Market Design
ECON 40041 (Fall 2022)
Department of Economics • University of Notre Dame

Instructor: Maciej H. Kotowski ⟨mkotowsk@nd.edu⟩
Office Hours: Wednesday 16:30–18:00 [JNH 3016 or Zoom; scheduled online.]
Class Meetings: Monday & Wednesday 09:30–10:45 [JNH B044]
Course Website: ⟨https://canvas.nd.edu⟩

---

1. Overview

This course studies the theory and practice of market design, with particular focus on auctions, matching mechanisms, and platforms. Using the tools of microeconomics, game theory, and mechanism design, the course examines the operation of markets and the design of effective market rules. Key topics include spectrum and internet auctions, entry-level labor markets, school choice programs, and financial markets, among others.

1.1. Audience

This course is suitable for undergraduate students majoring in economics. Upper-year students in other quantitively-oriented disciplines, such as computer science or mathematics, or students from the business school may also find the course interesting. While the course emphasizes economic content rather than minute technical details, mathematical arguments are employed often. Students with little or no mathematical training will likely be better served by delaying the course until they develop the proper skills.

1.2. Prerequisites

The most important prerequisites for the course are a willingness for critical and creative thinking, imagination, and some grit.

Economics: The formal prerequisite for the course is successfully completing a course in intermediate microeconomics. Some prior familiarity with game theory is helpful but is not required. Students who do not satisfy the formal prerequisite but who otherwise have a strong quantitive background may enroll in the course with the instructor's permission.

Mathematics: Basic algebra and high-school level calculus appear in the course. Otherwise, the course is mathematically self-contained. Skills in logical thinking and a willingness to follow mathematical proofs are essential.

2. Requirements and Grading

The course requirements include the completion of several problem sets, a midterm exam, and a research paper. Your grades on these tasks will be weighted as follows:

Problem Sets	15 %		
Midterm Exam	35 %		
Research Paper	50 %	Proposal	5 %
		Draft	10 %
		Final Paper	35 %
Total	100 %		

Letter grades will be assigned based on your final weighted score.

2.1. Problem Sets

Problem sets are graded primarily for completion and only a "✓± / no credit" will be offered for feedback. You are responsible for consulting the suggested solutions on your own to verify your mastery of the material. Earning a "✓−" or better gives you full credit for the problem set. Sloppy, half-hearted, late, or incomplete work is unlikely to receive credit. Your lowest problem set grade will be dropped when calculating your course grade.

Unless noted otherwise, you may work in small groups (two or three students) on the problem sets. However, you must hand in independently written-up solutions. If you collaborate, identify other group members on your write-up. There is no need to type up your solutions, but sloppy work will not receive credit. Problem set due dates are the following:

Problem Set	Due Date	Problem Set	Due Date
1	September 7	4	October 12
2	September 14	5	October 26
3	September 28	6	November 21

2.2. Midterm Exam

There will be an in-class, closed-book midterm exam on November 2, 2022.

If you miss the midterm exam and your absence is excusable per university policy (e.g., a documented illness), a rescheduled exam will be arranged on a case-by-case basis. Unexcused absences will receive a grade of zero for this part of the course.

2.3. Research Paper

You must write a research paper on a topic related to the course. The approximate length is 4,000–5,000 words. See the course handout "[1] Research Paper Instructions" for details.

- A paper proposal is due at 18:00 on September 23, 2022.
- A preliminary draft of at least 1,000 words is due at 18:00 on November 14, 2022.
- The final paper is due at 09:30 on December 7, 2022.

3. Readings

All required readings are accessible online through the University library.

There is no official or required textbook for the course. The textbook

- [Haeringer] *Market Design: Auctions and Matching* by Guillaume Haeringer (MIT Press, 2018)

covers many of the topics on the syllabus. Among all books for the course, this one checks the most boxes. Sometimes, this book is less advanced than the class material.

