# SYMBOLIC SOFTWARE LAB: LATEX 2

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110111 Symbolic Software Lab, Module II
2014-11-06

# Goal of Today's Lecture

1. non-text components of scientific texts
2. what they should look like
3. how to achieve this using LaTeX

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3. how to achieve this using LaTeX

4. Please do course evaluation.

# Outline

1. Figures and Page Layout
   - Graphics
   - Tables
   - Table-Like Mathematics
2. Bibliographies
3. Short Break
4. Programming in LaTeX
5. Useful Packages and Outlook

# 1. Figures and Page Layout

## Contents

# 1. Figures and Page Layout

## Figure Examples



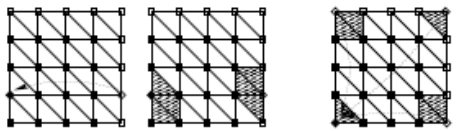

Figure 4.6. The identification of an inactive node ◊ with its active counterpart ♦ is shown on the *left*, correspondingly the support of the associated basis function is disconnected *(middle)*, leading to a different node neighborhood structure. For corner nodes *(right)*, there are even more components of the support.

our problem to $\Lambda^\delta = [0,1]^3 \supset [1/8, 7/8] = \Lambda^{\delta\beta}$, $\beta = 1/8$. Let us point out that $\Lambda^{\delta\beta}$ determines the computational cost (where the boundary layer overhead contributes by power 3). This amounts to a computational overhead of about 137 % compared to a simulation only on the evaluation domain $\Lambda^\delta$.

Table 7.38 indicates that $\beta = 1/8$ is also a useful value for non-artificial trabecular objects. The same thickness of a boundary layer to be ignored is obtained in a similar approach in [340]. The authors of [340] consider cylindrical specimens and model a standard mechanical experiment with stress-free side boundary which leads to artificial softening of the structure compared to its in situ properties.

### 4.3 Composite Finite Element Discretization

Let us now discuss the peculiarities of the CFE method used for homogenization. Periodic boundary conditions are treated in Section 4.3.1, the constraints of the form $fU = 0$ are discretized in Section 4.3.2 and an algorithm for cell problems for periodic fundamental cells is given in Section 4.3.3.

#### 4.3.1 Periodic Boundary Conditions

Periodic boundary conditions in the FE context are treated in the standard way by identifying certain degrees of freedom. In this section we describe what these identification means in the CFE context and how it is implemented.

Let us introduce some notation for the nodes involved. A node $r$ is called *inactive node* if, by periodicity assumption, the value of $u$ at $r$ is the value of $u$ at a counterpart node and thus no DOF is associated to $r$. The node to which we actually associate a DOF and that DOF will be called *active counterpart node* and *active counterpart DOF*, respectively. For an active node, the terms active counterpart node and active counterpart DOF just refer to the node/DOF itself. See Figure 4.6 for an example.

This identification of inactive DOF and their active counterparts also means identifying the associated CFE basis function, implying that the support of such basis functions is disconnected within $\Lambda^\delta$ (because it extends to an adjacent cell).





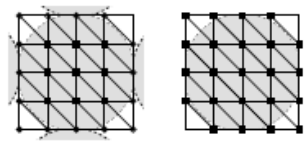

Figure 4.7. The CFE mesh for one periodic cell has the set of DOF shown as filled ■ and ♦ symbols on the *left*. For the same geometric object being the full domain (and not merely one fundamental cell), the set of DOF is shown on the *right*, showing that these two sets are mutually not contained.

In case of complicated domains, counterparts of inactive nodes are not necessarily DOF on the CFE mesh determined only on $\Lambda^\delta$, even though periodicity implies the same intersection of the domain with opposing periodic faces of $\Lambda^\delta$, see Figure 4.7 for an example. This is not surprising, however, because a CFE mesh for the periodic extension of such domains does have DOF at such positions. In summary, we observe that the sets of CFE DOF and their active counterpart DOF may be distinct in the sense that none is subset of the other, see Figure 4.7 for an example.

Periodicity in data vectors and for matrices must be taken into account when passing between the interpretation of $\Lambda^\delta$ as a single cell and a periodic cell. For simplicity (and computational efficiency, albeit at the cost of additional memory requirement), we use data structures for a full discretization of the cell $\Lambda^\delta$.

When dealing with vectors containing point values, the point value at an inactive node equals the value at its active counterpart node, so the vector entries corresponding to inactive nodes are ignored in the data vectors and set to zero. We call this operation *periodic restriction* (as opposed to the grid transfer restriction $\mathcal{R}$ in multigrid methods) and denote it by $\mathcal{Q}$, see below for a precise definition. The inverse $\mathcal{Q}^{-1}$, filling those entries back in by copying them, will be referred to as *periodic extension*.

Identifying basis functions leads to larger support for those at active boundary nodes. So, when dealing with integrated quantities in data vectors or matrices (containing integrals of basis functions or integrals of their derivatives), this is translated to adding entries at inactive nodes to those at their active counterparts. We call this operation *periodic collapsion* and denote it by $\mathcal{S}$ (as in summation).

For matrices and vectors in these periodized interpretations, we use the notation $*^\delta$. It will be clear from the context whether this means $*^\delta = \mathcal{Q}(*)$ or $*^\delta = \mathcal{S}(*)$. In the vector-valued case, the operators are applied separately to all components of a block vector or all blocks of a block matrix.

The effect of the periodic collapsing $\mathcal{S}$ on a CFE mass matrix for a complicated domain is visualized in Figure 4.8. The visualization shows the effect of DOF removed because they are periodic copies of other nodes and DOF newly introduced as explained above. In particular, using band matrices requires introducing additional

# 1. Figures and Page Layout

## Figure Examples



Table 7.4. Sample geometries ($3 \times 3 \times 3$ trabeculae) with the same diameter-to-length ratios $d/l$ in all space directions and with thinner transverse trabeculae were resolved at different resolutions. Results obtained on $9^3$ to $257^3$ grids were compared to the results for a $513^3$ grid, considering the fraction of volume segmented, and a relative $L^2$ error of the displacement for compression and shear simulations, relative to the imposed displacement.

| | $d/l = (0.2, 0.2, 0.4)$ | | | $d/l = (0.4, 0.4, 0.4)$ | | |
|---|---|---|---|---|---|---|
| grid | volume fraction | rel. error (compr.) | rel. error (shear) | volume fraction | rel. error (compr.) | rel. error (shear) |
| $9^3$ | 0.841 816 | 0.040 175 | 0.033 242 | 0.883 848 | 0.055 986 | 0.027 218 |
| $17^3$ | 0.978 785 | 0.017 572 | 0.014 527 | 0.978 967 | 0.015 301 | 0.016 932 |
| $33^3$ | 0.992 192 | 0.006 604 | 0.010 219 | 0.992 375 | 0.007 203 | 0.011 090 |
| $65^3$ | 0.997 183 | 0.002 943 | 0.004 587 | 0.997 552 | 0.003 150 | 0.004 636 |
| $129^3$ | 0.999 167 | 0.001 486 | 0.001 654 | 0.999 344 | 0.001 287 | 0.001 877 |
| $257^3$ | 0.999 823 | 0.000 616 | 0.000 510 | 0.999 868 | 0.000 443 | 0.000 561 |

Table 7.5. For numerical consistency tests we considered the domain on the *left*. Results obtained at different resolutions were compared to reference solutions computed on $513^3$ and $257^3$ grids, respectively, using pointwise $\ell^2$ and Frobenius norms for the vector-valued displacement and its derivative.

| | scalar problem | | | elasticity problem | | |
|---|---|---|---|---|---|---|
| grid | $L^\infty$ error | $L^2$ error | $H^1$ error | $L^\infty$ error | $L^2$ error | $H^1$ error |
| $17^3$ | 0.055 279 | 0.008 245 | 0.359 515 | 0.266 884 | 0.007 583 | 0.564 360 |
| $33^3$ | 0.023 502 | 0.003 393 | 0.193 077 | 0.108 070 | 0.003 046 | 0.268 633 |
| $65^3$ | 0.009 512 | 0.001 092 | 0.097 312 | 0.051 376 | 0.000 939 | 0.121 923 |
| $129^3$ | 0.004 850 | 0.000 348 | 0.048 578 | 0.049 599 | 0.000 230 | 0.056 526 |
| $257^3$ | 0.002 119 | 0.000 090 | 0.023 283 | | | |

