Advanced Statistical Methods I
BSDS Second Year
2025-26 Semester 2

Class time: MW 2:30-4:00pm

Tutorial time: Th 2:30-3:30pm

Instructor: Rituparna Sen rsen@isibang.ac.in

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Grading:

In-class quiz (4):	10%, Only two top scores will be taken. Dates will NOT be announced.
Presentation:	10%
Homework (4):	10%, Lowest score will be dropped.
Midterm:	20%
Final:	50%

Midterm and final will have both theory and practical questions.

Syllabus:

Sampling Techniques

1. Simulating probability distributions through exact sampling: Algorithms for simulating standard univariate distributions, multivariate Normal and Multinomial.

2. Monte Carlo techniques: Basic Monte Carlo, Rejection sampling, Importance sampling. Application to evaluating integrals. Comparison with numerical integration.

3. Introduction to MCMC: Basic introduction to discrete time Markov chains. Gibbs sampling with application to sampling from conditional distributions.

Nonparametric methods

1. Nonparametric and distribution-free methods for testing: Sign test and signed rank test. Mann-Whitney test, Wilcoxon rank sum statistic. Nonparametric tests for one-sample and two-sample scale problems. Kolmogorov-Smirnov test. Kruskal-Wallis test for k-sample location problem.

2. Nonparametric density estimation: Shifted histogram and kernel density estimation. Bandwidth selection through cross-validation.

3. Nonparametric regression: k-nearest neighbor regression. Kernel smoothing. Bias and variance as functions of bandwidth. Bandwidth selection

through cross-validation. Splines and their applications to nonparametric regression.

Resampling techniques

1. Introduction to Resampling techniques: Jackknife, Bootstrap and Cross-Validation as data analytic tools. Application to inference for one parameter families and linear regression.

Reference Books

1. MCMC from Scratch by Masanori Hanada and So Matsuura
2. Nonparametric Statistical Methods Using R By John Kloke and Joseph McKean
3. Nonparametric Statistical Inference by Jean D. Gibbons and Subhabrata Chakraborti
4. Resampling Methods by Phillip I. Good
5. Theory and Methods of Statistics (Chapter 9) by P. K. Bhattacharya and P. Burman