DALHOUSIE UNIVERSITY

Faculty of Science Course Syllabus
Department of Mathematics and Statistics
Actuarial Models II — ACSC/STAT 4703
FALL 2023

Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people.

Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Instructor(s):	Toby Kenney tkenney@mathstat.dal.ca
Lectures:	TT: 13:05-14:25
Course Brightspace Page	https://dal.brightspace.com/d2l/home/250708
Laboratories:	None
Tutorials:	None

Course Description

In ACSC/STAT 3703, we covered a range of models that can be used in actuarial work. In this course we build upon these models, to study various aspects of applying these models in insurance contexts, including extreme value theory, aggregate loss models, model selection, loss reserving, credibility theory and ratemaking.

Course Prerequisites

ACSC/STAT 3703

Course Objectives/Learning Outcomes

- Create new continuous distributions by transformations, convolution, mixing and splicing of existing distributions,
- Estimate increased limit factors from loss data.
- Use increased limit factors to estimate distributional quantities.

- Understand the derivation of the Generalised Extreme Value and Generalised Pareto Distributions.
- Estimate the parameters of the Generalised Extreme Value and Generalised Pareto Distributions.
- Apply the Generalised Extreme Value and Generalised Pareto Distributions to the estimation of tail measures and probabilities.
- Compute the distribution of Aggregate losses on a portfolio of insurance contracts.
- Calculate the exact distribution for aggregate claims using a compound model in special cases.
- Use a recursive formula to calculate compound distributions where the primary distribution is from the $(a, b, 1)$-class.
- Approximate continous severity distributions by arithmetic distributions.
- Apply various standard plots to asses the fit of a model to data.
- Interpret the meaning of standard plots of goodness of fit.
- Apply the following tests of goodness of fit: Kolmogorov-Smirnov test, Anderson-Darling test, likelihood ratio test, Chi-square test.
- Apply AIC and BIC to select the model which best fits the data.
- Apply the Buhlmann and Buhlmann-Straub models of credibility and understand the connection to Bayesian analysis.
- Calculate credibility premiums using Bayesian analysis.
- Apply empirical Bayesian methods for estimating variances in credibility theory.
- Apply various methods for estimating outstanding claims reserves.
- Understand the theoretical assumptions behind loss reserving methods.
- Estimate the uncertainty in loss reserving methods.
- Adjust premium rates with differentials on the basis of new data, balancing back to ensure correct total premiums.

Course Materials

Textbook: *Loss Models: From Data to Decisions* (Fourth Edition)
by S. A. Klugman, H. J. Panjer and G. E. Wilmot
published by Wiley, 2012

Additional reading: *Introduction to Ratemaking and Loss Reserving for Property and Casualty Insurance* (Fourth Edition), 2015, by Brown and Lennox
Society of Actuaries, *SHORT-TERM ACTUARIAL MATHEMATICS STUDY NOTES* Available from the SoA website.

Course Brightspace Page: `https://dal.brightspace.com/d2l/home/250708`

The textbook was used for the prerequisite course 3703, so you should already have a copy. Older (or newer) versions of the textbook should be fine.

Course Assessment

Component	Weight (% of final grade)	Date
Midterm Exam	30	19th October
Final Exam	55	TBA during exam period.
Assignments	15	Assignment 1 — Thursday 21st September
		Assignment 2 — Thursday 28th September
		Assignment 3 — Thursday 5th October
		Assignment 4 — Thursday 12th October
		Assignment 5 — Thursday 2nd November
		Assignment 6 — Thursday 8th November
		Assignment 7 — Thursday 23rd November
		Assignment 8 — Thursday 30th November

Other Course Requirements

Conversion of numerical grades to Final Letter Grades follows the
Dalhousie Common Grade Scale

A+	(90–100)	**B+**	(77–79)	**C+**	(65–69)	**D**	(50–54)
A	(85–89)	**B**	(73–76)	**C**	(60–64)	**D**	< 50
A-	(80–84)	**B-**	(70–72)	**C-**	(55–59)	**D**	(50–54)

Delivery of Material

The course will be delivered in-person. Videos from previous years are available for some topics on the course Brightspace page, for individuals who cannot attend lectures. As the syllabus has changed from previous years, **material for some topics is not available**. Homeworks can be submitted either in-class or online through Brightspace. Exams will be in-person.

Course Policies

Late assignments will receive a grade of zero, as solutions are posted online immediately after the due date. The overall assignment mark is made up from the best 7 out of 8 assignments. Students unable to take the final exam should, wherever possible, notify the instructor prior to the start of the exam, and submit the Student Declaration of Absence. All reasonable efforts to provide a make-up exam will be made. Assignments are to be individual work.

