课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	**STA 5006: Advanced Stochastic processes**
2.	**课程性质** **Compulsory/Elective**	专业选修课 Professional Elective
3.	**课程学分/学时** **Course Credit/Hours**	3/48
4.	**授课语言** **Teaching Language**	英语 English
5.	**授课教师** **Instructor(s)**	张卓松，助理教授，统计与数据科学系 商学院大楼 334 zhangzs3@sustech.edu.cn Zhang, Zhuosong, Assistant Professor Rm. 334, School of Business zhangzs3@sustech.edu.cn
6.	**是否面向本科生开放** **Open to undergraduates or not**	是 YES
7.	**先修要求** **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） MAT 215 Probability Theories STA 203: Foundation of Probability Theory
8.	**教学目标** **Course Objectives**	

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

本课程主要涵盖现代随机过程的基本知识，主要包括马氏过程、泊松过程、更新过程、鞅、高斯过程和布朗运动。本课程不仅讲授理论基础，也会讨论在当今统计学和数据科学中的前沿应用，主要例子包括排队论、MCMC 算法、强化学习等方向上的应用。

本课程向高年级本科生和研究生开放。

通过学习本课程，学生应当学会：
1. 解释离散时间、连续时间的随机过程的基本概念。
2. 理解如何在当今统计学和数据科学中应用随机过程。
3. 掌握通过随机分析的方法解决实际问题。

对于研究生，还应当掌握随机过程中的一些理论分析方法。

This course offers an introduction to modern stochastic processes, including Markov processes, Poisson processes, Renewal processes, Martingales, Gaussian processes, and Brownian motion. The course will include not only a solid theoretical foundation, but also some applications to statistics and data science, including Queue theory, MCMC, reinforcement learning, and so on.

This course is open to both high-level undergraduates and graduate students.

Upon successful completion, students will have the knowledge and skills to:

1. Explain the fundamental concepts of stochastic processes in both discrete time and continuous time.
2. Understand the position of stochastic processes in some modern applications in statistics and data

science.
3. Apply problem-solving techniques using stochastic analysis methods in various situations.

Besides these, graduate students should also be able to:

Demonstrate mathematical reasoning through analyzing, proving, and explaining concepts from stochastic analysis.

9. 教学方法
Teaching Methods

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

理论课程，课堂讲授为主

Theoretical courses, mainly in teaching

10. 教学内容
Course Contents
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

Section 1 (2 hours)	准备知识： 概率论基础、随机变量、数学期望、条件期望、随机过程导论和例子 Introduction: Basic concepts in probability, random variables, mathematical expectations, conditional expectations, stochastic processes, and related examples.
Section 2 (6 hours)	马氏链： 定义和例子、转移概率、状态分类、平稳分布、极限性质、实例 Markov Chains: Definition and examples, transition probability, classification of states, stationary distributions, limit behavior, and real examples
Section 3 (4 hours)	泊松过程： 伯努利试验、等待时间、泊松过程、复合泊松过程 Poisson processes: Bernoulli trials, waiting time, Poisson processes, compound Poisson process
Section 4 (8 hours)	更新过程： 大数定律、更新过程、排队论的应用、跳跃过程、点过程 Renewal Processes: Law of large numbers, renewal processes, application to queueing theory, Jump processes, and point processes
Section 5 (8 hours)	连续时间的马氏链： 定义和例子、转移概率的计算、马氏链的极限、MCMC 的应用、强化学习的应用 Definitions and examples, computing the transition probability, limiting behavior, MCMC, applications to reinforcement learning.
Section 6 (8 hours)	鞅： 条件期望、鞅的定义和例子、停时、鞅的收敛定理 Martingales:

	Conditional expectation, definition and examples of martingales, stopping time, and convergence theorems
Section 7 (10 hours)	高斯过程和布朗运动： 高斯过程的定义、高斯过程在机器学习中的应用、布朗运动的定义、布朗运动的性质、布朗运动的应用 Gaussian processes and Brownian motion: Definition of Gaussian process, applications to machine learning, definition of Brownian motion, properties of Brownian motion, applications of Brownian motion.

11. 课程考核
Course Assessment

（①考核形式 Form of examination；②.分数构成 grading policy；③如面向本科生开放，请注明区分内容。If the course is open to undergraduates, please indicate the difference.）

平时成绩：40%
期中考试：30%
期末考试：30%

12. 教材及其它参考资料
Textbook and Supplementary Readings

Textbook:
Rick Durrett: Essentials of Stochastic Processes.

Supplementary Readings:

Sheldon Ross: Stochastic processes

Sheldon Ross: Introduction to probability models

Carl E. Rasmussen and Christopher K. I. Williams: Gaussian processes for machine learning

Richard S. Sutton and Andrew G. Barto: Reinforcement Learning