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- Assignments
- Mini-project
- Practicalities
- Examination
- Course improvements

# Bayesian Statistics and Data Analysis

## Course information

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Department of Statistics, Uppsala University



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## Section 1

### Course information



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## Course information

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The aims of this course are that, after this course you should:

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## Course information

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The aims of this course are that, after this course you should:

1. have knowledge in basic concepts, philosophy, and perspectives in Bayesian Statistics,
2. derive posterior distributions in simple situations,
3. derive and use predictive distributions,
4. identify and formulate Bayesian probabilistic models for analysis and predictions,
5. estimate models using contemporary computer-based methods for posterior approximations,
6. understand and use basic principles for decisions under uncertainty,
7. have knowledge about and be able to use Bayesian methods for model comparisons,
8. be able to critically evaluate Bayesian methods,
9. report, orally and in writing, a Bayesian statistical analysis

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# Pre-requisites

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- Basic probability theory
  - probability, probability density, distribution
  - sum, product rule, and Bayes' rule
  - expectation, mean, variance, median



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# Pre-requisites

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- Basic probability theory
  - probability, probability density, distribution
  - sum, product rule, and Bayes' rule
  - expectation, mean, variance, median
- Basic linear algebra and calculus



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# Pre-requisites

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- Basic probability theory
  - probability, probability density, distribution
  - sum, product rule, and Bayes' rule
  - expectation, mean, variance, median
- Basic linear algebra and calculus
- Basic visualisation techniques (R or Python)
  - histogram, density plot, scatter plot
- *Note!* This is a masters course in Statistics.



# Pre-requisites

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- Basic probability theory
  - probability, probability density, distribution
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  - expectation, mean, variance, median
- Basic linear algebra and calculus
- Basic visualisation techniques (R or Python)
  - histogram, density plot, scatter plot
- *Note!* This is a masters course in Statistics.

*First assignment is a recap.*





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# Course Outline

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Two main parts:

- Core Content (9 lecture blocks)



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# Course Outline

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Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)



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# Course Outline

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Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)
- Mini-project: do your own Bayesian data analysis (1-3 students)



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# Course Outline

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Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)
- Mini-project: do your own Bayesian data analysis (1-3 students)

Exact dates and details; see the course page.



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## Core Content

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- Every week: lectures (approx. 2-4h)
  - Online video material and reading assignments (approx. 2-4h, 50-90 pages a week)
  - Lecture(s): present overall theory and content (overview)
  - Assignment(s): Computational and theoretical individual work. (approx. 12-16h). **Deadline Sundays 23.59.**  
*Start monday morning every week!*



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# Core Content

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  - Lecture(s): present overall theory and content (overview)
  - Assignment(s): Computational and theoretical individual work. (approx. 12-16h). **Deadline Sundays 23.59.**  
*Start monday morning every week!*
- Recommended workflow for each week
  - Do the reading assignments
  - Watch the videos (although, optional)
  - Do self-study exercises
  - Start with the assignment
  - Attend lecture (bring questions!)
  - Attend Zoom datalabs (bring questions! Helps with debugging Stan code)
  - Submit the assignment



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## Section 2

### Assignments



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# Assignments

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## 1. Core components and concepts and state-of-the-art methods

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# Assignments

---

1. Core components and concepts and state-of-the-art methods
2. *Warning!* There might be bugs in the assignments!



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# Assignments

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1. Core components and concepts and state-of-the-art methods
2. *Warning!* There might be bugs in the assignments!
3. All labs can be turned in a three times (See Studium for details), but only first time can give VG:
  - 3.1 The week of the assignment
  - 3.2 The last day of the course
  - 3.3 2-4 weeks after the course



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## Assignments

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4. We will mark and return each assignment within **5** working days (max 10 working days).



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# Assignments

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5. *Important!* Do *not* write your name anywhere



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# Assignments

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6. *Important!* Do the assignment evaluation!



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5. *Important!* Do *not* write your name anywhere
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7. Three one hour zoom seminars per week with individual help on assignments. *Note!* Don't send us e-mail, instead use the Zoom seminars.



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# Assignments

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6. *Important!* Do the assignment evaluation!
7. Three one hour zoom seminars per week with individual help on assignments. *Note!* Don't send us e-mail, instead use the Zoom seminars.
8. We supply [grading information](#) for all assignments. Although, they may change!
9. We have quite strict [formatting guidelines](#). Read carefully!
10. Language models (eg ChatGPT) is not allowed. I will include "white herrings". Only what you can read in the assignment is included.





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# R vs Python and Colab

---

- We strongly recommend using R in the course as there are more packages for Stan and statistical analysis in general in R



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# R vs Python and Colab

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- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be useful to learn R



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## R vs Python and Colab

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- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be useful to learn R
- All data for the assignments are included in the R package. You can access the data data or data-raw in the [R package folder](#) in the repo if you need to get the data without using the bsda R package.



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- We supply a [Google Colab template](#) with everything pre-installed.



