill` at the end of the line. Normally `\` is used to separate lines.

tabular environment

<code>\begin{array}[pos]{cols}</code>	
<code>\begin{tabular}[pos]{cols}</code>	
<code>\begin{tabular*}[width][pos]{cols}</code>	

tabular column specification

<code>l</code>	Left-justified column.
<code>c</code>	Centered column.
<code>r</code>	Right-justified column.
<code>p{width}</code>	Same as <code>\parbox[t]{width}</code> .
<code>@{decl}</code>	Insert <i>decl</i> instead of inter-column space.
<code> </code>	Inserts a vertical line between columns.

tabular elements

<code>\hline</code>	Horizontal line between rows.
<code>\cline{x-y}</code>	Horizontal line across columns <i>x</i> through <i>y</i> .
<code>\multicolumn{n}{cols}{text}</code>	A cell that spans <i>n</i> columns, with <i>cols</i> column specification.

Math mode

For inline math, use `\(...\)` or `$...$`. For displayed math, use `\[...]` or `\begin{equation}`.

Superscript ^{<i>x</i>}	<code>^{\textit{x}}</code>	Subscript _{<i>x</i>}	<code>_{\textit{x}}</code>
$\frac{x}{y}$	<code>\frac{x}{y}</code>	$\sum_{k=1}^n$	<code>\sum_{k=1}^n</code>
$\sqrt[n]{x}$	<code>\sqrt[n]{x}</code>	$\prod_{k=1}^n$	<code>\prod_{k=1}^n</code>

Math-mode symbols

<code>\leq</code>	<code>\geq</code>	<code>\neq</code>	<code>\approx</code>
<code>\times</code>	<code>\div</code>	<code>\pm</code>	<code>\cdot</code>
<code>\circ</code>	<code>\circ</code>	<code>\prime</code>	<code>\cdots</code>
<code>\infty</code>	<code>\neg</code>	<code>\wedge</code>	<code>\vee</code>
<code>\supset</code>	<code>\forall</code>	<code>\forall</code>	<code>\rightarrow</code>
<code>\subset</code>	<code>\exists</code>	<code>\exists</code>	<code>\Rightarrow</code>
<code>\cup</code>	<code>\cap</code>	<code> </code>	<code>\Leftrightarrow</code>
<code>\dot a</code>	<code>\hat a</code>	<code>\bar a</code>	<code>\tilde a</code>
<code>\alpha</code>	<code>\beta</code>	<code>\gamma</code>	<code>\delta</code>
<code>\epsilon</code>	<code>\zeta</code>	<code>\eta</code>	<code>\epsilon</code>
<code>\theta</code>	<code>\iota</code>	<code>\kappa</code>	<code>\vartheta</code>
<code>\lambda</code>	<code>\mu</code>	<code>\nu</code>	<code>\xi</code>
<code>\pi</code>	<code>\rho</code>	<code>\sigma</code>	<code>\tau</code>
<code>\upsilon</code>	<code>\phi</code>	<code>\chi</code>	<code>\psi</code>
<code>\omega</code>	<code>\Gamma</code>	<code>\Delta</code>	<code>\Theta</code>
<code>\Lambda</code>	<code>\Xi</code>	<code>\Pi</code>	<code>\Sigma</code>
<code>\Upsilon</code>	<code>\Phi</code>	<code>\Psi</code>	<code>\Omega</code>

Bibliography and citations

When using `BIBTEX`, you need to run `latex`, `bibtex`, and `latex` twice more to resolve dependencies.

Citation types

<code>\cite{key}</code>	Full author list and year. (Watson and Crick 1953)
<code>\citeA{key}</code>	Full author list. (Watson and Crick)
<code>\citeN{key}</code>	Full author list and year. Watson and Crick (1953)
<code>\shortcite{key}</code>	Abbreviated author list and year. ?
<code>\shortciteA{key}</code>	Abbreviated author list. ?
<code>\shortciteN{key}</code>	Abbreviated author list and year. ?
<code>\citeyear{key}</code>	Cite year only. (1953)
All the above have an NP variant without parentheses; Ex. <code>\citeNP</code> .	

BIBTEX entry types

<code>@article</code>	Journal or magazine article.
<code>@book</code>	Book with publisher.
<code>@booklet</code>	Book without publisher.
<code>@conference</code>	Article in conference proceedings.
<code>@inbook</code>	A part of a book and/or range of pages.
<code>@incollection</code>	A part of book with its own title.
<code>@misc</code>	If nothing else fits.
<code>@phdthesis</code>	PhD. thesis.
<code>@proceedings</code>	Proceedings of a conference.
<code>@techreport</code>	Tech report, usually numbered in series.
<code>@unpublished</code>	Unpublished.

BIB_TE_X fields

address	Address of publisher. Not necessary for major publishers.
author	Names of authors, of format
booktitle	Title of book when part of it is cited.
chapter	Chapter or section number.
edition	Edition of a book.
editor	Names of editors.
institution	Sponsoring institution of tech. report.
journal	Journal name.
key	Used for cross ref. when no author.
month	Month published. Use 3-letter abbreviation.
note	Any additional information.
number	Number of journal or magazine.
organization	Organization that sponsors a conference.
pages	Page range (2,6,9--12).
publisher	Publisher's name.
school	Name of school (for thesis).
series	Name of series of books.
title	Title of work.
type	Type of tech. report, ex. "Research Note".
volume	Volume of a journal or book.
year	Year of publication.

Not all fields need to be filled. See example below.

Common BIB_TE_X style files

abbrv	Standard	abstract	alpha with abstract
alpha	Standard	apa	APA
plain	Standard	unsrt	Unsorted

The L^AT_EX document should have the following two lines just before `\end{document}`, where `bibfile.bib` is the name of the BIB_TE_X file.

```
\bibliographystyle{plain}
\bibliography{bibfile}
```

BIB_TE_X example

The BIB_TE_X database goes in a file called *file.bib*, which is processed with `bibtex` file.

```
@String{N = {Na\~ture}}
@Article{WC:1953,
  author = {James Watson and Francis Crick},
  title = {A structure for Deoxyribose Nucleic Acid},
  journal = N,
  volume = {171},
  pages = {737},
  year = 1953
}
```

Sample L^AT_EX document

```
\documentclass[11pt]{article}
\usepackage{fullpage}
\title{Template}
\author{Name}
\begin{document}
\maketitle
```

```
\section{section}
\subsection*{subsection without number}
text \textbf{bold text} text. Some math:  $\$2+2=5\$$ 
\subsection{subsection}
text \emph{emphasized text} text. \cite{WC:1953}
discovered the structure of DNA.
```

```
A table:
\begin{table}[!th]
\begin{tabular}{|l|c|r|}
\hline
first & row & data \\
second & row & data \\
\hline
\end{tabular}
\caption{This is the caption}
\label{ex:table}
\end{table}
```

```
The table is numbered \ref{ex:table}.
\end{document}
```