Table 7.6. The numbers of degrees of freedom and the total memory requirement (in MiB) are listed for the complicated domain elasticity simulations for $d/l = (0.2, 0.2, 0.4)$ (*left*) in Table 7.4 as well as for the scalar and elasticity problem with discontinuous coefficients in Table 7.5 (*middle* and *right*).

| | Tab. 7.4, $d/l = (0.2, 0.2, 0.4)$ | | Tab. 7.5, scalar | | Tab. 7.5, elasticity | |
|---|---|---|---|---|---|---|
| grid | # DOF | memory | # DOF | memory | # DOF | memory |
| $9^3$ | 1 395 | 4 | | | | |
| $17^3$ | 8 163 | 14 | 4 913 | 102 | 14 739 | 137 |
| $33^3$ | 39 789 | 67 | 35 937 | 132 | 107 811 | 263 |
| $65^3$ | 213 309 | 327 | 274 625 | 262 | 823 875 | 822 |
| $129^3$ | 1 358 175 | 1 837 | 2 146 689 | 874 | 6 440 067 | 3 515 |
| $257^3$ | 9 562 185 | 10 816 | 16 974 593 | 3 814 | 50 923 779 | 16 307 |
| $513^3$ | 71 219 541 | 73 163 | 135 005 697 | 19 656 | | |





**Heat Diffusion and Linear Elasticity with Discontinuous Coefficients.** Furthermore, we considered the $3^3$ rod interface shown in Table 7.5. For this configuration we computed the solutions of a scalar boundary value problem (isotropic coefficient with kink ratio $\kappa = 42$, boundary values 0 and 1 on two opposite faces of the cube) and an elasticity problem (compression by 1 in $z$ direction, which clearly lies far outside the physical range of (even non-)linear elasticity, and material parameters $E = 5$, $\nu = 0.2$ in the rods and $E = 1$, $\nu = 0.2$ in the embedding) [281]. The solutions were computed at different resolution and compared to a reference solution obtained on a $513^3$ grid (scalar problem) and a $257^3$ grid (elasticity problem). We evaluated the $L^\infty$, $L^2$, and $H^1$ norms of the difference by midpoint quadrature now on the finest $\mathcal{G}^\Delta$. In the elasticity case, pointwise $\ell^2$ and Frobenius norms were used for differences of the vector-valued quantity and its derivatives, respectively.

We observe in both problems that convergence in $L^\infty$ is far from second order (which is due to outliers at individual quadrature points) whereas convergence in $L^2$ is closer to order 2 and in $H^1$ we have almost perfect first order convergence.

**Memory Requirements.** As in [379] we also list the number of degrees of freedom and the memory requirements for some simulations in this section.

Table 7.6 shows that, unlike in the discontinuous coefficient case, not every node of $\mathcal{N}^\square$ was assigned degrees of freedom for a complicated domain. Moreover, the elasticity problems clearly need 3 DOF per grid node. Even though the interfaces are different in the two cases, one can see that higher density of matrix entries caused by larger parent sets $\mathbb{P}(z)$ of virtual nodes $z$ and the vector-valued CFE construction weights in the discontinuous coefficient case lead to larger memory requirement compared to the complicated domain case.

### 7.1.4 Condition Numbers of CFE Matrices

Let us now extend the investigation of condition numbers for CFE matrices in [282]. For this purpose and to pronounce the influence of intersected grid cells, we considered an interface perpendicular to the $x_1$ axis located in $(0.5, 0.75)$ where the computational resolution is $5^3$ and with higher sample density near the interval boundaries. A 2D projection of this division of the unit cube in two bricks is shown in Figure 7.7, the extension in the third space direction is constant.

We considered the matrix $M + \tau L$ for $\tau = h$ arising in an implicit Euler scheme for a time-dependent heat diffusion problem and the matrix for an elasticity problem with Dirichlet boundary conditions at the top and bottom. For the complicated domain case, the diffusivity was assumed to be 1 and the material properties for linear elasticity were set to $E = 1$ Pa, $\nu = 0.33$. For the discontinuous coefficients cases, the scalar kink ratio was $\kappa = 42$, in the vector-valued case we used $(E^-, \nu^-) = (70, 0.35)$ and $(E^+, \nu^+) = (3, 0.38)$. With $E$ in GPa, these are realistic values for aluminum and PMMA. Furthermore for the discontinuous coefficient cases, we varied the scalar kink ratio and the stiffness $E^-$ for $(E^-, 0.1)$ and $(E^+, \nu^+) = (1.0, 0.3)$ for fixed geometric location of the interface.

# 1. Figures and Page Layout

## Introduction to Figures I

Figures are non-text material (but of course may contain text)

- tables
- sketches
- plots
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LaTeX has two main environments for floating objects

- `figure`
- `table`

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## Figures in LaTeX

Example:

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\begin{figure}[t]
  \centering
  [place image here]

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- some LaTeX commands are “fragile” and require `\protect` in captions

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## Page Breaks

You sometimes need to manually do page breaks

- during drafting a document to have sections start on new page
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`\clearpage`

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- starts a new page

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- starts a new page

`\cleardoublepage`

- starts on a new odd (right) page in double-sided layout

# 1. Figures and Page Layout

## Footnotes

Footnotes[1] are annotations to the text that show up on the bottom of the page.

- additional information that would interrupt the flow of the text
- sometimes (usually not in the natural sciences) used for literature references
- use with care[2]
- don't use footnotes in presentations (as I did here)

[1] such as this one

[2] If it is important, include it in the text. If it is not important, skip it. Only if it is neither, use a footnote.

# 1. Figures and Page Layout

## Contents

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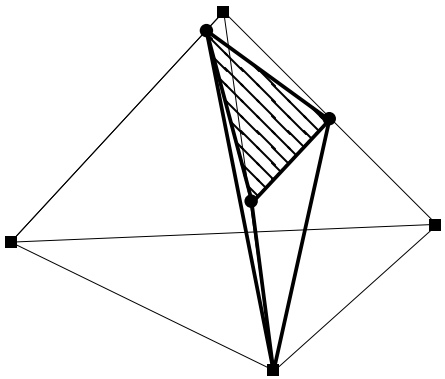
## Background on Graphic File Formats



pdfLaTeX can deal with three image formats:

**.pdf** for vector graphics

- consists of geometric objects, smooth representation
- useful for sketches and plots

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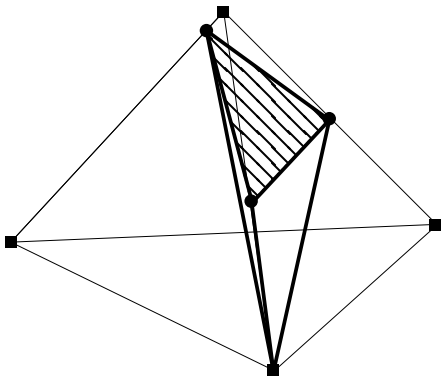

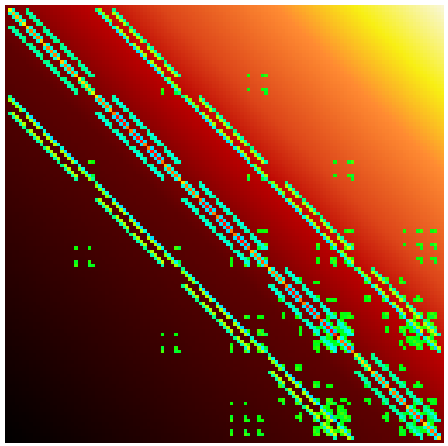

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**.png** for pixel graphics (small squares of constant color)

- lossless compression
- useful e.g. for scanned “line art”

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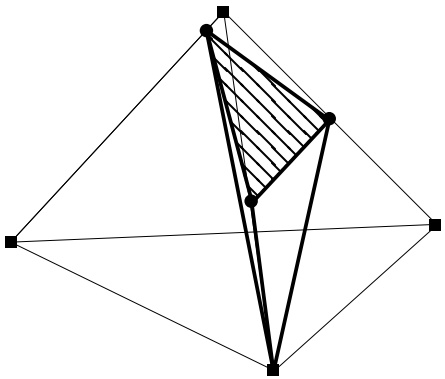

