**Course Instructor**
Prof. Ariel Amir, Pierce 321, Phone: 6174955818,  E-mail: arielamir@seas.harvard.edu
Office hours: Monday 10 AM - noon and by appointment.

**Teaching fellow**
Luyi Qiu, Pierce 402, E-mail: lqiu@g.harvard.edu
Office hours: Wednesday 2:30 PM - 4:30 PM and by appointment.

Kailas Amin, E-mail: kailas.amin@gmail.com

**Lectures**: Tuesday and Thursday 10:30 PM - 11:45 PM at Cruft 309

**Sections**: Thursday 4 PM - 5 PM at Cruft 309. Participation is not mandatory but highly recommended.

**Course Description**
The course will familiarize the students with various applications of probability theory, stochastic modeling and random processes, using examples from various disciplines, including physics, engineering, computer science, biology and economics.

Topics will include:
1. **Markov processes and Random walks.** Einsteinâ€™s derivation of the diffusion equation. Central limit theorem. Markov processes and application to the Google Page Rank algorithm.

2. **Langevin and Fokker-Planck equations.** Escape over-a-barrier, with applications to chemical reactions and physics. Discrete Langevin equation approach to cell size control. Modeling stock market dynamics and the Black-Scholes equation.

3. **Noise.** Power-spectra, Wiener Khinchin theorem, Telegraph and 1/f noise.

4. **Generalized Central Limit Theorem and Extreme Values Statistics.** Generalized central limit theorem and Levy-stable distributions, with application to anomalous diffusion and Levy flights. Gumbel, Weibull and FrÃ©chet universality classes for Extreme Value Statistics.

5. **Random matrix theory.** Semi-circle law and Wigner's surmise, Girko's law for non-hermitian matrices, applications in nuclear physics and ecology (stability of networks).

6. **Percolation theory.** Epidemic spreading, continuum percolation and its application to random resistor networks (variable-range-hopping) and flow through porous media.

7. **Anderson localization.** Transfer matrix approach in 1d systems. Implications for electronic transport and light propagation in disordered media.

8. **Glasses (time-permitting).** Spin-glasses, aging and slow relaxations.

Most exercises will be theoretical, but there will be some numerical exercises in MATLAB.

**Prerequisites**
Calculus and linear algebra, basic knowledge of probability theory. Knowledge of MATLAB will be helpful.

**Grading**
The students will be graded based on the following 2 elements:
6 Problem Sets  (60 % of final grade), Take-home exam (40% of final grade).

**References**
Amir A. 'Thinking Probabilistically: Stochastic Processes, Disordered Systems, and Their Applications'. Cambridge University Press; 2021.

**Exercises**
We will give 6 bi-weekly exercises. Most exercises will be theoretical, but there will be some numerical exercises in MATLAB. Exercises should be submitted by the beginning of class on the due date.

**Collaboration Policy**
Collaboration on homework assignments is welcome. After collaborating with your classmates, make sure that you can work through the problems yourself and ensure that your submitted solution is the result of your own efforts. Please mention any collaborators in your solution and cite any external material used. Using homework solutions from previous years is forbidden.

Late submissions will not be allowed unless coordinated beforehand with the course staff under special circumstances.

**Take-home exam**
The final (a 48 hour take-home exam) will be held from Monday December 6th, 9 AM to Wednesday, December 8th, 9 AM. The level of difficulty will be similar to the exercise sets.