Wissenschaftliches Arbeiten und Präsentation (WS 2019/20)

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3. Oktober 2019

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Telefonnummer (Sekr.): (0662) 8044-6328.

URL of course: `.../teaching/wiss_arbeiten/wiss_arbeiten.html`.

Lecture time: Friday 8^{00}–10^{45} (with a break of about 15–20 minutes).

Venue: PLUS, Computerwissenschaften, T01, Jakob-Haringer Str. 2.

Formalia: M. Held

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Note — graded according to continuous-assessment mode!

— regular attendance is compulsory!

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LVA-URL: http://www.cosy.sbg.ac.at/~uhl/student.html.

Abhaltezeit der LVA: Freitag 8^{00}–11^{00}.

Abhalteort der LVA: T03, Computerwissenschaften, Jakob-Haringer Str. 2.

Goals

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and that

- you'll learn where to find additional information and help if needed.

It is our sincere hope that this will help you with getting done the work more effectively which is needed for your studies.

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Symbolical Mathematics: Mathematica.

Obviously, time constraints do not allow us to discuss tons of software packages in detail. We have selected those packages according to whether we've personally found them useful for our own scientific work. All packages discussed are freely available (for students) and can be installed on any PC running Linux. (Some of them may also be available for MS-based platforms.)

Electronic Slides and Online Material

In addition to these slides, you are encouraged to consult the WWW home-page of this lecture:

http://www.cosy.sbg.ac.at/˜held/teaching/wiss_arbeiten/wiss_arbeiten.html.

In particular, this WWW page will contain links to online manuals.

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A Few Words of Warning

- I hope that these slides will help you to get acquainted with the software packages discussed. However, I would like to warn you explicitly not to regard these slides as the sole source of information on the topics of my lecture. It may and will happen that I'll use the lecture for talking about subtle details of some package that are not covered in these slides! In particular, by making these slides available to you I do not intend to encourage you to attend the lecture on an irregular basis.
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- See also In Praise of Lectures by T.W. Körner.
- Also, I hope that you will realize that most software packages dealt with in this lecture will only be fully appreciated after using them for yourself. It will be considerably more difficult to learn, say, LaTeX if you are not prepared and willing to get your hands on a computer and try it out personally.

Acknowledgments

I am happy to acknowledge that I benefited from material published by colleagues on diverse topics presented in this lecture. In particular, several sample codes (for LaTeX figures, PostScript, etc.) are borrowed from other publications. Similarly, some descriptions of software packages were copied from their respective user manuals. While some of the material used for this lecture was originally presented in traditional-style publications (such as textbooks), some other material has its roots in non-standard publication outlets (such as online documentations).

Andreas Uhl contributed slides for the first part of this course.

Information and data on publication statistics was provided by Katherine Eve (Publisher, Geochemistry and Geophysics, Elsevier Ltd.).

Salzburg, July 2019 Martin Held

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Table of Content

1. **Scientific Literature and Scientific Presentations**
    - Scientific Literature
    - Literature Search
    - Bibliographic Metrics
    - Discussion of the Current Scientific Publishing Scheme
    - Guidelines for Good Oral Presentations
    - Guidelines for Good Written Presentations
    - Ethical Issues

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- For many problems a lot of different solutions are already known and stored in the “literature”. When working on the solution of a problem in computer science one should, of course, consult the literature in order to avoid spending time on developing solution approaches that are already known.

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- Checking the literature and thinking about a solution are *alternating steps* that depend on each other and should be iterated:
  - Own attempts to solve a problem will clarify where a solution might be found in the literature.
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- For an efficient use of scientific literature it is necessary to know the *characteristics* of scientific literature and *how literature is organized*.

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- Still, in the following, we will concentrate on classical written documents when using the term “scientific literature”.

Types of Scientific Literature

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- articles in journals,
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These basic types of scientific literature have different characteristics with respect to

- authorship,
- contents,
- originality,
- production, organization,
- quality control.

Monographs

Authorship: A book has one or several authors who write the book. Upon writing a publisher has to be found for processing the book. In practice, usually a publisher is sought before the book is written. Often, scholars of high reputation are approached by publishers or editors of book series to write a book on a specific subject.

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Content: A monograph treats a specific area of computer science in a systematic and complete form. The area may be a traditional area seen under a new or specific perspective or a new area whose results are scattered in various other sources like journal articles and conference papers.

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Originality: Mostly, the results contained in a monograph are *not* new but were already published earlier in other sources. However, explaining everything in one uniform context or filling gaps in a systematic treatment etc. may be quite a creative process but it is not considered to be original research in computer science.

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Production and Organization: The authors write the book and transfer the the "copyright" to the publishing company which publishes. A certain number of copies of the book — an "edition" — is produced in one process and put on stock. The number of copies of one edition may range from a few hundreds to several thousand copies. Before a new edition is printed, authors are invited to update, improve and possibly extend the book.

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Contents and Originality: Journal articles contain *new* results within the scope of the journal. (Exceptionally, journals also publish survey articles on emerging and topical fields. Usually, such articles are "by invitation", i.e., top scholars in the respective field are asked to submit a survey). Journal articles are directed towards the relatively small group of expert readers that work in the field covered by the journal. There are approximately 1 000 "refereed" journals in the area of mathematics and computer science.

Journal Articles

Production and Organization: Like books, journals are published by publishing companies. The author prepares a manuscript and sends ("submits") it to the editor (or to one of the editors) of the journal. Sometimes the "editorial board" of a journal may be quite big – ten to fifteen people – in order to represent the scope of the journal well. (The impulse to start a new journal is a joint effort of a group of scholars who want to open a publication forum for their field of expertise and of a publishing company which sees a niche in the market.)

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If the editor accepts a manuscript after the refereeing process then it is sent to the publishing company for printing. Also, the editor may suggest an "issue" into which the paper should go. The issues of a journal appear on a regular basis, for example quarterly, bimonthly or monthly. Typically, an issue has 50–150 pages and contains several articles ("papers"). Several issues are combined in a volume; usually, a volume comprises the issues that appear in one calendar year.

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The publisher owns the copyright for the articles and no royalties are paid to the authors. (Sometimes authors are even asked to share the printing costs.) Journals are sold to "subscribers" (such as scientific libraries). Often, publishers grant reduced rates for individual subscriptions.

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4. If the paper is finally accepted it is sent to the publisher. Otherwise, it is rejected.

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Also, it is common that the referee has to judge his own level of competence in refereeing the paper (e.g. specialist, familiar with the field, ...).

Sample Referee's Form ("Computer-Aided Design")

```
Referee's comments on a manuscript for CAD journal.

Please mark the boxes which best describe your view of the paper.
----------------------------------------------------------------------

1. ORIGINALITY
[ ] Never been done before.
[ ] Never been done this way before.
[ ] Minor variation on a known technique.  (Can you cite a reference?)
[ ] Re-invention of a known technique.  (Can you cite a reference?)
----------------------------------------------------------------------
2. SIGNIFICANCE
[ ] Important problem [ ] of current interest.
[ ] Part of a problem [ ] of current interest.
[ ] An interesting insight.
[ ] Recreational.
----------------------------------------------------------------------
3. SOUNDNESS
[ ] Obviously sound.
[ ] Probably sound.
[ ] Contains errors of detail.  (What sort of errors?)
[ ] Seriously flawed.  (Where are the flaws?)
----------------------------------------------------------------------
```

Sample Referee's Form

```
4. DETAIL
[ ] Unnecessarily detailed.  (Which parts could be shortened?)
[ ] Enough for a graduate student to use the results.
[ ] Enough for the referee to use the results.
[ ] No-one could use the results.  (What's missing?)
-----------------------------------------------------------------------
5. REFERENCES
[ ] Too many background references of marginal value.
[ ] Virtually the same references the referee would have cited.
[ ] Out-of-date references: to old work only.
[ ] Shallow references: to new work only.
[ ] Totally inadequate references.  (What should be cited?)
-----------------------------------------------------------------------
6. COMPREHENSIBILITY
[ ] Understood at first reading.
[ ] Several readings required.
[ ] It would take a week to understand this paper.
-----------------------------------------------------------------------
```

Sample Referee's Form

```
7. PRESENTATION
[ ] Paper is too long.  (What could be omitted?)

[ ] Paper is well-balanced.
[ ] Paper is too short.  (What's missing?)
[ ] Rearrangement needed.  (How should the paper be arranged?)

[ ] Title not descriptive.  (Can you suggest a better title?)
[ ] Abstract not descriptive.  (What's wrong with it?)
[ ] Poor figures.  (What's wrong with them?)
-----------------------------------------------------------------------
8. RECOMMENDATION
[ ] Accept as is.
[ ] Accept after minor revision.
[ ] Major revision and further refereeing.  (What changes are
    essential?)
     [ ] I am prepared to look at a revised version.

[ ] Reject.  (What is the main reason for this recommendation?)
-----------------------------------------------------------------------

Please add any comments intended for the authors, which would explain
the problems with the manuscript and/or help them to improve it.
```

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- Still, never ever submit two (virtually) identical manuscripts to two journals in parallel. (Even competing journals tend to exchange information, and all editorial handling of your manuscripts will come to a grinding halt if multiple parallel submissions are detected.)

Articles in Collections

This is very similar to special issues of journals devoted to a specific topic.

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Production and Organization: A collection of articles is a single, independent publication. A group of scholars in cooperation with a publishing company might want to publish independent articles in a topical field. Typically, an editor is asked to organize the volume, i.e., to "solicit" papers from authors and write a "call for papers (CFP)" so that everybody who thinks (s)he might make a valuable contribution to the volume can submit a paper. Furthermore, the editor organizes the refereeing process, guides authors in the revisions, and finally makes a decision about which papers to accept and which to reject.

Conference Papers

Authorship and Originality: Similar to journal articles or articles in collections.

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- Nowadays it is common to use a web-based conference management system like EasyChair or OpenConf to handle submissions and reviewing.

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- Conferences are organized in sessions which have dedicated chairpersons.

Quality control: Obviously, quality control for conference papers cannot be as perfect as for journal papers due to the strict time schedule. Conference papers have the advantage of speedy publication and no backlog. Quality differs very much among the various conferences because the refereeing procedure may be quite different. Similarly, the acceptance rates vary drastically. As a rule of thumb, conferences organized by or under the direct auspicies of a large professional society like IEEE or ACM usually offer an excellent quality. (This comment does not apply to conferences which are just sponsered by IEEE, though.)

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Prestige: Although journal publications have a higher prestige than conference publications, it tends to be harder to get into some of the top CS conferences than into a good journal.

However, the prestige of a conference publication differs even within different fields of CS!

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Poster Presentations

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- It is important to show only the main ideas on the poster! If the poster is written using small fonts and very detailed graphics, nobody will take the time to study it thoroughly and the interest of the audience will be directed to the poster of your colleague just beside yourself. There is a tough competition at poster sessions to attract the attention of the potential audience!

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- The importance of technical reports has decreased vastly in recent years. In particular, traditional technical reports (mostly) got replaced by publications in online media, such as the archive service www.arXiv.org owned and operated by Cornell University (Ithaca, NY, USA).

Master's thesis: Demonstrates the author's ability to work with scientific literature and scientific tools in general. It usually gives an overview of a field in computer science and the discussion and solution of/to a specific problem. It is, of course, desirable to have original results in a Master's thesis but this is not mandatory by law. The quality is controlled by the thesis advisor. A Master's thesis is normally not published but may contain parts that have been published by the author elsewhere.

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Dissertation/PhD thesis: Demonstrates the author's ability to achieve original scientific results. It is mandatory to have original results in a PhD thesis and parts of it should definitely be published in modified form. The quality is controlled by the thesis advisor and a second referee. Quality control may and will differ among different schools, though.

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Habilitation thesis: Demonstrates that the author is an established researcher in his/her field of expertise. A Habilitation thesis is either a collection of already published journal and/or conference papers ("cumulative thesis") or a monograph. The quality is controlled by several (external) referees. Again, quality control may vary. Habilitation is only known in Middle Europe and, to some extent, Eastern Europe; it corresponds to achieving tenure (at the level of associate professor) at US universities.

Patent Descriptions

Contents: Description of an innovation for which a patent is sought, including a specification of the scope of the protection sought. So-called claims describe the essential features of the innovation and specify what will infringe the patent. What is patentable depends on the country where the patent application is filed.

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Patent Descriptions

- Quote from a US colleague regarding the scientific “quality” of his patent:

  As for the patent, that was initiated and written by a patent lawyer here at XYZ. When I reviewed the application that he wrote, I told him that it reads nothing like my concept. He explained that it’s not supposed to. It’s supposed to be written in legalese in such a way as to be as general as possible and still be patentable. When the patent was actually issued a few years later, I was quite surprised. I’m afraid to even read the patent for fear of what it actually says. Thus I am not sure if my actual concept is actually patented or not, but I’ll assume that it is.

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Bibliographic Data

- The bibliographic data of a publication is the information necessary
  - for the unique identification of the publication, and
  - for being able to find the publication in libraries or to order it from publishing companies, research institutions, remote libraries etc.
- From this definition and from the descriptions of the various types of publications on the previous slides the information items required to provide a complete bibliographic identification of a publication are easily inferred.

International Standard Book Number

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- Since 01-Jan-2007, thirteen-digit ISBNs are in use.
- The shift from ISBN-10 to ISBN-13 was motivated by two main reasons:
  1. To expand the numbering capacity of the ISBN system and remedy numbering shortages in some areas of the world;
  2. To align the ISBN scheme with the global EAN.UCC identification system.

- A new ISBN-13 consists of the following five elements:
  - Prefix element: Three-digit number made available by EAN International. Currently, “978” is used as prefix.
  - Registration group element: It identifies the country, geographical region, or language area. (E.g., “3” stands for “German”.)
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Each of the first 12 digits of the ISBN is alternately multiplied by 1 and 3. The check digit is equal to 10 minus the remainder resulting from dividing the sum of the weighted products of the first 12 digits by 10 with one exception. If this calculation results in an apparent check digit of 10, the check digit is 0.

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  E.g.: 978-0-11-000222 is assigned the check digit 4, since
  $9 + 21 + 8 + 0 + 1 + 3 + 0 + 0 + 0 + 6 + 2 + 6 = 56$, and
  $(10 - (56 \bmod 10)) \bmod 10 = 4$.

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- These five elements are separated by hyphens or spaces when displayed in human-readable form. Note that the middle three elements are of variable length.

Digital Object Identifiers

- The main problem of using URLs for specifying electronic documents is their lack of persistency: Since the location rather than the actual document is specified, access to a document is lost once the location of the document changes.

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- A Digital Object Identifier (DOI) provides a unique and persistent name for electronic documents.
- The document associated with a given DOI can be located by resorting to a DOI resolver, or by appending the DOI to the URL of the DOI System Proxy Server `http://dx.doi.org/`.
- DOI names can be used to identify free material as well as objects of commercial value.
- Publishers that offer online publishing programs are among the main users of the DOI system.

Bibliographic Data: Monographs

- family name, first name (initials) of the author(s),
- title,
- number of edition,
- (number of pages,)
- name of publishing company, (location of publishing company,)
- year of publication,
- ISBN,
- name of series, number of book within series (e.g. LNCS),
- family name and first name (initials) of the editor(s).

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Bibliographic Data: Journal Articles

- family name, first name (initials) of the author(s),
- title,
- name of journal,
- volume and number,
- year,
- first page and last page of the article,
- (name of publishing company, location of company).

Bibliographic Data: Articles in Collections

- family name, first name (initials) of the author(s),
- title,
- title of collection,
- family name and first name (initials) of the editor(s),
- name of publishing company, (location of publishing company,)
- year of publication,
- ISBN,
- first page and last page of the article.

Bibliographic Data: Conference Papers

- family name, first name (initials) of the author(s),
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- title of proceedings,
- (name of conference, location of conference, date of conference),
- name of publishing company, (location of publishing company,)
- family name and first name (initials) of the editor(s),
- year of publication,
- first page and last page of the paper.

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Bibliographic Data: Technical Reports

- family name, first name (initials) of the author(s),
- title,
- title of technical report series,
- number of the technical report,
- name and address of the institution publishing the series,
- year of publication.

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Bibliographic Data: Theses

- family name, first name (initials) of the author,
- title,
- name and address of research institution,
- type of thesis,
- year of publication.

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- Sample review journals:
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  - Mathematical Reviews (http://www.ams.org/publications/math-reviews/math-reviews),
  - Zentralblatt für Mathematik (https://zbmath.org),
  - SIAM Review (https://www.siam.org/Publications/Journals/SIAM-Review-SIREV).

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  - Mathematical Reviews (http://www.ams.org/publications/math-reviews/math-reviews),
  - Zentralblatt für Mathematik (https://zbmath.org),
  - SIAM Review (https://www.siam.org/Publications/Journals/SIAM-Review-SIREV).
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  - SIAM Review (https://www.siam.org/Publications/Journals/SIAM-Review-SIREV).
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- A *bibliography* on a particular area typically consists of an author index, a keyword (subject index), and a survey on the area together with literature references.

Science Citation Index and Science Citation Index Expanded

- The Science Citation Index was developed by the "Institute for Scientific Information" (ISI), then offered by Thompson Reuters, and is now owned by Clarivate Analytics.
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- Ordering at publishing companies, inter-library loan ("Fernleihe").

Science-Specific Search Engines

- Google Scholar at `https://scholar.google.com/`.
- ScienceDirect (by Elsevier) at `https://www.sciencedirect.com`
- CiteSeer (by NEC and PSU) at `http://citeseerx.ist.psu.edu/index`
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3. Send an email to the author and ask for an electronic copy of the paper. (You may also want to ask for any more recent paper on the same subject!)

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4. Ask your advisors, colleagues, and friends.
5. Send a letter to the author by conventional mail and ask for a "reprint" or a "preprint".
6. Shop around libraries.
7. Go for inter-library loan.

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1 Scientific Literature and Scientific Presentations

Journal Impact Factor and Eigenfactor

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- Its ranking scheme is similar to but more complicated than the JIF ranking. It is regarded to be more robust than the JIF ranking.

Problems With the Impact Factor

- Not all publication outlets – and not even all journals – are covered; publishers have to pay to have their journals included into the JIF ranking!
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- New branches of science have severe disadvantages.

H-Index

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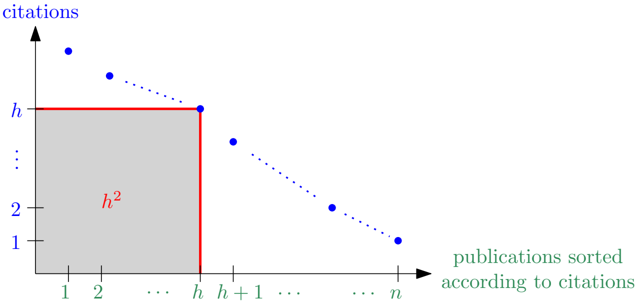

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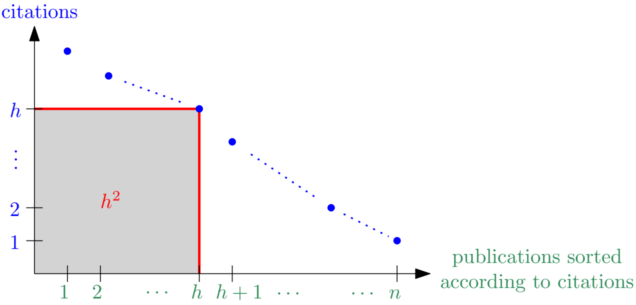

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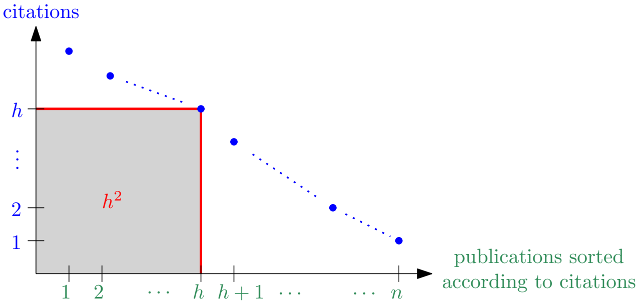

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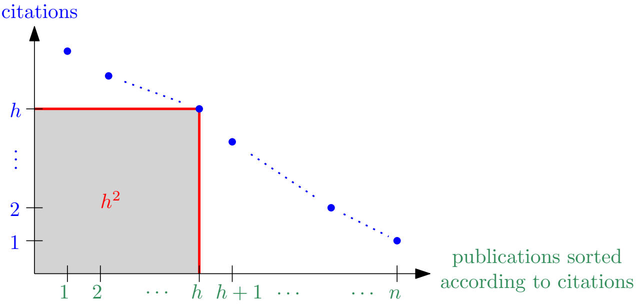

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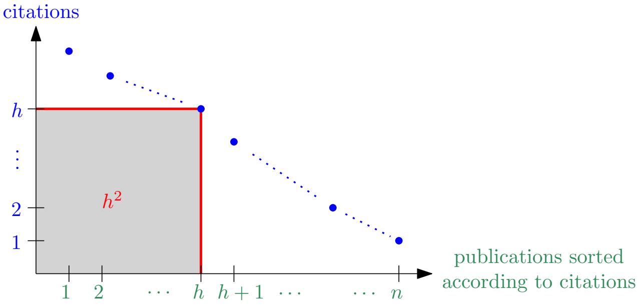

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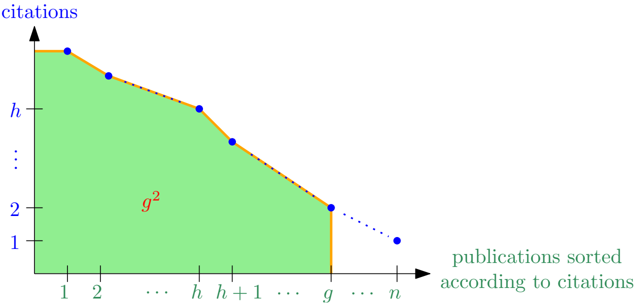

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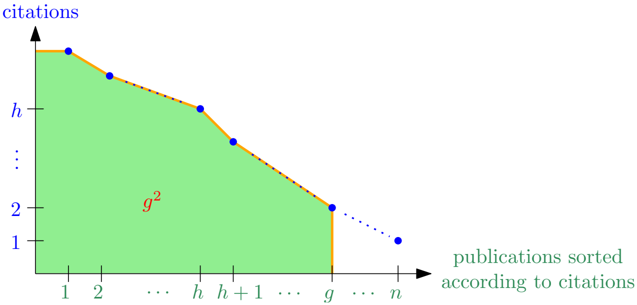

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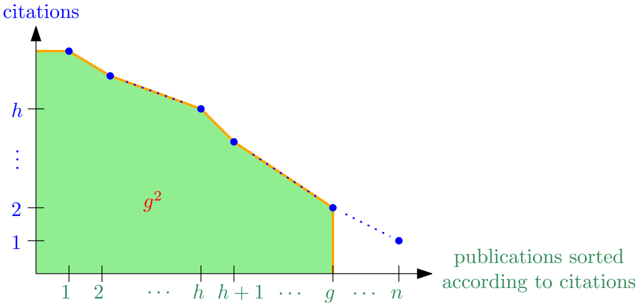

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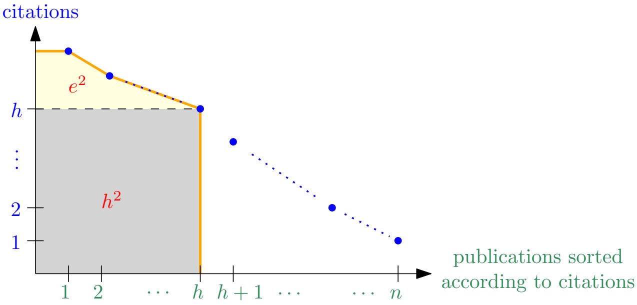

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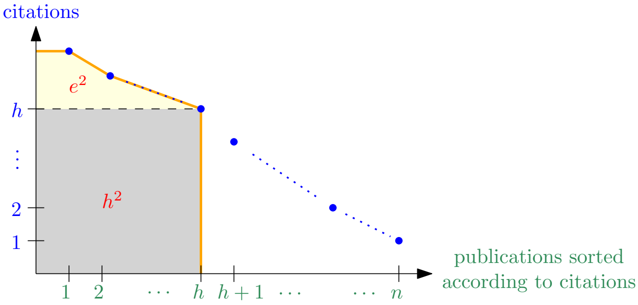

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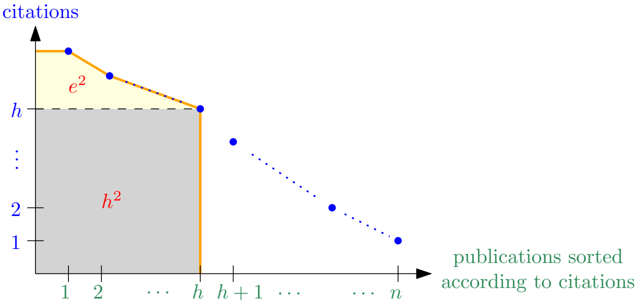

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  - Hence, the h-indices of Kurt Gödel, Albert Einstein or Evariste Galois would be disastrously low!
- In any case, all indices measure the life-time achievement of scholars. That is, they tend to increase with age!