Course Content

The planned schedule for covering the course is given in the following table. The schedule may change depending on coverage of material or cancellation of lectures due to weather or other reasons.

Week	Monday	Wednesday
4th September	Introduction and Preliminaries **5 Continuous Distributions:** • 5.2 Creating New Distributions — Transformation Q1-3.	• 5.2 Creating New Distributions — Convolution Q4. • 5.2.4 Mixture Distributions Q5-6. **8 Frequency and Severity with Coverage Modifications:** • 8.2–8.4 Deductibles and Limits (Revision) • IRLRPCI 5.2 Increased Limits Factors Q7
11th September	• IRLRPCI 5.2 Increased Limits Factors (cont.) Q8–12 **SN2 Extreme Value Distributions** • SN2 5.2 Introduction. • SN2 5.3 Block Maxima and Generalised Extreme Value Distributions Q13.	• SN2 5.3 Block Maxima and Generalised Extreme Value Distributions (cont.) Q14–17.
18th September	• SN2 5.3.4 Estimating GEV Parameters Q18. • SN2 5.4 Points over Threshold. • SN2 5.4.2 Generalised Pareto Distribution Q19–22. • SN2 5.4.2 The Hill Estimator Q23–24.	**7 Advanced Discrete Distributions** • 7.3 Mixed Frequency Distributions Q25. • 7.1 Compond Frequency Distributions Q26–29.
25th September	• 7.2 The Compound Poisson Distribution Q30–32. **9 Aggregate Loss Models:** • 9.1 Introduction. • 9.3 The compound model for aggregate claims Q33. • 9.4 Analytic results Q34.	• 9.4 Analytic results (cont.) Q35. • 9.5 Computing the aggregate claims distribution Q36. • 9.6 the recursive method. • 9.6.1 Applications to compound frequency models Q37-39.
2nd October	**IRLRPCI 4 Loss Reserving** • 9.6.2 Overflow/Underflow problems Q40. • 9.6.3 Numerical stability Q41. • 9.6.4 Continuous severity • 9.6.5 Constructing arithmetic distributions Q42.	**16 Model selection** • 16.3 Graphical comparison of density and distribution functions Q43–51. • 16.4 Hypothesis tests Q52
9th October	• 16.4 Hypothesis tests (cont.) Q53–55 • Score based approaches - AIC, BIC Q56 • 16.5 Model Selection	Revision chapters 9, 16, IRLRCPI 2, 4
16th October	Revision chapters 9, 16, IRLRCPI 2, 4	MIDTERM EXAMINATION
23rd October	**18 Greatest accuracy credibility** • 18.2 Conditional distributions and expectation Q57. • 18.3 Bayesian methodology Q58–60	• 18.4 The credibility premium Q61–63. • 18.5 The Buhlmann model Q64–65. • 18.6 The Buhlmann-Straub model Q66–67.
30th October	• 18.7 exact credibility Q68–69. **19 Empirical Bayes parameter estimation** • 19.2 Nonparametric estimation Q70–71.	• 19.2 Nonparametric estimation (cont.) Q72. • 19.3 Semiparametric estimation Q73–76.
6th November	**SN1 Loss Reserving** • 1 Introduction (Revision) • 2 Run-Off Triangles (Revision) • 2.2 Chain-Ladder Method (Revision) Q77. • 2.3 Inflation-adjusted Chain-Ladder Method Q78. • 3 Statistical Foundations for Chain-Ladder Method. • 3.2 Testing Chain-Ladder Assumptions Q79–80. • 3.3 Bornhuetter-Fergusson Method (Revision) Q81.	• 3.4 Buhlman-Straub credibility model Q82. • 3.5 Poisson model Q83. • 4 Mack's Model Q84.
13th November	STUDY BREAK	
20th November	• 5 Overdispersed Poisson Model Q85. • 6 Separate Modelling of Frequency and Severity Q86. **IRLRPCI 3 Ratemaking** • 4.8 Rate Change with Differentials Q87.	• 4.8 Rate Change with Differentials (cont.) Q88–89.
27th November	Revision	Revision

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel, and support. Visit or e-mail the Indigenous Student Centre at 1321 Edward St or elders@dal.ca. Additional information regarding the Indigenous Student Centre can be found at: `https://www.dal.ca/campus_life/communities/indigenous.html`

Internationalization

At Dalhousie, 'thinking and acting globally' enhances the quality and impact of education, supporting learning that is "interdisciplinary, cross-cultural, global in reach, and orientated toward solving problems that extend across national borders." Additional internationalization information can be found at: `https://www.dal.ca/about-dal/internationalization.html`

