THE UNIVERSITY OF BRITISH COLUMBIA

Department of Computer Science, Mathematics, Physics and Statistics
Okanagan Campus

Stat 403 Section 001
Stochastic Processes
2021 Winter Term 1

Instructor:
Name: Eric Foxall (he, him).
You can address me as Eric, Dr. Foxall, professor, whatever is comfortable for you.
Office: SCI 115
Email: eric.foxall@ubc.ca

Office Hours: Mon 9:30-10:20am, Fri 10:30-11:20am, and by appointment.

Note: Lectures will be delivered in person. I will be recording these lectures (just record my screen and my own voice through a headphone mic, so if you come to class you won't be in the recording except maybe as a distant voice asking a question), so if you can't make it to class one day you can watch the recording.

Course Description:

Stat 403 (3) Stochastic Processes
Random walks, Markov chains, Poisson processes, continuous time Markov chains, birth and death processes, exponential models, and applications of Markov chains. [3-0-0]
Prerequisite: STAT 303.

Course Format:

Lecture schedule: Wed Fri 12:30-2:00pm, in room FIP 124

One of our lectures (dates below under "Course Evaluation") will be reserved for a midterm. If for whatever reason you don't think you'll be able to make it to the midterm in person on the scheduled day and time, please get in touch with me, ahead of time if possible, for alternate arrangements.

Will lectures be recorded? Yes, all lectures will be recorded. I'll post them on Canvas somewhere.

Midterm break and other important calendar dates can be found at http://okanagan.students.ubc.ca/calendar/

Learning Outcomes: After completing this course, you will be able to:

• Understand and describe stochastic processes mathematically as both
    1. a collection of time-indexed random variables on a common sample space, and
    2. a random trajectory, or sample path, through a given state space.

• Understand the notion of an i.i.d. (independent and identically distributed) sequence of random variables.
• Study certain processes associated to i.i.d. sequences, such as record values for non-negative random variables, and runs of 1s for bernoulli random variables.
• Construct a random walk from an i.i.d. sequence of real-valued random variables.
• Define Markov chains in discrete time using transition probabilities, and in continuous time using transition rates.
• Construct a Markov chain model, based on a given description.
• Verify the Markov property for a given process.
• Compute the probability distribution for the location of a Markov chain at a given fixed time, using the Chapman-Kolmogorov (discrete time) or forward/backward Kolmogorov (continuous-time) equations.
• Define stopping times and understand the strong Markov property.
• Determine the communicating classes of a Markov chain from its transition probabilities/rates and use these to describe its long-term behaviour.
• Understand the phenomenon of periodicity in a discrete time Markov chain.
• Use conditioning and first-step analysis to obtain and solve sets of equations describing important objects associated to Markov chains, such as the hitting probability and expected hitting time of a set, and stationary distributions, when they exist.
• Understand the notions of recurrence and transience of a stochastic process. Determine the recurrence or transience of various random walks.

• Construct and analyze various models in discrete and/or continuous time and study their characteristic properties, such as:
    1. branching processes and their survival probability and asymptotic rate of growth,
    2. the radioactive decay model, and the time until complete decay,
    3. the ehrenfest urn model and its stationary distribution,
    4. queuing models, existence or non-existence of a stationary distribution and expected wait times,

5. general birth and death processes, probability of divergence, hitting times and stationary distributions,
6. the basic insurance model and the ruin probability,
7. the Moran model of population genetics, and its probability of fixation and expected time until fixation,
8. the stochastic SIR model of infection spread in a finite population, and its final size.

• Understand the connection between discrete time and continuous time Markov chains obtained by the embedded Markov chain.
• Construct a Markov chain mathematically:
    1. from an i.i.d. collection of uniform random variables, in discrete time, and
    2. from an i.i.d. collection of exponential random variables, and an i.i.d. collection of uniform random variables, in continuous time.

• Use the technique of coupling to study the convergence of a Markov chain to its stationary distribution, when one exists.

• Construct and analyze the Poisson point process and the corresponding counting process, the Poisson process. Understand its relationship with exponential random variables and with i.i.d. uniform random variables.

Passing Criteria: a grade of 50% or more will constitute a passing grade for this course. It represents at least a partial working knowledge of the topics covered.