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Problems of Citation-Based Bibliometric Indices

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- In any case, one can only compare scholars within the same discipline and based on the same database!!

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Open Researcher and Contributor ID

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- It is an alphanumeric code. E.g., Martin Held's ORCID is 0000-0003-0728-7545.
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- Starting from 01-Jan-2016, all scholars are required to provide an ORCID when submitting a grant proposal to the Austrian Science Fund (FWF).
- Other (funding) organizations, institutions, and publishers have already followed or are likely to follow.

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  - Data protection regulations require that scholars can control at any time what information is linked to their ORCID and which portion of that information is publicly available.

1. **Scientific Literature and Scientific Presentations**
   - Scientific Literature
   - Literature Search
   - Bibliographic Metrics
   - Discussion of the Current Scientific Publishing Scheme
     - Peer Reviewing
     - Drastic Increase in Number of Publications
     - Open Access
     - Publish or Perish
     - Predatory Publishing
   - Guidelines for Good Oral Presentations
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   - Ethical Issues

- The refereeing process involves the subjective opinion of individuals, and hence, of course, it cannot be completely objective. Therefore, one might have “bad luck” with incompetent or uninterested referees. On the other hand, a carefully written referee report can improve the quality of a manuscript significantly. If a referee is not an expert in the field of the paper which (s)he was asked to referee, (s)he should decline! However, every scholar should feel obliged to invest serious effort into the refereeing process since the entire community relies on this peer-review process.

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- See “We are sorry to inform you . . .” by Simone Santini, IEEE Computer, Dec. 2005, pp. 126–128, for a hilarious parody of how several great innovations in CS could easily have been rejected by ignorant reviewers. (The text on the next slide was extracted from this splendid paper.)

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- Ignorant review of "On Computable Numbers, with an Application to the Entscheidungs Problem" by Alan Turing:

  This is a bizarre paper. It begins by defining a computing device absolutely unlike anything I have seen, then proceeds to show — I haven't quite followed the needlessly complicated formalism — that there are numbers that it can't compute. As I see it, there are two alternatives that apply to any machine that will ever be built: Either these numbers are too big to be represented in the machine, in which case the conclusion is obvious, or they are not; in that case, a machine that can't compute them is simply broken!
  Any tabulating machine worth its rent can compute all the values in the range it represents, and any number computable by a function — that is, by applying the four operations a number of times — can be computed by any modern tabulating machine since these machines — unlike the one proposed here with its bizarre mechanism — have the four operations hardwired. It seems that the "improvement" proposed by Turing is not an improvement over current technology at all, and I strongly suspect the machine is too simple to be of any use.
  If the article is accepted, Turing should remember that the language of this journal is English and change the title accordingly.

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Data and Facts on Scientific Publishing

- Researchers are faced with an enormous number of publications: ISI Thomson's Science Citation Index lists about 1 000 journals that are classified as CS or math journals.
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- Quote provided by K. Eve, Elsevier Ltd., which was taken from *Neues Medicinisches Wochenblatt für Ärzte, Wundärzte, Apotheker, und Freunde der Naturwissenschaft*, as published in 1789:

  "This is truly the decade of the journal and one should seek to limit their number rather than to increase them, since there can be too many periodicals."

Open Access Publishing

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- Arguments for OA publishing:
  - Scholars can read and build on the findings of other scholars without restriction. In particular, access to prior work is not hampered by budgetary concerns.
  - Basic research often is financed by public funds. OA allows taxpayers to see the results of their investment!
  - Scholar, teachers and students have access to the latest top-notch research findings throughout the world.

Open Access Publishing: Creative Commons Licenses

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- Open access does not come for free, though: Publishing does generate costs!
- Commercial publishers offset the loss of income (due to reduced subscriptions or per-paper fees) by imposing "article processing charges" (APCs) onto the authors of an open-access paper. (Typical charges hover around 2 000 €.)

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- Funding agencies often cover APCs. However, recently FWF and several other agencies imposed caps on the maximum APC that they agree to refund.

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- In any case, getting a manuscript published has become more and more difficult, due in part to a substantial increase in the number of scholars worldwide.

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Purely Profit-Oriented Versus Scholarly Publishing

- Unfortunately, the main purpose of a few dubious conferences seems to be to form a cash cow for the organizers and some travel companies/hotels. Typically, such events are organized at spots of high touristic appeal, and fairly high registration fees and/or room rates for accommodation are charged, while the refereeing is carried out rather negligently or not at all.
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- Received from someone at XYZ in mid February of 2015 and on 26-Feb-2015:

  Dear Professor Held,
  We are organizing our conferences again in Vienna, Austria, in your beautiful country in March 15-17, 2015 (Sunday 15, Monday 16, Tuesday 17) and we would like to invite you to come as Invited Speaker from the University of Salzburg in our Conference to present an Invited Paper.
  So, select one of our conferences in Vienna via http://www.xyz.org and upload your invited paper until February 28 (Maximum 10 pages. Format see the web page of the conference).

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- Does XYZ really expect anybody to throw together a 10-page paper within a few days??

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- E.g, the OMICS Group claims to publish 700+ open-access peer-reviewed journals and organize 3 000+ conference-like events per year.

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- Check "Beall's List" Scholarly Open Access for a blacklisting of dubious conference organizers and author-pays vanity journals, and JournalGuide for a white list. (Jeffrey Beall's work is not entirely undisputed, though!)

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1 Scientific Literature and Scientific Presentations

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Oral Presentations

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  - The typical time for a conference presentation is 15–25 minutes plus 5 minutes of discussion.
  - A presentation given during an MSc final exam (here at Salzburg) is supposed to last for 15 minutes, while a presentation at a doctoral "defensio" may last about 30 minutes.

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- Availability of technical aids: video beamer, overhead projector, personal computer, Internet connection, flip-chart, blackboard, slide projector, VCR and TV set, . . .

Before planning an oral presentation the type of audience needs to be assessed and the general setting of the presentation has to be clarified:

- Audience: Scholars from your own discipline, scholars from related disciplines, students, politicians, . . .
- Available time-slot:
  - The typical time for a conference presentation is 15–25 minutes plus 5 minutes of discussion.
  - A presentation given during an MSc final exam (here at Salzburg) is supposed to last for 15 minutes, while a presentation at a doctoral “defensio” may last about 30 minutes.
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- Light conditions and structure of the lecture hall.

Oral Presentations: What is the Goal?

- The first step in planning an oral presentation is to identify the goal you want to pursue with this presentation. In this context it is not sufficient that one is aware of the subjects which should be covered by the talk.

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Main questions to be answered prior to preparing your presentation

- What can you expect the audience to know?
- What should the audience know/understand/... after listening to your presentation?
- Which activity should the audience be able to perform after listening?

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- Which activity should the audience be able to perform after listening?

- If the goal is communicated properly then a goal-driven approach delivers automatically an intrinsic motivation for listening to your presentation!

Oral Presentations: Main Guidelines

1. Scientific content:
   - You should only give an oral presentation if you have something interesting to say.
   - No chance to give a decent talk if you do not know the stuff you are supposed to talk about!

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3. Multi-media support: Visual presentation media should help to transport the content of your talk but must not replace it.
4. Presentation: Keep in mind that also a purely academic talk is a communication and consequently heavily influenced by the way it is communicated, including emotions!

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Oral Presentations: Structure

- Welcome: Who am I, where do I come from, . . .
- Introduction: Wwhat am I going to talk about;
- Structure/Contents: What is the outline of the talk, time plan;
- Main part:
  - Problem statement;
  - Problem solution;
  - Correctness, implementation, experiments;
- Conclusion;
- Acknowledgments.

Pictorial information and textual information

It is very important to realize that presentations which use *pictorial information and textual information* are significantly more effective than presentations which use only textual information.

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Oral Presentations: Visual Aids

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- Be careful when using scanned images! (And make sure to include references when using somebody else's material.)
- Animated graphics are nice but they may distract the attention of your audience from the content of your talk.

Oral Presentations: Using Graphics

Explain your graphics!

Graphics should not be considered to be self-explaining — your contribution is important!

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  - Omit everything else!
- Whatever can be seen has to be readable and understandable for the audience!
- If some entity in a graphics is too small or too difficult to be understood by the audience, or if you don't plan to explain it, then it is best to omit it completely!

Transparencies:

Pro: spontaneous;
Con: old fashioned, boring if badly prepared, wide availability increasingly uncertain.

Oral Presentations: Pros and Cons of Different Visual Media

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Flip-chart/Blackboard/Whiteboard:

Pro: interaction with audience, spontaneous;

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Video Projector:

Pro: perfect preparation, perfect graphics facilities;
Con: technical equipment may fail, presentation may give a "sterile" feeling, often presentations tend to be overloaded, careful a-priori planning of the schedule is needed.

- Too much information on one slide.

Oral Presentations: Mortal Sins When Producing Slides

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- Uses long, complicated sentence constructions: Do not read but speak without notes!!
- Walks around without any purpose.
- Stands at the same position during the entire talk.
- Hands are moving without connection to the content of the talk.

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1 Scientific Literature and Scientific Presentations

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Written Presentations

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Typically a scientific manuscript is structured as follows:

- Title Block,
- Abstract and Keywords,
- Main text,
- Bibliography.

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Written Presentations: Title Block

- The title block provides the first information on a publication and its authors:
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- The formulation of the title is a crucial issue:
  - On one hand, the reader should be able to decide on the basis of the title whether the publication is of any interest to her/him, on the other hand the title should be short and concise.
  - The title should neither be too general and nor too specific.
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- In any case, it should be clear from the title whether the publication is, e.g., an experimental study or a theoretical contribution (or both).

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Written Presentations: Abstract

- The abstract — typically one paragraph of 50–300 words — is a short description of the manuscript which should characterize the content of the paper as good as possible without the necessity to read the paper itself:
  - What has been done or achieved?
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  - Abbreviations and non-common jargon or non-common technical terms are to be avoided.
- The abstract advertises your publication; it can and should be "sexy" in order to attract the attention of a potential reader.
- However, don't overstate your claims! In particular, the abstract may not make promises that the entire manuscript fails to deliver.

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- Keywords are used for indexing the manuscript and, therefore, are very important for facilitating an efficient search for the paper. Hence, the keywords should reflect the content of the paper as closely as possible and should be neither too specific nor too general.
  - Make them informative, effective and attractive.
  - Use only well-known abbreviations.
  - Simply repeating the words of the title makes no sense!

Written Presentations: Main Text

- Introduction,
- Exact formulation of the problem,
- Exact formulation of the solution,
- Correctness considerations (if applicable),
- Implementation (if applicable),
- Experimental results and discussion (if any),
- Conclusion,
- Acknowledgments.

Written Presentations: Introduction

- Similar to the abstract, the introduction is a short description of the manuscript which contains a description of the problem and of the corresponding solution.

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- Similar to the abstract, the introduction is a short description of the manuscript which contains a description of the problem and of the corresponding solution.
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- It is important to state what has already been known and what is really new in this manuscript.
  - What are the major results of your work?
  - Why is your work better than existing solutions? (Be fair!)
  - What are the most serious limitations? (Be honest!)

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  Usually, references to existing related literature are given in the introduction.
- Distinguishing between original parts of the manuscript and already existing results is important for two reasons: “intellectual and scientific honesty” and “intellectual property protection”!

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- The structure described below is somewhat idealistic and is not followed by all scientific papers. Often, the “Black box” is omitted.
  - *Black box*: Parts of the manuscript for the “user”. Here, the problem and its solution are exactly described and sample applications are given. This is to give the user a timing advantage: (s)he should be able to take advantage of the content of the paper without necessarily going into all details that justify the solution of the problem.

Written Presentations: Formulation of the Problem and the Solution

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- Similarly, your BSc or MSc thesis does not necessarily get better if it is bloated. (But you might annoy your advisor . . .)

Written Presentations: Experiments and Discussion

- Describe the set-up of your experiments in such detail that a knowledgeable graduate student could repeat your experiments.
- In particular, describe the computing environment used for your experiments.
- Which data sets were tested? If the data is not publicly available then describe its characteristics.

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- Which data sets were tested? If the data is not publicly available then describe its characteristics.
- Make it evident how the test results are related to your work, and discuss all possible interpretations of your results.
- Refrain from claiming generalizations that are not supported by your tests.
- If your results conflict with prior art then discuss the differences and argue succinctly why the reader should believe in your results.

Written Presentations: Conclusion

Similar to the abstract, the conclusion is a short description of the manuscript. However, there are important additional features:

- We may suppose that the rest of the paper has been read.
- Specific details and cross connections to other work are emphasized.
- The conclusion refers to the results in the manuscript and thereby may "start the discussion".

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- Specific details and cross connections to other work are emphasized.
- The conclusion refers to the results in the manuscript and thereby may “start the discussion”.
- Open problems are stated.
- Possible future work in the area of the manuscript is described.

Written Presentations: Referring to Prior Publications

- When referring to the work of others, i.e., to already published material, we have to add a corresponding pointer to the entry in the bibliography which provides the bibliographics data. This usually looks like

  > *"In previous work [12], it was shown that this problem requires complex algorithms to be solved."*

  or, by involving the name(s) of the author(s),

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  "It was shown by Turing et al. [12] that this problem requires complex algorithms to be solved."

- In CS (and math) direct verbatim quotations are hardly ever used.
- In contrast to other fields, it is more essential what was stated but not how exactly it was stated. If required, a verbatim quotation would read as

  Turing [12] stated in this context: "There is no linear-time algorithm for . . ."

  or

  Turing [12] stated in this context that "there is no linear-time algorithm for . . ."

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- Note that “[12]” is only one out of many possibilities how pointers to the bibliography may look like. (Actually, this is what is produced by LaTeX’s `plain` bibliography style.)
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- The expression "et al." is only used in case of several authors (bibtex command `and others`).

Written Presentations: Style

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Written Presentations: Style

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- Failure to comply with standard rules of writing prose may result in down-grading (in case of an academic thesis) or rejection (in case of a submission to a conference or journal).
- Comment by an Elsevier editor on desk rejection: *“My rule of thumb is that if there are more than six grammatical errors in the abstract, then I don’t waste my time carefully reading the rest.”* [Thanks to K. Eve for that quote.]

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- Comment by an Elsevier editor on desk rejection: *"My rule of thumb is that if there are more than six grammatical errors in the abstract, then I don't waste my time carefully reading the rest."* [Thanks to K. Eve for that quote.]
- Keep your English sentences reasonably short and easy to parse: Native speakers of German tend to construct sentences that are far too complicated!
- In particular, avoid multiple claims or statements in one sentence.

Written Presentations: Style

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- Never use a font smaller than the standard font size for symbols in figures.
- Itemized lists, figures grouped within the text, or mathematical formulae have to be treated like standard words or groups of words.

Written Presentations: Style

- Watch the interplay of mathematical terms ("symbols") and normal text:
  - Do not start a sentence with a symbol. That is, write

    "The point P is contained in ..."

    rather than

    "P is contained in ..."

    even if it is well-known that P denotes a point.

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Written Presentations: Style

- Watch the interplay of mathematical terms (“symbols”) and normal text:
  - Do not start a sentence with a symbol. That is, write

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    even if it is well-known that P denotes a point.
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    "Since $p \in P$ we conclude that $q \notin A$ and ..."

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    "Since $p \in P$, $q \notin A$ and ...".

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    rather than

    "Since $p \in P$, $q \notin A$ and ...".
- Make sure to put LaTeX in math mode when mixing one-character variables and running text: That is, for the variable a, write "a" rather than "a".

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Written Presentations: Style

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- In any case, avoid massive use of “I/we”. (This is particularly true for the abstract.) I/we helps to emphasize own original work.
- Tense:
  - Present tense is good for known facts. Similarly, other people’s work is usually reported in present tense.
  - Past tense is used for describing the set-up and the results of one’s own experiments.
  - Similarly, authors usually write about their own original work in past tense.

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- Check for missing commas and periods.
- Watch for missing left or right parentheses in parenthetical remarks.

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Written Presentations: Grammar and Orthography

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- Check your spelling.
- When using English, decide whether to use British or American English, and stick to your decision.
- When using English words within German, decide on the interplay of German and English words, and stick to your decision.

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1 Scientific Literature and Scientific Presentations

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Ethical Issues: Plagiarism

- According to the Random House Compact Unabridged Dictionary [1995], *Plagiarism is the “use or close imitation of the language and thoughts of another author and the representation of them as one’s own original work.”*

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- Unfortunately, Austria seems to lag behind the international trend to go after plagiarism offenses.

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- See Univ. Salzburg's Richtlinien zur Sicherung guter wissenschaftlicher Praxis.
- See also the Code of Ethics of the Association for Computing Machinery (ACM).

2 LaTeX for Scientific Text Processing

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2 LaTeX for Scientific Text Processing

What is TEX?

"TEX is a new typesetting system intended for creation of beautiful books – and especially for books that contain a lot of mathematics. By preparing a manuscript in TEX format, you will be telling a computer exactly how the manuscript is to be transformed into pages whose typographic quality is comparable to that of the world's finest printers."

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- Donald Knuth was the winner of the 1974 ACM Turing Award.
- $\tau\varepsilon\chi\nu\eta$: (gr.) art.
- The design of TeX grew out of Knuth's frustration with the quality of galley proofs that he received for the second edition of "The Art of Computer Programming" in 1977.
- First version released in 1978, and rewritten from scratch till 1982.
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- Version 3.0 released in 1989.
- The version number approaches π: Knuth demanded that the "absolutely final change (to be made after my death)" will be to change the version number to π, at which point all remaining bugs shall become features. (A similar rule holds for Knuth's METAFONT, whose version number approaches *e*.)

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- Professional-quality layout;
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- All the TEX source code is publicly available;
- TEX comes for free.

"LaTeX adds to TeX a collection of commands that simplify typesetting by letting the user concentrate on the structure of the text rather than on formatting commands. In turning TeX into LaTeX, I have tried to convert a highly-tuned racing car into a comfortable family sedan. The family sedan isn't meant to go as fast as a racing car or be as exciting to drive, but it's comfortable and gets you to the grocery store with no fuss. However, the LaTeX sedan has all the power of TeX hidden under its hood, and the more adventurous driver can do everything with it that he can with TeX."

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- We are in a migration phase from LaTeX 2.09 to LaTeX3; the current version of LaTeX is called LaTeX 2_ε. (But, for the sake of simplicity, we will use the term “LaTeX” to denote the current version.)

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- LaTeX files are plain ASCII files, and your favorite text editor suffices for preparing a LaTeX document;
- LaTeX is the most widely accepted standard for writing scientific papers in the fields of computer science and mathematics;
- LaTeX is publicly available (under the LaTeX Project Public License (LPPL)), including its source code, and it comes for free.

Disadvantages of LaTeX

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- The support for non-English languages still ought to be improved;
- Complicated figures are hard to prepare using LaTeX, and require the use of some drafting package.

Books on TeX and LaTeX I

- D.E. Knuth.
  The TeXbook.
  Addison-Wesley, 1988. ISBN 978-0201134483.
- L. Lamport.
  LaTeX. A Document Preparation System. 2nd edition.
  Addison-Wesley, Nov 1994. ISBN 978-0201529838.
- F. Mittelbach et alii.
  The LaTeX Companion. 2nd edition.
  Addison-Wesley, May 2004. ISBN 978-0201362992.
- M. Goossens et alii.
  The LaTeX Graphics Companion. 2nd edition.
  Addison-Wesley, April 2007. ISBN 978-0321508928.
- H. Kopka and P.W. Daly.
  Guide to LaTeX. 4th revised edition.
  Addison-Wesley, 2003. ISBN 978-0321173850.

Books on TEX and LATEX II

- Wikibooks.
  LATEX Wikibook.
  Wikibooks, `https://en.wikibooks.org/wiki/LaTeX`.
- H. Voß.
  Einführung in LATEX: unter Berücksichtigung von pdfLATEX, XƎLATEX und LuaLATEX.
  Lehmanns Media, Feb 2012. ISBN 978-3865414625.
- M. Kohm.
  Koma-Script. 5th revised and extended edition.
  Lehmanns Media, 2014. ISBN 978-3-86541-613-1.

LaTeX Input Characters

- The input to LaTeX is an ASCII text file.
- Unless LaTeX add-on packages are used (e.g., to support UTF-8 encoding), the following characters are the only ones that normally appear in a LaTeX input file.

letters: A,. . . ,Z; a,. . . ,z;

digits: 0,. . . ,9;

punctuation chars: . : ; . ? ! ` ' " ( ) [ ] - / * @

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- Most (European) installations of LaTeX will be able to handle German "Umlaut" (and similar characters that do not belong to English) directly as part of the input. In particular, UTF-8 support has become widely available and de-facto standard.

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- Note that the percent sign (%) is interpreted by LaTeX as the start of a comment! (LaTeX will ignore the rest of a line after reading a % sign.)
- Similarly, all the other special characters have a special meaning for LaTeX.
- In order to produce any of the signs # $ % & _ { }, the sign itself has to be preceded by a back slash. That is, $ is produced by means of `\$`. Furthermore, `\textbackslash` produces \, `\textasciicircum` produces ^, and `\textasciitilde` produces ~.

Basic LaTeX Document

- The main part of a LaTeX document starts with a `\begin{document}` command and ends with `\end{document}`.
- The part of the input file preceding the command `\begin{document}` is called the *preamble*.
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- The preamble contains declarations which globally affect the appearance of the formatted text.
- LaTeX input is free-format:
  - The number of spaces (or line breaks) in the input file does not matter. One space is as good as ten spaces.
  - Also, LaTeX only cares about empty lines (that separate paragraphs), but does not care about how lines are broken between consecutive non-empty lines.

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Basic LaTeX Document

```
\documentclass[12pt,fleqn]{article}
   % Specifies the document class and the type size.
   % Also, we do not want equations to be centered.
   % The preamble begins here.
\title{\textbf{\LaTeXe\ }}
   % Declares the document's title. We request bold-face font.
\author{Martin Held}
   % Declares the author's name.
\date{October 29, 2013}
   % Deleting this command produces today's date.
\begin{document}
   % End of preamble and beginning of text.
\maketitle
   % Produces the title.
\section{Introduction}
   % Declares a section.
This is a short survey of the \LaTeXe\ typesetting system.
...
\end{document}
   % End of document. LaTeX won't read beyond this line!
```

Running LaTeX

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8. Use a device driver in order to convert the DVI file to a file that can be printed on your printer. E.g., `dvips -o foo.ps foo.dvi` in order to create PostScript.

Document Classes and Options

- Standard classes for ordinary documents are `article`, `report`, `book`, `letter`, and `slides`.
- By default every document is formatted for `10pt` types.
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- Additional document-class options include `fleqn` and `twoside`, among many others. See the LaTeX Book for details.
- User-defined options can be included, too. However, in this case the environment variable `TEXINPUTS` has to be set to the appropriate search path if a user-defined document-class option or package is not contained in the actual working directory. E.g., for `tcsh`:

  ```
  setenv TEXINPUTS .:${HOME}/figures:${TEXINPUTS}
  ```

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2 LaTeX for Scientific Text Processing

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Commands for High-Level Structuring

- A sectional unit is begun by a sectioning command with the unit's title as its argument.

```
\section{Commands for Structuring}
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- There is also an `\appendix` command, which does not directly produce text. Rather, it causes sectional units to be numbered properly for an appendix.

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- There is also an `\appendix` command, which does not directly produce text. Rather, it causes sectional units to be numbered properly for an appendix.
- Larger documents can be split into individual files, which are incorporated by `\include{...}` or `\input{...}`.
- Main difference: The command `\include{...}` causes LaTeX to start the material included on a new page.

Commands for Low-Level Structuring

- LaTeX uses a construction called *environment* in order to group portions of text that are subordinate to the surrounding text or that function as equal units.
- An environment is generated by typing the commands
  `\begin{name} ...\end{name}`,
  where `name` denotes the name of the environment.
- The `\begin` and `\end` commands delimit the scope of the environment.

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  where `name` denotes the name of the environment.
- The `\begin` and `\end` commands delimit the scope of the environment.
- Examples of environments are given by `quote`, for making quotations, `verse`, for doing poetry, and by `verbatim`, which is used for simulating typed text.

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List-Making Environments

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```
\begin{itemize}
  \item A single list item.
  \item And yet another one.
\end{itemize}
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\end{itemize}
```

- A single list item.
- And yet another one.

- And here comes an `enumerate`d list:

```
\begin{enumerate}
  \item A single list item.
  \item And yet another one.
\end{enumerate}
```

1. A single list item.
2. And yet another one.

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List-Making Environments

- In the `description` environment, the `item` command takes an optional argument:

```
\begin{description}
  \item[Foo:] A single list item.
  \item[FooFoo:] And yet another one.
\end{description}
```

Foo: A single list item.
FooFoo: And yet another one.

