M339J/M389J(unique: 53880/54230): Probability Models with Actuarial Applications
Spring 2022, University of Texas at Austin
Instructor: Milica Čudina

First-Day Information Sheet

Welcome! Here is some information and some ground rules. I will stick to these rules, and I assume you will, too. Read carefully, and let me know as soon as possible – **certainly by the** 12th **day of classes: February 2, 2022** – if there is anything unclear.

This syllabus is subject to change; students who miss class are responsible for learning about any changes to the syllabus.

<u>Treat this document like a contract.</u>

Technicalities

Lectures: Mon/Wed/Fri 1:00p-1:50pm via **Zoom**. There is a link to Zoom in Canvas on the left-hand side of the screen.

Office Hours: Tue/Thu 11am-12:30pm via **Zoom**. The link to the the office hours will be made available in the announcements on Canvas.

My e-mail: It's best to email me through Canvas. My email address is: mcudina@math.utexas.edu

Office: My usual office is PMA 13.142 (2515 Speedway, Austin, TX 78712), but I will **not** be spending any time there due to the pandemic.

About the Course

A few (serious) introductory remarks

◇ *Course URL.* `https://gordanz.github.io/cudina/M339J/M339J.html`

◇ *Course description.* This course is intended to provide the **mathematical foundations** necessary to prepare for a portion of the SOA exam STAM. The remainder of the STAM curriculum is exhibited in course M349P = M389P (also offered by the Department of Mathematics) This course also covers some of the "Section A - Probability Models" and "Section B – Statistics" material for CAS MAS-I.

The material exhibited includes: severity- and frequency-of-loss models, compound models, empirical estimation, maximum-likelihood estimation.

◇ *Learning objectives.*

- Students will become familiar with the basics of the programming language R and the RStudio IDE.
- Students will simulate random variables in R.
- Students will develop an understanding the stipulations of common insurance contracts useful in every-day life, including coverage modifications (deductibles, limits, coinsurance).
- Students will build up the vocabulary and the techniques indispensable in the workplace for every mathematics major focusing on actuarial science.
- Students will learn to build probabilistic models based on real-life problems with particular focus on short term insurance.
- Students will become competent in choosing appropriate probabilistic models for the applications mentioned above including, but not limited to, parameter value choice.
- Students will become versed in calculating the expected aggregate payments in the presence of coverage modifications for a variety of model choices as the first step towards policy pricing.

◇ *Prerequisites.* M362K and M358K (or M378K) with a grade of C- or better. Informally speaking, a thorough understanding of probability and basic statistics will be needed to advance through the variated and very dense material.

◇ *QR.* This course carries the *Quantitative Reasoning* flag. Quantitative Reasoning courses are designed to equip you with skills that are necessary for understanding the types of quantitative arguments you will regularly encounter in your adult and professional life. You should therefore expect a substantial portion of your grade to come from your use of quantitative skills to analyze real-world problems.

◇ *Textbook.* Our open-source textbook is available at:

https://ewfrees.github.io/Loss-Data-Analytics/

The supplemental short course is available at:

https://openacttexts.github.io/LDACourse1/

◇ *Class format and online attendance.* The class will be conducted completely online. Attendance for the purposes of grading will not be taken.

Online resources.

Zoom will be used for all classes and for office hours. Videos of all zoom sessions (except for private meetings) will be accessible to all students via Canvas. They will include transcripts of the lectures and chat logs (with possible delay due to processing).

Canvas will be used in this course to keep track of grades and for communication purposes. The students are responsible for the content of these announcements and email messages. The easiest way not to miss any is to turn on (i.e. not turn off) Announcements in their account's Notification menu and to check your email daily.

Ed Discussion will be used for informal class discussion. The system is highly catered to getting you help fast and efficiently from classmates and myself. Rather than emailing questions to the instructor, I encourage you to post your questions on Ed Discussion - accessible via the link in the left-hand side menu in Canvas.

Sharing of Course Materials is Prohibited.

No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings.

Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings.

On assignments and grading

Homework. Homework assignments will be available on the course website. Homework assignments will **not** be posted on Canvas, however you will be uploading your solutions using Canvas. Your solutions need to be in order and you should number the pages.

> **Having read and understood this *First-Day Handout* in its entirety will count as a homework assignment. To get the credit, read this entire document with understanding by February 2, 2022. Not handing in this assignment does not exempt you from abiding by this First-Day Handout.**

The lowest two homework scores will be dropped. The homework assignments and their due dates will be announced on the course website as the term progresses.

Quizzes. You will have various short warm-up and review worksheets to complete at home and upload to Canvas. Think of quizzes as "mini-homework". Most of the quizzes will include coding in R.

> The lowest four quiz scores will be dropped. The quizzes and their due dates will be announced on the course website as the term progresses.

The In-Term Exams. There will be a total of **three individual, take-home** in-term exams. The dates on which the exams will be **posted** are:

- Monday, February $14^{th}, 2022$
- Friday, March $25^{th}, 2022$
- Friday, May $6^{th}, 2022$

The dates on which the exams will be **due** are:

- Monday, February $21^{st}, 2022$
- Friday, April $1^{st}, 2022$
- Saturday, May 14, 2022

You will receive specific instructions for each exam by email.