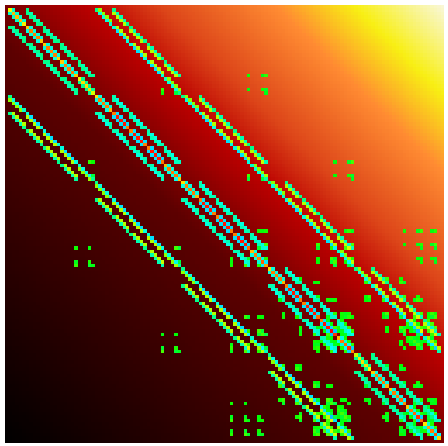

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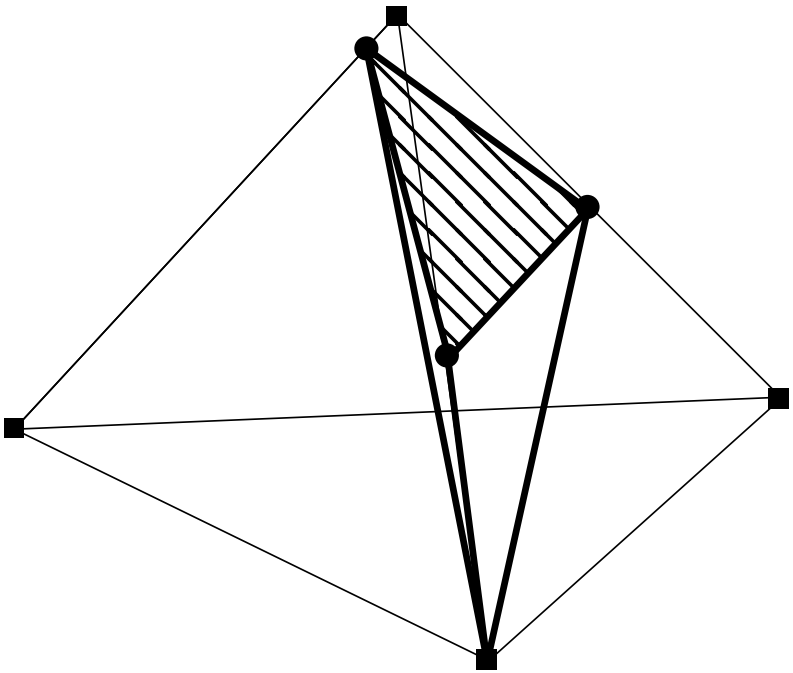
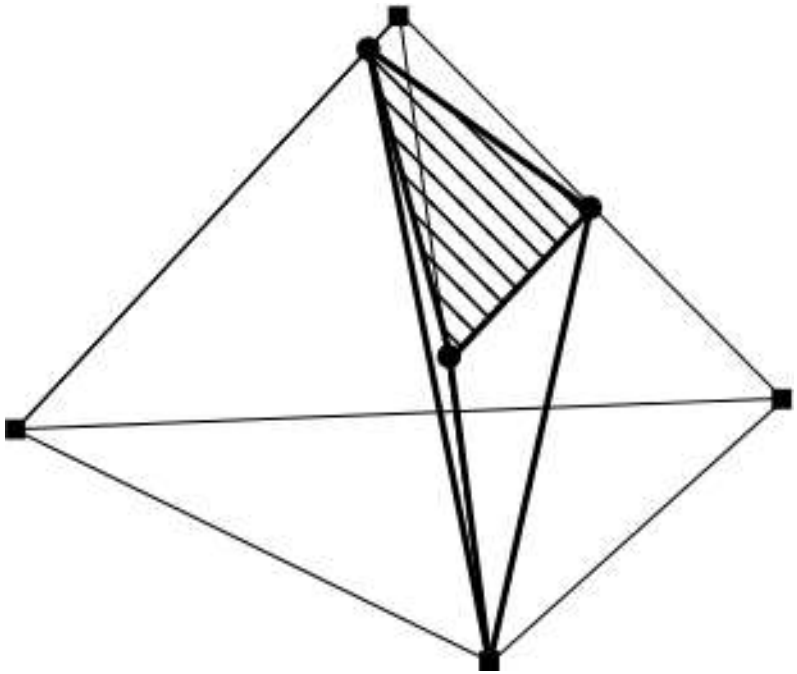
**.jpg** for pixel graphics (lossy compression)

- useful for photos (jpeg stands for “Joint Photographic Experts Group”)

# 1. Figures and Page Layout

## JPEG Artifacts





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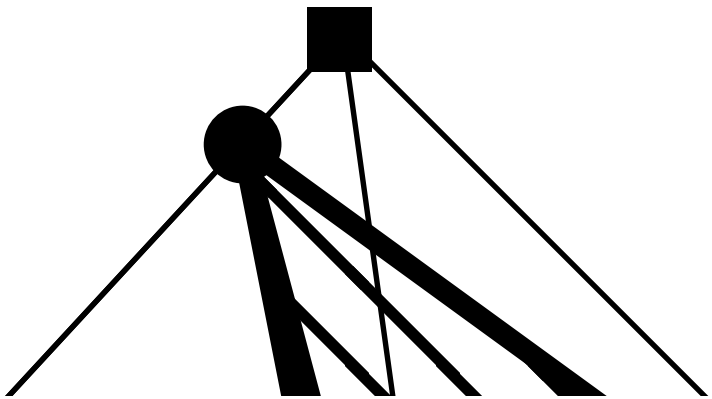

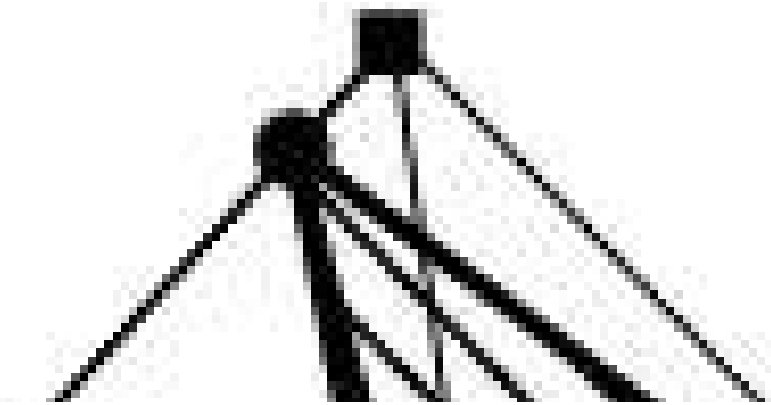

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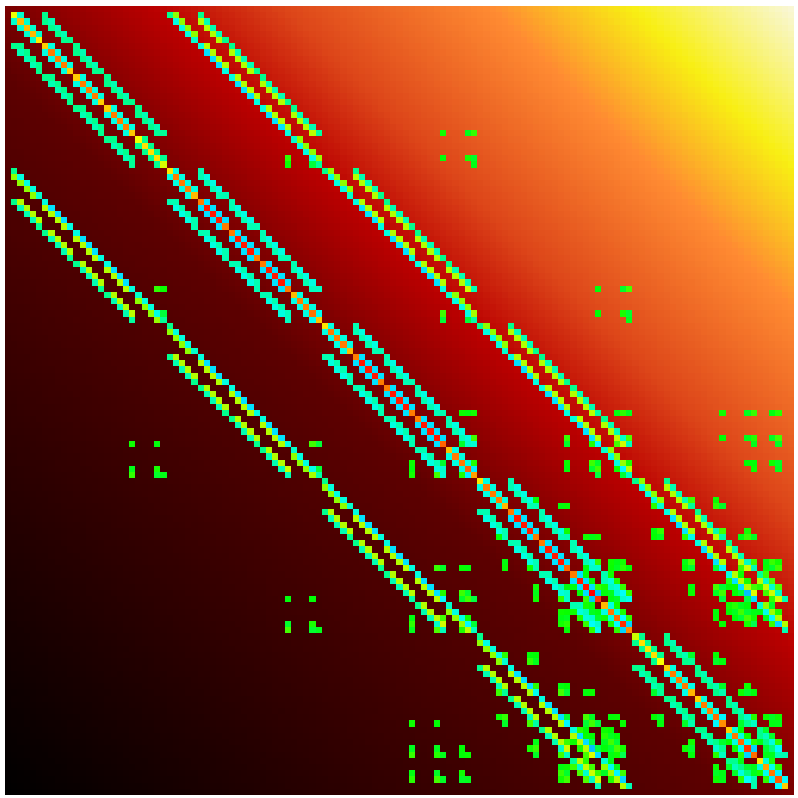