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3.
    a. There is a default numbering scheme for nested lists.
    b. Of course, you are free to change the default scheme if you don't like it.

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3.
   a. There is a default numbering scheme for nested lists.
   b. Of course, you are free to change the default scheme if you don't like it.
4. More customized lists can be generated by using the `list` environment. See the LaTeX Book for details.

Type Styles

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- LaTeX distinguishes between three components that specify a type style:
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  - *series* (Dt.: Stärke),
  - *family* (Dt.: Familie),

  which can be combined in order to produce more elaborate effects.
- E.g., specifying

```
\usepackage[T1]{fontenc}
\newcommand{\changefont}[3]{
\fontfamily{#1} \fontseries{#2} \fontshape{#3} \selectfont}
```

  in the preamble allows to select type styles as follows:

```
\changefont{family}{series}{shape}
```

  where `family`, `series` and `shape` stand for the font acronyms known to LaTeX.
- Then the command

```
\changefont{cmdh}{m}{n}
```

  turns on Computer Modern Dunhill.

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Type Styles

- Quite a few fancy typefaces and fonts are available; consult the LaTeX Companion for details.
- The old LaTeX 2.09 commands for changing standard type styles (e.g., `\tt`) are deprecated but they still work. In any case, the use of the new commands (e.g., `\texttt` instead of `\tt`) is encouraged.

Standard Type Styles

- Shown below are the basic type styles, together with the declarations that turn them on.

```
\textrm{This is a roman type style.}
\textbf{This is a bold type style.}
\textsf{This is a sans serif type style.}
\textsl{This is a slanted type style.}
\textsc{This is a Small Caps type style.}
\texttt{This is a typewriter type style.}
\textit{This is an italic type style.}
```

This is a roman type style.
This is a bold type style.
This is a sans serif type style.
This is a slanted type style.
THIS IS A SMALL CAPS TYPE STYLE.
`This is a typewriter type style.`
This is an italic type style.

Type Sizes

- The following declarations select a type size; they are listed below in non-decreasing size.
  - `\tiny`;
  - `\scriptsize`;
  - `\footnotesize`;
  - `\small`;
  - `\normalsize`;
  - `\large`;
  - `\Large`;
  - `\LARGE`;
  - `\huge`;
  - `\Huge`.

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  - `\tiny`;
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  - `\normalsize`;
  - `\large`;
  - `\Large`;
  - `\LARGE`;
  - `\huge`;
  - `\Huge`.
- Note that the actual type size produced by one of these size declarations depends on the default type size of the document.
- Note that some declarations may have the same effect, depending on the document class and default type size used.

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Type Sizes

- Of course, changes of type style and type size can be combined. For instance, the command `{\textit{\texttt{\LARGE word}}}` produces this *word*.

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- Note, however, that you should not expect your LaTeX installation to provide all the fonts for all imaginable combinations of type styles at all possible type sizes.
- If the `mktexpk` program is installed, `dvips` will automatically invoke METAFONT to generate fonts that do not already exist, *provided* that a METAFONT source for this font is available.

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Aligning Text in Columns

- In the `tabbing` environment, text is aligned by explicitly setting tab stops, as it is done with an ordinary typewriter.
- Tab stops are set using the `\=` command, and `\>` moves to the next tab stop.
- Lines are separated by the `\\` command.

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- Tab stops are set using the `\=` command, and `\>` moves to the next tab stop.
- Lines are separated by the `\\` command.
- The following LaTeX code produces the listing given below:

```
\begin{tabbing}
Bears: \= Kodiak Bear \= (Kodiak Island), \kill
Bears: \> Polar Bear  \> (Arctic Region),\\
       \> Kodiak Bear \> (Kodiak Island), \\
       \> Grizzly     \> (Western US, Canada).
\end{tabbing}
```

Bears:	Polar Bear	(Arctic Region),
	Kodiak Bear	(Kodiak Island),
	Grizzly	(Western US, Canada).

Aligning Text in Columns

- The `tabular` environment is somewhat similar to the `tabbing` environment.
- Columns are separated by `&`, and an input line is ended by `\\`.
- Frames can be made by requesting horizontal and vertical lines to be drawn by means of specifying `\hline` and |.

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```
\begin{tabular}{||l|c|r||} \hline
\multicolumn{3}{||c||}{Bears of the World} \\
\hline \hline
Bears & Polar Bear  & (Arctic Region) \\ \hline
      & Kodiak Bear & (Kodiak Island) \\ \cline{2-3}
      & Grizzly     & (Western US, Canada) \\
\hline \hline
\end{tabular}
```

Bears of the World		
Bears	Polar Bear	(Arctic Region)
	Kodiak Bear	(Kodiak Island)
	Grizzly	(Western US, Canada)

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Aligning Text in Columns

- Note that the `@{`*string*`}` construct makes it possible to specify the column separator. Effectively, this command kills the intercolumn space and replaces it by *string*.

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- Note that the `@{`*string*`}` construct makes it possible to specify the column separator. Effectively, this command kills the intercolumn space and replaces it by *string*.
- The following LaTeX code is a standard example for explaining how to line up decimal numbers in one decimal-point-justified column:

```
\begin{tabular}{c r @{.} l} \hline
Symbolic Term & \multicolumn{2}{c}{Numerical Value} \\ \hline
$\pi$                   & 3&1416  \\
$\pi^{\pi}$             & 36&46   \\
$(\pi^{\pi})^{\pi}$     & 80662&7 \\
\end{tabular}
```

Symbolic Term	Numerical Value
π	3.1416
π^{π}	36.46
$(\pi^{\pi})^{\pi}$	80662.7

Math Stuff

- LaTeX is especially good in displaying mathematical stuff.
- It provides the `displaymath` and `equation` environments for displaying formulae.
- These environments are the same except that `equation` numbers the formulae and `displaymath` does not number them.

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- It provides the `displaymath` and `equation` environments for displaying formulae.
- These environments are the same except that `equation` numbers the formulae and `displaymath` does not number them.
- For shorthand, `\[ ...\]` may be typed instead of `\begin{displaymath} ...\end{displaymath}`.

$$x' + y^2 = z_1^2$$

```
\[ x' + y^{2} = z_{1}^{2} \]
```

Math Stuff

- A numbered equation:

$$x' + y^2 = z_2^2 \tag{1}$$

```
\begin{equation} \label{eq:foo}
   x' + y^{2} = z_{2}^{2}
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```

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- A numbered equation:

$$x' + y^2 = z_2^2 \tag{1}$$

```
\begin{equation} \label{eq:foo}
   x' + y^{2} = z_{2}^{2}
\end{equation}
```

- A formula that appears in the running text, a so-called *in-line formula*, is produced by the `math` environment.
- For shorthand, this environment can be invoked and delimited by `\( ... \)` or by `$ ... $`.
- E.g., `$x' + y^{2} = z_{2}^{2}$` produces $x' + y^2 = z_2^2$.
- Another way for producing an in-line formula is the `\ensuremath` command. It is especially useful for defining a command that can appear in both normal text and formulae.

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- Subscripts and superscripts are made with the _ and ^ commands.

$$x_{1}^{y^{2}}$$

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- Fractions are denoted by the / symbol.
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$$\frac{x + y/2}{x - \frac{y}{z+1}}$$

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- Another option, especially within an inline formula, is to use `\nicefrac`: ${}^{y}\!/_{2}$.
- Note that `\nicefrac` can only be used after putting `\usepackage{nicefrac}` into the preamble.

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- As a rule of thumb, many mathematical symbols can be generated by typing commands that are related to the English names of the symbols.

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Sample Math

- More standard math declarations:

$$\sum_{i=1}^{n} \sqrt{x_{i}}$$

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$$\int_{0}^{1} x \sin 1/x \, dx$$

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Sample Math

- All the previous formulae were generated as off-line formulae. The following example demonstrates the effect of replacing `$ ... $` by `\[ ... \]`: in-line $\sqrt{\lim_{n\to\infty}\int_{-n}^{n}\frac{1}{x^2}\sin x\,dx}$; and off-line:

$$\sqrt{\lim_{n\to\infty}\int_{-n}^{n}\frac{1}{x^2}\sin x\,dx}.$$

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$$\sqrt{ \lim_{n \rightarrow \infty} \int_{-n}^{n} \frac{1}{x^{2}} \sin x \, dx }.$$

- And this is the corresponding math code (without `$ ... $` or `\[ ... \]`):

```
\sqrt{ \lim_{n \rightarrow \infty}
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```
\sqrt{ \lim_{n \rightarrow \infty}
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```

- Note that symbols like $\int$ are variable-sized. Their sizes do not only depend on the type size used but also on whether they are displayed off-line, i.e. within `\[ ... \]`, or in-line, i.e., within `$ ... $`.

Mathematical Symbols

- LaTeX supports a variety of special mathematical symbols. (See the LaTeX Book.) Symbols provided include
  - *(binary) operation symbols*, e.g. $\pm$ (`$\pm$`), $\div$ (`$\div$`), $\cdot$ (`$\cdot$`), $\cap$ (`$\cap$`), $\cup$ (`$\cup$`);

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  - *delimiters*, e.g. $\{$ (`$\{$`), $\lfloor$ (`$\lfloor$`), $\rangle$ (`$\rangle$`).
- Observe that all those symbols can only be used in the so-called math mode, i.e., within the scope of `$ ... $` or `\[ ... \]`.

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  - *miscellaneous symbols*, e.g. $\aleph$ (`$\aleph$`), $\forall$ (`$\forall$`), $\exists$ (`$\exists$`);
  - *delimiters*, e.g. $\{$ (`$\{$`), $\lfloor$ (`$\lfloor$`), $\rangle$ (`$\rangle$`).
- Observe that all those symbols can only be used in the so-called math mode, i.e., within the scope of `$ ... $` or `\[ ... \]`.
- Many more math-related symbols are contained in packages provided by $\mathcal{AMS}$-LaTeX, such as `amssymb`.

Mathematical Delimiters

- Delimiters can also be used in multi-line formulae. The commands `\left` and `\right` are used in order to make them "fit around".
- The following piece of code produces the following (nonsense) multi-line formula:

```
\[   \vec{a} + \vec{b} = \left(  \begin{array}{c}
                                      c_{x} \\
                                      c_{y}
                                    \end{array}
                          \right\}                  \]
```

$$\vec{a} + \vec{b} = \left(\begin{array}{c} c_{x} \\ c_{y} \end{array} \right\}$$

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$$\vec{a} + \vec{b} = \left(\begin{array}{c} c_{x} \\ c_{y} \end{array} \right\}$$

- LaTeX will complain if no matching right delimiter is found – you may use `\right.` as a dummy right delimiter in this case.

- For coding sequences of equations it is convenient to use the `eqnarray` environment, which is very much like a special `array` environment.

$$\begin{aligned} x &= 2y - 3z && (2)\\ 5x + 7y &\geq a + b + c + d + e + f + g + h + i + \\ & \quad j + k + l + m + n + o + p + q && (3) \end{aligned}$$

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   x          &    =    &  2y - 3z \\
   5x + 7y    &   \geq  &  a + b + c + d + e + f + g + h +
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\end{eqnarray}
```

- Note that the alignment is handled by LaTeX. You can put `\tiny` around the `eqnarray` construct, and it will again be aligned properly:

$$
\begin{aligned}
x &= 2y - 3z && (4)\\
5x + 7y &\geq a + b + c + d + e + f + g + h + i + \\
&\quad j + k + l + m + n + o + p + q && (5)
\end{aligned}
$$

Greek Characters

- LaTeX is also good in producing Greek and other (foreign) letters. The command for producing a Greek letter is obtained by placing a \ in front of the (English) name of the letter. For instance, `$\gammma$` produces γ.

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- Uppercase Greek letters are generated by capitalizing the first letter of the command name, as long as the uppercase Greek letter is not the same as its Roman equivalent. For instance, `$\Gamma$` produces Γ.

Floating Environments: Figures and Tables

- Since pictures and tables cannot be split at page breaks LaTeX provides two environments, `figure` and `table`, that can float to convenient places.

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- The `figure` environment is generally used for pictures and the `table` environment for tabular information.
- The major difference between both environments is how they are captioned: for several document classes the figure's caption ("Figure XX:...") is below the body of the figure whereas the table's caption ("Table XX:...") goes above the table.
- All LaTeX cares about is to find suitable positions, as long as possible, for placing their contents without generating half-empty pages.

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```
\begin{figure}[!tbph]
The body of the figure goes here. You may want to leave some space by using
the \vspace{...} command.
\caption{The caption goes here.}
\end{figure}
```

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- LaTeX's decision where to place a floating object can be influenced by specifying any combination of the parameters `t, b, p` and `h`, where `t` means that you suggest to place the figure at the top of the (following) page, relative to the position of the text around the place where you specified the figure in your input file.
- Similarly, `b` stands for bottom. A `p` indicates that LaTeX is allowed to generate an extra page of floats, which does not contain any text.

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- Similarly, `b` stands for bottom. A `p` indicates that LaTeX is allowed to generate an extra page of floats, which does not contain any text.
- If you are really keen on having the figure put exactly where you specified it, you may want to try `h` — for 'here'; LaTeX sometimes even cares about your wishes.
- If you add a `!` to the location, LaTeX tries harder to satisfy your request.

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- An EPS figure is imported by the following commands, typically placed into the body of a figure. (Of course, the centering command may be skipped.)

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- For our example, the figure will be scaled to fit into a horizontal space with width 8.3cm.
- Note, however, that in order to support this command the `graphicx` package must be included by putting `\usepackage{graphicx}` into the preamble.

LaTeX and PostScript Figures

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- The `width` or `height` command is optional; omitting it causes LaTeX to reproduce the figure at its original size.
- The size of a PostScript figure can also be specified relative to document measures:

```
\includegraphics[width=0.5\textwidth]{name_of_file}
```

- We will learn more about how to incorporate PostScript files after discussing packages for drawing figures . . .

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2 LaTeX for Scientific Text Processing

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Non-Latin Characters

- LaTeX was originally designed for English. It has limited built-in support for other languages.
- As far as German is concerned, a minimal subset of standardized commands for German has been agreed upon.
  - `\"a` or `"a` produces ä;
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- Of course, these commands are intended for sporadic use within a text, e.g., to typeset something like β-decay.
- Note that LaTeX does not hyphenate German (Greek, . . .) words correctly without being supplied with German (Greek, . . .) hyphenation patterns!

Internationalization

- In order to support truly multi-lingual texts, LaTeX needs to take care of the following issues:
  1. All automatically generated text elements (such as names of months) need to be set in the appropriate language (other than English).

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- If your LaTeX system is set up correctly, then the first three tasks are handled neatly by the package `babel`: E.g., put

  ```
  \usepackage[american,austrian]{babel}
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- The last language in your list of options will be active; use `\selectlanguage` to change the active language:

```
\selectlanguage{american}.
```

Internationalization

- LaTeX uses the `inputenc` package to provide support for input of non-latin characters directly from the keyboard. For instance, you may want to use ISO-LATIN 1 for encoding most European (Latin-like) character sets,

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  \usepackage[latin1]{inputenc}
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  or

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- Note, though, that the portability of your LaTeX input files depends heavily on the availability of these packages!
- Note also that different characters may map to the same encoding on different platforms or in different linguistic environments.
- For best-possible multi-lingual support you may want to resort to

  ```
  \usepackage[utf8]{inputenc}.
  ```

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  `\usepackage[OT2,T1]{fontenc}`.

  Then `\foreignlanguage{russian}{SSR}` will yield ССР, and `\foreignlanguage{russian}{Moskva}` will yield Москва.

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- After specifying `\usepackage[autostyle]{csquotes}` in the preamble, `\enquote{...}` automatically selects the language-specific appropriate quotes (if `\usepackage{babel}` was loaded).

Euro Symbol

- The European Commission defined the Euro symbol as a strictly geometric logo. That is, the official symbol was meant to be a sans serif character, always the same regardless of the font being used. This violates normal typesetting conventions. Nowadays the European Commission no longer insists on the use of the Euro logo (instead of font-based Euro symbols).

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- Good option for producing the Euro logo: Martin Vogel's *MarVoSym Font Package*.
- After putting `\usepackage{marvosym}` into the preamble (and after installing the proper font descriptions), the Euro symbol can be created: € (`\EUR`).

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- Conventional resizing commands of LaTeX may be applied. E.g., `{\LARGE\EUR}` produces a large € logo.

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Other Symbols

- The *MarVoSym F⚽nt Package* also provides quite a few other symbols. E.g.:
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  Information: @ (`\MVAt`), ☞ (`\PointingHand`), ⚒ (`\MineSign`), ♲ (`\Recycling`), (`\PackingWaste`), ℹ (`\Info`);

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Biology: ♀ (`\Female`), ♂ (`\MALE`), ⚥ (`\FemaleMale`);

- The *MarVoSym Font Package* also provides quite a few other symbols. E.g.:

Communication: ✉ (`\Letter`), ☎ (`\Telefon`), 📠 (`\Faxmachine`);
Navigation: ⏮ (`\RewindToIndex`), ▶ (`\Forward`), ⧗ (`\ToBottom`);
Computing: 🖱 (`\ComputerMouse`), 🖨 (`\Printer`), (`\SerialPort`), (`\ParallelPort`), ⌨ (`\Keyboard`);
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Miscellaneous: ₰ (`\Deleatur`), ☯ (`\YinYang`), ☹ (`\Frowny`), ☺ (`\Smiley`), ✂ (`\Rightscissors`), ⚽ (`\Football`), ♡ (`\Heart`), Ⓐ (`\CircledA`), 🚲 (`\Bicycle`);

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Laundry: 40 (`\AtForty`), (`\IroningII`), ⊠ (`\NoTumbler`);

Astronomy: ☉ (`\Sun`), ☽ (`\Moon`), ♁ (`\Earth`), ♆ (`\Neptune`);

Astrology: ♈ (`\Aries`), ♉ (`\Taurus`), ♑ (`\Capricorn`), ♓ (`\Pisces`).

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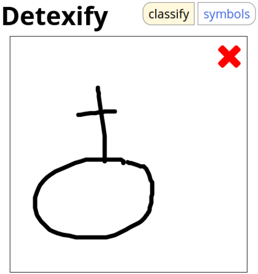

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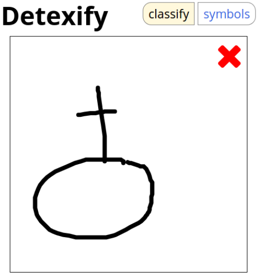

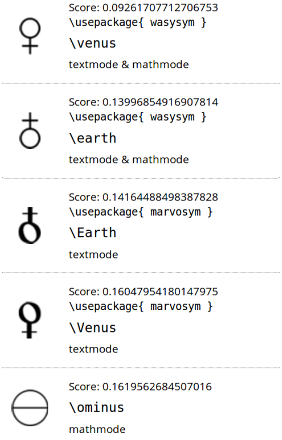

2 LaTeX for Scientific Text Processing

- Getting Started with LaTeX
- Basic LaTeX Layout Commands
- Beyond Latin Characters for English-Language Texts
- Cross-Referencing and Bibliographic References
  - Cross-Referencing
  - Bibliographic References
- Extending LaTeX
- Trouble Shooting

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Cross-Referencing

- LaTeX can automatically generate a table of contents and similar cross-references if asked to do so.
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- Note that it requires (at least) two runs in order to generate a correct table of contents.
- In the first run LaTeX extracts all necessary sectional information and writes it to a file with extension `.toc`.
- When invoked for the second time, it reads this file and generates a table of contents according to the layout arranged in the previous run. Besides, it issues a warning message if the actual sectional information does not correspond to the old table of contents read from the `.toc` file.

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- The commands `\listoffigures` and `\listoftables` produce a list of figures and a list of tables, respectively. They work just like the `\tableofcontents` command, except that files with extensions `.lof` and `.lot` are involved.

Cross-Referencing

- Nearly every numbered environment can be referred to after a *key* has been assigned to it.
- A key is assigned by means of the `\label{key}` command, which can be put anywhere within the scope of the environment to be referenced, and where `key` is the symbolic key.

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- As in the case of generating a table of contents, LaTeX needs two runs and one additional file, with extension `.aux`, for generating correct references.

Cross-Referencing

- For instance, recall that our first numbered equation was Equation 1.
- The label for this reference was generated by putting `\label{eq:foo}` within the environment of the equation to be referenced, and by referring to it as `\ref{eq:foo}`.

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- However, for references to pages it is necessary to substitute the `\ref` command by a `\pageref` command.
- Caveat: For establishing a reference to a figure or a table, make sure to put the `\label` command *after* the `\caption` command.

Bibliographic Citations

- A citation is a cross-reference to another publication, such as a book.
- With LaTeX you can use a separate program called BibTeX to generate bibliographical data from information stored in a bibliographical database, i.e., in a collection of files with extensions `.bib`.

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- If the bibliographical database is not contained in your actual working directory then you may want to inform LaTeX where to find this database by setting the environment variable `BIBINPUTS` to the appropriate search path, e.g.,

```
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- When calling BibTeX, the information requested by `\cite` commands is extracted from the bibliographical database and is stored in two files with extensions `.bbl` and `.blg`.

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Bibliographic Citations

- The following example shows a sample entry to a BIB file:

```
@string{AW      = "Addison-Wesley"}
@book{Lamp94,
      author={L. Lamport},
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- As long as the bibliographical database is not changed and no new `\cite` commands are added, the `.bbl` and `.blg` files correctly represent the bibliographical data needed for making citations.
- As with all other symbolic pointers LaTeX needs two runs in order to have all references established.

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- The placement of the bibliography is controlled by the placement of the `\bibliography{bib_file}` command within the LaTeX file.
- Here, `bib_file.bib` is the name of a file containing the bibliographical data. (It is also possible to use several bib-files as arguments of the `\bibliography` command.)
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- A somewhat more modern way to handle bibliographic citations is to resort to BibLaTeX and `biber` as a replacement for BibTeX.

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2 LaTeX for Scientific Text Processing

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Theorems and Similar Environments

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Hypothesis 1 (Murphy)

There is always one error lefft.

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- Like other numbered environments, theorems can also be referenced, and this sometimes even works in spite of Hypothesis 1, which was referenced by means of `\ref{hyp:murphy}`.

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New Commands and Environments

- The layout of a document heavily depends on the document-class options and add-on packages used for formatting it.
- These optional packages contain a myriad of control parameters, environments, and the like, which all can be modified individually in order to fit special purposes.
- However, this is the hard way of forcing LaTeX to modify its formatting strategies, i.e., this is the domain of LaTeX wizards!
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- And if all else fails, you can still use plain TeX commands — this is the really hard way and asking a TeX guru is recommended!
- The easier way to modify LaTeX's way of formatting a document is to use the `\newcommand` and `\newenvironment` commands, which allow to define new commands and environments based on already existing ones.
- Another easy alternative is to use one of the many existing add-on packages, see the LaTeX Book or the LaTeX Companion.

