# DSC8012: BAYESIAN REGRESSION MODELLING AND ANALYSIS

---

**Effective Term**
Semester A 2026/27

## Part I Course Overview

**Course Title**
Bayesian Regression Modelling and Analysis

**Subject Code**
DSC - Data Science

**Course Number**
8012

**Academic Unit**
Data Science (DS)

**College/School**
College of Computing (CC)

**Course Duration**
One Semester

**Credit Units**
3

**Level**
R8 - Research Degree

**Medium of Instruction**
English

**Medium of Assessment**
English

**Prerequisites**
Nil

**Precursors**
Nil

**Equivalent Courses**
SDSC8012 Bayesian Regression Modelling and Analysis

**Exclusive Courses**
Nil

## Part II Course Details

**Abstract**

This course aims to offer students rigorous and comprehensive knowledge of advanced Bayesian regression concepts, theory, and methods. It will develop students' abilities to apply Bayesian regression models to nonstandard and complex data analysis problems. Students will be trained to develop Bayesian models and apply software packages such as MATLAB R or WinBUGS to fit the developed models and perform Bayesian inference.

**Course Intended Learning Outcomes (CILOs)**

| | CILOs | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|---|---|---|---|---|---|
| 1 | Explain and apply Bayes theorem, Bayesian decision theory, empirical Bayesian estimation, and types of prior distributions (conjugate, Jeffreys, and reference priors) in the context of Bayesian linear models. | 20 | x | x | |
| 2 | Describe and implement Bayesian linear regression models, Bayesian generalized linear models, Bayesian model averaging, and Bayesian variable selection methods. | 25 | x | x | |
| 3 | Apply Markov chain Monte Carlo algorithms and integrated nested Laplace approximations to perform Bayesian regression with the help of software. | 15 | x | x | |
| 4 | Describe and implement Gaussian process modelling, and experiment designs for fitting Gaussian process models. | 20 | x | x | |
| 5 | Describe and implement Bayesian optimization, and Bayesian quadrature. | 20 | x | x | |

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

**Learning and Teaching Activities (LTAs)**

| | LTAs | Brief Description | CILO No. | Hours/week (if applicable) |
|---|---|---|---|---|
| 1 | Lectures | Students will engage in formal lectures to gain knowledge about Bayesian regression modelling and analysis. | 1, 2, 3, 4, 5 | 26 hours/semester |

| | | | | |
|---|---|---|---|---|
| 2 | Demonstration of MATLAB/R/ WinBUGS codes | Students will develop an understanding of the MATLAB/R/ WinBUGS codes included in the course materials by following an in-class demonstration and explanation of the codes. | 1, 2, 3, 4, 5 | 12 hours/semester |

**Assessment Tasks / Activities (ATs)**

| | ATs | CILO No. | Weighting (%) | Remarks ("-" for nil entry) | Allow Use of GenAI? |
|---|---|---|---|---|---|
| 1 | Midterm<br>Students will be assessed via the midterm their understanding of concepts learned in class, textbooks, and reading materials. | 1, 2, 3, 4, 5 | 25 | - | No |
| 2 | Two assignments<br>Students will work individually or in teams to develop Bayesian regression models and apply the models to analyse data with the help of software. | 1, 2, 3, 4, 5 | 50 | - | Yes |

**Continuous Assessment (%)**

75

**Examination (%)**

25

**Examination Duration (Hours)**

2

**Minimum Continuous Assessment Passing Requirement (%)**

0

**Minimum Examination Passing Requirement (%)**

30

**Additional Information for ATs**

Examination

Students will be assessed via the examination their understanding of concepts learned in class, textbooks, and reading materials.

**Assessment Rubrics (AR)**

**Assessment Task**

Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**
Midterm and assignments

**Excellent**
A+, A, A-

**Good**
B+, B, B-

**Fair**
C+, C, C-

**Marginal**
D

**Failure**
F

---

**Assessment Task**
Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**
Close-book but open-notes exam

**Excellent**
A+, A, A-

**Good**
B+, B, B-

**Fair**
C+, C, C-

**Marginal**
D

**Failure**
F

---

**Assessment Task**
Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**
Midterm and assignments

**Excellent**
A+, A, A-

**Good**
B+, B

**Marginal**

B-, C+, C

**Failure**

F

---

**Assessment Task**

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**

Close-book but open-notes exam

**Excellent**

A+, A, A-

**Good**

B+, B

**Marginal**

B-, C+, C

**Failure**

F

---

# Part III Other Information

**Keyword Syllabus**

- Likelihood, prior distribution, Bayes theorem, Bayesian linear regression model, utility/loss functions, quadratic loss function, zero-one loss function, admissibility, shortest credible intervals, empirical Bayesian estimation, conjugate prior, Jeffreys prior, reference prior, g-prior,

- Bayesian hierarchical linear model, Bayesian spline models,

- Bayesian model averaging, Bayesian variable selection methods, stochastic search variable selection, Bayesian LASSO, Bayesian generalized linear models, multivariate normal distribution, multivariate t distribution, Wishart and inverse Wishart distributions,

- Gibbs sampling, slice sampling, adaptive Metropolis-Hastings algorithms, integrated nested Laplace approximation, variational Bayesian methods

- Gaussian process regression, covariance functions, reproducing kernel Hilbert space, mean square continuity and differentiability, modelling with derivative information, Latin hypercube designs, maximum entropy sampling, maximin and minimax designs, separability and Cartesian product design

-Bayesian optimization, expected improvement, correlated knowledge gradient, noisy evaluations, multiobjective Bayesian optimization, Bayesian quadrature, Koksma-Hlawka inequality.

**Reading List**

**Compulsory Readings**

| | Title |
|---|---|
| 1 | Denison, D. G., Holmes, C. C., Mallick, B. K., & Smith, A. F. (2002). Bayesian methods for nonlinear classification and regression (Vol. 386). John Wiley & Sons. |
| 2 | Vidales, A. (2019). Machine learning with Matlab: Gaussian process regression, analysis of variance, and Bayesian optimization. Independently published. |

| | |
|---|---|
| 3 | Faraway, J. J., Wang, X., & Ryan, Y. Y. (2018). Bayesian Regression Modeling with INLA. Chapman and Hall/CRC. |
| 4 | Santner, T. J., Williams, B. J., Notz, W., & Williams, B. J. (2018). The design and analysis of computer experiments (2nd Edition). New York: Springer. |
| 5 | Rasmussen, C. E., & Williams, C. K. (2006). Gaussian Process Regression for Machine Learning. The MIT Press. |
| 6 | O'Hagan, A., & Forster, J. J. (2004). Kendall's advanced theory of statistics, volume 2B: Bayesian inference (Vol. 2). Arnold. |

**Additional Readings**

| | **Title** |
|---|---|
| 1 | Nil |