

# SDSC3105: BAYESIAN ANALYSIS

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**Effective Term**

Semester A 2024/25

## Part I Course Overview

**Course Title**

Bayesian Analysis

**Subject Code**

SDSC - Data Science

**Course Number**

3105

**Academic Unit**

Data Science (DS)

**College/School**

College of Computing (CC)

**Course Duration**

One Semester

**Credit Units**

3

**Level**

B1, B2, B3, B4 - Bachelor's Degree

**Medium of Instruction**

English

**Medium of Assessment**

English

**Prerequisites**

MA2506 Probability and Statistics or MA2510 Probability and Statistics

**Precursors**

Nil

**Equivalent Courses**

Nil

**Exclusive Courses**

Nil

## Part II Course Details

**Abstract**

This course aims at offering students rigorous knowledge of Bayesian statistical theory and methods, developing students' abilities of interpreting and communicating results, as well as training students to apply software packages such as R or Matlab to fit Bayesian models and conduct Bayesian analyses.

### Course Intended Learning Outcomes (CILOs)

| CILOs |                                                                                                                                                                       | Weighting (if DEC-A1 app.) |   | DEC-A2 | DEC-A3 |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---|--------|--------|
| 1     | Describe basic concepts and theory of Bayesian statistics                                                                                                             | 30                         | x |        |        |
| 2     | Apply Bayes theorem to derive the posterior distribution of statistical model parameters, and various approximation methods to approximate the posterior distribution | 30                         | x | x      |        |
| 3     | Apply numerical methods (e.g. numerical integration, Monte Carlo simulation) to perform Bayesian inference with the help of software packages                         | 25                         | x | x      |        |
| 4     | Implement Bayesian methods to analyse data                                                                                                                            | 15                         | 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 | Lectures          | 1, 2, 3, 4 | 3 hours/week               |

### Assessment Tasks / Activities (ATs)

| ATs |             | CILO No.   | Weighting (%) | Remarks (e.g. Parameter for GenAI use) |
|-----|-------------|------------|---------------|----------------------------------------|
| 1   | Assignments | 1, 2, 3, 4 | 30            |                                        |
| 2   | Test        | 1, 2, 3, 4 | 30            |                                        |

#### Continuous Assessment (%)

60

#### Examination (%)

40

#### Examination Duration (Hours)

2

#### Additional Information for ATs

Note: To pass the course, apart from obtaining a minimum of 40% in the overall mark, a student must also obtain a minimum mark of 30% in both continuous assessment and examination components.

### Assessment Rubrics (AR)

#### Assessment Task

Coursework

#### Criterion

Assignments and/or participation

#### Excellent (A+, A, A-)

High

#### Good (B+, B, B-)

Significant

#### Fair (C+, C, C-)

Moderate

#### Marginal (D)

Basic

#### Failure (F)

Not even reaching marginal levels

#### Assessment Task

Test

#### Criterion

Midterm test to assess students' understanding of Bayesian statistics.

#### Excellent (A+, A, A-)

High

#### Good (B+, B, B-)

Significant

#### Fair (C+, C, C-)

Moderate

#### Marginal (D)

Basic

#### Failure (F)

Not even reaching marginal levels

#### Assessment Task

Examination

#### Criterion

2-hour examination to assess students' understanding of Bayesian statistics. Examination questions are designed to assess student's level of achievement of the intended learning outcomes, with emphasis placed on understanding and correct

application, mostly through mathematical exposition, clear explanation, and numerical calculation, of the various aspects of Bayesian statistics.

#### **Excellent (A+, A, A-)**

High

#### **Good (B+, B, B-)**

Significant

#### **Fair (C+, C, C-)**

Moderate

#### **Marginal (D)**

Basic

#### **Failure (F)**

Not even reaching marginal levels

#### **Additional Information for AR**

Examination, test, and assignments, will be numerically-marked.

## **Part III Other Information**

#### **Keyword Syllabus**

##### Bayes theorem and decision theory

- Bayes theorem, prior distribution, posterior distribution
- Bayes risk

##### Types of prior distributions

- Conjugate priors, noninformative priors

##### Some basic Bayesian models

- Inference for discrete parameters
- Inference for binomial proportion and Poisson mean
- Inference for normal mean and variance
- Conjugate Bayesian models

##### Bayesian linear models

- Simple linear regression
- Multiple linear regression

##### Bayesian computation

- Normal approximation
- Numerical integration
- Monte Carlo simulation

#### **Reading List**

##### **Compulsory Readings**

| Title |                                                                                                                                                          |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). Bayesian data analysis (3rd Edition). Boca Raton: CRC press. |

##### **Additional Readings**

| Title |                                                                                                                                                        |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | Kruschke, J. K. (2014). Doing Bayesian data analysis: A tutorial with R, JAGS and Stan. Burlington: Academic Press.                                    |
| 2     | Press, S. J. (2003). Subjective and objective Bayesian statistics: principles, models, and applications (2nd Edition) . New Jersey: John Wiley & Sons. |
| 3     | Bolstad, W. M., & Curran, J. M. (2017). Introduction to Bayesian statistics (3rd Edition). New Jersey: John Wiley & Sons.                              |