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New Commands and Environments: Samples

- We define a template for a 2×2 matrix:

```
\newcommand{\mat_2x2}[4]{\ensuremath{{
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- If no environment for sketching a proof is supported by a document's class file, then one could define it as follows:

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\newenvironment{sketch}[1]{\noindent
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Then `\begin{sketch}Start of my proof $\ldots$ \end{sketch}` will yield the following:
Sketch of Proof: Start of my proof . . .

New Commands and Environments: Specifying the Date

- The command `\today` prints and formats the date of the compilation of the LaTeX document according to the language selected: E.g.,
  - `\selectlanguage{austrian}\today` yields 3. Oktober 2019,
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- One can also manipulate the TeX primitives `\day`, `\month`, and `\year`. E.g., the command `\myToday` yields 03-Oct-2019 after setting

```
\newcommand{\monthAsWord}[1]{
   \ifcase#1\or Jan\or Feb\or Mar\or Apr\or
                May\or June\or July\or Aug\or
                Sep\or Oct\or Nov\or Dec\fi}
\newcommand{\leadingZero}[1]{\ifnum #1<10 0\the#1\else\the#1\fi}
\newcommand{\myToday}{
   \leadingZero{\day}-\monthAsWord{\the\month}-\the\year\xspace}
```

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- More elaborate options for formating date and time are provided by the `datetime` package.

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Ready-to-use Packages

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- The `lineno` provides line numbering for an entire document or for individual paragraphs, with the possibility to establish references through the LaTeX `\ref` cross-referencing mechanism.

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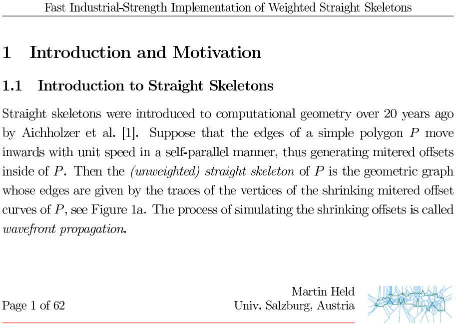
- The `lineno` provides line numbering for an entire document or for individual paragraphs, with the possibility to establish references through the LaTeX `\ref` cross-referencing mechanism.
- The `fancyhdr` package provides an easy way to customize a document by placing text on the top and/or bottom of every page.


Fast Industrial-Strength Implementation of Weighted Straight Skeletons

1 Introduction and Motivation

1.1 Introduction to Straight Skeletons

Straight skeletons were introduced to computational geometry over 20 years ago by Aichholzer et al. [1]. Suppose that the edges of a simple polygon P move inwards with unit speed in a self-parallel manner, thus generating mitered offsets inside of P. Then the *(unweighted) straight skeleton* of P is the geometric graph whose edges are given by the traces of the vertices of the shrinking mitered offset curves of P, see Figure 1a. The process of simulating the shrinking offsets is called *wavefront propagation*.

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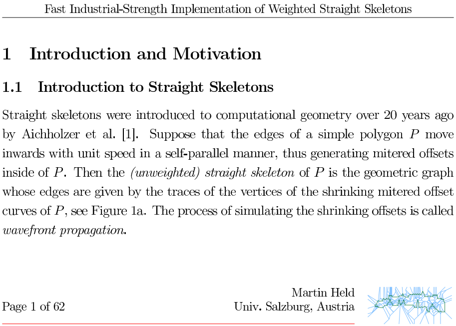
Ready-to-use Packages

- Keep in mind that LaTeX offers tons of special-purpose packages that are ready to use with little effort.
- E.g., the `url` package allows to use special characters such as _ and & without escaping them if provided as an argument of the `\url{...}` command.
- The `lineno` provides line numbering for an entire document or for individual paragraphs, with the possibility to establish references through the LaTeX `\ref` cross-referencing mechanism.
- The `fancyhdr` package provides an easy way to customize a document by placing text on the top and/or bottom of every page.


Fast Industrial-Strength Implementation of Weighted Straight Skeletons

1 Introduction and Motivation

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- The `mhchem` package allows to generate $2\,H_2 + O_2 \longrightarrow 2\,H_2O$ as `\ce{2 H2 +  O2 -> 2 H2O}`

Ready-to-use Packages: Colors

- The `xcolor` package lets you define the font color, text background and page background.
- You can choose from predefined colors or define your own colors using RGB, Hex, or CMYK.
- The predefined color names are

  red, green, blue, cyan, magenta, yellow, black, gray, white, darkgray, lightgray, brown, lime, olive, orange, pink, purple, teal, violet.

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- See latexcolor.com for hundreds of LaTeX color definitions.
- Sample use: `\textcolor{blue}{some text}` or `{\color{blue} some text}`, or `{\color[wave]{600} light ...}}` to generate light waves of 560 nm.

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  red, *green*, *blue*, *cyan*, *magenta*, *yellow*, *black*, *gray*, *white*, *darkgray*, *lightgray*, *brown*, *lime*, *olive*, *orange*, *pink*, *purple*, *teal*, *violet*.

- See latexcolor.com for hundreds of LaTeX color definitions.
- Sample use: `\textcolor{blue}{some text}` or `{\color{blue} some text}`, or `{\color[wave]{600} light ...}}` to generate light waves of 560 nm.
- See the documentation of the `xcolor` package for more details. The following sample was derived from code given in its manual:

Ready-to-use Packages: Specifying Page and Text Size

- Typically, LaTeX will format its output for the US "letter" paper format.

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- The `geometry` package provides a simple way to specify the size and layout of a page.
- E.g., the command

  ```
  \usepackage[a4paper,text={160mm,240mm},centering]{geometry}
  ```

  instructs LaTeX to place a text of total width 160mm and total height 240mm in a centered fashion on DIN A4 paper.
- See the package description of `geometry` for more elaborate options.

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  instructs LaTeX to place a text of total width 160mm and total height 240mm in a centered fashion on DIN A4 paper.
- See the package description of `geometry` for more elaborate options.
- Another simple option for changing the text layout is to resort to `\addtolength` commands:

  ```
  \addtolength{\textheight}{20mm}
  \addtolength{\textwidth}{30mm}
  \addtolength{\topmargin}{-15mm}
  \addtolength{\evensidemargin}{-8mm}
  \addtolength{\oddsidemargin}{-8mm}
  ```

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Ready-to-use Packages: “Eurocentric” Document Classes

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- The default LaTeX document classes are geared towards US typographic standards and paper sizes.
- The KOMA-Script bundle provides a versatile set of drop-in replacements for the default LaTeX document classes, with an emphasis on European typographic conventions, and with explicit support for DIN-sized paper.
- The KOMA classes `scrartcl`, `scrreprt`, `scrbook` and `scrlttr2` are the replacements of the standard LaTeX classes `article`, `report`, `book` and `letter`.

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- The KOMA classes `scrartcl`, `scrreprt`, `scrbook` and `scrlttr2` are the replacements of the standard LaTeX classes `article`, `report`, `book` and `letter`.
- The KOMA classes support default type sizes larger than `12pt`.
- The KOMA package `scrdate` provides not only the current date but also the name of the day, and the KOMA package `scrtime` allows to include the current time.
- See https://www.komascript.de for additional information.

- Documents with two columns can be created easily by passing the option `twocolumn` to the document class statement.
- This works for most document classes. And it works neatly!

Ready-to-use Packages: Multiple Columns

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- This works for most document classes. And it works neatly!
- The package `multicols` provides the `multicols` environment, which takes the number of columns as optional argument (up to a maximum of ten columns).
- The separation of the columns is controlled by `\columnsep`. E.g.,

```
\setlength{\columnsep}{10mm}
\begin{multicols}{3}
Lorem ipsum dolor sit amet, consetetur sadipscing elitr,
sed diam nonumy eirmod tempor invidunt ut labore et dolore
magna aliquyam erat, sed diam voluptua.
\end{multicols}
```

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Lorem ipsum dolor sit amet, consetetur sadipscing elitr,
sed diam nonumy eirmod tempor invidunt ut labore et dolore
magna aliquyam erat, sed diam voluptua.
\end{multicols}
```

- Note, though, that support for floating environments (still) is poor; floats will show up only at the top or bottom of the next page after they are inserted.

Ready-to-use Packages: AMS Math Packages

- The $\mathcal{AMS}$ math packages `amsmath`, `amssymb` and `amsthm` extend LaTeX's math capabilities. E.g., compare `\frac` to `\tfrac` and `\dfrac`:

$$\frac{1}{2}x^2 = \dfrac{1}{2}x^2 = \tfrac{1}{2}x^2$$

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\]
$
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- The package `amsmath` also contains the `cases` and `dcases` environments:

$$F_n = \begin{cases} 0 & n = 0, \\ 1 & n = 1, \\ F_{n-1} + F_{n-2} & n \geq 2. \end{cases}$$

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1                   & n = 1, \\
F_{n-1} + F_{n-2}   & n \ge 2.
\end{cases}    \]
```

- The $\mathcal{AMS}$ logo can be generated by means of `\AmS` or, if the `hologo` package was loaded, also by means of `\hologo{AmS}`. Similarly, `\hologo{AmSLaTeX}` generates $\mathcal{AMS}$-LaTeX.

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Ready-to-use Packages: SI Units

- The `siunitx` package helps with the correct typesetting of SI-units (and even some non-SI-units): `\SI{10}{\mega\hertz}` generates 10 MHz, and `\SIrange{10}{100}{\hertz}` produces 10 Hz to 100 Hz.

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- The language-specific decimal marker can be set with the option `\sisetup{output-decimal-marker= {,}}`. Compare 3,14 µV m^{-2} to 3.14 µV m^{-2}. Both outputs were generated by means of the command `\SI{3.14}{\micro\volt\per\square\metre}`.

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	numbers
α	3.14
β	100.1234
γ	−0.001 234
δ	2×10^{-4}

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α	3.14
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```
\begin{tabular}{cS}
  \multicolumn{2}{c}{numbers}\\ \hline
   $\alpha$ & 3.14 \\
   $\beta$  & 100,1234 \\
   $\gamma$ & -0,001234 \\
   $\delta$ & 2e-4
\end{tabular}
```

Ready-to-use Packages: Source-Code Listings

- The `listings` package allows to generate source-code listings:
  `\lstinputlisting[language=C,frame=tb]{code/horner.c}`

```c
/* Horner's Algorithm evaluates a polynomial of degree n at point x
 * @param p: array of n+1 coefficients
 * @param n: the degree of the polynomial
 * @param x: the point of evaluation
 * @return the evaluation result
 */
double evaluate(double *p, int n, double x)
{
  double h = p[n];

  for (int i = n - 1; i >= 0; --i)
    h = x * h + p[i];

  return h;
}
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```

- It supports more than 75 languages, including C/C++, Java, Python and LaTeX.
- Note that the `listings` package comes with many options to influence the style and layout of a listing.

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Ready-to-use Packages: Source-Code Listings

```
\begin{frame}[fragile]\frametitle{Ready-to-use Packages: Source-Code Listings}

\begin{itemize}
\item The \cmd{listings} package allows to generate source-code listings:
  \newline
      % We use \verb to include the LaTeX source code
      \verb+\lstinputlisting[language=C,frame=tb]{code/horner.c}+
\end{itemize}

\lstinputlisting[language=C,frame=tb]{code/horner.c}
\pause

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  and \LaTeX.
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  influence the style and layout of a listing.
\pause
\end{itemize}
\end{frame}
```

- That listing of the LaTeX source code which generated the previous slide was obtained by means of the following `listings` commands:

```
\lstinputlisting[language={[latex]tex},frame=single,
                    numbers=none,keywordstyle=\color{red},
                    commentstyle=\color{blue}]{package.tex}
```

Ready-to-use Packages: Pseudocode Listings

- Several LaTeX packages support the formating of pseudocode, such as `program`, `algorithmic` and `algorithm2e`. E.g., with `algorithmic`:

Data: $x, a \in \mathbb{R}$
Result: $y \in \mathbb{R}$
begin
    repeat
        $y \leftarrow \text{Compute}(x, a)$
        done $\leftarrow \text{Check}(x, a)$
        if *not done* **then**
            $a \leftarrow 10 \cdot a$
            reset data structures
        else
            report done;
    until *(done OR* $a > 10^{-10}$*)*

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      $a \leftarrow 10 \cdot a$
      reset data structures
    else
      report done;
  until *(done OR* $a > 10^{-10}$*)*

```
\begin{algorithm}[H]
\DontPrintSemicolon
\KwData{$x,a\in\R$}
\KwResult{$y\in\R$}
\Begin{
  \Repeat{(done ~OR~
           $a > 10^{-10}$)}{
    $y \leftarrow $ Compute$(x,a)$\;
    done $\leftarrow$ Check$(x, a)$\;
    \If{not done}{
      $a \leftarrow 10 \cdot a$\;
      reset data structures\;
    }
    \Else{
      report done;
    }
  }
}
\end{algorithm}
```

Ready-to-use Packages: Latexdiff for Marking Changes to Documents

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- It is a Perl script and requires an installation of Perl 5.8 or higher.

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- To compare two versions of a document, named `old.tex` and `new.tex`, it suffices to run it as follows:

```
latexdiff old.tex new.tex > diff.tex
```

- The markup information is stored in `diff.tex`, which can be processed with any standard LaTeX compiler.

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- The markup information is stored in `diff.tex`, which can be processed with any standard LaTeX compiler.
- Its default set-up is as follows:
  - Words that were removed are crossed out with a single line and colored red.
  - Words that were added are underlined with a squiggle and colored blue.
  - For changed equations, additions are marked with a blue color and removals are marked with a red color.
- Several options to influence how the markup shall be done . . .

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Automated Processing of a LaTeX Document: `latexmk`

- `Latexmk` is a Perl script for automating the processing of a LaTeX document.
- It is a highly specialized sibling of the general-purpose `make` utility.
- It runs LaTeX (and related programs like BibTeX) the appropriate number of times in order to resolve all symbolic references.
- It has a reliable algorithm for detecting dependencies among the input files.

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- It runs LaTeX (and related programs like BibTeX) the appropriate number of times in order to resolve all symbolic references.
- It has a reliable algorithm for detecting dependencies among the input files.
- It can also be instructed to start a previewer and then run LaTeX whenever a source file has changed.
- It supports the use of PDFTeX for generating a PDF output.

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2 LaTeX for Scientific Text Processing

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Trouble Shooting

- Always remember that LaTeX is nothing but a type setting system that has to rely on your commands.
- For instance, it cannot guess where you meant to insert a parenthesis but forgot to do so!
- Thus, it will bark about any syntactical error that it can detect.

Trouble Shooting

- Always remember that LaTeX is nothing but a type setting system that has to rely on your commands.
- For instance, it cannot guess where you meant to insert a parenthesis but forgot to do so!
- Thus, it will bark about any syntactical error that it can detect.
- Also, note that syntactical correctness need not imply a logical correctness.
- For instance, LaTeX will be perfectly happy to set an entire book in `\tiny` type size, which may be different from what you intended to do.

Trouble Shooting Guidelines

1. Consult the LaTeX Book and the LaTeX Companion. (Yes, indeed: RTFM!)

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3. Make sure that all `\begin` and `\end` commands occur in matching pairs. (Again, some editors support an easy entering of environment names.)
4. Similarly, all math delimiters need to occur in matching pairs.
5. Rerun LaTeX frequently. The load that it will place on the CPU is no issue with modern computers, but it will help you tremendously when attempting to locate problems.

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2. Make sure that all parentheses occur in matching pairs. It is good practice to enter `{}` prior to entering anything between the parentheses. (Some editors support this and will automatically re-position the cursor.)
3. Make sure that all `\begin` and `\end` commands occur in matching pairs. (Again, some editors support an easy entering of environment names.)
4. Similarly, all math delimiters need to occur in matching pairs.
5. Rerun LaTeX frequently. The load that it will place on the CPU is no issue with modern computers, but it will help you tremendously when attempting to locate problems.
6. At all positions where one space or empty line is allowed, several spaces and empty lines are allowed. It will help your first attempts to locate a problem if your LaTeX file is formatted neatly!

Trouble Shooting Guidelines

1. Consult the LaTeX Book and the LaTeX Companion. (Yes, indeed: RTFM!)
2. Make sure that all parentheses occur in matching pairs. It is good practice to enter `{}` prior to entering anything between the parentheses. (Some editors support this and will automatically re-position the cursor.)
3. Make sure that all `\begin` and `\end` commands occur in matching pairs. (Again, some editors support an easy entering of environment names.)
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5. Rerun LaTeX frequently. The load that it will place on the CPU is no issue with modern computers, but it will help you tremendously when attempting to locate problems.
6. At all positions where one space or empty line is allowed, several spaces and empty lines are allowed. It will help your first attempts to locate a problem if your LaTeX file is formatted neatly!
7. Recall that a % sign starts a comment for LaTeX, and that it will ignore the rest of the line.

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3 Drafting Figures and Generating Plots

- LaTeX and PostScript
- Drafting Packages
- Utilities
- Plotting

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3 Drafting Figures and Generating Plots

- LaTeX and PostScript
  - Drawing Figures in LaTeX
  - LaTeX Packages for Generating Special-Purpose Illustrations
  - PostScript
- Drafting Packages
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- Simple figures can be generated using the *picture* environment of LaTeX:
  `\begin{picture}(`*width*`,`*height*`)(`*x-lower_left*`,`*y-lower_left*`)`
  `\end{picture}`
  with all coordinates being expressed in terms of `\unitlength`.
- The unit length can be set using the command `\setlength`. E.g., the following command sets the unit length to 5*mm*:
  `\setlength{\unitlength}{5mm}`.
- `(`*x-lower_left*`,`*y-lower_left*`)` specifies the coordinates of the lower-left corner of the picture. If absent, the lower-left corner has coordinates `(0,0)`.
- Two standard line widths are available within the picture environment: `\thinlines` and `\thicklines`.

Drawing Figures with LaTeX

- The `\begin{picture}` command puts LaTeX into *picture mode*. The only things that can appear inside the picture environment are the commands `\put`, `\multiput`, `\qbezier`, and `\graphpaper`, and declarations such as `\thicklines`.
- The basic command for drawing is the `\put` command:
  `\put(`*x-coord*`,`*y-coord*`)`{*picture object*}.

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- The basic command for drawing is the `\put` command:
  `\put(`*x-coord*`,`*y-coord*`){`*picture object*`}`.
- Valid picture objects are text, (dashed) boxes, lines, arrows, (filled) circles, ovals:
  - `\put(`*x-coord*`,`*y-coord*`){`*my_text*`}`
  - `\put(`*x-coord*`,`*y-coord*`){\framebox(`*width*`,`*height*`){`*my_text*`}}`
  - `\put(`*x-coord*`,`*y-coord*`){\line(`*x-dir*`,`*y-dir*`){`*length*`}}`
  - `\put(`*x-coord*`,`*y-coord*`){\vector(`*x-dir*`,`*y-dir*`){`*length*`}}`
  - `\put(`*x-coord*`,`*y-coord*`){\circle{`*radius*`}}`
  - `\put(`*x-coord*`,`*y-coord*`){\oval(`*width*`,`*height*`)}`

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- The reference point of a box is its lower-left corner.
- The box-drawing commands take one or two additional optional arguments for specifying the position of the text relative to the box: `l` (left), `r` (right), `t` (top), `b` (bottom). The default is to center the text horizontally and vertically within the box.

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- Objects can be saved by means of the `\savebox` and reused with the `\usebox` command.
- Repeated patterns can be generated with the `\multiput` command.

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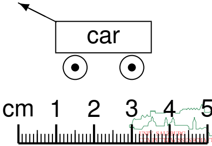
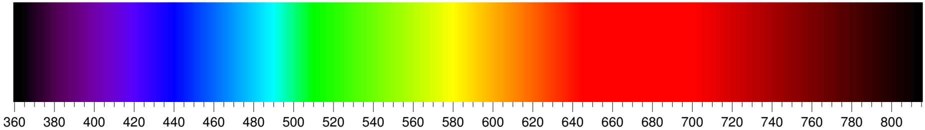
Sample LaTeX Picture

```
\newcounter{cms}
\setlength{\unitlength}{1.5mm}
\begin{center}
  \begin{picture}(50,39)
    \put(0,7){\makebox(0,0)[b]{cm}}
    \multiput(10,7)(10,0){5}
      {\addtocounter{cms}{1}\makebox(0,0)[b]{\arabic{cms}}}
    \put(15,20){\circle{6}}
    \put(30,20){\circle{6}}
    \put(15,20){\circle*{2}}
    \put(30,20){\circle*{2}}
    \put(10,24){\framebox(25,8){car}}
    \put(10,32){\vector(-2,1){10}}
    \multiput(1,0)(1,0){49}{\line(0,1){2.5}}
    \multiput(5,0)(10,0){5}{\line(0,1){3.5}}
    \thicklines
    \multiput(0,0)(10,0){6}{\line(0,1){5}}
    \put(0,0){\line(1,0){50}}
  \end{picture}
\end{center}
```



Sample LaTeX Picture Based on xcolor Package



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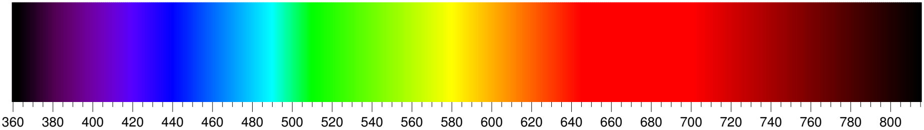


```
\newcount\WL \unitlength.75pt
\begin{picture}(460,60)(355,-10)
  \sffamily \tiny \linethickness{1.25\unitlength} \WL=360
  \multiput(360,0)(1,0){456}%
  {{\color[wave]{\the\WL}\line(0,1){50}}\global\advance\WL1}
  \linethickness{0.25\unitlength}\WL=360
  \multiput(360,0)(20,0){23}%
  {\picture(0,0)
    \line(0,-1){5} \multiput(5,0)(5,0){3}{\line(0,-1){2.5}}
    \put(0,-10){\makebox(0,0){\the\WL}}\global\advance\WL20
  \endpicture}
\end{picture}
```

- LaTeX provides several ready-to-use packages for creating illustrations for specific applications.

LaTeX Packages for Generating Special-Purpose Figures: Chemistry

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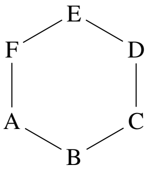
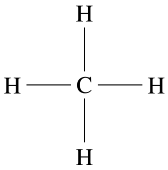
- E.g., the `chemfig` packages allows to draw chemical structures:

```
\chemfig{A*6(-B-C-D-E-F-)}
\chemfig{C(-[:0]H)(-[:90]H)(-[:180]H)(-[:270]H)}
```





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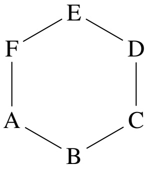
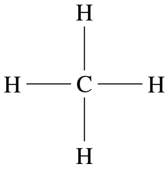
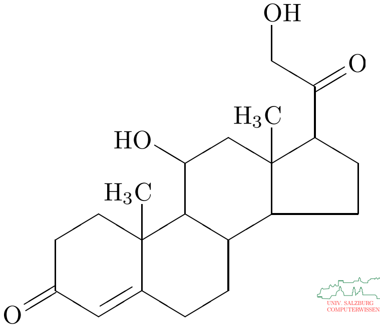




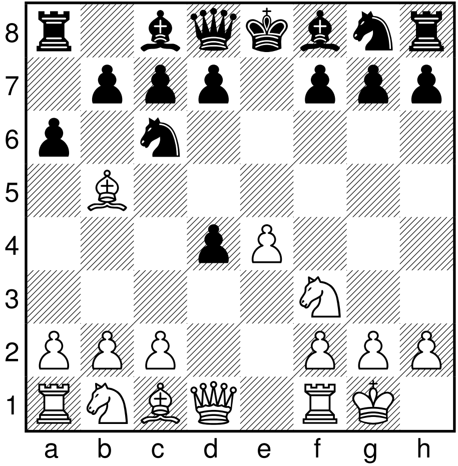
- A representation of Corticosterone, which is a 21-carbon steroid hormone produced in the cortex of the adrenal glands, can be generated by means of the `carom` package.



- The following chessboard was produced by means of `skak` commands:

```
\newgame\mainline{1.e4 e5 2.Nf3 Nc6 3.d4 e5xd4 4.Bb5 a6 5.O-O}
\showboard
```

1 e4 e5 2 ♘f3 ♘c6 3 d4 e×d4 4 ♗b5 a6 5 O-O



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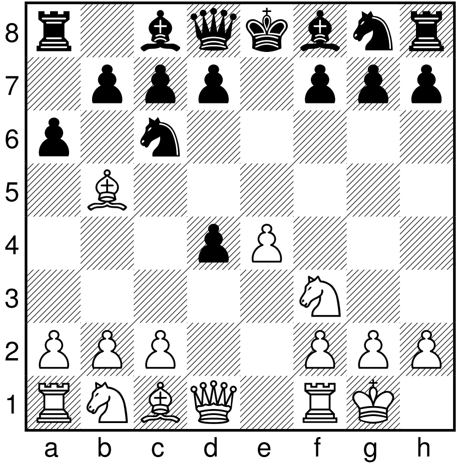

- Note that `skak` (Danish for chess) is able to handle the Forsyth-Edwards Notation (FEN), which is the standard notation for describing a specific board position of a chess game.

PostScript

- Designed by Adobe, Inc. in 1982, and documented in the PostScript Language Reference Manual (“The Red Book”) in 1985.
- PostScript (PS) is a device-independent *Page Description Language* (PDL) and has become a de-facto industrial standard. (It also has many elements of a Printer Control Language.)

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- It is a *stack-oriented* programming language that relies on *reverse Polish notation* (RPN):

C:	sqrt ((3 $*$ 3) + (4 $*$ 4))
Lisp:	(sqrt (+ ($*$ 3 3) ($*$ 4 4)))
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- Standard procedural (e.g., C, Ada) or functional (e.g., LISP) programming languages need parentheses in order to specify the order of execution of the clauses. PS needs no parentheses since its stack accumulates intermediate results, and the order of execution is always defined by the order in which the operations are pushed onto the stack.
- Most programming languages use stacks internally. However, in general a user has no direct access to them.

- The following function takes a Fahrenheit temperature and returns the corresponding Celsius temperature:

C:	int f2c (int t) { return ((t - 32) ∗ 5 / 9); }
Lisp:	(defun f2c (t) (/ (∗ 5 (- t 32)) 9))
PostScript:	/f2c { 32 sub 5 mul 9 div } def

- PS features polymorphic operators and late binding. It is weakly typed.

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Sample PostScript Code

- The following PS code produces a shadowed PS logo:

```
/Times-Italic findfont 100 scalefont setfont

/PrintPS
{ 0 0 moveto
  (PostScript) show
} def

100 400 translate
.95 -0.05 0
{ setgray PrintPS -1.5 0.7 translate} for
1 setgray PrintPS

showpage
```

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PostScript

PostScript Document Structuring Conventions

- A raw PS file lacks any easy-to-understand logical structure.
- Adobe specified the "*PostScript Document Structuring Conventions*" (DSC) for providing additional structural data in a PS file.
- A PS file is called conforming if it adheres to Adobe's DSC.
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- In general, every application that generates PS output is expected to conform to Adobe's DSC.
- A line of DSC data is marked by %% or %! in the first two characters of the line. (%! is the so-called "file magic"; it may only appear in the very first line of a PS file.)
- The DSC data is partitioned into header comments, body comments, and trailer comments.

PostScript Document Structuring Conventions

- Here comes (part of) the header of a PS file generated by LaTeX and `dvips`:

```
%!PS-Adobe-2.0
%%Creator: dvips(k) 5.993 Copyright 2013 ...
%%Title: drafting.dvi
%%Pages: 11
%%PageOrder: Ascend
%%BoundingBox: 0 0 596 842
%%DocumentPaperSizes: A4
%%EndComments
```

- Individual pages of a multi-page PS document are marked by `%%Page:` (followed by the page number).

Encapsulated PostScript

- Encapsulated PostScript files (EPS) are used for including PS data into an other PS applications (such as LaTeX).
- What turns an ordinary PS file into an EPS file is the BoundingBox, i.e., data that describes where the figure sits on the page.
- It is specified by four numbers: The x, y-coordinates of the lower-left corner of the figure, followed by the x, y-coordinates of the upper-right corner of the image.

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  ```
  %%BoundingBox:  0 0 453 216.
  ```

  In this example, the figure sits right down in the bottom left-hand corner of the page. The numbers are points with 1pt = 1/72 inches. So, this figure is about 6 inches wide and 3 inches high.
- The BoundingBox information typically resides in the first few lines of an EPS file.

