Brownian motion and noise in physical devices

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Timetable: 20 hrs. Class meets on Tuesday and Thursday from 14:30 to 16:30. First lecture on Tuesday, September 3, 2013. Room DEI/G (Dept. of Information Engineering, Via Gradenigo 6/a, Padova).

Course requirements: Basic background in probability.

Examination and grading: 4 Homework assignments (to be handed in one week later).

Aim: Elements of stochastic calculus. Fundamental models of physical Brownian motion and electric networks with noisy resistors.

Course contents:

Topics will be selected from those listed below.

- Probabilistic background:
  1. Physical Brownian motion.
  2. Construction of the Wiener process.
  3. Basic properties of the Wiener process.
  4. Finite-energy Markov diffusions. The change of variables formula.
  5. The Fokker-Planck equation.
  6. Square-integrable martingales.
- Dynamical theories of Brownian motion:
  1. Langevin.
  2. The Einstein-Smoluchowsky model, Einstein's fluctuation-dissipation relation.
  3. The Nyquist-Johnson noisy resistor.
  4. The Ornstein-Uhlenbeck model.
  5. Gibbs postulate and the Maxwell-Boltzmann distribution.
  6. Random oscillators.
  7. Maximum Entropy Problems and H-theorem.

References:

[1] M. Pavon, Lecture Notes on Brownian Motion, 2000 (will be distributed to students).
[2] E. Nelson. Dynamical Theories of Brownian Motion. Princeton University Press, Princeton, 1967.
[3] I. Karatzas and S. E. Shreve, Brownian Motion and Stochastic Calculus, 2nd edition, Springer- Verlag, New York, 1991.
[4] B. Øskendal, Stochastic Differential Equations, 4th edition, Springer, 1995.
[5] T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, Wiley, 2006.