Course Outline for "CT517: Statistical Estimation Theory"

1. Title: **Statistical Estimation Theory**

2. Credit Structure (L-T-P-Cr): 3 0 0 3

3. Course Code: To be assigned

4. Semester: SEM 2

5. Category: M. Tech specialization Core

6. Prerequisites: none

7. Foundation for: Advanced Wireless Communications

8. Abstract Content:

Primary: This course aims to introduce the students to the concepts of statistical estimation theory. It deals with parameter estimation in discrete time for both static and dynamic cases. This is a core course for first year M. Tech students of communications and signal processing (CSP) specialization. Basis background in probability theory would be helpful, a few important concepts on probability space and random variables would be covered in the first two modules of the course.

(Note: Final year B. Tech students with CGPA > 7.4/10 may also take it).

The detailed course outline is as follows:

Module 1: Probability space and random variables

- Introduction to probability space and random variables.
- Characterization of random variables using cumulative distribution function (CDF), probability density function (PDF).
- Moments of random variable.
- CDF and PDF computation for functions of random variables.

Module 2: Convergence and limit theorems of random variables (This module will be handled by Dr. Jaideep Mulherkar)

- Various modes of convergence of random variables.
- Chebyshev and Markov Inequality.
- Strong law of large numbers.
- Central limit theorem.

Module 3: Static parameter estimation

- Bayesian parameter estimation (minimum mean square error (MMSE), minimum mean absolute error (MMAE), maximum a-posterior probability (MAP) estimation methods).
- Non-random parameter estimation (sufficient statistics, Fisher's factorization theorem, minimum variance unbiased estimators (MVUE), Cramer-Rao lower bound (CRLB), etc).
- Maximum likelihood (ML) parameter estimation.

Module 4: Dynamic parameter and state estimation

- Introduction to state-space models.
- Kalman-Bucy filtering.
- Hidden Markov Model (HMM) filter.
- *Expectation Maximization (EM) algorithm.*

9. Suggested Text/s:

- An Introduction to Signal Detection and Estimation by H. V. Poor.
- Principles of Signal Detection and Parameter Estimation by Bernard C. Levy.
- Probability, Random Variables and Stochastic Processes by A. Papoulis and S. U. Pillai.

10. Detailed Contents:

Topic Name	Content	No. of Lectures
Probability space and random variables	Definition of probability space, random variables, CDF, PDF and their computation	8
Convergence and limit theorems of random variables	Modes of convergence, SLLN, CLT, Markov and Chebyshev Inequality	10
Static parameter estimation	MMSE, MMAE, MAP, MVUE, Sufficient statistics, ML estimation, etc	12
Dynamic parameter estimation	State space models, Kalman-Bucy filtering, HMM filtering, EM algorithm	10

11. Outcomes and Objectives:

- At the end of the course the student would be able to demonstrate understanding key concepts in statistical estimation theory.
- The course would be an excellent foundation course for students who intend to do research in the area of communications and signal processing.

12. Grading policy:

- 1 – Insem examination: 30%
- 2 – Insem examination: 30%
- Final examination: 40%