STAT 5376 – Stochastic Analysis, Control and Optimization, with Applications in Mathematical Finance

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Objectives: The objective of this course is to provide students with a rigorous foundation in stochastic analysis and its role in modern control and optimization theory, with a particular emphasis on applications in mathematical finance. The course aims to:

- Develop a deep understanding of stochastic processes, martingales, and stochastic differential equations as tools for modeling uncertainty.
- Introduce stochastic control methods and dynamic optimization techniques, including backward stochastic differential equations (BSDEs), Hamilton–Jacobi–Bellman equations, and Free-Boundary problem.
- Demonstrate how these mathematical frameworks are applied to problems in finance, such as option pricing, portfolio optimization, risk management, and financial decision-making under uncertainty.

Topics to be Covered:

- Stochastic Analysis: Martingale, Markov Process, SDE and Itô Calculus, BSDE, Girsanov's Theorem.
- LQ Optimal Control: Calculus of Variations Method, Riccati Equation
- Stochastic Control: Dynamic Programming, HJB Equation.
- Optimal Stopping: Free-Boundary Problem
- Applications in Mathematical Finance through relevant topics.

References:

Oksendal, B. *Stochastic differential equations: An introduction with applications*

Karatzas, I., & Shreve, S. E. *Brownian motion and stochastic calculus*

René Carmona. *Lectures on BSDEs, Stochastic Control, and Stochastic Differential Games with Financial Applications*

Yong, J., & Zhou, X. Y. *Stochastic controls: Hamiltonian systems and HJB equations.*

Peskir, G., & Shiryaev, A. N. *Optimal stopping and free-boundary problems*

Steven E. Shreve, *Stochastic Calculus for Finance II.*

Final Grade: Each student will be assigned a paper to read and present. The length of the presentation will be based on the number of enrollments. The final grade will be based on the presentation.