For many lectures, there are supplemental readings from other books. Sometimes, these books are more advanced than the class material.

- [Bichler] *Market Design: A Linear Programming Approach to Auctions and Matching* by Martin Bichler (Cambridge University Press, 2017).
- [Klemperer] *Auctions: Theory and Practice* by Paul Klemperer (Princeton University Press, 2004).
- [Krishna] *Auction Theory* by Vijay Krishna (Academic Press, 2002/2009).
- [Milgrom] *Putting Auction Theory to Work* by Paul Milgrom (Cambridge University Press, 2004).
- [Roth and Sotomayor] *Two-Sided Matching: A Study of Game-Theoretic Modeling and Analysis* by Alvin E. Roth and Marilda A. Oliveira Sotomayor (Cambridge University Press, 1990).

Among the above titles, Krishna (2009) is the most useful book for the auction theory portion of the course. Roth and Sotomayor (1990) is the most useful book for the matching theory portion of the course. Bichler (2017) covers auction and matching theory. Bichler (2017) and Klemperer (2004) can be freely accessed online via the Notre Dame library.

There are several popular books that qualify as course-related leisure reading. The following books are informative, readable, and less technical than the course material.

- [Roth] *Who Gets What—And Why: The New Economics of Matchmaking and Market Design* by Alvin E. Roth (Houghton Mifflin Harcourt, 2015).
- [Fisman and Sullivan] *The Inner Lives of Markets: How People Shape Them-And They Shape Us* by Ray Fisman and Tim Sullivan (PublicAffairs, 2016).
- [Evans and Schmalensee] *Matchmakers: The New Economics of Multisided Platforms* by David Evans and Richard Schmalensee (HBR Press, 2016).
- [Hubbard and Paarsch] *Auctions* by Timothy P. Hubbard and Harry J. Paarsch (MIT Press Essential Knowledge Series, 2016).

4. Audio/Video Recordings

I kindly ask you to not make personal audio or video recordings of the lectures.

5. COVID-19 Response and Resilience

The ongoing public health situation is a challenge for university operation. *I am nevertheless committed to delivering the best possible learning experience.* Please help me in this endeavor and together we can have a rewarding class. Points to keep in mind this term:

- Please follow the University's health and safety guidance when on campus.
- There is a risk that in-person instruction may be disrupted during the term. Please be prepared to switch to dual-mode or remote instruction if mandated by the University.
- Except for the in-class midterm exam, all class work will be submitted online. This ensures you can submit assignments as scheduled even if the class is disrupted. Submitting work online will require you to upload a `*.pdf` file with your answers. Please ensure you are familiar how to do this.
- In exceptional cases of a prolonged health-related absence or an unexpected disruption to in-person instruction, a take-home exam may be offered at instructor's discretion instead of the planned in-class midterm exam.

6. Advice

1. Understand and follow the University's Academic Honor Code.
2. Exam questions will resemble problem set questions. Seek out further practice problems—look beyond the assigned class material.
3. Read the assigned readings twice—before *and* after lecture.
4. If pressed for time, practice solving problems in lieu of memorizing a text's details.
5. Please inform the instructor of typos and suspected mistakes in course materials.
6. Please ask questions in class. Illuminating digressions are exciting.
7. Please make use of office hours. Even if you have no specific questions about the course material, please feel welcome to visit, chat, ask questions, or simply say hello.

7. Credits and Acknowledgements

In preparing this course I have drawn on the course materials, lectures, research papers, and presentations of many scholars and colleagues. I have also benefited from informal discussions with many of them. In addition to sources on the reading list, the following influenced this course's curriculum, content, and exposition.

