Semester	**EIGHT**
Course	**Major**
Paper Code	**C4ST230811T**
Paper Title	**Bayesian Data Analysis & Biostatistics**
No. of Credits	**6**
Theory / Practical /Composite	**Theory**
Classes per week	**Module 1: 2 periods/week** **Module 2: 2 periods/week**
Module	**2**

Course Outcomes for Module I

1. **Remember** the fundamental concepts of Bayesian inference, subjective probability, Bayes' theorem, and Bayesian decision-making principles.
2. **Understand** the differences between Bayesian and frequentist paradigms and explain prior, posterior, credible intervals, and Bayesian hypothesis testing.
3. **Apply** Bayes' theorem and conjugate prior models to solve statistical inference problems.
4. **Analyze** posterior distributions, credible intervals, prior assumptions, and Bayesian decision-making in practical situations.
5. **Evaluate** Bayesian computational methods, MCMC algorithms, convergence diagnostics, and the suitability of Bayesian models for data analysis.
6. **Create** Bayesian models and computational solutions using Monte Carlo and MCMC techniques for real-world data analysis problems.

Course Outcomes for Module II

1. **Remember** the phases of clinical trials, types of endpoints, classifications of clinical trial designs, and basic concepts of survival analysis including censoring and truncation.
2. **Understand** the objectives of each phase of clinical trials, the role of endpoints across phases, different trial designs, and the theoretical foundations of survival and hazard functions.
3. **Apply** appropriate clinical trial designs, endpoint selection, sample size considerations, and survival analysis methods such as Kaplan–Meier estimation and parametric models to real-world datasets.

4. **Analyze** clinical trial data and survival data by comparing different designsand interpreting results from models such as the Cox proportional hazards model.
5. **Evaluate** the effectiveness and limitations of clinical trial methodologies, adaptive designs, and survival analysis techniques in terms of bias, efficiency, ethical considerations, and statistical validity**.**

Syllabus

Unit/Module	Content	No. of lectures	CO mapping	Cognitive levels
Module I	**Bayesian Data Analysis**			
Unit 1	***Foundations of Bayesian Inference and Decision Making:*** Bayesian paradigm versus frequentist paradigm; Subjective definition of probability; Bayes theorem; applications of Bayes theorem (spam filtering, Bayesian search); conjugate models (Beta–Binomial, Normal–Normal, Poisson–Gamma); Jeffrey's prior; posterior estimates; credible intervals (equal-tailed and HPD); Bayesian hypothesis testing**.**	16	CO1 CO2 CO3 CO4	K1 K2 K3 K4
Unit 2	**Bayesian Computation Methods:** Challenges in posterior computation; Monte Carlo methods, importance and acceptance-rejection sampling; MCMC algorithms (Metropolis–Hastings, Gibbs sampling); convergence diagnostics.	10	CO3 CO4 CO5	K3 K4 K5
Module II	**Biostatistics**			
Unit 1	**Clinical Trials:** *Basic Concepts:* Introduction to clinical trials; phases of clinical trials with illustrative examples; unmet	5	CO1	K1

	medical need and target population; classification of clinical trials—superiority, non-inferiority, and equivalence trials; parallel-group, crossover, single-arm, and multi-arm designs; open-label, single-blind, and double-blind trials; clinical trial endpoints—primary, secondary, and exploratory endpoints; treatment effect and its statistical considerations; sample size determination; cost considerations in clinical trial design. *Adaptive Methods:* Adaptive randomization, sample size re-estimation, modification of the number of treatment arms, and adaptive dose-finding designs. Benefits and challenges of adaptive designs, with illustrative examples. *Study Protocols and Regulatory Framework:* Overview of clinical study protocols and clinical study reports. Role of regulatory bodies and guidelines. FDA, EMA, and ICH regulations.	5 3	CO2 CO4 CO3 CO5 CO2 CO5	K2 K4 K3 K5 K2 K5
Unit 2	**Survival Analysis:** *Fundamentals of Survival Analysis:* Introduction to survival data; survival time, censoring and truncation; Type I, Type II, and random censoring; right, left, and interval censoring, with biological illustrations. Functions of survival time: survival function, hazard	8	CO1 CO2 CO3 CO4	K1 K2 K3 K4

	function, and mean residual life function. Non-parametric estimation of the survival function: actuarial (life-table), Kaplan–Meier, and Nelson–Aalen estimators. *Statistical models for survival data:* Parametric models for survival data: exponential, Weibull, log-normal, log-logistic, and gamma distributions. Regression models for survival data: Cox proportional hazards model.	5	CO3 CO4	K3 K4

