



UPPSALA
UNIVERSITET

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

Bayesian Statistics and Data Analysis

Course information

Måns Magnusson
Department of Statistics, Uppsala University



UPPSALA
UNIVERSITET

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

Section 1

Course information



UPPSALA
UNIVERSITET

Course information

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

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



UPPSALA
UNIVERSITET

Course information

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

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



UPPSALA
UNIVERSITET

Pre-requisites

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

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



UPPSALA
UNIVERSITET

Pre-requisites

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

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



UPPSALA
UNIVERSITET

Pre-requisites

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

- 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



UPPSALA
UNIVERSITET

Pre-requisites

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

- 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

First assignment is a recap.



UPPSALA
UNIVERSITET

Course Outline

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

Two main parts:

- Core Content (9 lecture blocks)



UPPSALA
UNIVERSITET

Course Outline

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

Two main parts:

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



UPPSALA
UNIVERSITET

Course Outline

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

Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)
- Mini-project: do your own Bayesian data analysis (2-3 students)



UPPSALA
UNIVERSITET

Course Outline

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

Two main parts:

- Core Content (9 lecture blocks)
- Assignments (8 individual assignments)
- Mini-project: do your own Bayesian data analysis (2-3 students)

Exact dates and details; see the course page.



UPPSALA
UNIVERSITET

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

Core Content

- Every week: lectures/and assignments (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. *Start monday morning every week!*
- An individual assignment (approx. 12-16h). Deadline Sundays 23.59.



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

Core Content

- Every week: lectures/and assignments (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. *Start monday morning every week!*
- An individual assignment (approx. 12-16h). Deadline Sundays 23.59.
- 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 datalabs (bring questions!)
 - Submit the assignment



UPPSALA
UNIVERSITET

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

Section 2

Assignments



UPPSALA
UNIVERSITET

Assignments

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

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



UPPSALA
UNIVERSITET

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

Assignments

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



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first).
See Studium for details.



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere
6. *Important!* Do the assignment evaluation!



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere
6. *Important!* Do the assignment evaluation!
7. Three one hour zoom seminars per week with individual help on assignments.



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere
6. *Important!* Do the assignment evaluation!
7. Three one hour zoom seminars per week with individual help on assignments.
8. We supply [grading information](#) for all assignments. Although, they may change!



UPPSALA
UNIVERSITET

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

Assignments

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 (but use the first). See Studium for details.
4. We will mark and return each assignment within 10 working days.
5. *Important!* Do *not* write your name anywhere
6. *Important!* Do the assignment evaluation!
7. Three one hour zoom seminars per week with individual help on assignments.
8. We supply [grading information](#) for all assignments. Although, they may change!
9. We have quite strict [formatting guidelines](#). Read carefully!



UPPSALA
UNIVERSITET

R vs Python and Colab

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

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



UPPSALA
UNIVERSITET

R vs Python and Colab

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

- We strongly recommend using R in the course as there are more packages for Stan and statistical analysis in general in R
- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be more useful to learn also R



UPPSALA
UNIVERSITET

R vs Python and Colab

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

- We strongly recommend using R in the course as there are more packages for Stan and statistical analysis in general in R
- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be more useful to learn also R
- We supply a [Google Colab template](#) with everything pre-installed.



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

- We strongly recommend using R in the course as there are more packages for Stan and statistical analysis in general in R
- If you are already fluent in Python, but not in R, then using Python may be easier, but it can still be more useful to learn also R
- We supply a [Google Colab template](#) with everything pre-installed.
- We also supply a knitR \LaTeX [template](#) suitable for [Overleaf](#).



UPPSALA
UNIVERSITET

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

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



UPPSALA
UNIVERSITET

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

Section 3

Mini-project



UPPSALA
UNIVERSITET

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

Mini-project

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



UPPSALA
UNIVERSITET

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

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.



UPPSALA
UNIVERSITET

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

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.
- 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*.



UPPSALA
UNIVERSITET

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

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.
- 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)



UPPSALA
UNIVERSITET

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

Section 4

Practicalities



UPPSALA
UNIVERSITET

Practicalities

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

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



UPPSALA
UNIVERSITET

Practicalities

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

- Course page/content: Github – please do a PR if something is wrong!
- Communication: Studium



UPPSALA
UNIVERSITET

Practicalities

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

- Course page/content: Github – please do a PR if something is wrong!
- Communication: Studium
- Schedule: Time Edit/Studium
- Assignments submissions: Studium



UPPSALA
UNIVERSITET

Practicalities

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

- Course page/content: Github – please do a PR if something is wrong!
- Communication: Studium
- Schedule: Time Edit/Studium
- Assignments submissions: Studium
- Acknowledgements: Aki Vehtari



UPPSALA
UNIVERSITET

Practicalities

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

- Course page/content: Github – please do a PR if something is wrong!
- Communication: Studium
- Schedule: Time Edit/Studium
- Assignments submissions: Studium
- Acknowledgements: Aki Vehtari
- Teaching assistant: Väinö Yrjänäinen

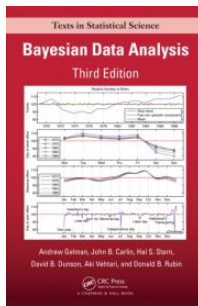


UPPSALA
UNIVERSITET

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

Literature

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



- Additional articles and blog posts



UPPSALA
UNIVERSITET

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

Section 5

Examination



UPPSALA
UNIVERSITET

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

Examination

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



UPPSALA
UNIVERSITET

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

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



UPPSALA
UNIVERSITET

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

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*.



UPPSALA
UNIVERSITET

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

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.



UPPSALA
UNIVERSITET

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

Section 6

Course improvements



UPPSALA
UNIVERSITET

Course improvements since last time

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

- Multiple short TA sessions over zoom



UPPSALA
UNIVERSITET

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

Section 6

Course improvements



UPPSALA
UNIVERSITET

Comments from previous students

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

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



UPPSALA
UNIVERSITET

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

Questions?

Questions?