The Final Exam.

> **Due to extenuating circumstances, there will be no comprehensive final exam.**

These are the things you should have available during an exam:

i. a sufficient amount of paper to work on;
ii. calculators of any kind (I recommend the *Texas Instruments TI-30XS MultiView Scientific Calculator*; it works well and it is allowed in actuarial exams).

There are extensive tables necessary to solve problems in this course. The link to said tables is: `https://www.soa.org/globalassets/assets/Files/Edu/2019/2019-02-exam-stam-tables.pdf` You will be given the ability to access these tables online during the exams. These are the things you *must not* have available during the exams: books, notes, manuals, cheat sheets, anything containing solved problems.

> **Since you will not be in our regular classroom setting, it is of utmost importance to preserve the integrity of your exam-taking. It is imperative that you do not communicate with anyone about the exam content prior to the due time of the exam. Finally, consulting the internet it out of bounds.**

If you provide me with a written proof that you absence was "legitimate"(e.g., a note from your doctor), make-up arrangements will be made on a case-by-case basis.

Your scores are non-negotiable.

The Final Grades. These are the **weights** assigned to the assessment components:

   Homework average (after the two lowest scores are dropped): 20%

   Quizzes (after the four lowest scores are dropped): 20%

   In-term exams (each): 20%

I trust that the way this course is organized will be conducive to no late assignment submissions or missed in-term exams. Having said this, if you do experience any technical or health difficulties in timely assignment submission, let me know and we'll work to find a solution. As always, and especially in these extreme circumstances, if there are non-academic issues you are facing, feel free to reach out to your instructor.

Graduate students. Students who are taking this as a graduate course will be having extra special homework assignments. They should contact the instructor about the exact content of those assignments.

Final grades. The final letter grades will be assigned relative to your numerical score obtained from the above scheme in the following way:

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
94-100	90-94	86-90	82-86	78-82	74-78	70-74	65-70	60-65	55-60	50-55	0-50

The grades will not be "curved"!!!!!

Some friendly advice

◇ *Please, come prepared to every class meeting* – review your notes, pay attention to the current material, and bring the necessary supplies (most importantly – the calculator of your choosing).

> **Meaningful class and Ed Discussion participation will earn you extra credit at the sole discretion of your instructor.**

◇ *Discuss the course with your colleagues* - In order to be able to participate in class, you first need to build up a vocabulary - and there will be a lot of new vocabulary in the beginning. Who better to practice the new concepts with than your classmates who are in the same situation? I suggest that you try to work on homework assignments in pairs and small groups. You can set up your own Zoom meetings with colleagues. Of course, you will be required to write up your own final version (and I urge you to do so - that is the only way you will be able to tell what your individual knowledge is, as opposed to the collective knowledge of your study-group).

> **Due to social distancing, it is impossible for you to have your regular study-group meetings. Please, take advantage of the "Discussions" feature in Canvas or use Piazza.**

◇ *Don't try to cheat* - This is an unpleasant topic, but unfortunately a necessary one! One is often tempted to stretch the boundaries of mere discussion/collaboration with a fellow student into the territory of pure and simple cheating. In short, everything that you present as your own work (especially the work that is supposed to be graded!) should, in fact, be your own work, and not something copied from an external source. In case that a student is caught in violation of the principles of academic honesty enforced at this university, they will immediately be reported to the higher authorities and assigned a failing grade in this course. You are expected to have read and understood the current issue of General Information Catalog, published by the Registrars Office, for information about procedures and about what constitutes scholastic dishonesty. Please visit

`https://deanofstudents.utexas.edu/conduct/academicintegrity.php`.

> **Some might find the virtual-assessment environment tempting. Remember that you are Longhorns!**

◇ *Have realistic impressions of your performance* The grading scheme for this course is described above and I do not intend to stray from it. You are solely responsible for keeping a tally of your scores throughout the semester and entering your results in the grading formula above to avoid any surprises at the end of the semester.

◇ *On email and office hours* - Email should be used for brief messages about the organization of and current goings on in the course. As a rule, you should first consult the first-day handout to see if your question is answered here. If there is still any ambiguity, contact the instructor. Your instructor is handling a great number of email messages. You should not expect to have your particular email answered in less than 48 hours. If you have a math question, you can take a photo/scan of your work and email it to me as an attachment. To get an answer to this type of questions, you should then come to Zoom office hours and ask in person. When coming to office hours, you should be able to present the mathematical question you have, the route(s) you took in attempting to solve the problem and the obstacles you encountered. Posting your question on Ed Discussion would be the most expedient course of action.

Finally, I frequently use mass email to communicate what needs to be communicated to the class. If you do not check your email and miss an important announcement (including any assignments), that is your own responsibility. For more on the University policy on email communication, please, visit:

`https://it.utexas.edu/policies/university-electronic-mail-student-notification-policy`.

General and UT mandated notes

◇ *Drop dates.* The last drop date for this class is the one announced on the academic calendar of the University of Texas at Austin (see http://registrar.utexas.edu/calendars/). This term it is **April 4, 2022**.