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## R vs Python and Colab

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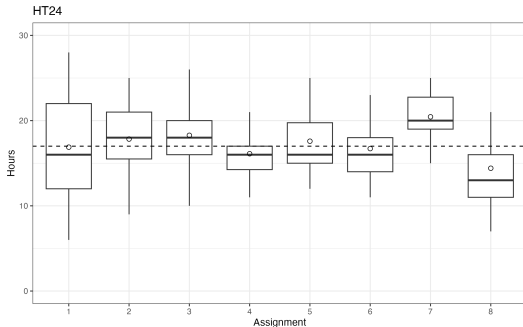
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- We supply a [Google Colab template](#) with everything pre-installed.
- We also supply a knitR  $\text{\LaTeX}$  [template](#) suitable for [Overleaf](#).



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# Course Workload

- Conclusions from 2024
  - Better balance between Assignment 7 and 8.
  - White herrings and Large Language Model use.
  - New idea (test) of mini project.



Student course workload



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# Stan

- Stan is a probabilistic programming framework (PPF) and ecosystem
- 40+ developers, 100+ contributors, 100K+ users
- R, Python, Julia, Scala, Stata, Matlab, command line interfaces
- More than 120 R packages using Stan
- Many packages to support diagnostics and workflow
- Can be used for frequentist inference as well
- Alternative PPF exists, Turing (Julia), Pyro (PyTorch), etc.



[mc-stan.org](https://mc-stan.org)



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## Section 3

### Mini-project





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## Mini-project

---

- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.



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## Mini-project

---

- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.



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## Mini-project

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- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.
- Ideally, use a model not presented in this course.
- Project will last two weeks (half time) - but start earlier.
- The project should use Stan.
- Approximate 40 hours of work *per student*.



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## Mini-project

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- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.
- Ideally, use a model not presented in this course.
- Project will last two weeks (half time) - but start earlier.
- The project should use Stan.
- Approximate 40 hours of work *per student*.
- The project should result in a 4 page report (PDF) using the ICML LaTeX template (see course page).
- Project oral presentation (10-15 minutes)



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## Mini-project

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- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.
- Ideally, use a model not presented in this course.
- Project will last two weeks (half time) - but start earlier.
- The project should use Stan.
- Approximate 40 hours of work *per student*.
- The project should result in a 4 page report (PDF) using the ICML LaTeX template (see course page).
- Project oral presentation (10-15 minutes)
- The first author is corresponding author



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## Mini-project

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- See project instructions on webpage for details.
- Data analysis of choice on real data.
- 2-3 students.
- Supply a half-page project proposal of data and problem in the middle of the course.
- Ideally, use a model not presented in this course.
- Project will last two weeks (half time) - but start earlier.
- The project should use Stan.
- Approximate 40 hours of work *per student*.
- The project should result in a 4 page report (PDF) using the ICML LaTeX template (see course page).
- Project oral presentation (10-15 minutes)
- The first author is corresponding author
- This year: Test to implement complex models in Stan as project - reach out to me. Will get more teacher time.



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### Practicalities



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# Practicalities

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- Course page/content: Github – please do a PR or submit an issue if something is wrong!

<https://github.com/MansMeg/BSDA/issues>





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<https://github.com/MansMeg/BSDA/issues>
- Communication: Studium



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<https://github.com/MansMeg/BSDA/issues>
- Communication: Studium
- Schedule: Time Edit/Studium
- Assignments submissions: Studium



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# Practicalities

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- Acknowledgements: Aki Vehtari



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# Practicalities

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- Communication: Studium
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- Assignments submissions: Studium
- Acknowledgements: Aki Vehtari
- Teaching assistant: Väinö Yrjänäinen

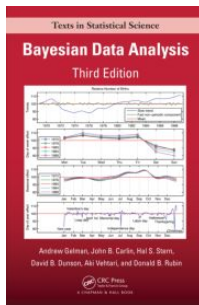


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# Literature

- Book: Gelman, Carlin, Stern, Dunson, Vehtari & Rubin: Bayesian Data Analysis, Third Edition. (online pdf available)



- Additional articles and blog posts (see reading list per week)



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## Section 5

### Examination



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# Examination

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1. To pass (G): All labs, mini-project, and project review need to be passed



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# Examination

---

1. To pass (G): All labs, mini-project, and project review need to be passed
2. To pass with distinction (VG): 7/10 VG points





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# Examination

---

1. To pass (G): All labs, mini-project, and project review need to be passed
2. To pass with distinction (VG): 7/10 VG points
3. If everything is correct in an assignment ( $\geq 90\%$ ), 1 VG point is awarded *on the first submission deadline*.



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# Examination

---

1. To pass (G): All labs, mini-project, and project review need to be passed
2. To pass with distinction (VG): 7/10 VG points
3. If everything is correct in an assignment ( $\geq 90\%$ ), 1 VG point is awarded *on the first submission deadline*.
4. The mini-project is worth 2 VG-points (if it is passed with distinction).
5. Ph.D. students: I suggest you get VG to pass the course. Make the project a potential paper.
6. Reassessment of grades (supply form to course admin)
7. Failing the course: You will need to redo all assignments and mini-project.
8. Large language models, e.g. chatGPT, are **not allowed**.



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# Course improvements since last time

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- Three step project
- Improving assignment balance



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## Section 6

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## Comments from previous students

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- Be ready to put the work in!
- Don't be afraid to ask questions.
- Try complete all the assignment on time.



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# Questions?

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Questions?