- Course syllabi and/or online course materials from similar courses at other institutions, including those by Peter Cramton, Ettore Damiano, Guillaume Haeringer, Fuhito Kojima, Scott Kominers, Paul Milgrom, Daniel Quint, Al Roth, and others.
- My personal and class notes from the course "Auction Theory" taught by Takashi Kunimoto (McGill University, 2006) and from game theory and information economics courses taught by Ben Hermalin, Shachar Kariv, Botond Kőszegi, and Matthew Rabin (University of California, Berkeley, 2006–9).
- Presentation slides from the AEA Continuing Education Program on "Matching Market Design" (Abdulkadiroğlu, Agarwal, and Pathak, January 7–9, 2018).
- Feedback and comments from students in prior iterations of this course.

I have also benefited from many conversations with Chris Avery, Ivan Balbuzanov, Sangram Kadam, Alex Teytelboym, and Richard Zeckhauser relating to this course's topics and subject matter.

8. Course Calendar and Reading List

You are expected to read essential and required readings. Lectures may reference classic and supplemental readings, but they are optional.

Key

- •• *essential reading* — something you must read, period.
- • *required reading* — the lecture presumes you have read this.
- ○○ *classic reading* — an important classic paper; read if you have time.
- ○ *supplemental reading* — consult for more information.

[1] August 24 / Introduction.

- •• Gale, David, and Lloyd S. Shapley. 1962. College Admissions and the Stability of Marriage. *American Mathematical Monthly* 69(1):9–15.
- ○ Bichler, Chapter 1.
- ○ Eisenmann, Thomas R., and Scott Duke Kominers. 2018. Making Markets. Harvard Business School Technical Note 818-096.
- ○ Haeringer, Chapter 1.
- ○ Roth, Alvin E. 2018. Marketplaces, Markets, and Market Design. *American Economic Review* 108(7):1609–1658.

[2] August 29 / Technical Essentials 1: Games with Perfect Information.

- • Handout [3] Essential Game Theory, Sections 1–4, Appendix A.
- ○ Bichler, Chapter 2.
- ○ Haeringer, Appendices A.1–A.3.
- ○ Krishna, Appendix F.

[3] August 31 / Auctions 1: Introduction to Auctions.

[4] **September 5** / Technical Essentials 2: Probability Theory.

- Handout [4] Essential Probability Theory.
- Haeringer, Appendices C.1–C.4.
- Krishna, Appendices A–C.

[5] **September 7** / Technical Essentials 3: Games with Incomplete Information.

- Handout [3] Essential Game Theory, Sections 5–6.
- Bichler, Chapter 2.
- Haeringer, Appendix A.4.
- Krishna, Appendix F.

[6] **September 12** / Auctions 2: The Independent Private Values (IPV) Model.

- Handout [5] Essential Order Statistics
- Vickrey, William. 1961. Counterspeculation, Auctions, and Competitive Sealed Tenders. *Journal of Finance* 16(1):8–37.
- Bichler, Chapter 4.1–4.3.
- Haeringer, Chapter 2.
- Klemperer, Chapter 1.
- Krishna, Chapter 2.
- Matthews, Steven A. 1995. A Technical Primer on Auction Theory I: Independent Private Values. Northwestern University Discussion Paper No. 1096. ⟨https://www.sas.upenn.edu/~stevenma/Papers/aucprim.pdf⟩

[7] **September 14** / Auctions 3: The IPV Model and Auction Revenue.

- Bichler, Chapter 4.4.
- Haeringer, Chapter 2.
- Krishna, Chapter 3.
- Klemperer, Chapter 1 (Appendix 1.A).
- Milgrom, Chapter 4.

[8] **September 19** / Auctions 4: Optimal Auctions & Mechanism Design.

- Bulow, Jeremy, and John Roberts. 1989. The Simple Economics of Optimal Auctions. *Journal of Political Economy* 97(5):1060–1090

○○ Myerson, Roger B. 1981. Optimal Auction Design. *Mathematics of Operations Research* 6(1):58–73.

○○ Riley, John G., and William F. Samuelson. 1981. Optimal Auctions. *American Economic Review* 71(3):381–392.

○ Bichler, Chapter 4.7.

