# Syllabus for Finance 651
# PDEs and Stochastic Calculus

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# Catalog Course Description

The course covers PDEs (Partial Differential Equations) and calculus in a stochastic environment.

# Learning Outcomes of the MFE

- Graduates will be able to analyze complex problems in financial mathematics.
- Graduates will be able to evaluate and correlate stochastic processes.
- Graduates will be able to forecast stochastic events in finance and related fields as weather (hurricanes, floods, volcanoes).
- Graduates will have the computational skills to program complex stochastic processes in finance and related fields.
- Graduates will be able to apply their knowledge in the insurance, risk-management, and investment banking industry as well as in related fields.

Finance 651 addresses goals a) and c).

# Assessment of Learning Outcomes

**Grading:** 25% Midterm, 25% Final, 50% weekly activities

**Grading Scale:**

| Point Interval | Letter Grade | Point Interval | Letter Grade |
|---|---|---|---|
| $[95, 100]$ | $A$ | $[73.33, 76.66)$ | $C$ |
| $[90, 95)$ | $A-$ | $[70, 73.33)$ | $C-$ |
| $[86.66, 90)$ | $B+$ | $[66.66, 70)$ | $D+$ |
| $[83.33, 86.66)$ | $B$ | $[63.33, 66.66)$ | $D$ |
| $[80, 83.33)$ | $B-$ | $[60, 63.33)$ | $D-$ |
| $[76.66, 80)$ | $C+$ | $[0, 60)$ | $F$ |

# Textbooks

- Salih Neftci's **Mathematics of Financial Derivatives**, published around 2000.
- John C. Hull, **Futures, Options, and Other Derivatives**, 7th edition, mostly a reference and the main text in another course

# Schedule, Subject to Change

- **Week 1:** Concepts of Probability: Probability space, conditional probability, random variables (normal, uniform, lognormal, binomial, Poisson, discrete vs continuous, CDFs, PDFs, joint distributions, expectations, moments)
- **Week 2:** Continue with Concepts of Probability
- **Week 3:** Principles of Differentiation, Higher order Differentiation, Partial Differentiation, Differentiation rules, Taylor expansions in several variables
- **Week 4:** Principles of Integration (Riemann, Riemann-Stieltjes, Lebesque)
- **Week 5:** Introduce PDEs and the Black-Scholes-Merton (BSM) PDE
- **Week 6:** Introduce stochastic processes (Brownian motion, the Wiener process, some generalizations of the Wiener process, Markov property)

# Tentative Schedule, cont'd

- **Week 7:** Introduce stochastic differential equations (SDEs)
- **Week 8:** Midterm Exam
- **Week 9:** Interest Rate SDEs: From CRR via Vasicek, Hull White and HJM to LMM; relationship to SABR
- **Week 10:** Risk neutral pricing property and arbitrage theorem
- **Week 11:** Martingales: Properties of Martingales, Equivalent Martingale Measures, Converting non-martingales to Martingales
- **Week 12:** Transforming Measures: Girsanov Theorem and Radon-Nikodym Derivative, Change of Numeraire Technique

# Tentative Schedule, slide 3

- **Week 13:** Stochastic Integration; Ito's Integral and Ito's Lemma
- **Week 14:** Correlation: Nature and properties of financial correlations; Basic concepts (Pearson's $\rho$) and rank correlations (Spearman's $\rho$, Kendall's $\tau$), Copula correlation model
- **Week 15:** Final Exam

# Contact Information

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