Required Materials:

We will mostly follow Chapters 1-4 of the following book:
Essentials of stochastic processes, Rick Durrett

which can be freely accessed at the following link:
https://services.math.duke.edu/~rtd/EOSP/EOSP2E.pdf

Here are a couple of other good, free (and optional) references:

Probability: theory and examples, Rick Durrett
https://services.math.duke.edu/~rtd/PTE/PTE5_011119.pdf

The above is an excellent book on probability theory. It goes deeper into many of the topics from the "essentials" book as well as foundational results of probability theory. It is, however, written at a fairly high level, so if you want to dive into it, expect to spend time and try things out for yourself in order to understand it. I'll emphasize that the "essentials" book will generally suffice for Stat 403, although I may borrow a topic or two from the "theory and examples" book.

Markov chains and mixing times, by D. Levin, Y. Peres and E. Wilmer
https://pages.uoregon.edu/dlevin/MARKOV/markovmixing.pdf

This is also a great book. It focuses mostly on discrete time, finite state Markov chains and the question of "mixing time", the amount of time until the distribution is close to the stationary distribution (think of card shuffling: how long until the deck is "fully shuffled"). Again, this text is optional, although I may borrow from it occasionally – I'll let you know if I do.

Here is yet another optional reference. It is written at a friendly, introductory level and contains lots of examples and exercises. It is, however, not free to purchase.

Introduction to Probability Models, Sheldon M. Ross

I believe the current edition is number 12 although not much has changed since at least the 9th edition. If you are unable to find a copy of a suitable edition online or elsewhere, you can buy a physical or electronic copy from the bookstore.

Course Evaluation:

Evaluation will consist of the following components:

Assignments (5 total)	40%	See below
Midterm	20%	Oct 22
Final Exam	40%	TBA
Total	100%	

Assignments: Assignments will be due every second week (skipping over reading break) on Thursdays at 11pm Pacific Daylight Time. So, assignment due dates will be Sep 16, Sep 30, Oct 14, Oct 28 and Nov 18. Assignments will be available on Canvas at least one week ahead of the due date and will be submitted on Canvas by uploading your work.

Midterm: the midterm will take place during lecture (12:30-2pm) in class on the Friday listed above.

Final exam: should occur on campus during exam period (Dec 11-22) unless some pandemic-related reason prevents it, date and time TBA.

Mode of delivery of exams: both the midterm and final exam will occur on campus, in person, unless the university itself closes in-person meetings. If you can't make it to an exam in person, please let me know ahead of time so we can make alternate arrangements.

Formats for online submissions: please ensure you can upload your work in an easily recognizable file format, such as .pdf, .jpg or .jpeg, and .png. Please avoid formats such as .HEIC (default image file type for certain phones) as these need to be individually converted before they can be read. There are many apps you can use to convert image files of arbitrary formats into one of the three recommended formats above. This will help save time when grading your work and is much appreciated.

Final grades will be based on the evaluations listed above and the final grade will be assigned according to the standardized grading system outlined in the UBC Okanagan Calendar.

Note: Any requests for changes to final exams must be sent to the office of the Associate Dean of Students (bsasdeansoffice.ubco@ubc.ca).

Missed Assignments and Exams (if applicable)

If you think you might miss an assignment or a test, please *get in touch with me right away!* It may not be guaranteed to have it omitted, but it's much easier to sort it out if you tell me before the due date. See the link in the paragraph below for an explanation of the valid reasons for which you can

have an assignment or a test omitted (with the weight shifted to the remainder of your evaluated material).

If ill health is an issue, students are encouraged to seek attention from a health professional. Campus Health and Counselling will normally provide documentation only to students who have been seen previously at these offices for treatment or counselling specific to conditions associated with their academic difficulties. Students who feel that requests for consideration have not been dealt with fairly by their instructors may take their concerns first to the Head of the discipline, and if not resolved, to the Office of the Dean. Further information can be found at: http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,48,0,0.

Late Policy

Except in cases of academic concessions (see link above), no late assignments will be accepted. With this in mind, please ensure that you leave yourself enough time to scan/photograph and upload your assignments before the deadline.

Outline of Lectures

An outline of the lecture schedule and topics will be posted on Canvas sometime before the first day of class.

Note: the remainder of this outline consists of standard material that you should find on every course outline

Grading Practices

Faculties, departments, and schools reserve the right to scale grades in order to maintain equity among sections and conformity to University, faculty, department, or school norms. Students should therefore note that an unofficial grade given by an instructor might be changed by the faculty, department, or school. Grades are not official until they appear on a student's academic record.

http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,41,90,1014

Final Examinations

The examination period for W2021 Term 1 is Dec 11-22. Except in the case of examination clashes and hardships (three or more formal examinations scheduled within a 24-hour period) or unforeseen events, students will be permitted to apply for out-of-time final examinations only if they are representing the University, the province, or the country in a competition or performance; serving in the Canadian military; observing a religious rite; working to support themselves or their family; or caring for a family member. Unforeseen events include (but may not be limited to) the following: ill health or other personal challenges that arise during a term and changes in the requirements of an ongoing job.
Further information on **Academic Concession** can be found under **Policies and Regulation in the *Okanagan Academic Calendar*** http://www.calendar.ubc.ca/okanagan/index.cfm?tree=3,48,0,0

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at: http://okanagan.students.ubc.ca/calendar/index.cfm?tree=3,54,111,0.