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- The BoundingBox information typically resides in the first few lines of an EPS file.
- If you view a PS image with `ghostview`, the x, y-coordinates are displayed as you move the mouse to point at different parts of the image. Also, `ghostview` will display only the portion of the page described by the file's BoundingBox line. Thus, you can use `ghostview` to help you edit the BoundingBox line and to view the results.

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- An EPS need not include the PS command "showpage", which is the cue to a printer to actually print the page. Thus, an EPS file need not print by itself!

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LaTeX and Encapsulated PostScript

- When TeX was implemented, PS and other graphics formats (like JPEG) did not exist. Thus, TeX does not have direct support for importing graphics.
- However, TeX allows DVI files to contain `\special` commands directed at programs that use DVI files.
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- With the release of LaTeX 2$_\varepsilon$, the “LaTeX graphics bundle” was also released.
- The graphics bundle contains the “standard” `graphics` package and the “extended” `graphicx` package.
- Both packages offer roughly the same functionality, although the `graphicx` package is widely regarded as more user-friendly and slightly more efficient.

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- A file `foo.eps` can be included into a LaTeX document by using the `\includegraphics` command as follows:

  `\includegraphics[`*options*`]{`*foo.eps*`}`

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- Note that `\includegraphics` does not end a paragraph. Thus, small symbols can be included into the running text.

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- Watch for non-standard EPS files! For instance, Mathematica developed its own “improved” flavor of PS.
- Some of those trouble makers, including Mathematica output, can be cleaned with the `psfix` utility (on Unix systems).

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- Also, note that the proper inclusion of EPS files into LaTeX requires the use of compatible DVI drivers and previewers.
- Normally, `xdvi`, `dvips`, and Ghostscript/Ghostview do not cause any troubles when handling EPS files included into a LaTeX document.
- On systems that support pipes, the `graphicx` package can also be used to include compressed and non-EPS graphics files.

3 Drafting Figures and Generating Plots

- LaTeX and PostScript
- Drafting Packages
  - TGIF
  - Ipe
- Utilities
- Plotting

TGIF

- `Tgif` is an Xlib-based interactive 2D *drawing tool* that allows the user to draw and manipulate objects under the X Window System.
- `Tgif` supports the hierarchical construction of drawings, and an easy navigation between sets of drawings.
- It is also a hyper-graphics editor/browser on the WWW.
- `Tgif` is purely based on Xlib. It requires a three-button mouse.
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- The source code for `tgif` is freely available on the WWW.
- `Tgif` is free for non-commercial applications.
- `Tgif` supports a variety of primitive objects.
- Objects can be grouped together to form a *grouped* object.
- Commands applied to a grouped object are applied to all sub-objects of the group.
- Typically, `tgif` objects are stored in files with an .obj extension (referred to as an *object file*). (So-called "building-block" objects are stored in files with a `.sym` extension (referred to as a *symbol file*).)
- Both types of files are stored in the form of Prolog facts. Prolog code can be written to interpret the drawings!

TGIF File Input/Output

- `Tgif` can generate output in several different formats:
  - PS,
  - EPS,
  - PDF (needs `ps2pdf` from the `ghostscript` package),
  - X11 bitmap (XBM), or XPM for color output),
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- Files in other raster formats (e.g, PNG, JPEG, TIFF, etc.) can also be imported into and exported from `tgif` if external tools can be used to convert them into X11 XBM/XPM files.
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- By default, tgif drawings are formatted for printing on letter-size paper. Tgif offers a compile-time flag in order to make DIN A4 the default paper size.

Ipe

- Ipe is a drawing editor that generates drawings in XML, PDF or EPS format.
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- Objects supported include (poly)lines, polygons, splines, splinegons, circles and ellipses, circular arcs, rectangles, and marks. Bitmaps are supported, too.

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- Ipe is written in standard C++ using the STL.
- The GUI is implemented using the portable toolkit Qt, and, thus, can be compiled for Unix, Windows, and Mac OS X.
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- Importing PDF files: `pdftoipe`.

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Special Features of Ipe

- Ipe is extendible. One can easily interface personal editing functions, so-called *Ipe extensions* or *Ipe User Macros* (IUMs), with Ipe.

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- One of the nicest features of Ipe is the possibility to have the mouse *snap* to other objects. That is, the user can make certain objects in the drawing canvas *magnetic*, which makes it very easy to align an object under construction to other objects.
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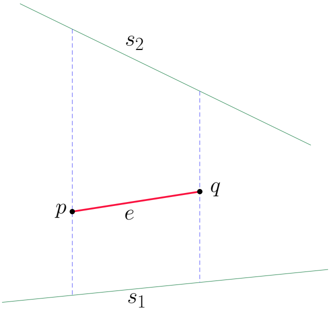
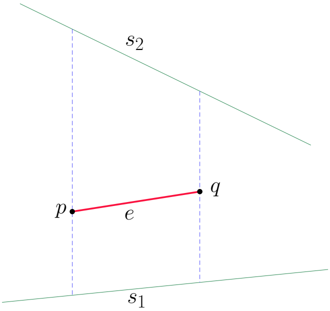
- Ipe supports three types of snapping: *grid snapping* (to grid points), *context snapping* (to vertices, boundaries, intersections), and *directional/angular snapping*.

Sample Snapping in Ipe

- Suppose we are given the segments s_1, s_2 and e, with end points p and q, and want to add vertical extensions through p and q between s_1 and s_2.

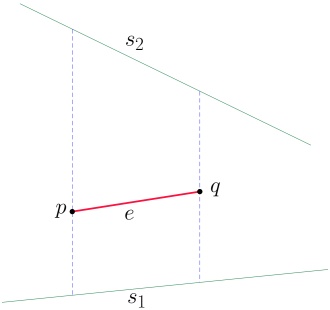


1. Turn on vertex snapping (.), e.g., by pressing F4, and go into polyline mode.



Sample Snapping in Ipe

1. Turn on vertex snapping (.), e.g., by pressing F4, and go into polyline mode.
2. Move cursor near *p* and set the coordinate origin by pressing F1.



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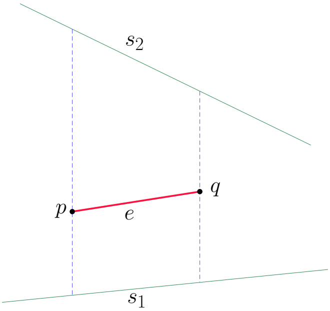
1. Turn on vertex snapping (.), e.g., by pressing F4, and go into polyline mode.
2. Move cursor near *p* and set the coordinate origin by pressing F1.
3. Turn on directional snapping (–) by pressing F5.



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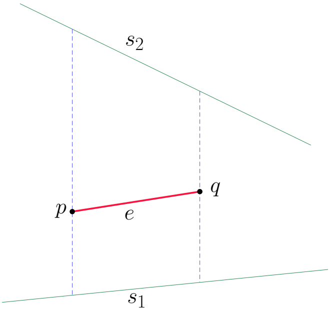

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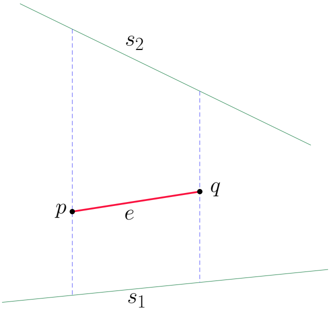

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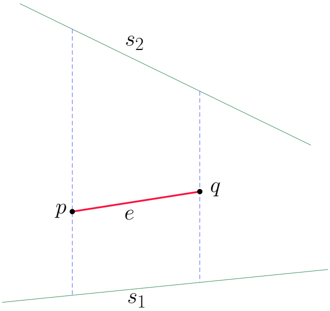

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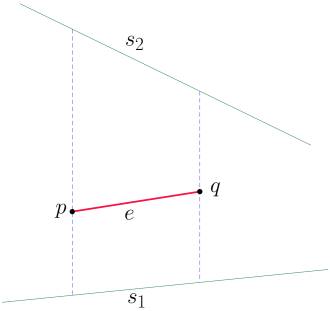

- Note that pressing F1 at point p and then pressing F2 at point q will set the coordinate origin at p and will align one coordinate axis with the line through p and q.

3 Drafting Figures and Generating Plots

- LaTeX and PostScript
- Drafting Packages
- Utilities
  - PSfrag
  - Pstoedit
  - Convert
  - xwd
- Plotting

PSfrag for Generating LaTeX Symbols

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PSfrag for Generating LaTeX Symbols

- While `Tgif` can generate PS output that is suitable for inclusion into a LaTeX document, it cannot generate all the (mathematical) symbols that LaTeX supports.
- PSfrag is a set of LaTeX macros for overlaying PS figures (or any other PS text) with fragments of LaTeX.
- More precisely, the PSfrag macros allow specific pieces of PS text (so-called “tags”) in a PS figure to be replaced with arbitrary fragments of LaTeX. When the document is latex’ed and dvips’ed, each piece of PS text is replaced by the properly sized, aligned, and rotated LaTeX text.
- In this way, Greek letters, super- and subscripts and mathematical symbols can be used in PS files with a typography that is consistent with the rest of the LaTeX document.

PSfrag and LaTeX

- For each tag word in the EPS file, one adds a command to the LaTeX document to specify how this tag is to replaced, as follows:

  `\psfrag{`tag`}[`posn`][`psposn`][`scale`][`angle`]{`LaTeX text`}`

- All data given in brackets `[]` is optional and is used to specify the exact position and orientation of the LaTeX text with respect to the bounding box of the tag string. (See the manual for details.)

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- Most DVI previewers (such as `xdvi`) are incapable of displaying the replaced text correctly.
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- Most DVI previewers (such as `xdvi`) are incapable of displaying the replaced text correctly.
- Note that `psfrag` relies on the PostScript `\special` command.
- A `\psfrag` replacement will remain in effect until its surrounding environment is exited.
- Thus, one can define global `\psfrag` commands which will apply to every figure of a LaTeX file, or one can define `\psfrag` commands inside an environment (e.g., a `figure` environment) which will apply to only one EPS file.

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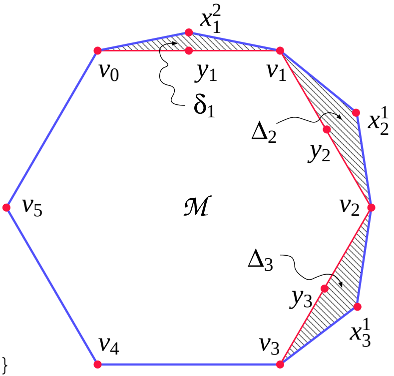
Sample PSfrag Code

```
\psfrag{v0}{{\Large $v_0$}}
\psfrag{v1}{{\Large $v_1$}}
\psfrag{v2}{{\Large $v_2$}}
\psfrag{v3}{{\Large $v_3$}}
\psfrag{v4}{{\Large $v_4$}}
\psfrag{v5}{{\Large $v_5$}}
\psfrag{x12}{{\Large $x_1^2$}}
\psfrag{x21}{{\Large $x_2^1$}}
\psfrag{x31}{{\Large $x_3^1$}}
\psfrag{y1}{{\Large $y_1$}}
\psfrag{y2}{{\Large $y_2$}}
\psfrag{y3}{{\Large $y_3$}}
\psfrag{delta1}{{\Large $\delta_1$}}
\psfrag{Delta1}{{\Large $\Delta_1$}}
\psfrag{Delta2}{{\Large $\Delta_2$}}
\psfrag{Delta3}{{\Large $\Delta_3$}}
\psfrag{hex}{{\Large $\cal{M}$}}
\includegraphics{grasp_hex}
```



PSfrag and LaTeX

- PSfrag requires a recent version of LaTeX.
- A compatible DVI-to-PS driver is required, too. PSfrag works best with `dvips`, the DVI-to-PS driver from Radical Eye Software.
- Note that the file `psfrag.sty` has to be installed in a location searched by the LaTeX search path for macros. For `kpathsea`-based systems such as `teTeX`, this path is determined by the `TEXINPUTS` environment variable.
- Also, the DVI-to-PS driver has to be able to find the file `psfrag.pro`.

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Pstoedit Utility

- The utility `pstoedit` translates PS (and PDF) graphics into other vector formats.
- Currently, `pstoedit` can generate the following formats (among many others):
  - PDF,
  - OBJ (for `tgif`),
  - FIG (for `xfig`),
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  - HPGL,
  - SVG,
  - gnuplot format.
- Note that you will need a PS interpreter to get `pstoedit` to work.
- Also, your PS interpreter needs to be capable of processing PDF if you'd like to use `pstoedit` to convert PDF to other vector formats.

Convert Utility

- The utility `convert`, which is part of the `ImageMagick` suite of tools, lets you convert between image formats.
- It supports reading and/or writing more than 100 major image formats.
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- But it is more than just a simple converter. The following example was taken from www.imagemagick.org/script/command-line-processing.php:

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convert label.png +matte
        \( +clone -shade 110x90 -normalize -negate +clone
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- This command transforms  to .

xwd – Making X11 Screen Dumps

- `Xwd` is a utility for storing X11 window images in a specially formatted dump file.
- This file can then be read by various other X11 utilities (such as `gimp`) for redisplay, printing, editing, formatting, archiving, image processing, etc.
- The target window is selected by clicking the mouse pointer in the desired window. The keyboard bell is rung once at the beginning of the dump and twice when the dump is completed.
- `Xwd` is part of the standard X11 distribution.

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- `Xwd` is part of the standard X11 distribution.
- Sample command sequence for dumping a window into a file `foo.xwd`, and for converting it into a PostScript file:

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- If `xpr` is not available, but `convert` is available, then the following command will work:

```
convert foo.xwd foo.ps
```

xwd – Making X11 Screen Dumps

- `Xwd` is a utility for storing X11 window images in a specially formatted dump file.
- This file can then be read by various other X11 utilities (such as `gimp`) for redisplay, printing, editing, formatting, archiving, image processing, etc.
- The target window is selected by clicking the mouse pointer in the desired window. The keyboard bell is rung once at the beginning of the dump and twice when the dump is completed.
- `Xwd` is part of the standard X11 distribution.
- Sample command sequence for dumping a window into a file `foo.xwd`, and for converting it into a PostScript file:

```
xwd > foo.xwd
xpr -device ps -portrait  -psfig foo.xwd > foo.ps
```

- If `xpr` is not available, but `convert` is available, then the following command will work:

```
convert foo.xwd foo.ps
```

- Several packages for drafting and image manipulation also support capturing part or all of an X11 display.

3 Drafting Figures and Generating Plots

- $\LaTeX$ and PostScript
- Drafting Packages
- Utilities
- Plotting
  - Xgraph
  - Gnuplot

Xgraph – A Simple Plotting Program

- Xgraph plots simple graphs, displaying them in a window that it creates.
- In its simplest form it is invoked as `xgraph foo`, where `foo` is a data file containing coordinates of points, one per line, with the *x*- and *y*-coordinates separated by spaces. These points will be drawn connected by lines, with axes that are automatically scaled to the range of the *x*- and *y*-coordinates.

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- Xgraph can plot several graphs superimposed by specifying more than one datafile, or by putting several datasets into one file, separated by blank lines.
- Various options allow one to plot points instead of or as well as lines, to plot on a log scale, and to change titles, etc.
- One can zoom into a plot interactively.
- One can convert plots to PS, and prepare them for inclusion into a LaTeX document.
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- One can convert plots to PS, and prepare them for inclusion into a LaTeX document.
- Xgraph supports the construction of multiple bar graphs, and allows a crude animation of the data set.
- The main advantage of xgraph is that it is convenient to use for simple tasks.
- Its main disadvantage is its somewhat limited functionality.

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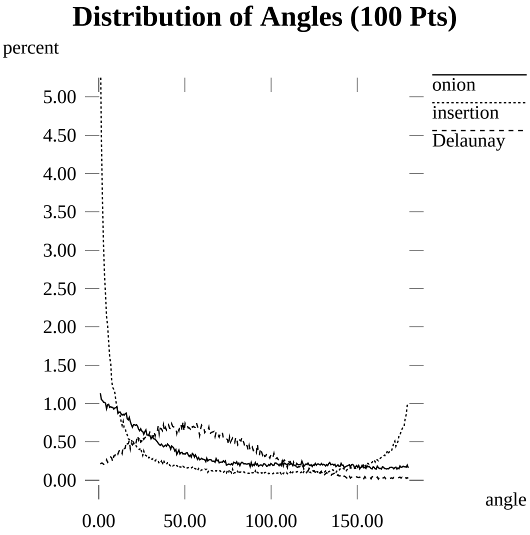
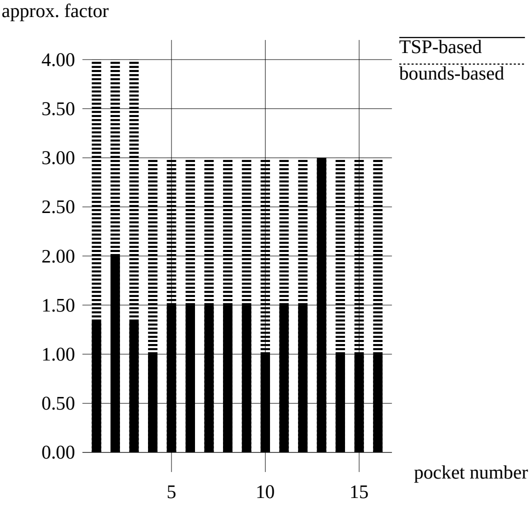

Distribution of Angles (100 Pts)
percent
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
50.00
100.00
150.00
angle
onion
insertion
Delaunay

Sample Xgraph Plot



Gnuplot

- Gnuplot is a command-line driven interactive plotting tool.
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- The command `set term pslatex` instructs gnuplot to generate a LaTeX picture of the plot, i.e., a LaTeX .tex file. The advantage of using the LaTeX picture environment is that all LaTeX commands can be used for making labels, etc. Its main disadvantage is that any LaTeX picture is limited by the small number of slopes that lines can be drawn with. Thus, the appearance of a plot is likely to be less than satisfying.

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- If the `epic.sty` and `eepic.sty` style files for the extended picture environment of LaTeX are available then LaTeX can handle more general pictures, and gnuplot can be instructed to set its terminal type to `set term eepic`. Note, however, that this currently does not support dashed lines in the plots!

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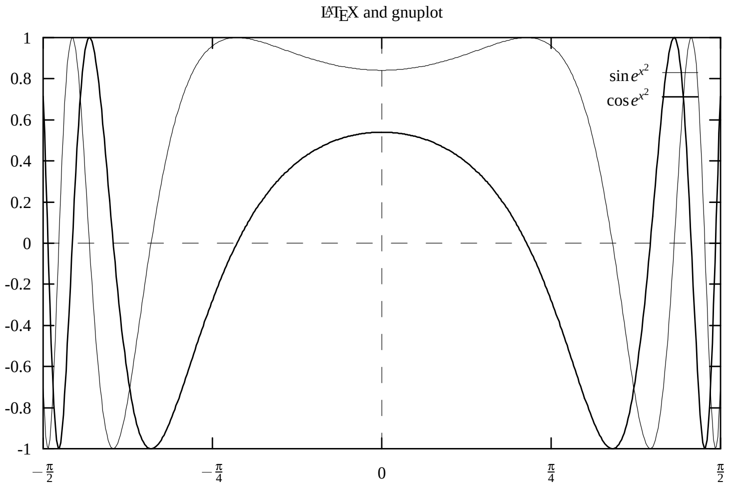
- Another alternative for incorporating LaTeX text into a gnuplot plot is to `set term eps`, and to use `\psfrag` commands for replacing tag strings by actual LaTeX text.

Sample Gnuplot Plot

- The following plot was generated by means of gnuplot, and included into LaTeX by using the `eepic` environment:

```
f(x)=sin(exp(x**2))
g(x)=cos(exp(x**2))
set samples 500
set term eepic
set output 'gnuplot.tex'
set title '\LaTeX\ and gnuplot'
set xrange [-pi/2:pi/2]
set xtics ('$-\frac{\pi}{2}$' -pi/2, \
           '$-\frac{\pi}{4}$' -pi/4, '0' 0, \
           '$\frac{\pi}{4}$' pi/4, \
           '$\frac{\pi}{2}$' pi/2)
plot f(x) title '$\sin e^{x^2}$', \
     g(x) title '$\cos e^{x^2}$'
```

Sample Gnuplot Plot



4 pdfLaTeX and the Generation of Slides

- Portable Data Format (PDF)
- pdfTeX and pdfLaTeX
- Generating PDF Slides: LaTeX Beamer Class
- Current LaTeX-Related Projects

4 pdfLaTeX and the Generation of Slides

- Portable Data Format (PDF)
  - Introduction to PDF
  - Creating and Viewing a PDF File
- pdfTeX and pdfLaTeX
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Basics of PDF

- PDF (Portable Document Format) is a cross-platform high-resolution universal document exchange format created by Adobe, with Hypertext and multi-media functionality.
- PDF files are not HTML web pages.
- PDF files are a fast way to publish existing documents on the WWW without having to recreate them in HTML and without compromising the printed image quality.

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- PDF files can be viewed by a variety of tools that are freely available.
- Virtually any PS file can be *distilled* into a PDF file.
- Typically, a PDF file is much smaller than its corresponding PS file.
- PDF is a pure data format. Contrary to PostScript, it does not require complex operations to be performed prior to output.
- PDF is an object-oriented data format; individual PDF objects/pages can easily be extracted from a PDF file.

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- PDF is a pure data format. Contrary to PostScript, it does not require complex operations to be performed prior to output.
- PDF is an object-oriented data format; individual PDF objects/pages can easily be extracted from a PDF file.
- At least in theory, the creator of a PDF document can block a user from copying of text or graphics, making changes, and printing the document. (This feature needs encryption; see later.)

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- PDF (Portable Document Format) is a cross-platform high-resolution universal document exchange format created by Adobe, with Hypertext and multi-media functionality.
- PDF files are not HTML web pages.
- PDF files are a fast way to publish existing documents on the WWW without having to recreate them in HTML and without compromising the printed image quality.
- PDF files can be viewed by a variety of tools that are freely available.
- Virtually any PS file can be *distilled* into a PDF file.
- Typically, a PDF file is much smaller than its corresponding PS file.
- PDF is a pure data format. Contrary to PostScript, it does not require complex operations to be performed prior to output.
- PDF is an object-oriented data format; individual PDF objects/pages can easily be extracted from a PDF file.
- At least in theory, the creator of a PDF document can block a user from copying of text or graphics, making changes, and printing the document. (This feature needs encryption; see later.)
- The PDF file format was standardized by ISO in 2008.

Pros of PDF

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- PDF files can be magnified up to 800% without loss of clarity in text or graphics.
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- Better document security than with HTML.
- PDF files can be magnified up to 800% without loss of clarity in text or graphics.
- Fonts can be embedded in a PDF file.
- PDF has a built-in per-page compression.
- PDF is truly platform-independent, with support for reading PDF documents being available on all major platforms and operating systems (Unix/Linux, Windows, MacOS).
- MS Word can be instructed to output a document in PDF format, which, likely, is the simplest approach to making Word documents readable for Unix users without loss of visual quality.

Cons of PDF

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- While a PDF file generally is smaller than a PS file, a gzipped PS file generally is much smaller than a gzipped PDF file.
- Unless care is taken, the embedding of fonts may cause huge PDF files.

