Training Course on Bayesian Statistics for Data Science

Professional Development Training Course Outline

Category	Data Science	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Training Course on Bayesian Statistics for Data Science dives deep into **Bayesian statistics**, a powerful paradigm for **probabilistic modeling** and **uncertainty quantification** in the realm of **data science**. In an era dominated by **big data**, **machine learning**, and **AI**, traditional statistical methods often fall short in capturing the full spectrum of **data uncertainty** and integrating **prior knowledge**. This program equips participants with the essential **analytical skills** and **computational techniques** to build robust **predictive models**, make informed **data-driven decisions**, and unlock deeper **insights** from complex datasets, pushing the boundaries of **advanced analytics**.

Mastering Bayesian statistics is becoming increasingly critical for modern data professionals. This course goes beyond theoretical concepts, emphasizing **practical application** through **hands-on exercises**, **real-world case studies**, and the use of industry-standard **probabilistic programming** libraries. Participants will learn to leverage Bayesian methodologies for enhanced **prediction accuracy**, improved **risk assessment**, and dynamic **model updating**, enabling them to tackle cutting-edge challenges in **AI explainability**, **causal inference**, and **decision intelligence**.

Programme Curriculum

Training Course on Bayesian Statistics for Data Science: Probabilistic Modeling and Inference

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Course Objectives

1. Grasp the fundamental principles of Bayesian inference and differentiate it from frequentist approaches for enhanced statistical reasoning.
2. Develop proficiency in constructing sophisticated probabilistic graphical models for diverse data science problems.
3. Effectively quantify and communicate uncertainty in predictions and model parameters using posterior distributions and credible intervals.
4. Apply Bayesian linear and generalized linear models for robust predictive analytics and feature importance.
5. Utilize hierarchical Bayesian models to analyze grouped data and account for variability across different levels.
6. Gain practical expertise in MCMC algorithms (e.g., Gibbs sampling, Hamiltonian Monte Carlo) for efficient posterior sampling.
7. Design and interpret Bayesian A/B tests for more insightful and reliable experimental design and optimization.
8. Learn strategies for effective prior distribution selection, including conjugate priors, informative priors, and uninformative priors.
9. Compare and select optimal Bayesian models using techniques like Bayes Factors and WAIC/LOO-CV.
10. Introduce advanced concepts in Bayesian nonparametrics for flexible and adaptive modeling.
11. Understand how Bayesian methods enhance traditional machine learning algorithms (e.g., Bayesian Neural Networks, Gaussian Processes).
12. Apply Bayesian approaches to tackle missing data imputation, small sample size inference, and robust estimation.
13. Discuss the role of Bayesian statistics in promoting explainable AI (XAI) and responsible AI practices.

Organizational Benefits

- Foster a culture of data-driven decision-making with a deeper understanding of inherent uncertainties and improved risk assessment.
- Develop more accurate and robust predictive models that leverage prior knowledge and adapt to new data, leading to better forecasts and resource allocation.
- Improve strategic planning and operational efficiency through more reliable insights and a clear quantification of risks and opportunities.

- Equip teams with cutting-edge analytical skills in probabilistic modeling, differentiating the organization in the competitive data science landscape.
- Make more informed decisions in critical areas like fraud detection, financial forecasting, and medical diagnostics by explicitly accounting for uncertainty.
- Drive innovation by integrating Bayesian principles into advanced AI and Machine Learning initiatives, especially for tasks requiring confidence intervals and model interpretability.
- Encourage more thoughtful data collection and analysis by emphasizing the importance of prior beliefs and evidence.
- Build more transparent and interpretable models, crucial for regulatory compliance and stakeholder trust, particularly in critical applications.

Target Audience

1. Data Scientists
2. Machine Learning Engineers
3. Statisticians and Quantitative Analysts
4. Researchers
5. Business Analysts
6. AI/ML Practitioners
7. Ph.D. Students and Academics .
8. Anyone with a solid foundation in traditional statistics and programming (Python/R)

Course Outline

Module 1: Foundations of Bayesian Thinking

- Introduction to Probability Theory and Bayes' Theorem.
- Comparing Frequentist vs. Bayesian Paradigms: Strengths and Weaknesses.
- Understanding Prior, Likelihood, and Posterior Distributions.
- Conjugate Priors and their analytical tractability.
- **Case Study**: Estimating the probability of a defective product given a small sample size in manufacturing.

Module 2: Setting up Your Bayesian Environment

- Introduction to Probabilistic Programming Languages (PPLs): Stan, PyMC, Pyro.
- Installation and setup of chosen PPL (e.g., PyMC with ArviZ for visualization).
- Basic data manipulation and visualization in Python/R.
- Understanding and interpreting computational graphs in PPLs.
- **Case Study**: Simulating coin flips to understand prior and posterior updates using a simple PPL model.

Module 3: Bayesian Inference for Common Distributions

- Inference for Binomial Data: Beta-Binomial Model.
- Inference for Poisson Data: Gamma-Poisson Model.
- Inference for Normal Data: Normal-Inverse Gamma Model.
- Choosing uninformative vs. weakly informative priors.
- **Case Study**: Estimating conversion rates for a new website feature (Binomial) or customer call volume (Poisson).

Module 4: Markov Chain Monte Carlo (MCMC)

- Introduction to Sampling Methods: Why MCMC is necessary.
- Understanding the Metropolis-Hastings Algorithm.
- Exploring Gibbs Sampling and its applications.
- Hamiltonian Monte Carlo (HMC) and its efficiency.
- **Case Study**: Estimating parameters of a complex distribution where analytical solutions are intractable, like a mixture model.