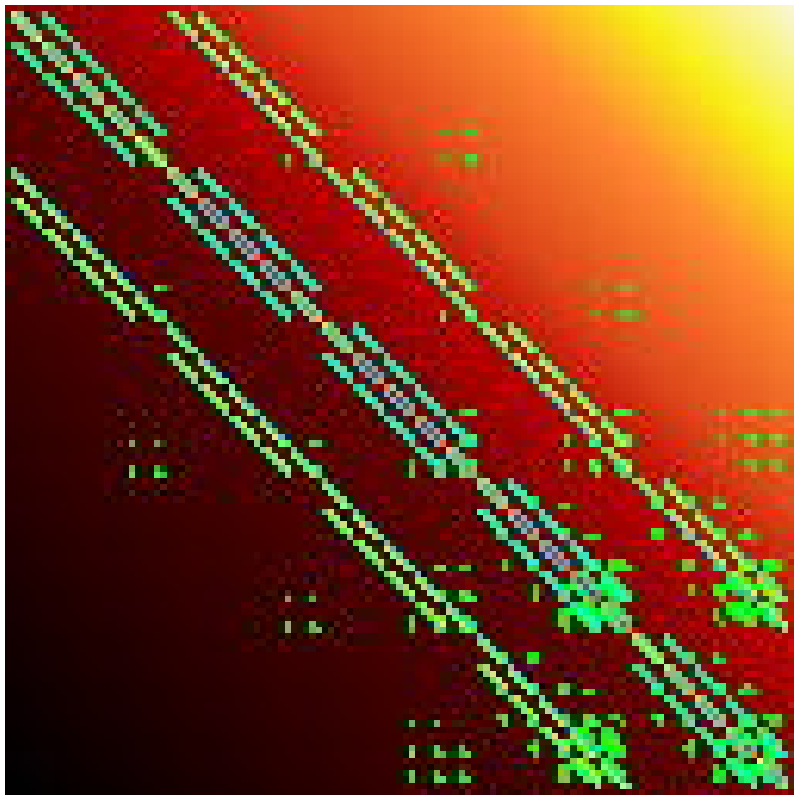

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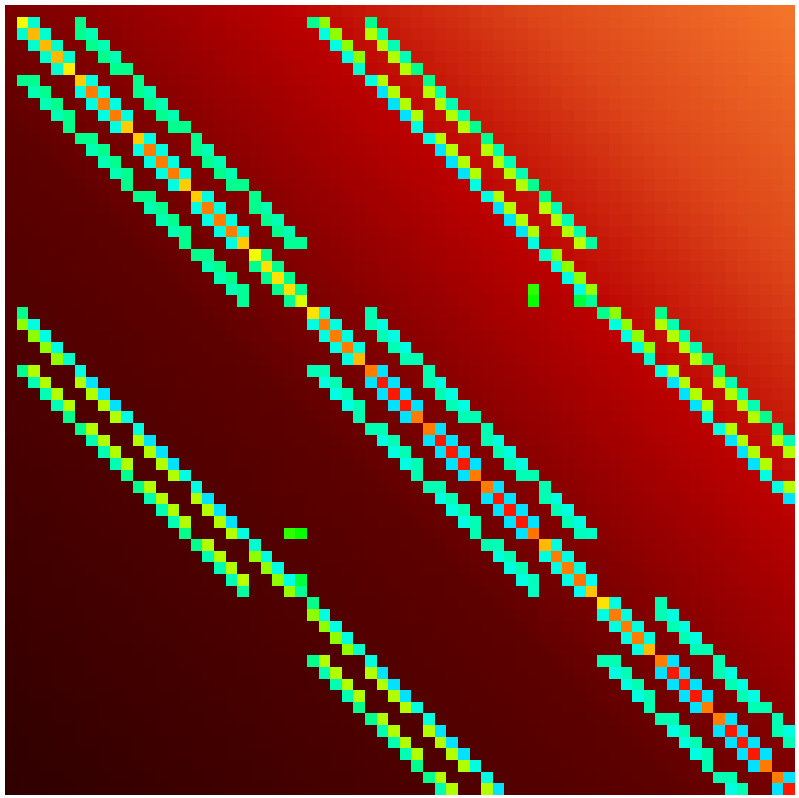

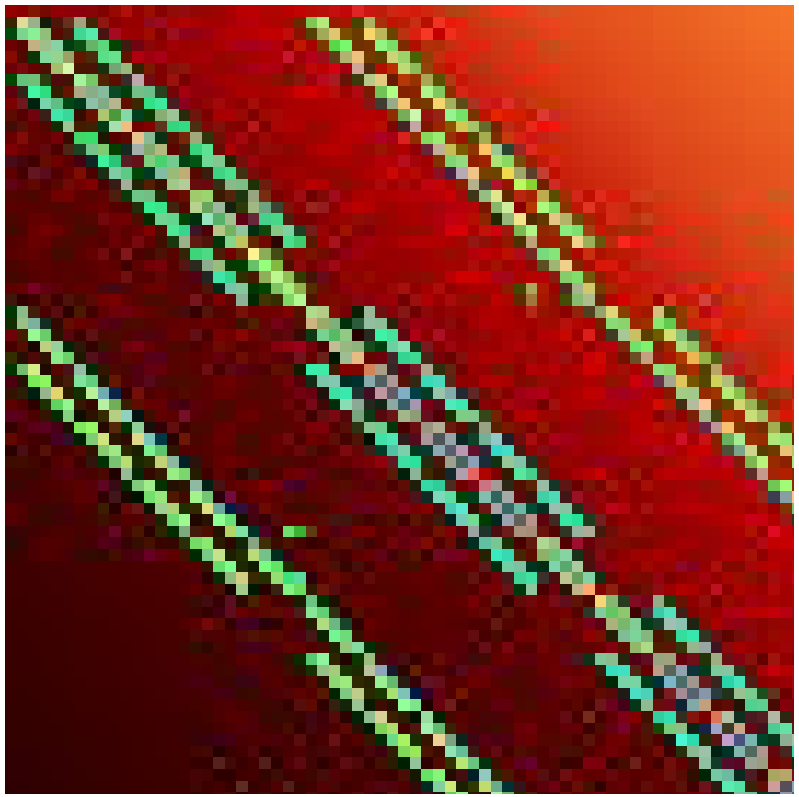

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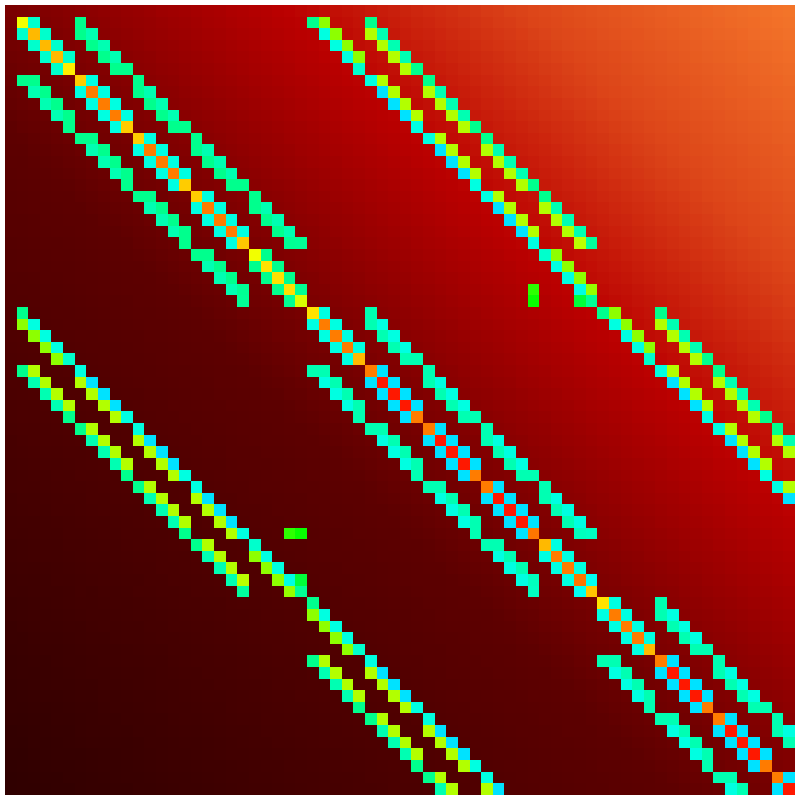