Cooperation vs. Cheating

Working with others on assignments is a good way to learn the material and we encourage it. However, there are limits to the degree of cooperation that we will permit. Any level of cooperation beyond what is permitted is considered cheating.

When working on programming assignments, you must work only with others whose understanding of the material is approximately equal to yours. In this situation, working together to find a good approach for solving a programming problem is cooperation; listening while someone dictates a solution is cheating. You must limit collaboration to a high-level discussion of solution strategies, and stop short of actually writing down a group answer. Anything that you hand in, whether it is a written problem or a computer program, must be written by you, from scratch, in your own words. If you base your solution on any other written solution, you are cheating. If you provide your solution for others to use, you are also cheating.

Copyright Disclaimer

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Grievances and Complaints Procedures

A student who has a complaint related to this course should follow the procedures summarized below:

- The student should attempt to resolve the matter with the instructor first. Students may talk first to someone other than the instructor if they do not feel, for whatever reason, that they can directly approach the instructor. If the complaint is not resolved to the student's satisfaction, the student should e-mail the Associate Head of Mathematics, Sylvie Desjardins at sylvie.desjardins@ubc.ca or the Department Head pro tem, Dr. Andrew Jirasek at andrew.jirasek@ubc.ca

Student Service Resources

Disability Assistance

The Disability Resource Centre ensures educational equity for students with disabilities, injuries or illness. If you are disabled, have an injury or illness and require academic accommodations to meet the course objectives, e-mail us or visit our website for more information.
Web: http://students.ok.ubc.ca/drc/welcome.html **E-mail** DRC at: drc.questions@ubc.ca

Equity, Human Rights, Discrimination and Harassment

UBC Okanagan is a place where every student, staff and faculty member should be able to study and work in an environment that is free from human rights-based discrimination and harassment. If you require assistance related to an issue of equity, discrimination or harassment, please contact the Equity Office, your administrative head of unit, and/or your unit's equity representative. **UBC Okanagan Equity Advisor: ph. 250-807-9291**
Web: https://equity.ok.ubc.ca/ **E-mail:** equity.ubco@ubc.ca

Health & Wellness - UNC 337

At UBC Okanagan health services to students are provided by Health and Wellness. Nurses, physicians and counsellors provide health care and counselling related to physical health, emotional/mental health and sexual/reproductive health concerns. As well, health promotion, education and research activities are provided to the campus community. If you require assistance with your health, please contact Health and Wellness for more information or to book an appointment.
Web: www.students.ok.ubc.ca/health-wellness **Email:** healthwellness.okanagan@ubc.ca

Sexual Violence Prevention and Response Office (SVPRO)

A safe and confidential place for UBC students, staff and faculty who have experienced sexual violence regardless of when or where it took place. Just want to talk? We are here to listen and help you explore your options. We can help you

find a safe place to stay, explain your reporting options (UBC or police), accompany you to the hospital, or support you with academic accommodations. You have the right to choose what happens next. We support your decision, whatever you decide. Visit svpro.ok.ubc.ca or call us at 250-807-9640

Independent Investigations Office (IIO)

If you or someone you know has experienced sexual assault or some other form of sexual misconduct by a UBC community member and you want the Independent Investigations Office (IIO) at UBC to investigate, please contact the **IIO**. Investigations are conducted in a trauma informed, confidential and respectful manner in accordance with the principles of procedural fairness. You can report your experience directly to the **IIO by** calling 604-827-2060.
Web: https://investigationsoffice.ubc.ca/ **E-mail:** director.of.investigations@ubc.ca

The Hub

The Student Learning Hub (LIB 237) is your go-to resource for free math, science, writing, and language learning support. The Hub welcomes undergraduate students from all disciplines and year levels to access a range of supports that include **tutoring in math, sciences, languages, and writing, as well as help with study skills and learning strategies**. **Web:** (https://students.ok.ubc.ca/student-learning-hub/) **Ph:** 250-807-9185.

SAFEWALK - Download the UBC SAFE – Okanagan app.
Don't want to walk alone at night? Not too sure how to get somewhere on campus? **Call Safewalk at 250-807-8076** For more information: https://security.ok.ubc.ca/safewalk/