

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

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

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}`.
latexsym 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>ö \v o</code> | <code>ő \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>ı \i</code> | <code>¿ ?‘</code> | | |

Delimiters

| | |
|-------------------------------|--|
| <code>‘ ‘ “ “ ‘ ‘ { \{</code> | <code>[[((< \textless</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

`\begin{array}[pos]{cols}`
`\begin{tabular}[pos]{cols}`
`\begin{tabular*}[width][pos]{cols}`

tabular column specification

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

tabular elements

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

Math mode

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

| | | | |
|---------------------------------|--------------------------|-------------------------------|----------------------------|
| Superscript ^{<i>x</i>} | <code>\^{}{x}</code> | Subscript _{<i>x</i>} | <code>_{}{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. `\citeNP`.

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}
```