COLORADO STATE UNIVERSITY

ECE/MATH 522 – Fall 2020

Random Walks

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Communication policy: Responses to emails will be provided within 36 hours. *Office hours will be held once a week via Zoom*. Additional Zoom meeting times can be scheduled with the instructor as needed. Due to the COVID-19 ongoing situation no face-to-face office hours will be conducted this year.

Resident course meeting times: Tuesday, Thursday, 2:00 – 3:15 PM, Scott 229

Online course recorded lectures: Echo360 lectures will be posted in the course website (Canvas).

Course website: https://colostate.instructure.com/courses/112633

COVID-19 information: Please visit the CSU recovery website: https://covidrecovery.colostate.edu/

All students in the resident course should fill out a student-specific symptom checker each day before coming to class (https://covidrecovery.colostate.edu/daily-symptom-checker/).In addition, please utilize the symptom checker to report symptoms, if you have a positive test, or exposed to a known COVID contact. You will not be in trouble or penalized in any way for reporting. If you report symptoms or a positive test, you will receive immediate instructions on what to do and CSU's Public Health Office will be notified. Once notified, that office will contact you and most likely conduct contact tracing, initiate any necessary public health requirements and/or recommendations and notify you if you need to take any steps.

Pre-requisites: Calculus-based probability theory, Fourier and Laplace transforms.

Course Description & Objectives: Mathematical aspects of random walks and diffusion processes. Stochastic modeling of complex systems.

This course provides analytical tools to students working on stochastic processes and stochastic models that involve diverse areas such as tracking, relaxation processes, scattering, signal analysis, systems biology, and network traffic.

Upon the completion of this course, students will be able to:

1. Apply concepts of probability theory to stochastic and fractional processes.
2. Utilize transforms to find statistics of stochastic processes.
3. Understand the relation between random walks and diffusion processes.
4. Employ random walks to model sub- and super-diffusion.
5. Write and solve the Master equation for different Markov chains.
6. Understand the connection between first passage times and occupation statistics.
7. Model complex stochastic processes using different types of random walks including percolation, continuous time random walks, and Lévy flights.
8. Understand basic concepts of percolation theory and its applications.

Examples of applications:

- Biophysics
- Climate studies
- Dielectric relaxation in complex materials
- Electrical networks, electrical power grids
- Epidemiology, spread of disease in a population
- Finance, insurance, stock prices and gambling
- Genetic drift, biological evolution
- Information networks, social networks, neural networks
- Photon scattering and absorption
- Physical chemistry, chemical kinetics
- Polymer physics
- Time series analysis
- Scale-free networks
- Spatial search and foraging
- Systems biology

Topics to be covered:

- Review of characteristic functions and Laplace transforms
- Fluctuations in coin tossing. Reflection principle; returns to the origin
- Brownian motion
- Generalized central limit theorem; Lévy stable distributions
- Generating functions; first passage times (first hitting time, survival models)
- Renewal theory; continuous time random walks (CTRW)

- Lévy walks and Lévy flights
- Master equations
- Long-range dependence (long-memory) processes
- Generalized Fokker –Planck equation
- Fractional calculus (fractional derivatives); fractional diffusion equation
- Graph theory and networks
- Percolation and fractals

Textbook:

J. Klafter and I. M. Sokolov, First Steps in Random Walks: From Tools to Applications, Oxford University Press, 2011

Students will also receive journal articles and excerpts from the book by W. Feller, An Introduction to Probability Theory and Its Applications (Vols. 1 & 2), 3rd Ed., Wiley 1968

Participation/Behavioral Expectations: For successful completion of the course, it is expected that students spend on average 2.5 hours/week attending lectures or watching recorded lectures, 8 hours/week solving assignments, 6 hours/week reading the textbook or articles.

Please review the core rules of netiquette for some guidelines and expectations on how to behave in an online learning environment.

Students in the resident course: I expect you to refrain from using laptops, cell phones and other electronic devices during class. The use of mobile phones (including sending and/or reading text messages) is not accepted during class. Classroom activities may be recorded by a student for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published or otherwise used for any other purpose without the express written consent of the instructor.

Method of evaluation: Assignments: 33%, Midterm exam: 24%, Final project: 28%, Readings: 10%, Quizzes 5%

A+ = 98-100	B+ = 87-89	C+ = 76-79
A = 94-97	B = 84-87	C = 65-75
A- = 90-93	B- = 80-83	D = 50-64
		F = 0-49

Homework assignments: Homework assignments will be posted on Canvas. Each assignment will be due at a specific date, approximately two weeks after it is posted. There will be a total of FIVE assignments during the semester. Assignments are submitted in Canvas as a single PDF file. Homework turned in after the due date requires prior approval from the instructor.

Assignment guidelines:

1. On the first page in the upper right-hand corner, write your first and last name, homework number, and course number.
2. Your solutions to the problems must be in the correct order.
3. Solutions can be hand-written or typed. Answers should be boxed or highlighted. There should be a logical flow to your homework. Solutions must be clear, and you must include how you reach your results. Writing only the final solution is not acceptable.
4. Use a computer or a ruler when making drawings.
5. All supporting material to solve a problem such as MATLAB or Python codes should be submitted with the homework.
6. Please be neat and write legibly. If I cannot read it, I will have to assume it is incorrect.
7. Written solutions should be scanned and submitted as a single pdf. Adobe Scan and Office Lens are free apps that can be used to make a pdf from your smart phone.
8. You **may not use** a solutions manual or copy any part of an assignment from another student, including those from previous years.