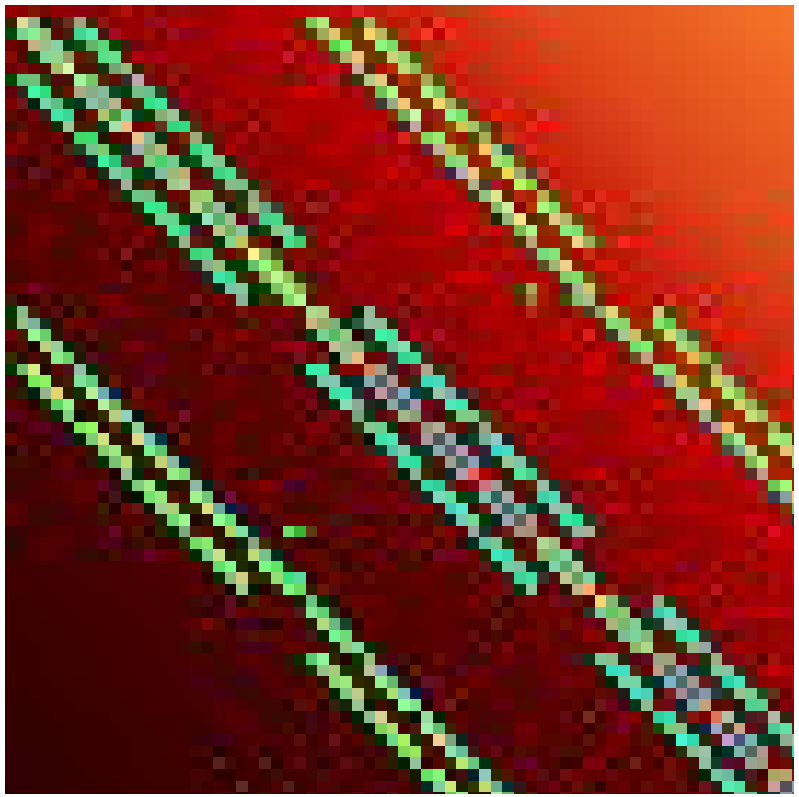

- use appropriate file formats

# 1. Figures and Page Layout

## Including Graphics in LaTeX

- in preamble

  ```
  \usepackage{graphicx}
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- crop image when including (`trim= 0mm 5mm 5mm 0mm, clip=true`)
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- rotate image (`angle=45`)

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## Example With Poor Layout

| Country | Capital City | Area | Continent |
|---|---|---|---|
| Afghanistan | Kabul | 652,230 $km^2$ | Asia |
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| Algeria | Algiers | 2,381,741 $km^2$ | Africa |
| Andorra | Andorra La Vella | 468 $km^2$ | Europe |

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- consists of rows and columns
- first row and column may be of “headline”-type
- column alignment
- lines

# 1. Figures and Page Layout

## Example With Good Layout

| Country | Capital City | Area in $km^2$ | Continent |
|---|---|---|---|
| Afghanistan | Kabul | 652,230 | Asia |
| Albania | Tirana | 28,748 | Europe |
| Algeria | Algiers | 2,381,741 | Africa |
| Andorra | Andorra La Vella | 468 | Europe |

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### Recommendations

- use appropriate alignment (left/right, centered is rarely useful)
- use no vertical lines
- use few horizontal lines
- units can go in table heading

# 1. Figures and Page Layout

## Tables in LaTeX

```
\begin{tabular}{llrl}
  Country     & Capital City     & Area in km$^{2}$ & Continent \\
  Afghanistan & Kabul            & 652,230          & Asia      \\
  Andorra     & Andorra La Vella & 468              & Europe    \\
  [...]
\end{tabular}
```

- `tabular` environment with column alignment

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- `tabular` environment with column alignment
  - `l` left, `r` right

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  - `c` centered, `|` vertical line (use with care)

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  [...]
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- `&` separates columns in one row

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\end{tabular}
```

- `tabular` environment with column alignment
  - `l` left, `r` right
  - `c` centered, `|` vertical line (use with care)
- `&` separates columns in one row
- `\\` separates rows
- you can, but don't need to align the `&` and `\\` in your input

# 1. Figures and Page Layout

## Nice Tables in LaTeX

```
\begin{tabular}{llrl}
  \toprule
  Country     & Capital City     & Area in km$^{2}$ & Continent \\
  \midrule
  Afghanistan & Kabul            & 652,230          & Asia      \\
  Andorra     & Andorra La Vella & 468              & Europe    \\
  \bottomrule
\end{tabular}
```

- this requires `\usepackage{booktabs}` in the preamble
- three types of rules available

# 1. Figures and Page Layout

## Contents

# 1. Figures and Page Layout

## Vectors and Matrices LaTeX

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \tag{1}$$

- structure-wise, matrices are “mathematical tables”

```
\left(
  \begin{array}{cc}
    a & b \\
    c & d
  \end{array}
\right)
```

- `&` and `\\` work as before
- they are usually put in brackets
  - ✘ could use `\left(, \right)`
  - ✔ there is a more convenient possibility

# 1. Figures and Page Layout

## AMS Vectors and Matrices

`\usepackage{amsmath}`

provides the `pmatrix` and `bmatrix` environments

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \qquad \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \tag{2}$$

```
\begin{pmatrix}
  a & b \\
  c & d
\end{pmatrix}
\begin{pmatrix}
  x \\ y
\end{pmatrix}
```

```
\begin{bmatrix}
  a & b \\
  c & d
\end{bmatrix}
\begin{bmatrix}
  x \\ y
\end{bmatrix}
```

- no alignment specification necessary
- again, `&` and `\\` are used

# 1. Figures and Page Layout

## Alignment in Equations

Instead of the `equation` environment, use `align`
(also provided by the `amsmath` package)

$$A_{\text{total}} = 2 \cdot A_{\text{cap}} + A_{\text{side}} \tag{3}$$

$$= 2 \cdot \pi r^2 + 2\pi rl \tag{4}$$

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```
\begin{align}
  A_{\text{total}} & = 2 \cdot A_{\text{cap}} + A_{\text{side}} \\
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\end{align}
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\end{align}
```

- again, `&` and `\\` are used
- see `amsmath` documentation for other environments
- don't use `eqnarray`

# 1. Figures and Page Layout

## Cases in Equations

The Heaviside function[3] is defined as

$$H(x) = \begin{cases} 0 & x < 0 \\ 1 & x \geq 0 \end{cases} \tag{5}$$

[3] named after the British mathematician and physicist Oliver Heaviside, 1850–1925

# 1. Figures and Page Layout

## Cases in Equations

The Heaviside function[3] is defined as

$$H(x) = \begin{cases} 0 & x < 0 \\ 1 & x \geq 0 \end{cases} \tag{5}$$

This uses the `cases` environment

```
H (x) =
\begin{cases}
  0 & x < 0 \\
  1 & x \ge 0
\end{cases}
```

- once more, `&` and `\\` are used

[3] named after the British mathematician and physicist Oliver Heaviside, 1850–1925

# 2. Bibliographies

## Contents

# 2. Bibliographies

## Introduction

What is a bibliography?

- list of other peoples' work your article/thesis/... is based on

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**Example**

Fermat's Last Theorem [1] states that no three positive integers can satisfy the equation $a^n + b^n = c^n$ for integer $n$ greater than two.

[1] Andrew Wiles. Modular elliptic curves and Fermat's last theorem. *The Annals of Mathematics*, 141(3):443–551, 1995.

# 2. Bibliographies

## Formatting

Things that need to be consistent

- format of citations in the text

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  - Fermat's Last Theorem [42] states ...
  - the experimental procedure described in [Mi86] and [DCT+05] ...
  - an overview is given in (Miller et al. 2003)

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and you don't want to do that manually for 100+ references

# 2. Bibliographies

## BibTeX and LaTeX

Separate files

- the `.tex` file
  - your document
  - `\cite{name}` literature

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  - contains entries identified by `name`
  - can be reused for other documents

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  - can be reused for other documents
- a bibliography style
  - different ones provided by your LaTeX distribution
  - defines how citations should look and be sorted

# 2. Bibliographies

## BibTeX and LaTeX Usage

- in the text, write things like

```
Fermat's Last Theorem~\cite{Wil1995} states that
```

- at the end of the document, write