Academic Integrity

At Dalhousie University, we are guided in all our work by the values of academic integrity: honesty, trust, fairness, responsibility, and respect. As a student, you are required to demonstrate these values in all the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. Additional academic integrity information can be found at: `https://www.dal.ca/dept/university_secretariat/academic-integrity.html`

Accessibility

The Student Accessibility Centre is Dalhousie's centre of expertise for matters related to student accessibility and accommodation. If there are aspects of the design, instruction, and/or experiences within this course (online or in-person) that result in barriers to your inclusion, please contact the Student Accessibility Centre (`https://www.dal.ca/campus_life/academic-support/accessibility.html`) for all courses offered by Dalhousie with the exception of Truro. For courses offered by the Faculty of Agriculture, please contact the Student Success Centre in Truro (`https://www.dal.ca/about-dal/agricultural-campus/student-success-centre.html`)

Conduct in the Classroom – Culture of Respect

Substantial and constructive dialogue on challenging issues is an important part of academic inquiry and exchange. It requires willingness to listen and tolerance of opposing points of view. Consideration of individual differences and alternative viewpoints is required of all class members, towards each other, towards instructors, and towards guest speakers. While expressions of differing perspectives are welcome and encouraged, the words and language used should remain within acceptable bounds of civility and respect.

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness (Strategic Priority 5.2). Additional diversity and inclusion information can be found at: `http://www.dal.ca/cultureofrespect.html`

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner - perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. The full Code of Student Conduct can be found at: `https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html`

Fair Dealing Policy

The Dalhousie University Fair Dealing Policy provides guidance for the limited use of copyright protected material without the risk of infringement and without having to seek the permission of copyright owners. It is intended to provide a balance between the rights of creators and the rights of users at Dalhousie. Additional information regarding the Fair Dealing Policy can be found at: `https://www.dal.ca/dept/university_secretariat/policies/academic/fair-dealing-policy-.html`

Originality Checking Software

The course instructor may use Dalhousie's approved originality checking software and Google to check the originality of any work submitted for credit, in accordance with the Student Submission of Assignments and Use of Originality Checking Software Policy. Students are free,

without penalty of grade, to choose an alternative method of attesting to the authenticity of their work and must inform the instructor no later than the last day to add/drop classes of their intent to choose an alternate method. Additional information regarding Originality Checking Software can be found at: `https://www.dal.ca/dept/university_secretariat/policies/academic/student-submission-of-assignments-and-use-of-originality-checking-software-policy-.html`

Student Use of Course Materials

Course materials are designed for use as part of this course at Dalhousie University and are the property of the instructor unless otherwise stated. Third party copyrighted materials (such as books, journal articles, music, videos, etc.) have either been licensed for use in this course or fall under an exception or limitation in Canadian Copyright law. Copying this course material for distribution (e.g. uploading to a commercial third-party website) may lead to a violation of Copyright law.

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: `https://www.dal.ca/dept/university_secretariat/academic-integrity.html`

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: `https://www.dal.ca/campus_life/academic-support/accessibility.html`

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Statement:`http://www.dal.ca/cultureofrespect.html`

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Information:`https://www.dal.ca/campus_life/communities/indigenous.html`

Important Dates in the Academic Year (including add/drop dates)

`https://www.dal.ca/academics/important_dates.html`

University Grading Practices

`https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html`

Student Resources and Support

Advising

General Advising `https://www.dal.ca/campus_life/academic-support/advising.html`
Science Program Advisors: `https://www.dal.ca/faculty/science/current-students/academic-advising.html`
Indigenous Student Centre: `https://www.dal.ca/campus_life/communities/indigenous.html`
Black Students Advising Centre: `https://www.dal.ca/campus_life/communities/black-student-advising.html`

International Centre: `https://www.dal.ca/campus_life/international-centre/current-students.html`

Academic supports

Library: `https://libraries.dal.ca/`

Writing Centre: `https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html`

Studying for Success: `https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html`

Copyright Office: `https://libraries.dal.ca/services/copyright-office.html`

Fair Dealing Guidelines `https://libraries.dal.ca/services/copyright-office/fair-dealing.html`

Other supports and services

Student Health & Wellness Centre: `https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html`

Student Advocacy: `https://dsu.ca/dsas`

Ombudsperson: `https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html`

Safety

Biosafety: `https://www.dal.ca/dept/safety/programs-services/biosafety.html`

Chemical Safety: `https://www.dal.ca/dept/safety/programs-services/chemical-safety.html`

Radiation Safety: `https://www.dal.ca/dept/safety/programs-services/radiation-safety.html`

Scent-Free Program: `https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html`