

**MATH4427 Loss Models and Their Applications**  
**Course Outline**  
**Fall Semester 2023-2024**

**1. Instructor:**

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Office Hours: Every Thursday 6:00 p.m.- 7:30 p.m. (@Room 3420)

**2. Meeting time and Venue**

Lectures: (Tues) 4:30p.m.-6:50p.m. @Room 1409

(Thurs) 4:30p.m.-5:50p.m. @Room 1409

(\*Note 1: The tutorial on Tuesday will also be used as lecture.)

(\*Note 2: The classes will be conducted in face-to-face mode. All students are expected to attend the classes.)

**3. Course Description**

**Credit point:** 3 credits

The key objective in this course is to explore how to construct a mathematical model to study the risk management problem faced by an insurance company. During the process, you are going to learn how do probability theory and statistical theory that you learnt from earlier courses be applied in practice.

- In the first part of this course, we first construct a simple model (severity model, frequency model and aggregate loss model) for studying the losses faced by the company. We also study the probability tools needed in studying the target.
- In the second part of this course, we shall study how to fit the model with the actual data. The analysis requires a lot of statistical analysis including elementary point estimation, interval estimation and hypothesis testing. Lastly, we also examine how to evaluate the entire model in the sense that whether the given model is consistent with the actual data in reality.

Additional note:

This course will cover

- (Old) 60~70% of the content covered in Exam STAM (Short-term actuarial mathematics) offered by the Society of Actuaries
- 70% of the content covered in FAM (FAM-S) exam and ASTAM exam offered by the Society of Actuaries.

**Prerequisites:** Since this course is an advanced course in actuarial mathematics and is very **difficult exciting**, we expect that all students should have solid background in basic calculus/multivariable calculus (MATH2023), probability and statistical theory (MATH2411 + MATH2421), elementary financial knowledge and **good problem solving skill** (MATH2511). Some knowledge in real analysis (MATH2033/MATH3033), is also helpful, although is not essential.

#### 4. Intended Learning Outcome (ILOs)

(Quoted from Learning Outcome in SOA STAM Exam syllabus)

1. Upon successful completion of this course, students are expected to be familiar with severity, frequency and aggregate models, and use statistical methods to estimate parameters of such models given sample data. Students are expected to identify steps in modelling process, understand the underlying assumptions implicit in each family of models, recognize which assumptions are applicable in a given business application, and appropriately adjust models for impact of insurance coverage modifications.

#### 5. Student Learning Resources

We will use our own Lecture notes in this course. Additional problem sets (optional) will be provided. The materials can be downloaded from <https://canvas.ust.hk> once they are available.

The following reference books will be useful:

1. Klugman, Panjer and Wilmot, 2012, "Loss models: From data to decisions", 4<sup>th</sup> edition, SOA.  
(\*This is also a textbook recommended by SOA for their SOA exams. Earlier edition of this book can be borrowed from HKUST library. Alternatively, borrow the book via HKALL.)
2. Brown, R.L., Gottlieb, L.R., "Introduction to ratemaking and loss reserving for property and casualty insurance", 3<sup>rd</sup> edition, ACTEX.

#### 6. Teaching and Learning Activities

Lectures (4 hours per week)

#### 7. Tentative Course Schedules

##### Chapter 1: A quick review on basic probability theory

- Basic review on random variables
- Expected, moments, skewness and kurtosis
- Moment generating function and probability generating function
- Mixed distribution

## Chapter 2: Severity Model, Frequency Model and coverage modification

- Probability distributions for claim severity and claim frequency.
- Criteria in selecting models for claim severity and claim frequency
- Coverage modifications: Deductible, policy limit, maximum covered loss and coinsurance. Effect of coverage modification on claim payment.

## Chapter 3: Aggregate Loss models

- Models for aggregate claims: Collective Risk Model and Individual Risk Model
- Computing the aggregate claims distribution
- Effect of individual policy modifications on aggregate payments
- Risk measures: VaR (Value-at-risk) and TVaR
- Reinsurance and stop-loss premium

## Chapter 4: Parameter estimation in parametric model

- Basics in parameter estimation
- Method of moment and percentile matching
- Maximum likelihood method: Complete data, Grouped data and truncated/censored data.
- Variance and interval estimation of maximum likelihood estimator (Harder)
- Introduction to Delta method.
- Bayesian Analysis: An introduction.

## Chapter 5: Additional topic: Premium calculation and risk management in non-life insurance (If time allowed)

- Basic principle of premium calculation and ratemaking
- Basic idea of loss reserving
- Methods of loss reserving: Expected Loss Ratio (ELR) method, Chain Ladder (CL) Method, Bornhuetter-Ferguson (BF) Method etc.

## 8. Assessment Scheme

There are 3 assessment tasks in this course:

	Weight	CLOs assessed
Assignment	15% + Bonus	1
Midterm Examination	15%	1
Final examination	70%	1

### (a) Assignment (15% of the total grade + Bonus)

There are required problems and optional problems in each of the assignments. You are required to complete all required problems. Also, you may complete some of the optional problems for bonus score (which may improve your final grade).

**(b) Midterm Examination (15% of the total grade)**

Date: 26<sup>th</sup> Oct, 2023 (Thursday)

Time: 4:30p.m.-5:50p.m. (Class hour)

It will be an in-class midterm and covers the materials taught before the midterm. The exact coverage of the midterm exam will be announced around 1 week before the midterm exam.

**(c) Final Examination (70% of the total grade)**

It is a 2.5 - 3 hours closed book on campus exam. The final exam will cover all materials (including proof) covered in the course. The date and venue of the final exam will be confirmed by ARR. The detailed arrangement of the exam will be announced later.

(\*Note: You can pass the course for sure if you get at least 40% of the overall grade and get at least 25 points (out of 100) in final examination.)