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- While a PDF file generally is smaller than a PS file, a gzipped PS file generally is much smaller than a gzipped PDF file.
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- While in the early years of PDF one had to resort to “patches” of open-source viewers to navigate around the security features of PDF, nowadays mainstream viewers let the user choose whether or not to obey DRM restrictions.

Adobe's Commercial PDF Tools

Acrobat Distiller converts a PS file into a PDF file. It first applies a “normalization” to the PS file in order to free it from non-standard features and flavors. Supposedly, it can handle virtually any flavor of PostScript.

Acrobat Exchange supports a minimal amount of editing and formatting for final customization. Its input is a distilled PDF file. In Acrobat Exchange, one can supply hypertext links to other portions of the document (e.g., to a table of contents) or to other PDF files or WWW sites. Sounds and Quicktime movies can be included, too.

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Acrobat Reader, `acroread`, which is provided free of charge by Adobe, lets you display and print PDF files.

Warning

Adobe's official Linux version of `acroread` has not been updated since June 2013, and it is known to contain unfixed vulnerabilities that allow PDF exploits! It is wise to use `acroread` only for trustworthy PDF files, if at all.

Tools for Viewing PDF Files

Evince is the default document viewer of the Gnome project; it displays also other formats like `.ps`, `.djvu`, `.tiff` and `.odt` files.

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pdfpc — PDF presenter console — is a GTK-based viewer which uses multi-monitor output to provide meta information to the speaker during the presentation.

BeamerPresenter also offers dual-monitor output and is similar to `pdfpc`; it tries to implement all features available in the LaTeX `beamer` class; works only on GNU/Linux with the X Window System.

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FoxitReader is a decent viewer/editor.

No truly perfect solution on Linux

Unfortunately, so far none of the alternatives has managed to solve all problems:

- Some PDF files are displayed correctly only by `acroread`. (This includes PDF files generated with LibreOffice and pdfLaTeX!)
- Some government documents and forms to be filled in also cause troubles ...

PostScript-to-PDF Conversion

- The PostScript utility `ps2pdf` converts a PS file to a PDF file.
- It is based on Aladdin Ghostscript (`gs`).
- Currently, `ps2pdf` does a reasonable job on filled/stroked graphics, and on text in the 14 built-in PDF fonts in the intersection of Windows and ISO Latin-1 encodings.

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- It may convert all other text in the PS file to bitmaps in the PDF file, which are resolution-dependent. (It does only write the bitmap for each character once per page, though, and only on pages where the character is actually used.)
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- The PERL script `epstopdf` does a similar job for EPS files, and it also relies on Ghostscript.

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4 pdfLaTeX and the Generation of Slides

- Portable Data Format (PDF)
- pdfTeX and pdfLaTeX
- Generating PDF Slides: LaTeX Beamer Class
- Current LaTeX-Related Projects

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pdfTEX and pdfLATEX

- Quote from the pdfTEX user manual:

  "The pdfTEX package is an extension of LATEX/TEX that can create PDF *directly from TEX/LATEX source files and improve/enhance the result of TEX typesetting with the help of* PDF*."*

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- It produces PDF output that looks (virtually) identical to the DVI output.
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- The `pdftex` command uses the equivalent of the plain TeX format, and the `pdflatex` command uses the equivalent of the LaTeX format.

pdfTEX and pdfLATEX

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  "The pdfTEX package is an extension of LATEX/TEX that can create PDF *directly from TEX/LATEX source files and improve/enhance the result of TEX typesetting with the help of* PDF*."*

- It produces PDF output that looks (virtually) identical to the DVI output.
- The typical use of the pdfTEX-package is with pre-generated formats for which PDF output has been enabled.
- The `pdftex` command uses the equivalent of the plain TEX format, and the `pdflatex` command uses the equivalent of the LATEX format.
- Currently, `pdftex`/`pdflatex` generate PDF Level 1.5 output. One can request Level 1.6 and Level 1.7 by setting, e.g., `\pdfminorversion=7` but this will not really change anything besides replacing the string 1.5 by, e.g., 1.7 in the PDF output file. (Level 2.0 has been published but is hardly supported by any application.)
- The package `pdfx.sty` provides (partial or experimental) support for other recent ISO standards for PDF.

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Macro Packages Supported by pdfTeX

- Currently, all mainstream macro packages offer pdfTeX support in some way.
- When using such a package, it makes sense to turn on this support in the appropriate way, otherwise one cannot be sure whether things will be set up correctly.

Macro Packages Supported by pdfTEX

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- For instance, the `hyperref` package has substantial support for pdfTEX, and provides access to most of its features. The user merely needs to load `hyperref` with the `pdftex` option, and all cross-references will be converted to PDF hypertext links.

```
\usepackage[pdftex]{hyperref}
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  Bookmarks can be created to match the table of contents.
- Similarly, the LATEX packages `graphicx` and `xcolor` have options for pdfTEX, which allow the use of the standard commands for color, text rotation, and graphics inclusion.

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Macro Packages Supported by pdfTEX

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  ```
  \usepackage[pdftex]{hyperref}
  ```

  Bookmarks can be created to match the table of contents.
- Similarly, the LATEX packages `graphicx` and `xcolor` have options for pdfTEX, which allow the use of the standard commands for color, text rotation, and graphics inclusion.
- PDF support can also be turned on globally:

  ```
  \documentclass[...,pdftex,...]{...}
  ```

Manual Cross-Referencing, Bookmarks, URLs

- Manual tagging for cross-referencing:

```
\hyperlink{myref}{Clicking here will take you to ...}
\hypertarget{myref}{... this target}
```

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- Similarly, bookmarks can be set manually:

```
\pdfbookmark[level]{bookmark text}{myref}
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- Similarly, bookmarks can be set manually:

```
\pdfbookmark[level]{bookmark text}{myref}
```

- Clicking on an `href` construct will start a web browser and take you to the page specified:

```
\href{http://www.cosy.sbg.ac.at}{Departmental home page}
\url{http://www.cosy.sbg.ac.at}
```

Manual Cross-Referencing, Bookmarks, URLs

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\href{http://www.cosy.sbg.ac.at}{Departmental home page}
\url{http://www.cosy.sbg.ac.at}
```

- Similarly for other descriptors:

```
\href{ftp://...}
\href{mailto:...}
\href{run:...}
```

Manual Cross-Referencing, Bookmarks, URLs

- Manual tagging for cross-referencing:

```
\hyperlink{myref}{Clicking here will take you to ...}
\hypertarget{myref}{... this target}
```

- Similarly, bookmarks can be set manually:

```
\pdfbookmark[level]{bookmark text}{myref}
```

- Clicking on an `href` construct will start a web browser and take you to the page specified:

```
\href{http://www.cosy.sbg.ac.at}{Departmental home page}
\url{http://www.cosy.sbg.ac.at}
```

- Similarly for other descriptors:

```
\href{ftp://...}
\href{mailto:...}
\href{run:...}
```

- Menu functions of `acroread` can be accessed via links, e.g.:

```
\Acrobatmenu{Print}{print this document}
```

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pdfLaTeX and PostScript

- Native pdfLaTeX supports the inclusion of pictures in PNG, JPEG, TIFF and PDF format.

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- Similarly, the `pstricks` can be used by an up-to-date TeX distribution with the following command:

  ```
  \usepackage[pdf]{pstricks}
  ```

pdfLaTeX and PostScript

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- EPS files can be converted to PDF by Ghostscript, Acrobat Distiller, or by the PERL script `epstopdf`; PS files can be converted by `ps2pdf`.
- If you want to be able to build PS and PDF files from the same source, leave off the file extensions from the image filenames in the `\includegraphics` calls.
- Since TeX Live 2010, pdfLaTeX automatically converts EPS files to PDF, via the `epstopdf` package. (Same for XeLaTeX.)
- Similarly, the `pstricks` can be used by an up-to-date TeX distribution with the following command:

  ```
  \usepackage[pdf]{pstricks}
  ```

- The standard `\psfrag` replacements can be used with the command

  ```
  \usepackage{auto-pst-pdf}
  ```

  provided that shell escapes are allowed: For TeX Live we use

  ```
  pdflatex --shell-escape   ...
  ```

  while the command-line option `--enable-write18` should work for MiKTeX.

4 pdfLaTeX and the Generation of Slides

- Portable Data Format (PDF)
- pdfTeX and pdfLaTeX
- Generating PDF Slides: LaTeX Beamer Class
  - Structuring
  - Special Frames
  - Partial Builds and Overlays
  - Animations
  - Visual Appearance
- Current LaTeX-Related Projects

LaTeX Beamer Class

- Created by Till Tantau in 2003, and distributed via the Comprehensive TeX Archive Network (CTAN, `https://ctan.org/`).
- The LaTeX beamer class allows to create slides directly within LaTeX, with no need to resort to postprocessing by other software packages.
- It can be used with `pdflatex`, but also with `dvips`.
- Professional layouts and sophisticated overlays can be achieved.

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- It can be used with `pdflatex`, but also with `dvips`.
- Professional layouts and sophisticated overlays can be achieved.
- These slides (and the corresponding handouts) were prepared using `pdflatex` and the LaTeX beamer class — based on one set of source files for all three PDF outputs.
- Note that the word "beamer" is a pseudo-anglicism.

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LaTeX Beamer Class: Structuring

- Section:

  ```
  \section{...}
  ```

LaTeX Beamer Class: Structuring

- Section:

```
\section{...}
```

- Subsection:

```
\subsection{...}
\subsubsection{...}
```

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- Section:

```
\section{...}
```

- Subsection:

```
\subsection{...}
\subsubsection{...}
```

- Slide:

```
\begin{frame}\frametitle{...} ... \end{frame}
```

LaTeX Beamer Class: Structuring

- Section:

```
\section{...}
```

- Subsection:

```
\subsection{...}
\subsubsection{...}
```

- Slide:

```
\begin{frame}\frametitle{...} ... \end{frame}
```

- Block:

```
\begin{block} ... \end{block}
\begin{alertblock} ... \end{alertblock}
\begin{exampleblock} ... \end{exampleblock}
```

LaTeX Beamer Class: Structuring

- Section:

  ```
  \section{...}
  ```

- Subsection:

  ```
  \subsection{...}
  \subsubsection{...}
  ```

- Slide:

  ```
  \begin{frame}\frametitle{...} ... \end{frame}
  ```

- Block:

  ```
  \begin{block} ... \end{block}
  \begin{alertblock} ... \end{alertblock}
  \begin{exampleblock} ... \end{exampleblock}
  ```

- (Standard) LaTeX lists:

  ```
  \begin{itemize} ... \end{itemize}
  \begin{enumerate} ... \end{enumerate}
  \begin{description} ... \end{description}
  ```

- Multiple columns:

Block: Lorem ...

Lorem ipsum dolor sit amet, ...

Warning: Pseudo Latin

Lorem ipsum dolor sit amet, consectetur adipisici elit, sed eiusmod tempor incidunt ut labore et dolore magna aliqua. Ut enim ...

Example

Lorem ipsum dolor sit amet, ...

- Multiple columns:

Block: Lorem ...

Lorem ipsum dolor sit amet, ...

Warning: Pseudo Latin

Lorem ipsum dolor sit amet, consectetur adipisici elit, sed eiusmod tempor incidunt ut labore et dolore magna aliqua. Ut enim ...

Example

Lorem ipsum dolor sit amet, ...

```
\begin{columns}[c]
  \column{0.25\textwidth}
  \begin{block}{Block: Lorem ...}
      Lorem ipsum dolor sit amet, consectetur adipisici elit, ...
  \end{block}
  \column{0.45\textwidth}
  \begin{alertblock}{Warning: Pseudo Latin}
      Lorem ipsum dolor sit amet, consectetur adipisici elit, ...
  \end{alertblock}
  \column{0.15\textwidth}
  \begin{exampleblock}{Example}
      Lorem ipsum dolor sit amet, consectetur adipisici elit, ...
  \end{exampleblock}
\end{columns}
```

LaTeX Beamer Class: Special Frames

- Title page:

```
\begin{frame}[plain]
    \titlepage
\end{frame}
```

LaTeX Beamer Class: Special Frames

- Title page:

```
\begin{frame}[plain]
    \titlepage
\end{frame}
```

- Table of content:

```
\begin{frame}\frametitle{Contents} % or something else
                                   % as frame title
    \tableofcontents[subsectionstyle=hide
                     subsubsectionstyle=hide]
\end{frame}
```

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LaTeX Beamer Class: Special Frames

- Title page:

```
\begin{frame}[plain]
    \titlepage
\end{frame}
```

- Table of content:

```
\begin{frame}\frametitle{Contents} % or something else
                                    % as frame title
    \tableofcontents[subsectionstyle=hide
                     subsubsectionstyle=hide]
\end{frame}
```

- At the begin of a section:

```
\AtBeginSection[]{
\begin{frame}
\tableofcontents[sectionstyle=show/hide,hideothersubsections,
                          subsubsectionstyle=hide/hide/hide]
\end{frame}
}
```

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LaTeX Beamer Class: Partial Build

- The `\pause` command can be used for simple partial builds of a page.

```
\begin{itemize}
  \item The \verb#\pause# command can be used for simple
        partial builds of a page.
\pause
  \item Note that using \verb#\verb# or the \verb#verbatim#
        environment ...
\end{itemize}
```

- The `\pause` command can be used for simple partial builds of a page.

```
\begin{itemize}
  \item The \verb#\pause# command can be used for simple
        partial builds of a page.
\pause
  \item Note that using \verb#\verb# or the \verb#verbatim#
        environment ...
\end{itemize}
```

- Note that using the `\verb` command or the `verbatim` environment in conjunction with `\pause` requires to specify the option `[fragile]` after `\begin{frame}`:

```
\begin{frame}[fragile]\frametitle{\LaTeX\ Beamer Class:
                                              Partial Build}
```

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```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

LaTeX Beamer Class: Overlays

```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

Overlay 1

- only on overlay 1
- blue text only on overlays 1–3
- on all overlays except 2

LaTeX Beamer Class: Overlays

```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

Overlay 2

- blue text only on overlays 1–3
- only on overlay 2

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LaTeX Beamer Class: Overlays

```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

Overlay 3

- blue text only on overlays 1–3
- on all overlays except 2
- on overlay 3 and all subsequent overlays

LaTeX Beamer Class: Overlays

```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

Overlay 4

- blue text only on overlays 1–3
- on all overlays except 2
- on overlay 3 and all subsequent overlays
- only on overlay 4

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```
\begin{itemize}
  \item<1>{only on overlay 1}
  \item<1->{\color<1-3>{blue}{blue text only on overlays 1--3}}
  \item\alt<2>{only on overlay 2}{on all overlays except 2}
  \item<3->{on  overlay 3 and all subsequent overlays}
  \item<4>{only on overlay 4}
  \item<5>{The overlay specification ...}
\end{itemize}
```

Overlay 5

- blue text only on overlays 1–3
- on all overlays except 2
- on overlay 3 and all subsequent overlays

- The overlay specification can be used with quite a few other LaTeX commands, too. E.g., `\includegraphics<1|handout:0>{...}`.

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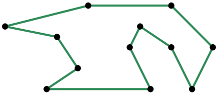
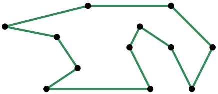
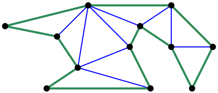
LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

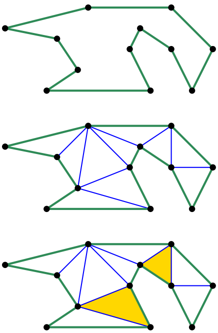


- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,





- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,



- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,

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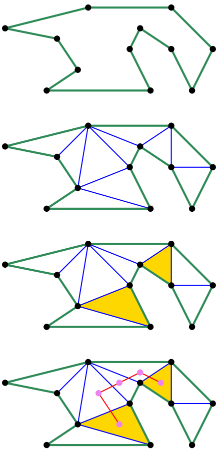
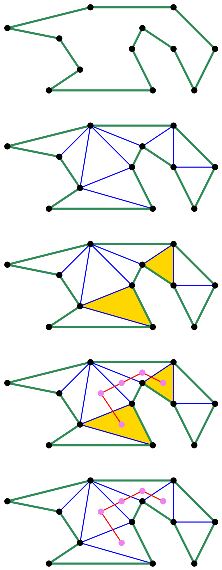
LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

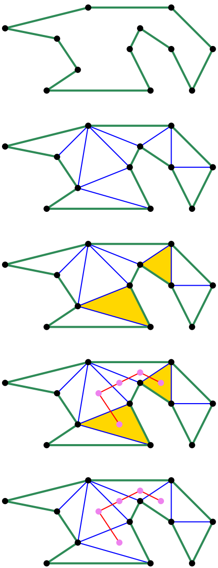


- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them,

LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

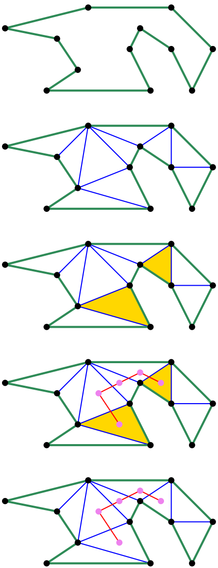


- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them, and
  5. only the path.



- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them, and
  5. only the path.
- Ipe allows to group contents of a figure into layers which can be turned on and off indvidually.

LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views



- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them, and
  5. only the path.
- Ipe allows to group contents of a figure into layers which can be turned on and off indvidually.
- An Ipe *view* is a list of layers that are turned on.
- When saved as a PDF file, each view becomes a single page in the PDF.

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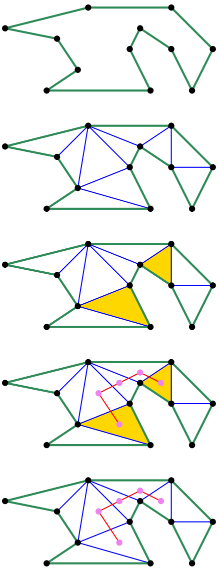
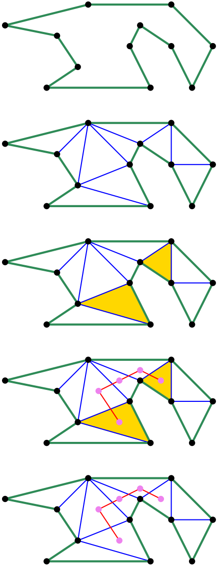
LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views



- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them, and
  5. only the path.
- Ipe allows to group contents of a figure into layers which can be turned on and off indvidually.
- An Ipe *view* is a list of layers that are turned on.
- When saved as a PDF file, each view becomes a single page in the PDF.
- Individual pages of such a PDF can be incorporated into a LaTeX "beamer" document by resorting to the `page` option of the `\includegraphics` command:
  `\includegraphics<1->[page=1,...]{views}`
  `\includegraphics<2->[page=2,...]{views}`

LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views



- Suppose that we want to explain a concept that requires to display similar figures repeatedly. E.g.,
  1. a polygon,
  2. its triangulation,
  3. two specific triangles,
  4. the triangles and a path between them, and
  5. only the path.
- Ipe allows to group contents of a figure into layers which can be turned on and off indvidually.
- An Ipe *view* is a list of layers that are turned on.
- When saved as a `PDF` file, each view becomes a single page in the `PDF`.
- Individual pages of such a `PDF` can be incorporated into a LaTeX "beamer" document by resorting to the `page` option of the `\includegraphics` command:
  `\includegraphics<1->[page=1,...]{views}`
  `\includegraphics<2->[page=2,...]{views}`
- This makes it easy to "build" a figure or an animation, without (re-)drawing the figure multiple times.

LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

```
\begin{columns}[c]
 \column{0.45\textwidth}
    \includegraphics<1|handout:0>[page=1]{views}%
    \includegraphics<2|handout:0>[page=2]{views}%
    \includegraphics<3|handout:0>[page=3]{views}%
    \includegraphics<4|handout:1>[page=4]{views}%
  \column{0.6\textwidth}
  \begin{enumerate}
    \item<1-> A polygon,
    \item<2-> its triangulation,
    \item<3-> two specific triangles, \only<4->{and}
    \item<4-> the triangles and a path between them.
  \end{enumerate}
\end{columns}
```

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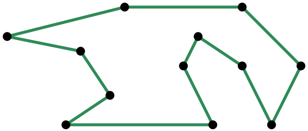
LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

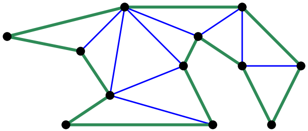
```
\begin{columns}[c]
 \column{0.45\textwidth}
    \includegraphics<1|handout:0>[page=1]{views}%
    \includegraphics<2|handout:0>[page=2]{views}%
    \includegraphics<3|handout:0>[page=3]{views}%
    \includegraphics<4|handout:1>[page=4]{views}%
  \column{0.6\textwidth}
  \begin{enumerate}
    \item<1-> A polygon,
    \item<2-> its triangulation,
    \item<3-> two specific triangles, \only<4->{and}
    \item<4-> the triangles and a path between them.
  \end{enumerate}
\end{columns}
```



1. A polygon,

LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

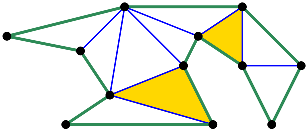
```
\begin{columns}[c]
 \column{0.45\textwidth}
    \includegraphics<1|handout:0>[page=1]{views}%
    \includegraphics<2|handout:0>[page=2]{views}%
    \includegraphics<3|handout:0>[page=3]{views}%
    \includegraphics<4|handout:1>[page=4]{views}%
  \column{0.6\textwidth}
  \begin{enumerate}
    \item<1-> A polygon,
    \item<2-> its triangulation,
    \item<3-> two specific triangles, \only<4->{and}
    \item<4-> the triangles and a path between them.
  \end{enumerate}
\end{columns}
```



1. A polygon,
2. its triangulation,

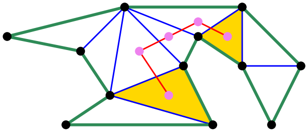
LaTeX Beamer Class: Overlays in Conjunction with Ipe's Views

```
\begin{columns}[c]
 \column{0.45\textwidth}
    \includegraphics<1|handout:0>[page=1]{views}%
    \includegraphics<2|handout:0>[page=2]{views}%
    \includegraphics<3|handout:0>[page=3]{views}%
    \includegraphics<4|handout:1>[page=4]{views}%
  \column{0.6\textwidth}
  \begin{enumerate}
    \item<1-> A polygon,
    \item<2-> its triangulation,
    \item<3-> two specific triangles, \only<4->{and}
    \item<4-> the triangles and a path between them.
  \end{enumerate}
\end{columns}
```



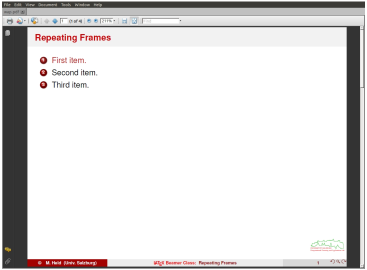
1. A polygon,
2. its triangulation,
3. two specific triangles,

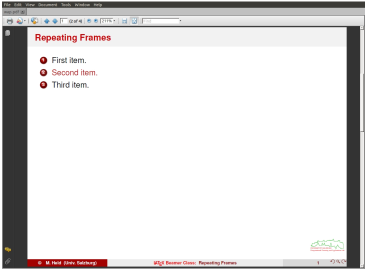
```
\begin{columns}[c]
 \column{0.45\textwidth}
    \includegraphics<1|handout:0>[page=1]{views}%
    \includegraphics<2|handout:0>[page=2]{views}%
    \includegraphics<3|handout:0>[page=3]{views}%
    \includegraphics<4|handout:1>[page=4]{views}%
  \column{0.6\textwidth}
  \begin{enumerate}
    \item<1-> A polygon,
    \item<2-> its triangulation,
    \item<3-> two specific triangles, \only<4->{and}
    \item<4-> the triangles and a path between them.
  \end{enumerate}
\end{columns}
```

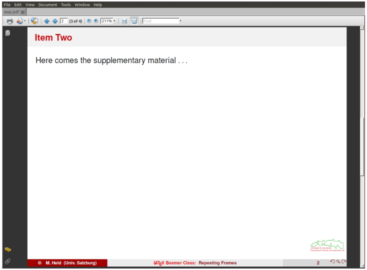


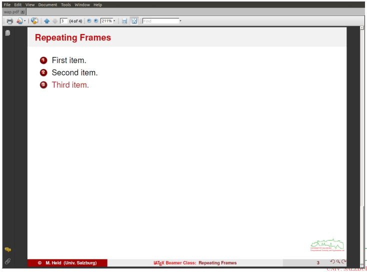
1. A polygon,
2. its triangulation,
3. two specific triangles, and
4. the triangles and a path between them.

LaTeX Beamer Class: Repeating Frames









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LaTeX Beamer Class: Repeating Frames

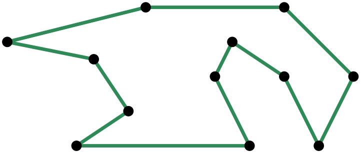
- The following LaTeX code produces the four slides shown on the previous slide:

```
\begin{frame}<1-2>[label=myframe]\frametitle{Repeating Frames}
  \begin{enumerate}
    \item<alert@1> First item.
    \item<alert@2> Second item.
    \item<alert@3> Third item.
  \end{enumerate}
\end{frame}
```

```
\begin{frame}\frametitle{Item Two}
  Here comes the supplementary material $\ldots$
\end{frame}
```

```
\againframe<3>{myframe}
```

LaTeX Beamer Class: Animations



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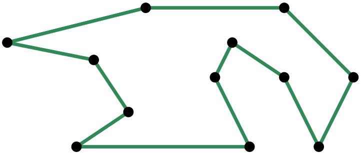
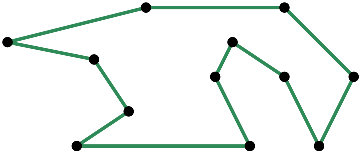


- For an *n*-page `PDF` file `foo.pdf`:

  `\animategraphics[autoplay,loop]{fps}{foo}{0}{n-1}`



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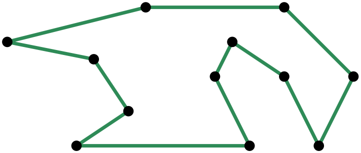

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  `convert -coalesce foo.gif foo.png`

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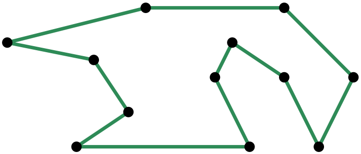

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- The use of `animategraphics` requires the `animate` package to be loaded in the preamble.

LaTeX Beamer Class: Themes

- The visual appearance of slides can be influenced by choosing among multiple pre-defined layouts and coloring schemes.
- Combinations and personal customizations of the pre-defined options allow to create a virtually unlimited variety of layouts.

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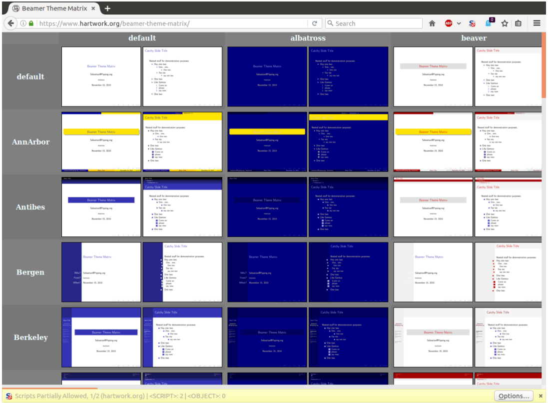
- Combinations and personal customizations of the pre-defined options allow to create a virtually unlimited variety of layouts.
- A great survey of the basic combinations is provided by the Beamer Theme Matrix, `www.hartwork.org/beamer-theme-matrix`.



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LaTeX Beamer Class: Themes

- These slides and handouts were generated with the following setting:

```
\ifdefined\ishandout
\documentclass[handout,...options...]{beamer}
  \usetheme{default}
  \usecolortheme{dove}
  \usecolortheme[named=BrickRed]{structure}
%  \usepackage{pgfpages}
%  \pgfpagesuselayout{4 on 1}[border shrink=5mm,landscape]
\else \ifdefined\nopause
\documentclass[handout,...options...]{beamer}
  \usetheme{Madrid}
  \usecolortheme{beaver}
  \usecolortheme[named=BrickRed]{structure}
\else
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```

- LaTeX commands: `pdflatex "\def\ishandout{1} \input{wap}"` or `pdflatex "\def\nopause{1} \input{wap}"` or simply `pdflatex wap`.

