Geophysics 9531a: Computer Modeling of Natural Processes
Course Syllabus – Fall 2017
(lectures start on **September 14**)

Course Instructor: Dr. Robert Shcherbakov   (office: B&GS 1080; e-mail: rshcherb [at] uwo.ca)
Lectures: Tuesday 10:30 a.m. – 11:30 a.m. and Thursday 1:30 p.m. – 2:30 p.m., B&GS 0184
Labs: Tuesday 11:30 a.m. – 12:30 p.m. and Thursday 2:30 pm – 3:30 p.m., B&GS 0184
Office Hours: by appointment

Course description:

      This course provides an introduction into computer modeling of physical processes responsible for various natural phenomena. It introduces two fundamental approaches how to model the kinetic behavior of such processes. The first approach utilizes stochastic and Monte Carlo simulations of various cellular automata to model the occurrence of earthquakes, land-slides, forest-fires, percolation and diffusion limited aggregation, fracture and flow of materials and rocks. Stochastic modeling of different point and branching processes is also going to be analyzed and the connection to earthquakes is discussed. The second approach employs numerical solutions of ordinary or partial differential equations to describe such processes as diffusion phenomena, convection, fluid flow, wave propagation, etc. This course also introduces notions of chaos, fractals, and complexity, long and short-range correlations, analysis of discrete and continuous dynamical systems, importance of phase transitions and self-organized criticality in order to understand the behavior of the above systems. During the course students will be given an introduction into several fundamental concepts related to the modeling and design of computer algorithms in order to simulate the above processes. Matlab is going to be used as a programming and visualization environment.

> **Prerequisites:** Permission of the instructor. *(Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.)*

Summary of Lecture Topics (*approximate and subject to change*!):
1) Cellular automata and Monte Carlo simulations:
   a) Theory of self-organized criticality, scale invariance and fractals, spatial and temporal correlations and memory;
   b) Sandpile, forest-fire, Manna, OFC and similar models;
   c) Slider-block models and earthquakes, friction laws;
   d) Modeling of fracture and flow of materials and rocks, fiber-bundle model;
   e) Percolation and diffusion limited aggregation;
   f) Lattice-gas cellular automata.
2) Stochastic processes and simulations:
   a) Homogeneous and non-homogeneous Poisson processes, branching and point processes;

    b) Earthquake simulation and modeling as a point process in space and time.
3) Continuous problems:
    a) Simulation of the slider-block models;
    b) Dynamical systems and chaos, deterministic chaos.

Recommended Textbooks:
- Chopard, B. and Droz, M., *Cellular Automata Modeling of Physical Systems*, Cambridge University Press, 1998.
- Schiff, J., *Cellular Automata*, Wiley, 2008.
- Wolf-Gladrow, D., *Lattice-Gas Cellular Automata and Lattice Boltzmann Models*, Springer, 1999.
- Press, W., Teukolsky, S., Vetterling, W., and Flannery, B., *Numerical Recipes: The Art of Scientific Computing*, Cambridge University Press, 2007.
- Jensen, H., *Self-Organized Criticality: Emergent Complex Behavior in Physical and Biological Systems*, Cambridge University Press, 1998.
- Gould, H., Tobochnik, J., and Christian, W., *An Introduction to Computer Simulation Methods*, Addison Wesley, 3rd ed., 2007.
- Lowrie, W., *Fundamentals of Geophysics*, Cambridge University Press, 2007.
- Ranalli, G., *Rheology of the Earth*, 2nd Edition, Chapman and Hall, London, 1995.

Some material is going to be covered by reviewing recent publications.

Course Work

      Assignments will consist of examination-style answer questions, and require no formal writeup. Late submissions will be accepted with a **5% per day penalty**. Under exceptional circumstances, late submissions will be accepted with no penalty, provided that adequate documentation is given. With a few exceptions, only SI units should be used to report any physical quantities.

      The project will involve a written report (5-10 pages) and a brief oral presentation (10-15 minutes). The topic will be chosen by the student and approved by the instructor. Research topics must be in any area covered during the course. The project must include references to the scientific literature. Projects are due November 30, and oral presentations will be given during the last week of the term. (*Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).)*

Method of Evaluation

Assignments	Project	Participation	Seminar Presentation
30%	50%	10%	10%

Statement on Academic Offences: "Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:
http://www.uwo.ca/univsec/handbook/appeals/scholoff.pdf ."

Statements on special circumstances:

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's office as soon as possible and contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved and the instructor has been informed. In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office immediately. For further information please see:
http://www.uwo.ca/univsec/handbook/appeals/medical.pdf

A student requiring academic accommodation due to illness, should use the Student Medical Certificate when visiting an off-campus medical facility or request a Records Release Form (located in the Dean's Office) for visits to Student Health Services. The form can be found here: https://studentservices.uwo.ca/secure/medical_document.pdf