

MATH-336

**Randomization and causation**

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Cursus	Sem.	Type
Mathematics	BA6	Opt.
Statistics	MA2	Obl.

Contact language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Lecture	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

This course covers formal frameworks for causal inference. We focus on experimental designs, definitions of causal models, interpretation of causal parameters and estimation of causal effects.

**Content**

- Experimental design
  - Randomisation
  - Matched pairs, block designs, (fractional) factorial designs and latin squares
- Defining a causal model
  - Causal axioms
  - Falsifiability
  - Structural equations
  - Causal directed acyclic graphs
  - Single world intervention graphs
- Interpretation of causal parameters
  - Individual and average level effects
  - Mediation and path specific effects
  - Instrumental variables
  - Statistical inference: Estimands, estimators and estimates
    - Relation to classical statistical models
    - Doubly and multiply robust estimators

**Keywords**

Causality; Causal inference; Randomisation; Experimental design; Structural equation models; Causal Graphs; Estimands.

**Learning Prerequisites****Required courses**

The students are expected to know the basics of statistical theory and probability theory. The courses “probability” (Math-230), “statistics” (Math-240) and “linear models” (Math-341).

### Recommended courses

Courses in regression models and statistical inference.

### Important concepts to start the course

Likelihood theory and principles of statistical testing. Experience with R is an advantage, but is not required.

### Learning Outcomes

By the end of the course, the student must be able to:

- Design experiments that can answer causal questions
- Describe the fundamental theory of causal models
- Critique assess causal assumptions and axioms.
- Distinguish between interpretation, identification and estimation
- Describe when and how causal effects can be identified and estimated from non-experimental data.
- Estimate causal parameters from observational data.

### Transversal skills

- Demonstrate the capacity for critical thinking
- Communicate effectively, being understood, including across different languages and cultures.

### Teaching methods

Classroom lectures, where I will use Beamer slides and the blackboard.

### Assessment methods

Final written exam and continuous assessment.

Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

### Resources

#### Bibliography

#### Teaching resources

- Hernan, M.A. and Robins, J.M., 2020. Causal inference: What if?
- Pearl, J., 2009. Causality. Cambridge university press.

#### Ressources en bibliothèque

- [Causal Inference / Hernan & Robins](#)
- [Causality / Pearl](#)

#### Moodle Link

- <https://go.epfl.ch/MATH-336>