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4 pdfLaTeX and the Generation of Slides

- Portable Data Format (PDF)
- pdfTeX and pdfLaTeX
- Generating PDF Slides: LaTeX Beamer Class
- Current LaTeX-Related Projects
  - Future Developments
  - Collaborative LaTeX Environments

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The Future of pdfLaTeX

- Work on pdfLaTeX has mostly been finished, and future releases should be expected to contain only bug fixes.

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- LuaTeX/LuaLaTeX:
  - It has been adopted as the official successor of pdfLaTeX.
  - Based on the Lua scripting engine.
  - It supports multi-directional typesetting.
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- XeTeX/XeLaTeX:
  - It is a recent development that supports Unicode in a native way and that can use any font installed on the system, with no extra configurations needed.
  - Its input files are assumed to be in UTF-8 encoding.
  - It also supports more advanced typographic features than pdfLaTeX.
  - It is included in the TeX Live, MiKTeX, and MacTeX bundles.
  - Logos obtained as `\XeTeX` and `\XeLaTeX`, as provided by the `metalogo` package.

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Overleaf

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- The basic full version is free but it allows only one collaborator per project. Furthermore the free version imposes some limitations on the number of projects and on the storage provided.
- Premium (pay-per-month) plans allow more collaborators per project and come with additional features, such as a synchronization with DropBox or GitHub.

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CoCalc

- CoCalc, https://cocalc.com, is a cloud-based computing platform designed for collaborative computational mathematics and academic writing.
- It is part of the open-source SageMath project (http://www.sagemath.org/).
- Run in an Ubuntu Linux environment, and accessed via standard web browers.
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- Allows the use of several mathematical software packages, such as R, Maxima, Octave (which is syntax-compatible with MATLAB).
- Offers a Linux terminal, which provides access to standard Linux tools and programming languagess, e.g., C/C++, Java, Perl, Ruby.
- All files are backed up every few minutes to Google's cloud storage.

SyncTeX

- Written by Jérôme Laurens, and distributed with the TEX Live and MiKTEX distributions.
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- SyncTEX creates additional files that support this synchronization.
- Since these files may become quite large it is advisable to request a compression (by means of `gzip`) by passing the run-time option `--synctex=1` to pdfLATEX (or some other LATEX engine that supports SyncTEX). Alternatively, one can put `\synctex=1` into the preamble of the LATEX document.
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- SyncTEX does not (yet) work fully in conjunction with the LATEX beamer package.

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5 Mathematica for Symbolic Computation

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- Mathematica is a software package – "*computer algebra system*" (CAS) – for use in mathematical applications that require symbolic computation.
- It was conceived by Stephen Wolfram, starting in late 1986, and has been developed by Wolfram Research at Champaign (IL, USA).

Basics of Mathematica

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- It also provides graphics capabilities, and can produce two- and three-dimensional graphs.
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- Mathematica is a commercial product, and it is available for a variety of platforms.
- Student licenses for "work at home" can be obtained via the web page of PLUS ITServices:
  See https://it-info.sbg.ac.at/index.php?title=SoftwareStudierende.

Other Packages for Symbolic Computation

- Maple: By MapleSoft, Waterloo (ON, Canada); https://www.maplesoft.com/
- Maxima: Based on MIT's legendary Macsyma; http://maxima.sourceforge.net/
- Axiom: By T. Daly, Pittsburgh (PA, USA); http://axiom.axiom-developer.org
- Magma: By Computational Algebra Group, U. Sidney (Australia), http://magma.maths.usyd.edu.au/magma/
- MATLAB: Via the MuPAD symbolic engine, by MathWorks, Natick (MA, USA); https://www.mathworks.com/products/matlab.html
- SageMath: By W. Stein, U. Washington (WA, USA); http://www.sagemath.org/
- ...

User Interface

- Mathematica can run in an *ASCII terminal mode*, or it can display *notebooks* as an *X11 client*.
- To run Mathematica from an ASCII terminal, enter `math`. To run Mathematica as an X11 client, enter `mathematica`.
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- Calculations that take too long can be aborted by typing `ALT ,` (in a notebook environment), or `CTRL c` (in terminal mode).
- Mathematica offers several *palettes* for facilitating the input of characters and symbols.
- Functions can often be entered via *templates*, and `TAB` can be used for moving among *placeholders*.
- Many symbols can also be entered directly. E.g., `ESC p ESC` will generate π.

Basic Math in Mathematica

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- Mathematica labels its input and output as `In[`n`]` and `Out[`n`]`, where n is a counter that is stepped for every input/output pair.

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In[1] :=  3 + 5
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$$\texttt{In[1]} := 3 + 5$$
$$\texttt{Out[1]} = 8$$

- One can refer to the last output generated as `%`. A string of *k* percent signs refers to the *k*-th previous output, and `%`*n* refers to the output numbered *n*.

$$\texttt{In[2]} := \% + 3^2$$
$$\texttt{Out[2]} = 17$$

$$\texttt{In[3]} := \% - 2 * \%1$$
$$\texttt{Out[3]} = 1$$

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- Mathematica distinguishes between two types of values, *exact* and *approximate*.
  - Exact values may either be (a) integers or fractions, in which case Mathematica keeps as many digits as necessary to express the value exactly, or (b) symbolic names for constants such as e, π, $\sqrt{2}$, for which Mathematica knows how to find as many digits as necessary in any computation.

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- An exact value of x can be converted to an n-digit approximate value by calling the function $\mathrm{N}[x, n]$.

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Warning

Mathematica will apply inexact computation (and approximate all exact values) even if an expression contains just one approximate value!

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- Note, however, that spaces are required if $*$ is omitted: x 2 is different from x2!
- The expression $x = value$ assigns *value* to x.

Warning

Note that this is a *permanent assignment*, and Mathematica will substitute *value* in all subsequent occurrences of x, until or unless explicitly told otherwise.

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- Any value assigned to x can be removed via $x = .$ or $\mathrm{Clear}[x]$.

```
In[5] :=  x = 4
Out[5] =  4

In[6] :=  3 * √x
Out[6] =  6

In[7] :=  Clear[x]

In[8] :=  3 * √x
Out[8] =  3 √x
```

- Any value assigned to x can be removed via $x = .$ or $\mathrm{Clear}[x]$.

In[5] := $x = 4$
Out[5] = 4

In[6] := $3 * \sqrt{x}$
Out[6] = 6

In[7] := $\mathrm{Clear}[x]$

In[8] := $3 * \sqrt{x}$
Out[8] = $3\sqrt{x}$

Advice

In order to avoid mistakes, it is advisable to clear assignments as soon as they are no longer needed.

```
In[9]  := 123456789123456789 + 987654321987654321
Out[9]  = 1111111111111111110

In[10] := 40!
Out[10] = 815915283247897734345611269596115894272000000000

In[11] := Binomial[5, 2]
Out[11] = 10

In[12] := x = N[π]
Out[12] = 3.14159

In[13] := Sin[π]
Out[13] = 0

In[14] := Sin[x]
Out[14] = 1.22465 10^-16
```

Mathematica as a Scientific Calculator

```
In[15]  :=
```
$1.0 / (\mathrm{Sin}[x] \text{ ^ } 1000)$

```
Out[15]  =
```
$9.75322579165\,10^{15911}$

```
In[16]  :=
```
$x = 1/3 + 1/5$

```
Out[16]  =
```
$\frac{8}{15}$

```
In[17]  :=
```
$(15\,x)/8$

```
Out[17]  =
```
1

```
In[18]  :=
```
$\mathrm{Clear}[x]$

```
In[19]  :=
```
$\sqrt[6]{64}$

```
Out[19]  =
```
2

```
In[20]  :=
```
$\pi\text{^}2 / 6.$

```
Out[20]  =
```
1.64493

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Lists as Mathematica Objects

- Many Mathematica objects are based on *lists*. Also, most operations can be applied to whole lists, which get treated as single objects.

In[21] := $x = \{2, 3, 4\}$
Out[21] = $\{2, 3, 4\}$

In[22] := x^2
Out[22] = $\{4, 9, 16\}$

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- Many Mathematica objects are based on *lists*. Also, most operations can be applied to whole lists, which get treated as single objects.

```
In[21] :=  x = {2, 3, 4}
Out[21] =  {2,3,4}

In[22] :=  x^2
Out[22] =  {4,9,16}
```

- The commands $\mathrm{Part}[x, i]$ and $x[[i]]$ extract the i-th element of the list x.

```
In[23] :=  x
Out[23] =  {2,3,4}

In[24] :=  x[[2]] = 10
Out[24] =  10
```

Lists as Mathematica Objects

- The commands $\mathrm{Part}[x, i]$ and $x[[i]]$ extract the i-th element of the list x.

```
In[25] :=  x
Out[25] =  {2, 10, 4}

In[26] :=  x[[1]] + x[[2]] + x[[3]]
Out[26] =  16
```

- The commands $\mathrm{Part}[x, i]$ and $x[[i]]$ extract the i-th element of the list x.

```
In[25]  :=  x
Out[25]  =  {2, 10, 4}

In[26]  :=  x[[1]] + x[[2]] + x[[3]]
Out[26]  =  16
```

- Typically, parentheses `()` are used for grouping, brackets `[]` enclose function arguments, curly braces `{}` delimite lists, and double brackets `[[]]` are used for indexing.

- Vectors and matrices are lists and lists of lists, respectively.

```
In[27] :=
```
$m[x\_] := \{\{\mathrm{Cos}[x], -\mathrm{Sin}[x], 0\}, \{\mathrm{Sin}[x], \mathrm{Cos}[x], 0\}, \{0, 0, 1\}\}$

```
In[28] :=
```
$\mathrm{MatrixForm}[m[x]]$

```
Out[28] =
```
$$\begin{pmatrix} \mathrm{Cos}[x] & -\mathrm{Sin}[x] & 0 \\ \mathrm{Sin}[x] & \mathrm{Cos}[x] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

```
In[29] :=
```
$\mathrm{Simplify}[\mathrm{Det}[m[x]]]$

```
Out[29] =
```
1

```
In[30] :=
```
$\mathrm{Transpose}[m[x]]$

```
Out[30] =
```
$\{\{\mathrm{Cos}[x], \mathrm{Sin}[x], 0\}, \{-\mathrm{Sin}[x], \mathrm{Cos}[x], 0\}, \{0, 0, 1\}\}$

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- Vectors and matrices are lists and lists of lists, respectively.

```
In[31] :=  Dimensions[m[x]]
Out[31] =  {3,3}

In[32] :=  v = {1, 0, 1}
Out[32] =  {1,0,1}

In[33] :=  w = m[π/2] . v
Out[33] =  {0,1,1}

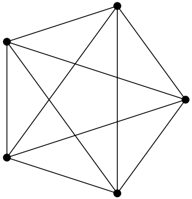
In[34] :=  Cross[v, w]
Out[34] =  {−1,−1,1}

In[35] :=  v. w
Out[35] =  1
```

- Mathematica can also deal with graphs and similar combinatorical entities.

`In[36] :=` CompleteGraph[5]

`Out[36] =`



`In[37] :=` MatrixForm[AdjacencyMatrix[%]]

`Out[37] =`

$$\begin{pmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 \end{pmatrix}$$

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- Expand and Factor can be used for transforming algebraic expressions.

```
In[38]  :=  1 + x^2 - 2x
Out[38]  =  1 - 2 x + x^2

In[39]  :=  % * (2 + x)
Out[39]  =  (2 + x) (1 - 2 x + x^2)

In[40]  :=  Expand[%]
Out[40]  =  2 - 3 x + x^3

In[41]  :=  Factor[%]
Out[41]  =  (-1 + x)^2 (2 + x)

In[42]  :=  % /. {x -> 1}
Out[42]  =  0
```

- Expand and Factor can be used for transforming algebraic expressions.

In[43] := %% /. {x -> {a + 2}}
Out[43] = $\{(1+a)^2\,(4+a)\}$

In[44] := %%% * x/ ((x − 1)^3 * (x + 1))
Out[44] = $\frac{x\ (2+x)}{(-1+x)\ (1+x)}$

In[45] := Expand[%]
Out[45] = $\frac{2\ x}{(-1+x)\ (1+x)} + \frac{x^2}{(-1+x)\ (1+x)}$

In[46] := ExpandAll[%]
Out[46] = $\frac{2\ x}{-1+x^2} + \frac{x^2}{-1+x^2}$

Simplifying Algebraic Terms with Mathematica

- Getting expressions into a simple form sometimes is an art, and may require a bit of experimenting with Simplify and similar commands.

In[47] := Simplify[%]

Out[47] = $\frac{x\ (2+x)}{-1+x^2}$

In[48] := % * (y + 1) / (y - 1)

Out[48] = $\frac{x\ (2+x)\ (1+y)}{(-1+x^2)\ (-1+y)}$

In[49] := ExpandAll[%]

Out[49] = $\frac{2\ x}{1-x^2-y+x^2\ y}+\frac{x^2}{1-x^2-y+x^2\ y}+\frac{2\ x\ y}{1-x^2-y+x^2\ y}+\frac{x^2\ y}{1-x^2-y+x^2\ y}$

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- Getting expressions into a simple form sometimes is an art, and may require a bit of experimenting with Simplify and similar commands.

```
In[50] := % * (1 - x^2) (1 - y)
```

$$\text{Out[50]} = \left(\left(\frac{2\ x}{1-x^2-y+x^2\ y}+\frac{x^2}{1-x^2-y+x^2\ y}+\frac{2\ x\ y}{1-x^2-y+x^2\ y}+\frac{x^2\ y}{1-x^2-y+x^2\ y}\right)(1-x^2)\,(1-y)\right)$$

```
In[51] := Simplify[%]
```

$$\text{Out[51]} = x\,(2+x)\,(1+y)$$

```
In[52] := Expand[%]
```

$$\text{Out[52]} = 2\ x+x^2+2\ x\ y+x^2\ y$$

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- Getting expressions into a simple form sometimes is an art, and may require a bit of experimenting with Simplify and similar commands.

```
In[53] :=  FactorTerms[%, y]
Out[53] =  (2 x + x^2) (1 + y)

In[54] :=  Collect[Expand[%], y]
Out[54] =  2 x + x^2 + (2 x + x^2) y
```

5 Mathematica for Symbolic Computation

- Mathematica can handle differentiation and integration symbolically.

```
In[55]  :=  D[x (1 + x^4), x]
Out[55]  =  1 + 5 x^4
```

$\texttt{In[55] :=}\ \mathrm{D}[x\ (1\ +\ x\hat{}4),\ x]$

$\texttt{Out[55] =}\ 1 + 5\ x^4$

$\texttt{In[56] :=}\ \mathrm{D}[2x\ +\ x\hat{}2\ +\ (2\ x\ +\ x\hat{}2)\ y,\ y]$

$\texttt{Out[56] =}\ 2\ x + x^2$

$\texttt{In[57] :=}\ \mathrm{Integrate}[\%\ /\ (x\ +1),\ x]$

$\texttt{Out[57] =}\ x + \frac{x^2}{2} - \log[1 + x]$

$\texttt{In[58] :=}\ \mathrm{D}[\%,\ x]$

$\texttt{Out[58] =}\ 1 + x - \frac{1}{1+x}$

$\texttt{In[59] :=}\ \mathrm{Factor}[\%]$

$\texttt{Out[59] =}\ \frac{x\ (2+x)}{1+x}$

- Mathematica can handle differentiation and integration symbolically.

In[60] := $\mathrm{D}[f[x] \,/\, x,\ x]$
Out[60] = $-\frac{f[x]}{x^2} + \frac{f'[x]}{x}$

In[61] := $\mathrm{Integrate}[\%,\ x]$
Out[61] = $\frac{f[x]}{x}$

In[62] := $\mathrm{D}[x\hat{}y,\ x]$
Out[62] = $x^{-1+y}\ y$

In[63] := $\% \,/.\, \{y \rightarrow x\}$
Out[63] = x^x

- Of course, an integral need not always exist. Still, one may be able to get a numerical approximation of a corresponding definite integral.

```
In[64] :=  %
Out[64] =  x^x

In[65] :=  Integrate[%, x]
Out[65] =  ∫ x^x dx

In[66] :=  Integrate[%%, {x, 0, 1}]
Out[66] =  ∫_0^1 x^x dx

In[67] :=  N[%]
Out[67] =  0.783431

In[68] :=  D[%%%, x]
Out[68] =  x^x
```

Sums and Products

- Mathematica can also handle sums and products.

```
In[69]  :=  Sum[i, {i, 1, 5}]
Out[69]  =  15

In[70]  :=  Product[i, {i, 1, 5}]
Out[70]  =  120

In[71]  :=  Sum[Product[x + i, {i, 0, j}], {j, 0, 3}]
Out[71]  =  x + x (1 + x) + x (1 + x) (2 + x) + x (1 + x) (2 + x) (3 + x)

In[72]  :=  Expand[%]
Out[72]  =  10 x + 15 x^2 + 7 x^3 + x^4

In[73]  :=  Sum[1 / 2^i, {i, 0, ∞}]
Out[73]  =  2

In[74]  :=  D[x Sum[1 / 2^i, {i, 0, ∞}], x]
Out[74]  =  2
```

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- Mathematica can handle limits.

```
In[75] :=  Sin[x] / x
Out[75] =  Sin[x]/x

In[76] :=  % /. {x -> 0}
Out[76] =  Indeterminate

In[77] :=  Limit[%%, x-> 0]
Out[77] =  1
```

- Mathematica can handle ordinary differential equations.

```
In[78] :=  DSolve[ { y'[x] == a y[x] + 1, y[0] == 0}, y[x], x]
Out[78] =  {{y[x] → (-1+e^(a x))/a}}
```

$$\text{Out[78]} = \left\{\left\{y[x] \to \frac{-1+e^{a\,x}}{a}\right\}\right\}$$

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- Mathematica can handle ordinary differential equations.

In[78] := $\text{DSolve}[\{\, y'[x] \;==\; a\, y[x] + 1,\; y[0] \;==\; 0\},\; y[x],\; x]$
Out[78] = $\{\{y[x] \to \frac{-1+e^{a\,x}}{a}\}\}$

- As of Version 9.0, Mathematica can also handle multi-dimensional calculus without the need to load additional packages.