```
\bibliographystyle{plain}
\bibliography{literature}
```

- the file `literature.bib` needs to contain an entry `Wil1995`

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## BibTeX and LaTeX Work Flow

Need a two-step procedure (usually done by your editor)

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## BibTeX and LaTeX Work Flow

Need a two-step procedure (usually done by your editor)

- run pdfLaTeX to write out which citations are needed
- run bibTeX to extract, format and sort entries of bibliography
- run pdfLaTeX again to input citations and print bibliography
- [**??**] and bibTeX error messages indicate missing entries

# 2. Bibliographies

## BibTeX Literature Databases

Different types of literature represented by different bibTeX entry types

- article
- book
- inproceedings
- phdthesis
- etc.

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# 2. Bibliographies

## BibTeX Literature Databases

Different types of literature represented by different bibTeX entry types

- article
- book
- inproceedings
- phdthesis
- etc.

Use a systematic way to name the entries, e.g. `FirSecThiYYYY`

Pay attention to your bibliography, even if that is a boring task!

"If this author did not even manage to copy bibliographic information, what can I expect from the rest?"

# 2. Bibliographies

## BibTeX Entry: Article Example

```
@ARTICLE{AdaBreHu2003,
  author = {Adams, Mark and Brezina, Marian and Hu, Jonathan
    and Tuminaro, Ray},
  title = {Parallel Multigrid Smoothing: Polynomial versus
    {G}auss-{S}eidel},
  journal = {Journal of Computational Physics},
  year = {2003},
  volume = {188},
  pages = {593--610},
  number = {2},
}
```

- author format is {LastName, FirstName and OtherLastName, OtherFirstName}
- bibstyle may abbreviate first names, database should contain complete names
- title may be converted to lower case (unless enclosed in {G})

# 2. Bibliographies

## BibTeX Entry: Book Example

```
@BOOK{All2002,
  title = {Shape Optimization by the Homogenization Method},
  publisher = {Springer-Verlag},
  year = {2002},
  author = {Allaire, Gr{\'{e}}goire},
  volume = {146},
  series = {Applied Mathematical Sciences},
  address = {New York},
  isbn = {0-387-95298-5}
}
```

- accents etc. should be entered in LaTeX syntax and/or carefully checked
- imagine the cited person reads your thesis and you got the name wrong . . .
- ISBN ignored by many bibstyles, but useful nonetheless

# 2. Bibliographies

## BibTeX Entry: Inproceedings Example

```
@INPROCEEDINGS{BerEppGil1990,
  author = {Bern, Marshall and Eppstein, David and
    Gilbert, John},
  title = {Provably Good Mesh Generation},
  booktitle = {Proceedings of 31st Annual Symposium
    on Foundations of Computer Science},
  year = {1990},
  pages = {231--241},
  doi = {10.1109/FSCS.1990.89542}
}
```

- DOI can create clickable hyperlink if supported by bibstyle

# 2. Bibliographies

## BibTeX Entry: PhDThesis Example

```
@PHDTHESIS{Dua1996,
  author = {Duarte, Carlos Armando},
  title = {The $hp$ cloud method},
  school = {University of Texas at Austin},
  year = {1996}
}
```

- formulas in titles etc. can be used

# 2. Bibliographies

## BibTeX Entry: Misc Example

```
@MISC{AruBroTit2012,
  title={Best Practices for Scientific Computing},
  author={Aruliah, D. A. and Brown, C. Titus and
    Hong, Neil P. Chue and others},
  note={arXiv preprint 1210.0530v2},
  year={2012}
}
```

- misc can be used for “not officially published” material
- “and others” may appear as et al.

# 2. Bibliographies

## Bibliography Entries and Files

- some publishers provide bib entries for their journals (of variable quality)

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- rather than editing bib files manually, try jabref (after this course)
  - table-view and graphical user interface
  - allows linking to pdf files and calling websites
  - allows you to keep track of literature you found at some point

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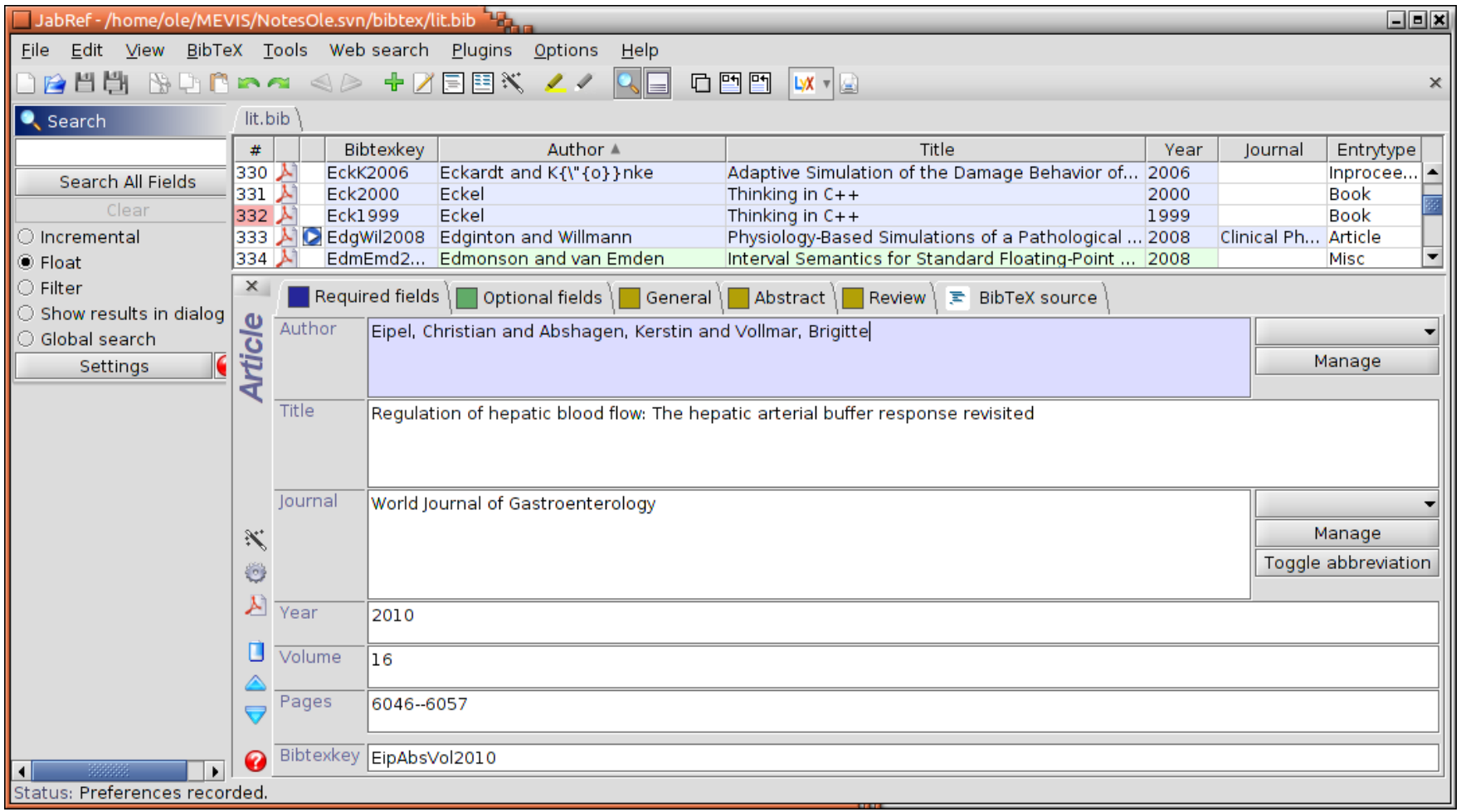
  - allows you to keep track of literature you found at some point
- when finding something useful, immediately write down where it came from

# 2. Bibliographies

## Jabref

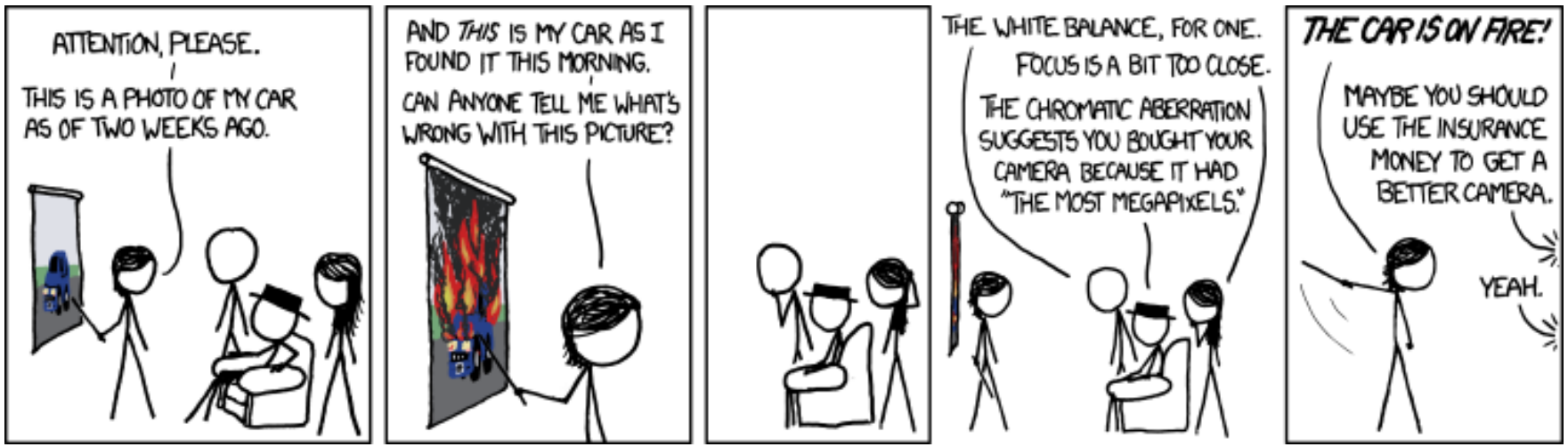


# 3. Short Break

## Contents

# 3. Short Break

## Pictures . . .




[http://xkcd.com/1014/, CC-NC-BY-2.5]

# 4. Programming in LaTeX

## Contents

# 4. Programming in LaTeX

## Defining Commands

- LaTeX is (to some extent) a programming language
- defining your own commands is sometimes useful
  - for flexible notation
  - for repeated things

# 4. Programming in LaTeX

## Defining Commands