Module 5: Diagnosing and Improving MCMC Chains

- Convergence Diagnostics: R-hat, ESS (Effective Sample Size).
- Trace Plots, Autocorrelation Plots, and Posterior Histograms.
- Strategies for improving MCMC sampling: Reparameterization, NUTS sampler.
- Dealing with divergent transitions and low ESS.
- **Case Study**: Diagnosing a poorly converging model in a real-world financial fraud detection scenario.

Module 6: Bayesian Regression Models

- Bayesian Linear Regression: Formulation and Implementation.
- Interpreting Posterior Distributions of Regression Coefficients.
- Bayesian Regularization (Lasso, Ridge) and Shrinkage.
- Bayesian Logistic Regression for binary outcomes.
- **Case Study**: Predicting housing prices using Bayesian linear regression, explicitly quantifying prediction uncertainty.

Module 7: Hierarchical Bayesian Models

- Introduction to Hierarchical Modeling: Borrowing Strength.
- Partial Pooling vs. No Pooling vs. Complete Pooling.
- Multi-level Models for Nested Data Structures.
- Implementing varying intercepts and varying slopes models.
- **Case Study**: Analyzing student test scores across different schools, accounting for school-level effects.

Module 8: Bayesian Model Comparison and Selection

- Introduction to Model Comparison: Why and How.
- Information Criteria: WAIC (Widely Applicable Information Criterion) and LOO-CV (Leave-One-Out Cross-Validation).
- Bayes Factors: Principles and Practical Calculation.
- Comparing and selecting the best model for a given problem.
- **Case Study**: Choosing between different epidemiological models for disease spread based on observed data.

Module 9: Bayesian A/B Testing and Decision Making

- Framing A/B Tests within a Bayesian Framework.
- Calculating the Probability of Superiority.
- Sequential Testing and Early Stopping Rules.
- Decision-making under uncertainty using expected loss.
- **Case Study**: Optimizing marketing campaign effectiveness with a Bayesian A/B test, determining which creative yields higher conversions.

Module 10: Time Series and State-Space Models

- Introduction to Bayesian Time Series Analysis.
- Kalman Filters and Hidden Markov Models (HMMs) from a Bayesian perspective.
- Dynamic Linear Models (DLMs).
- Forecasting with uncertainty using Bayesian models.
- **Case Study**: Predicting future sales for a retail company, incorporating seasonality and trend with uncertainty bounds.

Module 11: Bayesian Nonparametrics and Gaussian Processes

- Introduction to Bayesian Nonparametrics.
- Gaussian Processes for Regression and Classification.
- Kernel Functions and Covariance.
- Applications of Gaussian Processes in machine learning.
- **Case Study**: Building a flexible predictive model for sensor data with non-linear relationships using Gaussian Processes.

Module 12: Advanced Bayesian Applications

- Causal Inference with Bayesian Networks.
- Bayesian Networks for Probabilistic Graphical Models.
- Missing Data Imputation using Bayesian methods.
- Robust Bayesian Statistics for Outlier Handling.
- **Case Study**: Inferring causal relationships between marketing spend and sales, accounting for confounding factors.

Module 13: Practical Considerations and Best Practices

- Workflow for Bayesian Data Analysis.
- Communicating Bayesian Results Effectively.
- Addressing Scalability Issues with Large Datasets.
- Ethical Considerations in Bayesian Modeling and AI.
- **Case Study**: Presenting the results of a Bayesian clinical trial analysis to non-technical stakeholders, emphasizing uncertainty.

Module 14: Integrating Bayesian Statistics with Industry Tools

- Using Bayesian models within a production data science pipeline.
- Deployment strategies for Bayesian models.
- Connecting PPLs with popular data science libraries (e.g., scikit-learn).
- Version control and collaborative practices for Bayesian projects.
- **Case Study**: Deploying a Bayesian spam filter for real-time email classification and monitoring its performance.

Module 15: Future Trends and Specialized Topics

- Approximate Bayesian Computation (ABC).
- Automated Bayesian Inference.
- Bayesian Deep Learning and Neural Networks.
- Quantum Computing and its potential for Bayesian methods.
- **Case Study**: Exploring the use of Bayesian deep learning for medical image analysis with uncertainty quantification.

Training Methodology

This course adopts a **blended learning approach** to maximize engagement and practical skill development:

- **Interactive Lectures**: Clear explanations of complex Bayesian concepts with visual aids and real-world analogies.
- **Hands-on Coding Labs**: Extensive practical exercises using Python (PyMC, ArviZ, NumPy, Pandas, Matplotlib, Seaborn) or R (Stan, Tidyverse) to implement Bayesian models.
- **Case Study-Driven Learning**: Each module will feature dedicated time for analyzing and solving real-world data science problems using Bayesian techniques. Participants will work through structured case studies, from problem definition to model deployment and interpretation.
- **Live Coding Demonstrations**: Instructors will demonstrate coding solutions and best practices in real-time.
- **Group Discussions and Q&A**: Encouraging peer learning and addressing specific challenges.
- **Project-Based Learning**: A capstone project allowing participants to apply their learned skills to a self-chosen or provided dataset.
- **Feedback and Mentorship**: Regular feedback on assignments and a dedicated forum for ongoing support.
- **Resource Sharing**: Access to comprehensive course notes, code repositories, recommended readings, and supplementary materials.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-t

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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