Reading/Reference list

1. Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2014). *Bayesian Data Analysis* (3rd ed.). CRC Press.
2. Ghosh, J. K., Delampady, M., & Samanta, T. (2006). *An Introduction to Bayesian Analysis: Theory and Methods.* New York: Springer.
3. McElreath, R. (2020). *Statistical Rethinking: A Bayesian Course with Examples in R and Stan* (2nd ed.). CRC Press.
4. Hoff, P. D. (2009). *A First Course in Bayesian Statistical Methods*. Springer. Robert, C. P., & Casella, G. (2004). *Monte Carlo Statistical Methods* (2nd ed.). Springer.
5. Gilks, W. R., Richardson, S., & Spiegelhalter, D. J. (1996). *Markov Chain Monte Carlo in Practice*. Chapman & Hall/CRC.
6. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., & Granger, C. B. (2015). *Fundamentals of clinical trials*. springer.
7. Hulley, S. B., Cummings, S. R., Browner, W. S., Grady, D. G., & Newman, T. B. (2013). *Designing clinical research* (4th ed.). Lippincott Williams & Wilkins.
8. Miller, R. G., Jr. (1998). *Survival analysis* (2nd ed.). John Wiley & Sons.
9. Smith, P. J. (2002). *Analysis of failure and survival data*. Chapman & Hall/CRC.
10. Klein, J. P., & Moeschberger, M. L. (2003). *Survival analysis: Techniques for censored and truncated data* (2nd ed.). Springer.

Evaluation

	CIA: 30 End-Sem: 70 Total: 100	
Paper Structure for Semester Exam	**Module 1 (35 marks)**	**Module II (35 marks)**
	Short questions (5 marks each): 4 out of 6 Long questions (15 marks each): 1 out of 2	Short questions (5 marks each): 4 out of 6 Long questions (15 marks each):1 out of 2

CO	CO Description for Module I	Cognitive levels
CO1	**Remember** the fundamental concepts of Bayesian inference, subjective probability, Bayes' theorem, and Bayesian decision-making principles.	K1
CO2	**Understand** the differences between Bayesian and frequentist paradigms and explain prior, posterior, credible intervals, and Bayesian hypothesis testing.	K2
CO3	**Apply** Bayes' theorem and conjugate prior models to solve statistical inference problems.	K3
CO4	**Analyze** posterior distributions, credible intervals, prior assumptions, and Bayesian decision-making in practical situations.	K4
CO5	**Evaluate** Bayesian computational methods, MCMC algorithms, convergence diagnostics, and the suitability of Bayesian models for data analysis.	K5
CO6	**Create** Bayesian models and computational solutions using Monte Carlo and MCMC techniques for real-world data analysis problems.	K6

CO	CO Description for Module II	Cognitive levels
CO1	**Remember** the phases of clinical trials, types of endpoints, classifications of clinical trial designs, and basic concepts of survival analysis including censoring and truncation.	K1
CO2	**Understand** the objectives of each phase of clinical trials, the role of endpoints across phases, different trial designs, and the theoretical foundations of survival and hazard functions.	K2
CO3	**Apply** appropriate clinical trial designs, endpoint selection, sample size considerations, and survival analysis methods such as Kaplan–Meier estimation and parametric models to real-world datasets.	K3
CO4	**Analyze** clinical trial data and survival data by comparing different designs and interpreting results from models such as the Cox proportional hazards model.	K4
CO5	**Evaluate** the effectiveness and limitations of clinical trial methodologies, adaptive designs, and survival analysis techniques in terms of bias, efficiency, ethical considerations, and statistical validity**.**	K5