◇ "Counselling and Mental Health Center Student Services Bldg (SSB), 5th Floor Hours: M–F 8am–5pm; phone: 512 471 3515(appointments), 512 471 CALL (crisis line); `http://www.cmhc.utexas.edu`"

◇ "The university is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Services for Students with Disabilities (SSD). Please refer to SSD's website for contact and more information: `http://diversity.utexas.edu/disability/`. If you are already registered with SSD, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course."

◇ "Your physical health and wellness are a priority. University Health Services is an on-campus high-quality medical facility providing care to all UT students. Services offered by UHS include general medicine, urgent care, a 24/7 nurse advice line, women's health, sports medicine, physical therapy, lab and radiology services, COVID-19 testing and vaccinations and much more. For additional information, visit `healthyhorns.utexas.edu` or call 512-471-4955."

◇ "Student Emergency Services in the Office of the Dean of Students helps students and their families during difficult or emergency situations. Assistance includes outreach, advocacy,

intervention, support, and referrals to relevant campus and community resources. If you need to be absent from class due to a family emergency, medical or mental health concern, or academic difficulty due to crisis or an emergency situation, you can work with Student Emergency Services. SES will document your situation and notify your professors. Additional information is available at `https://deanofstudents.utexas.edu/emergency/` or by calling 512-471-5017."

◇ "Religious holy days sometimes conflict with class and examination schedules. Sections 51.911 and 51.925 of the Texas Education Code relate to absences by students and instructors for observance of religious holy days.

Section 51.911 states that a student who misses an examination, work assignment, or other project due to the observance of a religious holy day must be given an opportunity to complete the work missed within a reasonable time after the absence, provided that he or she has properly notified each instructor.

It is the policy of The University of Texas at Austin that the student must notify each instructor at least fourteen days prior to the classes scheduled on dates he or she will be absent to observe a religious holy day. For religious holidays that fall within the first two weeks of the semester, the notice should be given on the first day of the semester. The student may not be penalized for these excused absences but the instructor may appropriately respond if the student fails to complete satisfactorily the missed assignment or examination within a reasonable time after the excused absence."

This syllabus is subject to modification. Any changes will be announced in class.

A <u>TENTATIVE</u> schedule.

#	Wday	Date	Material to be covered
1	W	Jan 19	Orientation. Modeling.
2	F	Jan 21	Cumulative distribution function. Survival function. Types of random variables.
3	M	Jan 24	Probability mass function. Probability density function.
4	W	Jan 26	The exponential distribution.
5	F	Jan 28	Random number generation. The inverse transform method.
6	M	Jan 31	Basics of **R**. **R** scripts and **R** notebooks.
7	W	Feb 2	Functions in **R**. *If … else* in **R**. Simulations of random variables.
8	F	Feb 4	The expected value.
9	M	Feb 7	SLLN. Monte Carlo simulation.
10	W	Feb 9	Moments. Variance. Coefficient of variation.
11	F	Feb 11	The excess loss random variable.
12	M	Feb 14	Per-payment and per-loss random variables.
13	W	Feb 16	The limited-loss random variable.
14	F	Feb 18	Percentiles. mgf and pgf. Sums of independent random variables.
15	M	Feb 21	Parametric distributions. Scale distributions.
16	W	Feb 23	More transformations. $k-$point mixtures.
17	F	Feb 25	Continuous mixtures.
18	M	Feb 28	More on continuous mixtures.
19	W	Mar 2	Splicing. Franchise deductibles.
20	F	Mar 4	Loss elimination ratio. Inflation. Policy limits (with no deductible)
21	M	Mar 7	Coinsurance. Policy limits. Ordinary deductibles (again).
22	W	Mar 9	Policy-modifications practice. The Poisson distribution.
23	F	Mar 11	More on the Poisson distribution.
24	M	Mar 21	Poisson thinning. The negative binomial distribution.
25	W	Mar 23	The Poisson-gamma mixture.
26	F	Mar 25	The binomial distribution.
27	M	Mar 28	The $(a, b, 0)$ class.
28	W	Mar 30	The impact of deductibles on claim frequency.
29	F	Apr 1	The individual risk model.
30	M	Apr 4	Monte Carlo for the individual risk model.
31	W	Apr 6	The collective risk model.
32	F	Apr 8	Monte Carlo for the collective risk model.
33	M	Apr 11	Stop-loss insurance.
34	W	Apr 13	The interpolation theorem.
35	F	Apr 15	Compound Poisson.
36	M	Apr 18	A few compound Poissons.
37	W	Apr 20	The recursive formula for the distribution of aggregate losses.
38	F	Apr 22	Aggregate losses with an ordinary deductible per-loss.
39	M	Apr 25	Maximum-likelihood estimation: First principles. Individual unmodified data.
40	W	Apr 27	Maximum-likelihood estimation: Grouped data.
41	F	Apr 29	Maximum-likelihood estimation: Truncation and censoring.
42	M	May 2	Maximum-likelihood estimation: Bernoulli and Poisson.
43	W	May 4	Maximum-likelihood estimation: Negative binomial and binomial.
44	F	May 6	Problem-solving session.