```
\newcommand{\measTC}{\psi}
```

- allows you to write `\measTC` throughout your document and change the notation at a single position

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## Defining Commands

```
\newcommand{\measTC}{\psi}
```

- allows you to write `\measTC` throughout your document and change the notation at a single position

```
\newcommand{\fPRef}[1]{Figure~\ref{#1} on page~\pageref{#1}}
```

- `see \fPRef{fig:testPlot}` results in "see Figure 2.3 on page 42"

# 4. Programming in LaTeX

## Redefining Commands

```
\renewcommand{\thepage}{-- \roman{page} --}
```

- `\renewcommand` changes existing command

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```
\renewcommand{\thepage}{-- \roman{page} --}
```

- `\renewcommand` changes existing command
- `\thepage` prints the page number on each page
  more commands starting with `\the` exist

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# 4. Programming in LaTeX

## Redefining Commands

```
\renewcommand{\thepage}{-- \roman{page} --}
```

- `\renewcommand` changes existing command
- `\thepage` prints the page number on each page
  more commands starting with `\the` exist
- `page` (note the missing backslash) is a counter
- `\roman` prints a counter in roman numerals

# 4. Programming in LaTeX

## Defining Commands

Another example: including all of your (many) plots with the same size.

# 4. Programming in LaTeX

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Another example: including all of your (many) plots with the same size.

```
\newcommand{\includePlot}[3]{%
  \begin{figure}
    \centering
    \includegraphics[width=0.4\textwidth]{plots/#1}

    \caption{#2}\label{#3}
  \end{figure}
}
```

# 4. Programming in LaTeX

## Defining Commands

Another example: including all of your (many) plots with the same size.

```
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    \includegraphics[width=0.4\textwidth]{plots/#1}

    \caption{#2}\label{#3}
  \end{figure}
}
```

### Use Command

- `\includePlot{inputPlot.pdf}{Measured inflow concentration to aquarium}{fig:inputPlot}`
- `\includePlot{outputPlot.pdf}{Measured outflow concentration from aquarium}{fig:outputPlot}`
- `\includePlot{weightPlot.pdf}{Estimated weight of fish }{fig:weightPlot}`

# 4. Programming in LaTeX

## Working with Big Documents

- usually no problem to work on documents with 100s of pages
- you can put separate parts (sections, chapters, ...) in separate files

```
\documentclass{article}
\begin{document}
\input{introduction.tex}
\input{materialAndMethods.tex}
\input{results.tex}
\end{document}
```

# 5. Useful Packages and Outlook

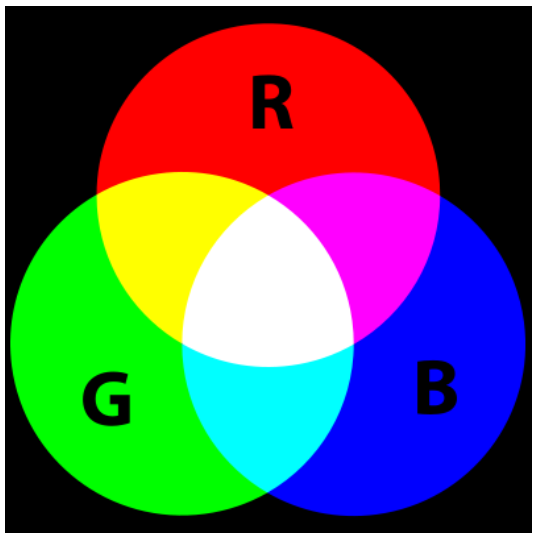
## Contents

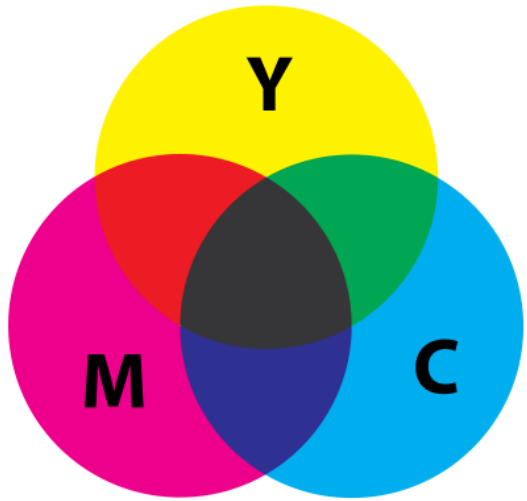
# 5. Useful Packages and Outlook

## Color

### Technical Background

- monitors and projectors (additively) mix red, green, and blue (RGB)
- printers (subtractively) mix cyan, magenta, yellow, black (CMYK)




images from http://en.wikipedia.org/wiki/File:AdditiveColor.svg and http://en.wikipedia.org/wiki/File:SubtractiveColor.svg, public domain

# 5. Useful Packages and Outlook

## Use Color With Care!

You don't know in advance

- if the reader will use a b/w printer
- if the reader is color-blind
- how color will be printed/displayed/projected

# 5. Useful Packages and Outlook

## 21 Shades of Grey

Can you distinguish all of them on this display?

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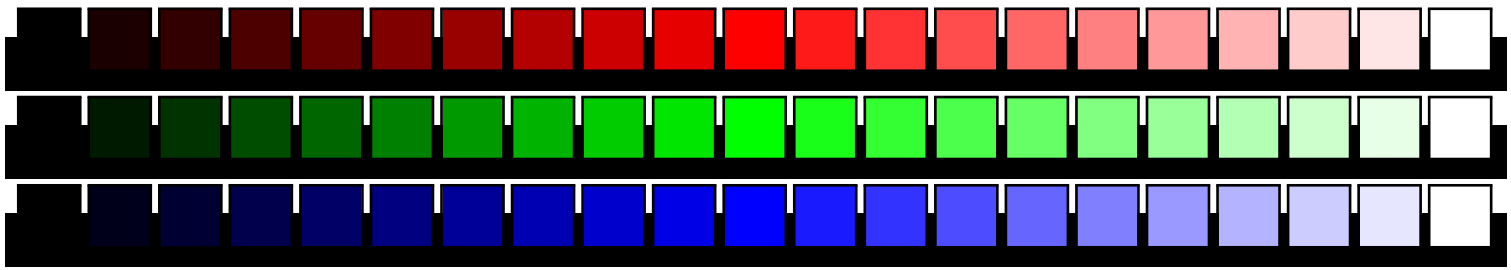
## 21 Shades of Grey

Can you distinguish all of them on this display?

What about red, green, blue?