Take-home midterm exam:

One midterm take-home exam will be given. You can consult any material, but you must work on the exam alone. You are required to reference all consulted materials.

Final project

In the final project the you will demonstrate skills to model complex stochastic processes. The project is expected to include a critical literature survey, numerical simulations, and analytical tools. Project planning will be done together with the class instructor. Students will give a short presentation on their project and submit a three-page report. It is recommended to start planning early, so you are advised to start a discussion with the instructor before the end of September.

Readings

Journal articles will be regularly assigned as Readings. you need to write one or two paragraphs summarizing the article and providing a critique about what they consider to be strong and weak points of the article. The summary is submitted directly in Canvas and it is strictly limited to 2500 characters (including spaces and punctuation). It is mandatory to include a character count after the summary. You are expected to read the summaries submitted by peers.

Quizzes

Students in the course will sign up into teams of two students (pairs). To join a group (or see your group afterwards), click the People link to the left, then click the Team Quiz

Groups tab, open the groups and you can join your group of choice. For additional information on groups, see How do I join a group as a student?

At the end of each module you will receive a short quiz. A single answer is submitted per team. Each quiz will be specific to one module. Submissions must consist of a single pdf file that includes, in the top, the names of all both team members. Along with the submission, *each team needs to state how you communicated* to solve the problem as a team, including the platform used (Zoom, Teams, in-person, etc.) and the time spent during these communications. You can resubmit the quizzes as many times as you want in order to increase your grade.

Canvas Information, Technical Support, & MATLAB Access

Canvas is where course content, grades, and communication will reside for this course.
Support: info.canvas.colostate.edu
For passwords or any other computer-related technical support, contact the Central IT Technical Support Help Desk.

- (970) 491-7276
- help@colostate.edu

The Technical Requirements page identifies the browsers, operating systems, and plugins that work best with Canvas. If you are new to Canvas quickly review the Canvas Student Orientation materials.

You can access Matlab on your home computer by going to this link: https://www.engr.colostate.edu/ets/matlab/ . This is probably the easiest option. If you prefer, you can alternatively access the Engineering Virtual Classroom by going to this link: https://www.engr.colostate.edu/ets/virtual-classroom/ where Matlab is already installed.

Academic Integrity & CSU Honor Pledge

This course will adhere to the CSU Academic Integrity/Misconduct policy as found in the General Catalog and the Student Conduct Code.

Academic integrity lies at the core of our common goal: to create an intellectually honest and rigorous community. Because academic integrity, and the personal and social integrity of which academic integrity is an integral part, is so central to our mission as students, teachers, scholars, and citizens, I will ask that you affirm the CSU Honor Pledge as part of completing your work in this course.

Further information about Academic Integrity is available at CSU's Academic Integrity - Student Resources.

Universal Design for Learning/Accommodation of Needs

I am committed to the principle of universal learning. This means that our classroom, our virtual spaces, our practices, and our interactions be as inclusive as possible. Mutual respect, civility, and the ability to listen and observe others carefully are crucial to universal learning.

If you are a student who will need accommodations in this class, please contact me to discuss your individual needs. Any accommodation must be discussed in a timely manner. A verifying memo from The Student Disability Center may be required before any accommodation is provided.

The Student Disability Center (SDC) has the authority to verify and confirm the eligibility of students with disabilities for the majority of accommodations. While some accommodations may be provided by other departments, a student is not automatically eligible for those accommodations unless their disability can be verified and the need for the accommodation confirmed, either through SDC or through acceptable means defined by the particular department. Faculty and staff may consult with the SDC staff whenever there is doubt as to the appropriateness of an accommodative request by a student with a disability.

The goal of SDC is to normalize disability as part of the culture of diversity at Colorado State University. The characteristic of having a disability simply provides the basis of the support that is available to students. The goal is to ensure students with disabilities have the opportunity to be as successful as they have the capability to be.
Support and services are offered to student with functional limitations due to visual, hearing, learning, or mobility disabilities as well as to students who have specific physical or mental health conditions due to epilepsy, diabetes, asthma, AIDS, psychiatric diagnoses, etc. Students who are temporarily disabled are also eligible for support and assistance.

Any student who is enrolled at CSU, and who self-identifies with SDC as having a disability, is eligible for support from SDC. Specific accommodations are determined individually for each student and must be supported by appropriate documentation and/or evaluation of needs consistent with a particular type of disability. SDC reserves the right to ask for any appropriate documentation of disability in order to determine a student's eligibility for accommodations as well as in support for specific accommodative requests. The accommodative process begins once a student meets with an accommodations specialist in the SDC.

Religious Observances

CSU does not discriminate on the basis of religion. Reasonable accommodation should be made to allow individuals to observe their established religious holidays. Students seeking an exemption from attending class or completing assigned course work for a religious holiday will need to fill out the Religious Accommodation Request Form and turn it in to the Division of Student Affairs, located on the second level of the Administration building.

Once turned in, the Division of Student Affairs will review the request and contact the student accordingly. If approved, the student will receive a memo from the Dean of Students to give to their professor or course instructor.

Students are asked to turn in the request forms as soon as the conflict is noticed. Similarly, unanticipated conflicts requiring a religious observance, such as a death in the family, can also be reviewed.

Diversity and Inclusion

The Mission, Vision, and Focus webpage of the Vice President for Diversity includes a comprehensive statement of CSU's commitment to diversity and inclusion.