STAT 345 / STAT 445 / PQHS 481
Theoretical Statistics I

Instructor: Jený Brynjarsdóttir

Tue/Thu 2:30 - 3:45 pm, Nord 206

Fall semester 2024

Welcome to Theoretical Statistics I
STAT 345 / STAT 445 / PQHS 481

- Theoretical Statistics I and II
    - Mathematical foundations of Statistics

- STAT 345 / STAT 445
    - Probability
        - Definition of probability, univariate and multivariate random variables, distributions, joint, marginal and conditional distributions, expectation, covariance, sampling distributions, ...

- STAT 346 / STAT 446
    - Statistical Inference
        - Point estimation, hypothesis testing, interval estimation, ...

- Goals:
    - Understand and apply the rules of probability
    - Begin to raise the level of rigor of your Mathematics

About the instructor:

- Born and rased in Iceland

Eyjafjallajökull

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- Born and rased in Iceland

Background

- BSc (Mathematics) and MSc (Industrial Engineering)
  from the University of Iceland
- PhD in Statistics from The Ohio State University 2011
- Postdoc 2011 - 2013 at the Statistical and Applied Mathematical
  Sciences Institute (SAMSI) and Duke University
- Joined CWRU in August 2013
  - Associate Professor in the Department of Mathematics, Applied
    Mathematics and Statistics

The complicated last name: Brynjarsdóttir
It's actually not that complicated!

- About 90% of Icelanders do not have a family name

- Patronymic (occasionally matronymic) system:
  Take your fathers (or mothers) *first* name and add either
    - "dóttir" for daughter or "son" for son

For example:

- My father: Brynjar Bragason, My mother: Anna Ingólfsdóttir
    - Paternal grandparents: Bragi Helgason, Sigrún Halldórsdóttir
      Maternal grandparents: Ingólfur Magnússon, Jenný Karlsdóttir

Me and my brothers:

- Jenný Brynjarsdóttir

- Bragi Brynjarsson

- Baldur Brynjarsson

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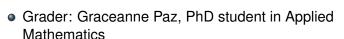   - "dóttir" for daughter or "son" for son

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Me and my brothers:

- Jenný *Brynjar*sdóttir

- Bragi *Brynjar*sson

- Baldur *Brynjar*sson

  What is your Icelandic last name?

Syllabus - Please read the Syllabus!

- **Required Textbook:** Statistical Inference, 2nd edition by George Casella and Roger L. Berger
  - First chapter on Canvas.

- Grader: Graceanne Paz, PhD student in Applied Mathematics

- Graduate students: STAT 445 and PQHS 481

- Office hours
  - Tuesdays 12:30-1:30pm and Thursdays 4:00 - 5:00pm in 2145 Adelbert Rd, Room 202C.
    - Front door card access only, Back door should be unlocked
  - By appointment on Fridays - Appointments can be made on Google calendar

Statistical Inference

Second Edition

George Casella
Roger L. Berger

More from the Syllabus

- Homework assignments (15%)
  - 8 homework assignments, 10 points each. Grade out of 70 points

- Quizzes (25%)
  - 4 quizzes, 20 points each. Grade out of 60 points.

- Midtem exam 10/17 (30%)
  - *There is always hope rule:*
    ```
    if MidtemGrade < FinalGrade
       then MidtermGrade = FinalGrade
    ```

- Final Exam 12/17 (30%)

How to approach this course

- Key to success in this course:

    Read, write, ask – repeat!

- Read the assigned reading carefully

- Write detailed notes both in class and when reading the textbook

- Ask when anything is unclear, in class or in office hours

Warning: There will be proofs!

Prereqs: Better if you have taken MATH 223 or MATH 227

Contents of the course

- Probability theory
  - Sets, prob. axioms, cond. prob., Random Variables, cdf, pdf, pmf, ...

- Transformations and expectation
  - Functions of a random variable, $E(X)$, mgf, ...

- Common families of distributions
  - Discrete and continuous, Families, some "$\leq$" and "$=$"

- Multiple Vandom variables
  - Joint and marginal, cond. distr., Bivariate Transformations, $\mathrm{Cov}(X, Y)$

- Properties of random samples
  - Sums of random variables, t, χ^2, and F distributions, order statistics

Corresponds to Chapters 1 – 5 of the textbook

Interpretation of Probability

Frequentist interpretation of Probability

Probability of an event is the *relative frequency* in which that event happens if the process were repeated many times under similar conditions.

- $P(A) = p$ means: If the process (e.g. sampling) is repeated N times the event A happens about pN times.

- **Example: throwing a fair coin**
  - $P(\text{Head}) = 0.5$, $P(\text{Tail}) = 0.5$,
  - If we throw a coin many times we get a Head about 50% of the time

- **Example: Pick a card at random out of a deck**
  - $P(\text{Spade}) = 0.25$
  - If we pick a card at random from many decks of cards (or same deck with replacement) we get a spade about 25% of the time.

Bayesian Interpretation of Probability

Bayesian interpretation of Probability

Subjective view Probability of an event is a degree of belief in whether the event will happen

- Sometimes framed in terms of *betting*. The bets you are willing to make represent your (personal) probabilities.

- This is a subjective interpretation: Two people could have different probabilities for the same event

Remember: Regardless of interpretation, the mathematics of probability are the same - no controversy there.

In this course we focus on the mathematics