The seminar addresses fundamental concepts of (calculus based) undergraduate probability that are most relevant for a smooth transition to Baruch MFE program. Special attention will be paid to (1) probabilistic ideas, language, and notation; (2) examples and models that are relevant to financial engineering.

Probabilistic topics (selected):
- Discrete distributions.
- Continuous distributions.
- Computation of expectations, variances, and generating functions.
- Joint distributions.
- Conditional distributions and conditional expectations.
- Laws of large numbers.
- Central limit theorem.

Financial topics (selected):
- Binomial asset pricing model.
- Risk and expected return of a portfolio.
- Black-Scholes model.
- Risk-neutral probabilities.
- Options pricing.
- Monte-Carlo simulation.

Dates and Times:
Lectures: February 2, 9, 16, 23, and March 1, 8, 15, 22, 2016, 6-10pm; Final Exam: March 29, 2016, 6-9pm

Instructors: Elena Kosygina, Faculty, Baruch College Financial Engineering Program

Tuition: $1,450
Attending the Probability Theory for Financial Applications and passing the final exam meets the probability pre-requisite for the Baruch MFE Program. Upon request, recommendation letters reflecting performance in the seminar will also be provided.

Registration: To register or to receive more information about the Pre-MFE Probability Seminar, send an email to baruch.mfe@baruch.cuny.edu

Textbooks:
- Instructor’s notes (posted on the course web page for every session)

Prerequisites: Multivariable calculus and some previous exposure to probability (for example, a probability or statistics course previously taken).
Students should read in advance the following sections from the textbook:
Chapter 1, Sections 1.1–1.3 and do all exercises within the text for these sections and exercises 1.7.1–1.7.3 from Section 1.7.

**Detailed Syllabus**

**Session 1:**
- Random experiments. Events and operations with them.
- Counting and combinatorics.
- Probability measure and its properties.
- Conditional probabilities.
- Independence of events.

*Financial applications:*
- Binomial asset pricing model.
- Market probabilities versus risk-neutral probabilities.

*Textbook sections:* Chapter 1 and instructor’s notes.

**Session 2:**
- Independence of random variables.

*Financial applications:*
- Most frequently used discrete distributions: binomial, Poisson, geometric, negative binomial, hypergeometric (time permitting).
- Modeling with discrete distributions: which one to use for a given set of data?

*Textbook sections:* Sections 2.1–2.3 and instructor’s notes.

**Session 3:**
- Random vectors (discrete case).
- Covariance and correlation.
- Conditional distributions and expectations (discrete case).
- Moment generating function (time permitting).

*Financial applications:*
- Risk and expected return of a portfolio.
- Calibration of a binomial model.
- Pricing of European derivative securities (binomial model).

*Textbook sections:* Sections 2.4–2.6 and instructor’s notes.

**Session 4:**
- Random walk on integers. Path counting.
- First passage times.
- Reflection principle.

*Financial applications:*
- Pricing of path-dependent options.
- An idea of dynamic programming: pricing of American options.

*Textbook sections:* Chapter 3 and instructor’s notes.

**Session 5:**
• Probability density functions. Continuous random variables.
• Expectation.
• Random vectors and independence.

Financial applications:
• Most frequently used continuous distributions: uniform, exponential, normal, gamma, log-normal.
• Geometric Brownian motion and Black-Scholes model.

Textbook sections: Sections 5.1–5.6 and instructor’s notes.

Session 6:
• Functions of random variables and vectors.
• Conditional distributions and expectations.

Financial applications:
• Distributions of the sum, minimum, and maximum of several random variables. Order statistics (time permitting).
• What are “fat tails” and where do they appear in practice?

Textbook sections: Sections 5.7–5.10 and instructor’s notes.

Session 7:
• Infinitely many repetitions. Sequences of i.i.d. random variables.
• Laws of large numbers.
• Central limit theorem.

Financial applications:
• Monte-Carlo simulation: parameter and probability estimation, numerical integration.
• Black-Scholes model as a limit of binomial models.

Textbook sections: Chapter 4, Section 5.11, Sections 6.1–6.4, and instructor’s notes.

Session 8:
• Simulation methods: inverse transformation method, acceptance-rejection method.
• Variance reduction techniques (time permitting).

Financial applications:
• Sampling from frequently used distributions.
• Monte-Carlo simulation: pricing of path-dependent options.

Textbook sections: Instructor's notes.