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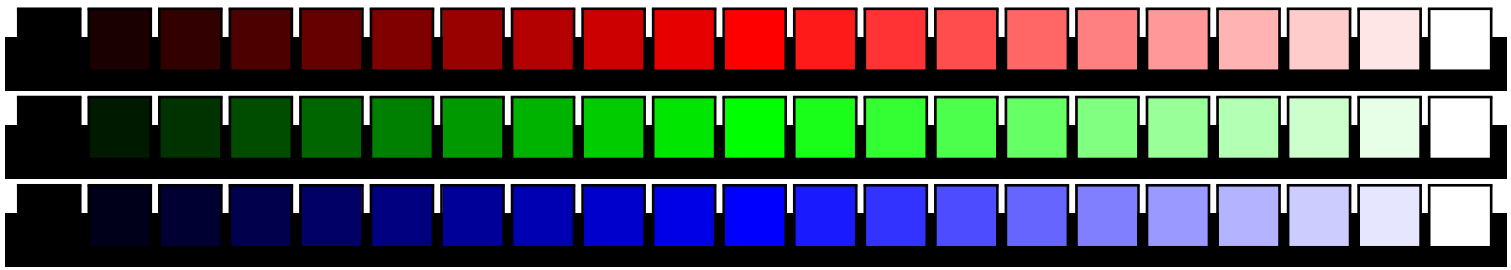
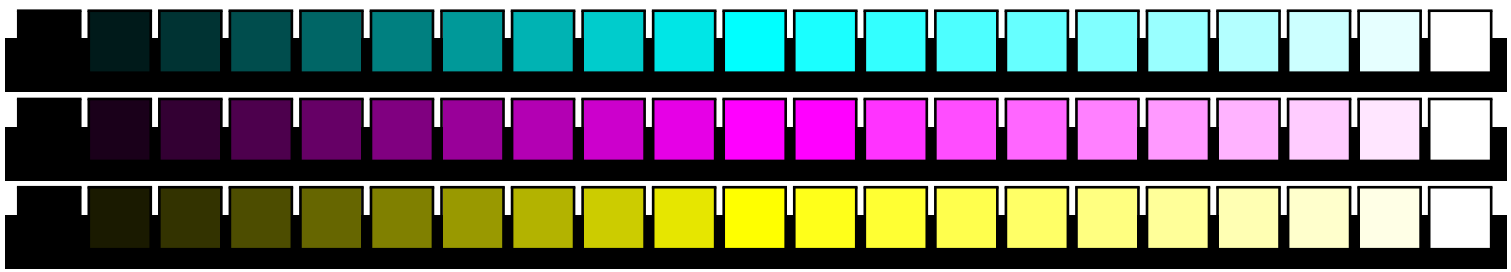


What about cyan, magenta, yellow?



# 5. Useful Packages and Outlook

## Use Color With Care!

So . . .

- think twice about using color in presentations
- think three times about using color for printed documents

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Other possibilities (in addition to or instead of color)

- use shading for areas
- solid/dashed/dotted lines, line thickness

# 5. Useful Packages and Outlook

## Using Color in LaTeX

`\usepackage{graphicx}` provides pre-defined colors

- `\textcolor{red}{text to be written in red}` uses color
- `\definecolor{myDarkRed}{rgb}{0.6,0.0,0.0}` defines a new color

# 5. Useful Packages and Outlook

## Introduction to Packages

- in the preamble, use `\usepackage{something}`
- in the text, commands provided by the package can then be used
- packages usually have documentation
  (or ask your favorite search engine)

sometimes, multiple packages define the same command (order may matter)

# 5. Useful Packages and Outlook

## Babel

`\usepackage[french]{babel}` changes language settings

- hyphenation rules
- texts like “Section”, “Table of Contents”, . . .

# 5. Useful Packages and Outlook

## Microtype

`\usepackage{microtype}`
uses some micro-typographical tricks to improve justification of text

'Margin kerning is the adjustments of the characters at the margins of a typeset text. A simplified employment of margin kerning is hanging punctuation. Margin kerning is needed for optical alignment of the margins of a typeset text, because mechanical justification of the margins makes them look rather ragged. Some characters can make a line appear shorter to the human eye than others. Shifting such characters by an appropriate amount into the margins would greatly improve the appearance of a typeset text.

Composing with font expansion is the method to use a wider or narrower variant of a font to make interword spacing more even. A font in a loose line can be substituted by a wider variant so the interword spaces are stretched by a smaller amount. Similarly, a font in a tight line can be replaced by a narrower variant to reduce the amount that the interword spaces are shrunk by. There is certainly a potential danger of font distortion when using such manipulations, thus they must be used with extreme care. The potentiality to adjust a line width by font expansion can be taken into consideration while a paragraph is being broken into lines, in order to choose better breakpoints.' [Thành 2000, p. 323]

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Compare the right margins.
(Two screenshots from R. Schlicht: The microtype package, v2.5a.)

# 5. Useful Packages and Outlook

## Hyperref

`\usepackage{hyperref}` enables clickable hyperlinks and other pdf features
Extended example usage:

```
\usepackage[colorlinks=true,
  linkcolor=black,citecolor=black,urlcolor=black,
  pdfstartview={Fit},pdfpagelayout={TwoPageRight}]{hyperref}
```

# 5. Useful Packages and Outlook

## TikZ and PGFPlots

Drawings and plots should ideally have same font (math capabilites etc.) as the text.

- LaTeX has built-in `picture` environment (neither convenient nor flexible)

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## TikZ and PGFPlots

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- better drawing and plotting from within your document via TikZ and PGFPlots

# 5. Useful Packages and Outlook

## Other Fonts

Changing fonts inside your document is not simple (because usually you shouldn't).

- `\usepackage{mathptmx}` changes serif font to Times plus matching math font
  -  Do this only if you're writing a newspaper or if you really have to.
- `\usepackage{helvet}` changes sans-serif font to Helvetica (Arial equivalent)
  -  Do this only if you have to.
- `\usepackage{courier}` changes typewriter font to Courier
- `\usepackage{mathpazo}` is what I usually use (Palatino equivalent with matching math font)

# 5. Useful Packages and Outlook

## Further Useful Packages

- for common symbols: `textcomp`, `wasysym`
- for units and prefixes: `siunitx`
- to print labels (during drafting): `showlabels`
- to print program source code listings: `listings`

# 5. Useful Packages and Outlook

## Further Useful Packages

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For other applications, ask your favorite search engine, one of the more than 3300+ packages currently available might provide a solution.

# 5. Useful Packages and Outlook

## Presentations: Beamer

`\documentclass{beamer}` can be used for presentations (such as this one).

### Basic format of Slides

```
\begin{frame}
  \frametitle{Goal of Today's Lecture}
  \begin{itemize}
  \item non-text components of scientific texts
    [...]
  \end{itemize}

\end{frame}
```

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\end{frame}
```

- format of slides very flexible
- detailed user guide available
  (contains general tips and tricks for good presentations)

# 5. Useful Packages and Outlook

## Uncovering Slides

```
\begin{frame}
  \frametitle{Background on Graphic File Formats}
  \begin{center}
    \visible<1->{\includegraphics{example-pdf-picture}}
    \visible<2->{\includegraphics{example-png-picture}}
  \end{center}

  \begin{itemize}
  \item .pdf for vector graphics\pause
  \item .png for pixel graphics
  \end{itemize}

\end{frame}
```

# 5. Useful Packages and Outlook

## Further Reading

- Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl: The not so short introduction to LaTeX 2ε (search for l2short.pdf)
  A general introduction to using LaTeX
- Markus Kohm, Jens-Uwe-Morawski: KOMA-Script, a versatile LaTeX 2ε bundle (search for scrguien.pdf)
  A detailed manual of different document classes with quite some typographical background
- Till Tantau, Joseph Wright, Vedran Miletić: The beamer class (search for beameruserguide.pdf)
  A detailed manual how to create presentations using LaTeX with tips and tricks for good presentations
- Till Tantau: The TikZ and PGF Packages (search for pgfmanual.pdf)
  A detailed manual on generating drawings in LaTeX
- Christian Feuersänger: Manual for Package pgfplots (search for pgfplots.pdf)
  A detailed manual on creating plots
- Scott Pakin: The Comprehensive LATEX Symbol List (search for symbols-a4.pdf)

# 5. Useful Packages and Outlook

## Info about In-Class Final (Tomorrow)

- 120 minutes: from 14:15 to 16:15 (be on time!)
- no late submission
- you may use your own laptop or a CLAMV computer
- when using your own computer, you are responsible for having working Mathematica and LaTeX
- you may bring and use any printed or electronic document
- you may use the internet and any search results you find, but no electronic or personal communication

# 5. Useful Packages and Outlook

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- one general question

Today's remaining lab time

- Mathematica questions: ask Zekun
- try to reproduce examples from today's lecture (Sections 1 and 2)
- Sections 3 to 5 from today's lecture not relevant for final
- Please do course evaluation.