In[79] := $\text{D}[\{\text{Sin}[\alpha], \text{Cos}[\alpha]\}, \alpha]$
Out[79] = $\{\text{Cos}[\alpha], -\text{Sin}[\alpha]\}$

In[80] := $\text{ArcLength}[\{\text{Sin}[\alpha], \text{Cos}[\alpha]\}, \{\alpha, 0, 2\pi\}]$
Out[80] = 2π

In[81] := $\text{Grad}[x^2 + y^2 + z^2, \{x, y, z\}]$
Out[81] = $\{2x, 2y, 2z\}$

5 Mathematica for Symbolic Computation

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- Mathematica provides the function `Solve` for computing symbolic solutions for equations.

```
In[82] :=  Solve[a x^2 + b x + c == 0, x]
```

$$\text{Out[82]} = \left\{\left\{x \to \frac{-b-\sqrt{b^2-4\ a\ c}}{2\ a}\right\}, \left\{x \to \frac{-b+\sqrt{b^2-4\ a\ c}}{2\ a}\right\}\right\}$$

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Symbolic Solutions for Equations

- Mathematica provides the function `Solve` for computing symbolic solutions for equations.

```
In[82] :=  Solve[a x^2 + b x + c == 0, x]
```
$$\texttt{Out[82]} = \left\{\left\{x \to \frac{-b-\sqrt{b^2-4\ a\ c}}{2\ a}\right\}, \left\{x \to \frac{-b+\sqrt{b^2-4\ a\ c}}{2\ a}\right\}\right\}$$

- The Mathematica command *expr/.rules* applies a list of rules to the expression *expr*.

```
In[83] :=  % /. {a -> 2, b -> 3, c -> 1/2}
```
$$\texttt{Out[83]} = \left\{\left\{x \to \tfrac{1}{4}\left(-3-\sqrt{5}\right)\right\}, \left\{x \to \tfrac{1}{4}\left(-3+\sqrt{5}\right)\right\}\right\}$$

```
In[84] :=  x /. %
```
$$\texttt{Out[84]} = \left\{\tfrac{1}{4}\left(-3-\sqrt{5}\right), \tfrac{1}{4}\left(-3+\sqrt{5}\right)\right\}$$

```
In[85] :=  %[[1]] * 4
```
$$\texttt{Out[85]} = -3-\sqrt{5}$$

Symbolic Solutions for Equations

- Mathematica provides the Solve function for computing symbolic solutions for equations.

```
In[86] := Solve[{x - y == 2, x + y == 0}, {x, y}]
Out[86] = {{x -> 1, y -> -1}}

In[87] := Eliminate[{x - y == 2, x + y == 0}, y]
Out[87] = x == 1

In[88] := Solve[Sin[x]^2 == a, x]
Out[88] = {{x -> -ArcSin[Sqrt[a]]}, {x -> ArcSin[Sqrt[a]]}}
```

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- We can use Mathematica to solve recurrence relations.

```
In[89]  :=  RSolve[{a[n] == 2a[n - 1], a[1] == 1}, a[n], n]
Out[89]  =  {{a[n] → 2^(-1+n)}}

In[90]  :=  Table[a[n] /. First[%], {n, 12}]
Out[90]  =  {1, 2, 4, 8, 16, 32, 64, 128, 256, 512}
```

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- We can use Mathematica to solve recurrence relations.

```
In[89]  :=  RSolve[{a[n] == 2a[n-1], a[1] == 1}, a[n], n]
Out[89]  =  {{a[n] -> 2^(-1+n)}}

In[90]  :=  Table[a[n] /. First[%], {n, 12}]
Out[90]  =  {1, 2, 4, 8, 16, 32, 64, 128, 256, 512}
```

- We can also directly tabulate the first few Fibonacci numbers.

```
In[91]  :=
RecurrenceTable[{a[n] == a[n-1] + a[n-2], a[1] == 1, a[2] == 1}, a, {n, 10}]
Out[91]  =  {1, 1, 2, 3, 5, 8, 13, 21, 34, 55}

In[92]  :=  Table[Fibonacci[n], {n, 10}]
Out[92]  =  {1, 1, 2, 3, 5, 8, 13, 21, 34, 55}
```

5 Mathematica for Symbolic Computation

- Mathematica provides functions for computing numerical approximations of sums, products, and integrals.

```
In[93]  :=  Sum[1 / i^2, {i, 1, ∞}]
Out[93]  =  π^2/6

In[94]  :=  N[%]
Out[94]  =  1.64493

In[95]  :=  NSum[1 / i^2, {i, 1, ∞}]
Out[95]  =  1.64493

In[96]  :=  NIntegrate[ Sin[xy], {x, 0, 1}, {y, 0, x}]
Out[96]  =  0.119906
```

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- It can also solve a (system of) polynomial equation(s) numerically, or search for an approximate solution of an arbitrary equation.

```
In[97]  :=  Solve[ x^3 - √π x^2 == 0, x]
Out[97]  =  {{x → 0}, {x → 0}, {x → √π}}

In[98]  :=  NSolve[ x^3 - √π x^2 == 0, x]
Out[98]  =  {{x → 0.}, {x → 0.}, {x → 1.77245}}

In[99]  :=  FindRoot[ Sin[x] == x, {x, 0.001}]
Out[99]  =  {x → 0.}
```

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5 Mathematica for Symbolic Computation

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- Mathematica lets one define functions that can then be used similar to built-in functions.

```
In[100]  :=  Expand[ Product[ x + i, {i , 1, 3}]]
Out[100]  =  6 + 11 x + 6 x^2 + x^3

In[101]  :=  exprod[n_] := Expand[ Product[ x + i, {i , 1, n}]]
In[102]  :=  exprod[3]
Out[102]  =  6 + 11 x + 6 x^2 + x^3

In[103]  :=  D[exprod[3], x]
Out[103]  =  11 + 12 x + 3 x^2

In[104]  :=  cex[n_, i_] := ( t = exprod[n]; Coefficient[t, x^i] )
In[105]  :=  cex[3, 2]
Out[105]  =  6
```

- Mathematica lets one define functions that can then be used similar to built-in functions.

```
In[106]  :=  Clear[cex]
In[107]  :=  t
Out[107] =   6 + 11 x + 6 x^2 + x^3
```

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- Mathematica lets one define functions that can then be used similar to built-in functions.

```
In[106]  :=  Clear[cex]
In[107]  :=  t
Out[107]  =  6 + 11 x + 6 x^2 + x^3
```

- This is not quite what we expected and want ...
- We resort to a module to encapsulate the local variable.

```
In[108]  :=  Clear[t]
In[109]  :=  cex[n_, i_] := Module[{t}, t = exprod[n]; Coefficient[t, x^i]]
In[110]  :=  cex[3, 2]
Out[110]  =  6

In[111]  :=  t
Out[111]  =  t
```

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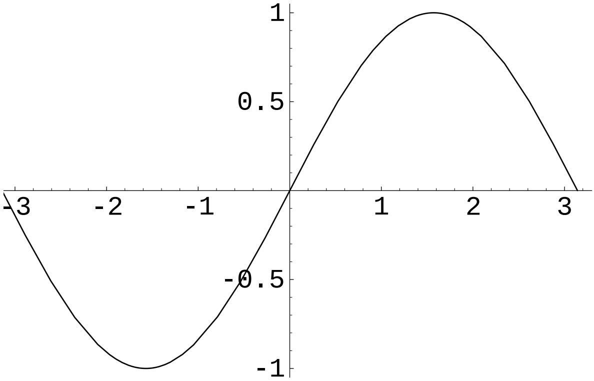
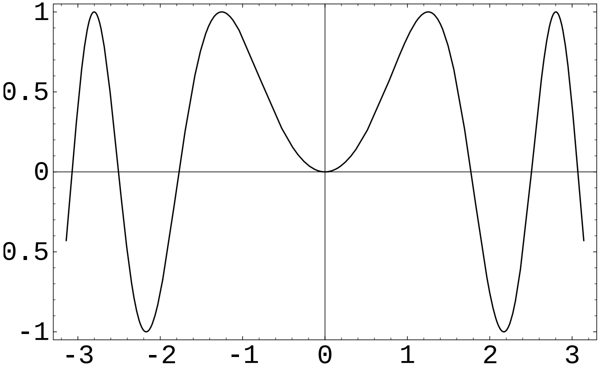
- `Plot` offers many features for drawing 2D graphs.

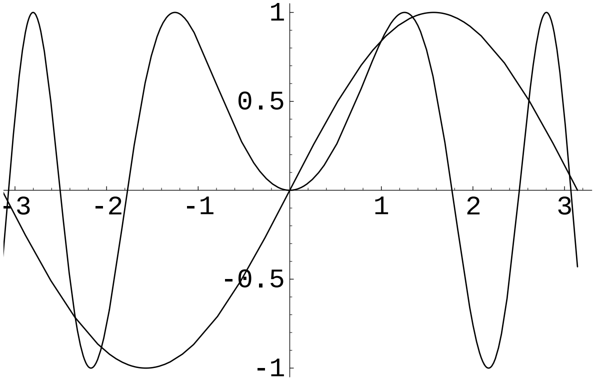
`In[112] :=` $p1 = \mathrm{Plot}[\,\mathrm{Sin}[x],\ \{x,\ -\pi,\ \pi\}]$



- `In[113] :=` $p2 = \mathrm{Plot}[\,\mathrm{Sin}[x\hat{}2],\ \{x,\ -\pi,\ \pi\},\ \mathrm{Frame} \text{->}\ \mathrm{True}]$

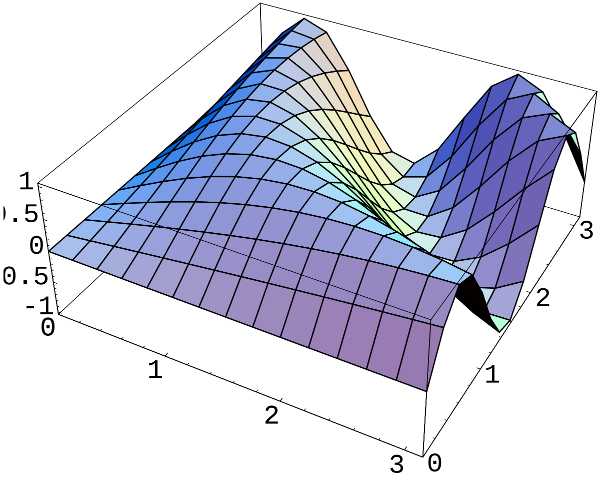


- `In[114] :=` $p3 = \text{Show}[p1, p2]$



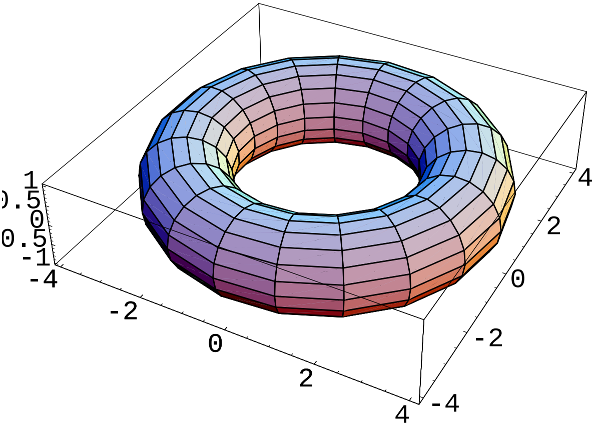
- Mathematica can also handle 3D plots.

In[115] := Plot3D[Sin[x y], {x, 0, π}, {y, 0, π}]



- Mathematica can also handle 3D plots.

```
In[116] :=  torus = ParametricPlot3D[
            {Cos[t] (3 + Cos[u]), Sin[t] (3 + Cos[u]), Sin[u]},
            {t, 0, 2π}, {u, 0, 2π}]
```



5 Mathematica for Symbolic Computation

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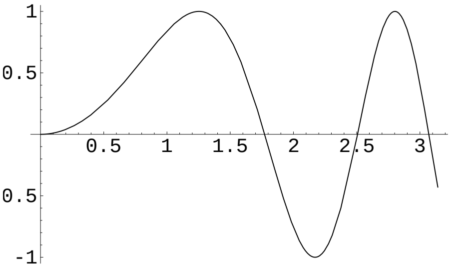
- Mathematica can export a plot as a graphics file. Supported formats include, among others, EPS, PDF, GIF, TIFF, PBM.

In[117] := Plot[Sin [x^2], {x, 0, π}]

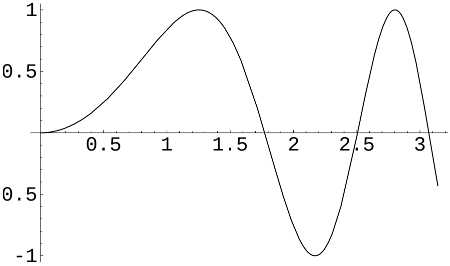


Out[117] =

In[118] := Export["*foo.eps*", %, "*EPS*"]

- Mathematica can export a plot as a graphics file. Supported formats include, among others, EPS, PDF, GIF, TIFF, PBM.

```
In[117] :=   Plot[ Sin [x^2], {x, 0, π}]
```




```
Out[117] =
```

```
In[118] :=   Export["foo.eps", %, "EPS"]
```

- (Portions of) Mathematica notebooks can also be printed as PostScript files. See Mathematica's `print` menu.

Exporting Mathematica Output

- Mathematica can export expressions in C or Fortran format. (C macros are defined in Mathematica's file `mdefs.h`.)

In[119] := $t = (x\hat{\ }2 - 1) \,/\, \sqrt{x - 1}$

Out[119] = $\frac{-1+x^2}{\sqrt{-1+x}}$

In[120] := CForm[t]

Out[120] = `(-1 + Power(x,2))/Sqrt(-1 + x)`

In[121] := FortranForm[t]

Out[121] = `(-1 + x**2)/Sqrt(-1 + x)`

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Exporting Mathematica Output

- Mathematica can export expressions in $\TeX$-format, too.

```
In[122]  :=  t
Out[122]  =  (-1+x^2)/Sqrt[-1+x]
```

$$\texttt{Out[122]} = \frac{-1+x^2}{\sqrt{-1+x}}$$

```
In[123]  :=  TeXForm[t]
Out[123]  =  \frac{-1 + x^2}{\sqrt{-1 + x}}
```

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Exporting Mathematica Output

- Mathematica can export expressions in $\TeX$-format, too.

```
In[122] :=  t
Out[122] =  (-1+x^2)/Sqrt[-1+x]
```

$$\texttt{In[122] :=}\quad t$$
$$\texttt{Out[122] =}\quad \frac{-1+x^2}{\sqrt{-1+x}}$$

$$\texttt{In[123] :=}\quad \mathrm{TeXForm}[t]$$

```
Out[123] = \frac{-1 + x^2}{\sqrt{-1 + x}}
```

- Also, Mathematica can export a notebook (or portions thereof) as a LaTeX-file. This LaTeX-file contains macros defined in Mathematica's style file `notebook.sty`. (This is the way all the Mathematica expressions of this document were generated.) See the `TeXSave` command for details.
- Personal experience tells me that the LaTeX-output generated by Mathematica needs a bit of manual polishing in order for LaTeX to digest it, and to format it neatly.

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- Bi-directional communication between Mathematica and an application program is supported by the *MathLink* standard. See the manual for details.
- Mathematica can be instructed to generate output suitable for display by Geomview. (The file `OOGL.m` is provided by Geomview.)

```
In[124] := << OOGL.m
In[125] := WriteOOGL["m_torus.off", torus]
```

- One can also use Geomview directly for displaying Mathematica graphics. The `Geomview` command invokes Geomview and sends the graphics to Geomview as an OOGL object. (For some reason, this does not work in our environment!)

5 Mathematica for Symbolic Computation

- We use Mathematica for plotting a Bézier curve.

`In[126] :=` $pnts =$
$\{\{0,0\},\{0,1\},\{1,3\},\{3,3\},\{5,0\},\{7,1\},\{8,2\},\{7,3\},\{5,4\},\{4,4\},\{4,3\}\}$
`Out[126] =`
$\{\{0,0\},\{0,1\},\{1,3\},\{3,3\},\{5,0\},\{7,1\},\{8,2\},\{7,3\},\{5,4\},\{4,4\},\{4,3\}\}$

`In[127] :=`
$\mathrm{Bezier}[n\_, pnts\_, x\_] := \mathrm{Sum}[pnts[[k+1]] * \mathrm{BernsteinBasis}[n,k,x], \{k, 0, n\}]$

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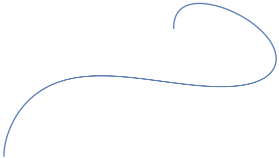
`In[127] :=`
$\mathrm{Bezier}[n\_, pnts\_, x\_] := \mathrm{Sum}[pnts[[k+1]] * \mathrm{BernsteinBasis}[n,k,x], \{k,0,n\}]$

`In[128] :=` $\mathrm{ParametricPlot}[\mathrm{Bezier}[10, pnts, x], \{x,0,1\}, \mathrm{Axes} \to \mathrm{False}]$

`Out[128] =` 

`In[129] :=` $\mathrm{Export}[\text{"}sample\_bezier.pdf\text{"}, \%, \text{"}PDF\text{"}]$

5 Mathematica for Symbolic Computation

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Symbolic Computation – Caveats

- Consider the class of terms generated from one variable x, constants for the rationals, π, and the function symbols $+, *, \mathsf{sin}, \text{abs}$. Caviness (1967) proved that the simplification problem with respect to functional equivalence is undecidable for this class of terms.

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- Similarly, Risch proved that the problem of integration in finite terms is undecidable for transcendental functions. In 1968–1969, Risch also described the first complete integration algorithm for algebraic and elementary transcendental functions.
- Several important algorithms of computer algebra have an exponential complexity, e.g., Collins' cylindrical algebraic decomposition for quantifier elimination.
- The bit complexity may grow substantially during a computation, thus potentially requiring a large main memory. In particular, the bit complexity of intermediate results may be significantly larger than the complexity of the input and the output. Some algorithms are well-known to be memory hoggers — consult textbooks prior to waiting for hours/days just in order to see the system crash due to lack of memory.

6 **Graphics and Visualization**

- Basics of Geomview
- Manipulation and Appearance of Geomview Objects
- Geomview I/O
- Geomview and External Applications

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- Geomview is in a mature and stable state, though! And it is still used widely and continues to evolve, see www.geomview.org
- Geomview is free software, released under a GNU license.
- It runs on a variety of systems using generic OpenGL or X11 graphics and a Motif interface.
- It builds on Mac OS X, and it can also run under MS Windows using Cygwin.

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Basics of Geomview

- The simplest way to use Geomview is as a *standalone viewer* to see and manipulate objects. It can display objects described in a variety of file formats.
- Geomview supports the following simple data types: polyhedra with shared vertices, quadrilaterals, rectangular meshes, vectors, and Bézier surface patches of arbitrary degree including rational patches.
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- Geomview allows multiple independently controllable objects and cameras. It provides interactive control for motion, appearances (including lighting, shading, and materials), picking on an object, edge or vertex level, snapshots, and adding or deleting objects.
- One can also use Geomview to handle the display of data coming from another program (*external module*) that is running simultaneously. As the other program changes the data, the Geomview image reflects the changes.
- Geomview can also display 3D graphics output from Mathematica and Maple.

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Object Manipulations

- Objects can be selected by clicking at the name of the object in the `Targets` browser of the `Main` panel. If `world` is selected, then any motion/transformation is applied to all objects currently drawn.
- The object selected is called the *target object*.
- Geomview lets you manipulate objects with the mouse. There are six different mouse motion modes: Rotate, Translate, Cam Fly, Cam Zoom, Geom Scale, and Cam Orbit. The `Tools` panel has a button for each of these modes; to switch modes, click on the corresponding button.

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- Most of the motion modes have *inertia*, which means that if one lets go of the button while moving the mouse, the motion will continue.
- Pressing the shift key while dragging with left or middle mouse buttons in most motion modes gives slow-speed motions, useful for fine control of object placements.

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- Pressing the shift key while dragging with left or middle mouse buttons in most motion modes gives slow-speed motions, useful for fine control of object placements.
- Generally, the left mouse button controls motion in the screen plane, while the middle mouse controls motion along or around the forward direction.
- The `Center` button undoes the target object's transformation, moving it back to its home position, which is where it was when it was originally loaded into Geomview.

Object Manipulations

- Geomview uses the *glass sphere model* for mouse-based rotations. Think of the object as being inside an invisible sphere, and regard the mouse cursor as a gripper outside the sphere. When one presses the left mouse button, the gripper grabs the sphere; when one releases the left mouse button, the gripper releases the sphere.
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- Press the middle mouse button in order to rotate the target object about an axis perpendicular to the view plane.
- One can pick any point on an object (not just its origin) as the center of motion by holding down the shift key while

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- Press the middle mouse button in order to rotate the target object about an axis perpendicular to the view plane.
- One can pick any point on an object (not just its origin) as the center of motion by holding down the shift key while clicking the right mouse button; this chooses a point of interest.
- In order to translate the target object, hold the left mouse button down (after selecting the `Translate` mode). The middle mouse button translates the target along an axis perpendicular to the view plane.

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- `Cam Fly` is a crude flight simulator that lets one fly around the scene. It works by moving the camera.

Object Manipulations

- `Cam Orbit` mode lets one rotate the current camera around the current center.
- `Cam Zoom` lets one change the current camera's field of view with the mouse.
- `Geom Scale` mode lets one enlarge or shrink an object.
- The `Stop` button causes all motion to stop.
- The `Look At` button causes the current camera to be moved to a position such that it is looking at the target object, and such that the target object more or less fills the window.
- The `Reset` button stops all motion and causes all objects to move back to their home positions.

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Modifying the Appearance of Objects

- Geomview uses a hierarchy of appearances to control the way things look. An *appearance* is a specification of information about how something should be drawn.
- There is an appearance associated with "World", which serves as the parent of each individual object's appearance. Also, there is a global "base" appearance, which is the parent of the World appearance.

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- There is an appearance associated with "World", which serves as the parent of each individual object's appearance. Also, there is a global "base" appearance, which is the parent of the World appearance.
- Appearances work in a hierarchical manner: if a certain appearance property, for example a face color, is not specified in a particular object's appearance, that object is drawn using that property from the parent appearance. If both the parent and the child appearance specify a property, the child's setting takes precedence unless the parent appearance is set to override.

Modifying the Appearance of Objects

- The `Appearance` panel controls various things about the way Geomview draws objects. For instance, the `[ae] Edges` button allows to toggle between having the object displayed with or without edges.
- The `Appearance` panel also lets one select colors (in RGB or HSV) and shading information (constant, flat, smooth).

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- The `Cameras` panel controls certain aspects of the target camera (such as its field of view). The use of multiple cameras is supported.
- The *Geomview command language* (gcl) provides complete control of all appearance data, including data that cannot be changed via the panels.

6 Graphics and Visualization

I/O Control

- The `Save` panel offers several possibilities for storing Geomview objects and other information in files.
- One can store gcl commands, geometric data, input data for RenderMan, PPM (software) snapshots, snapshots in PostScript format, and data for restoring all windows and panels in a subsequent session of Geomview.
- Commands in gcl format, which uses the syntax of lisp, can be entered via the `Commands` panel.

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- Commands in gcl format, which uses the syntax of lisp, can be entered via the `Commands` panel.
- Most panel interaction can be replaced by commands that have keyboard shortcuts. For instance, the keyboard shortcut for switching to `Rotate` mode is `r`.
- Some keyboard shortcuts consist of more than one key. In these cases one types the keys one after the other, with no `RET` afterwards. For instance, `g1ae` toggles the edge drawing for object ("geom") `g1`.

OOGL Files

- Geomview reads objects in the format of the *Object Oriented Graphics Library* (OOGL).
- Examples for many OOGL objects can be found in Geomview's `data/geom` directory.
- Most OOGL files are are free-format ASCII. (Binary formats are also defined for several objects types.)
- Typical OOGL objects begin with a key word designating the object type, possibly with modifiers indicating the presence of additional data (such as color).
- Most key words are case sensitive.
- When OOGL objects are input, the OOGL library uses the file suffix to guess at the file type.

OOGL Files

- Geomview supports inhomogeneous and homogeneous coordinates.
- Transformation matrices are given in a 4×4 row-vector representation, for multiplication on the right of vectors. That is, a row vector p (of a point in homogeneous coordinates) is transformed by a matrix $\mathbf{M}$ to a point p' as follows: $p' = p\,\mathbf{M}$.
- Appearances and texture maps can be specified; see the manual for details.

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OOGL Objects

QUAD: a collection of quadrilaterals. The default file suffix is `.quad`.

MESH: a rectangularly-connected mesh of dimension $n \times m$. The default file suffix is `.mesh`.

Bézier: a Bézier surface. The default file suffix is `.bez`.

OFF: an object in *object file format*. It is used for representing collections of planar polygons, possibly with shared vertices. This is a convenient way to describe polyhedra. The polygons may be concave but polygons with holes are not supported. The default file suffix is `.off`.

VECT: strings of connected line segments, possibly closed. The default file suffix is `.vect`.

SKEL: collections of points and polylines, possibly with shared vertices. The default file suffix is `.skel`.

SPHERE: a sphere, drawn as a collection of rational Bézier patches. The default file suffix is `.sph`.

INST: a 4×4 transformation, to be applied to another OOGL object. The default file suffix is `.inst`.

LIST: a list of OOGL objects. The default file suffix is `.list`.

TLIST: a list of 4×4 transformations. The default file suffix is `.grp`.

External Modules

- An *external module* is a program that interacts with Geomview. It communicates with Geomview through gcl commands and can control any aspect of Geomview that one can control through Geomview's user interface. Typically, Geomview acts as a *display engine* for the external module.

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- External modules known to Geomview are listed in the `Modules` browser in Geomview's `Main` panel. An external module can be invoked by clicking on its entry in the browser.
- In order to make an external module `foo` known to Geomview, include the following line in your local initialization file, `.geomview`:

  ```
  (emodule-define "Foo" "./foo")
  ```

  Here, `Foo` is the name of the external module that will appear in the `Modules` browser of Geomview. One can also execute this command on-line from the `Commands` panel.

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External Modules

- When starting an external module, Geomview creates *pipes* connected to the module's standard input and output.
- Geomview interprets everything that the module writes to its standard output as a gcl command. Likewise, if the exernal module requests any data from Geomview, Geomview writes that data to the module's standard input.

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- Note that this implies that the module cannot use standard I/O for communicating with the user!
- Sample external modules (`example*.c`) are available in Geomview's subdirectory `/geomview/doc`.

Using Geomview as an External Display Engine

- It is also possible to invoke Geomview from an application program, and to direct graphics output produced by the application to Geomview, thus using Geomview as an external display engine.
- Communication between the application program and Geomview is again carried out via *pipes*.

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- Communication between the application program and Geomview is again carried out via *pipes*.
- In a C environment, an input file `geomview_in` for Geomview is opened by the application program as follows:

```
geomview_in = popen("togeomview", "w");
```

- Then, the application writes any input for Geomview to `geomview_in`.
- Since pipes may be buffered, it is advisable to flush the pipe after data has been written to the pipe: `fflush(geomview_in)`.

Using Geomview as an External Display Engine

- Typically, we will want Geomview to create objects that can later on be modified (e.g., translated or rotated). The gcl command

  ```
  (geometry Foo { : foo })
  ```

  instructs Geomview to create an object ("geom") named `Foo` as an instance of the *handle* `foo`, where `Foo` is the name of the object as it will appear in the object browser of Geomview, and `foo` is the internal reference for Geomview.
- Handles allow one to name a piece of geometry whose value can be specified elsewhere, and which can be updated repeatedly. See the manual for details.

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- Handles allow one to name a piece of geometry whose value can be specified elsewhere, and which can be updated repeatedly. See the manual for details.
- If multiple objects are to be passed to Geomview, it is a good idea to turn off any scaling of the individual objects:

  ```
  (normalization Foo none)
  ```

The End!

I hope that you enjoyed this course, and I wish you all the best for your future studies.

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Computational Geometry and Applications Lab