○ Klemperer, Chapter 1 (Appendix 1.B); Part C.

○ Kotowski, Maciej H. 2018. On Asymmetric Reserve Prices. *Theoretical Economics* 13(1):205–238.

○ Krishna, Chapter 5.

○ Milgrom, Chapter 4.

[9] **September 21** / Auctions 5: Optimal Auctions & Mechanism Design (con't).

[10] **September 26** / Auctions 6: Auctions for Multiple Goods.

○ Bichler, Chapter 5.

○ Krishna, Chapters 12 and 13.

○ Milgrom, Chapter 7.

[11] **September 28** / Auctions 7: The Vickrey–Clarke–Groves (VCG) Mechanism.

○ Ausubel, Lawrence M., and Paul Milgrom. 2005. The Lovely but Lonely Vickrey Auction. In *Combinatorial Auctions*. Edited by Peter Cramton, Yoav Shoham, and Richard Steinberg. Cambridge, MA: MIT Press.

○ Haeringer, Chapter 4.

○ Krishna, Chapter 16.

○ Lucking-Reiley, David. 2000. Vickrey Auctions in Practice: From Nineteenth-Century Philately to Twenty-First-Century E-Commerce. *Journal of Economic Perspectives* 14(3):183–192.

○ Milgrom, Chapters 2 and 8.

[**12**] **October 3** / Auctions 8: Position Auctions and Internet Advertisements.

- Varian, Hal R. 2009. Online Ad Auctions. *American Economic Review: Papers & Proceedings* 99(2):430–434.

- Cowen, Tyler. "Hal Varian on Taking the Academic Approach to Business." *Conversations with Tyler*. Audio File [56:32]. June 19, 2019. ⟨https://bit.ly/3gH9ITU⟩

- Edelman, Benjamin, Michael Ostrovsky, and Michael Schwarz. 2007. Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords. *American Economic Review* 97(1):242–259.

- Varian, Hal R. 2007. Position Auctions. *International Journal of Industrial Organization* 25(6):1163–1178.

- Haeringer, Chapter 5.

- Krishna, Chapter 17.

[**13**] **October 5** / Matching Markets 1: The "Marriage Market" Model.

- Gale, David, and Lloyd S. Shapley. 1962. College Admissions and the Stability of Marriage. *American Mathematical Monthly* 69(1):9–15.

- Roth and Sotomayor, Chapters 2 and 3.

- Bichler, Chapter 11.2.

- Haeringer, Chapter 5.

[**14**] **October 10** / Matching Markets 2: The "Marriage Market" Model (con't).

[**15**] **October 12** / Matching Markets 3: The "Marriage Market" Model (con't).

[**16**] **October 24** / Matching Markets 4: The "College Admissions" Model.

- Roth and Sotomayor, Chapter 5.

- Roth, Alvin E. 1985. The College Admissions Problem is Not Equivalent to the Marriage Problem. *Journal of Economic Theory* 36(2):277–288.

[**17**] **October 26** / Matching Markets 5: The "College Admissions" Model (con't).

[18] October 31 / Application: The National Resident Matching Program.

- National Resident Matching Program. "How the NRMP Matching Algorithm Works." *YouTube.* Video File [4:51]. October 17, 2017. ⟨https://youtu.be/kvgfgGmemdA⟩
- Roth, Alvin E., and Elliott Peranson. 1999. The Redesign of the Matching Market for American Physicians: Some Engineering Aspects of Economic Design. *American Economic Review* 89(4):748–780.
- ○ Haeringer, Chapter 10.
- ○ Roth, Alvin E. 1984. The Evolution of the Labor Market for Medical Interns and Residents: A Case Study in Game Theory. *Journal of Political Economy* 92(6):991–1016.
- ○ Roth, Alvin E. 1986. On the Allocation of Residents to Rural Hospitals: A General Property of Two-Sided Matching Markets. *Econometrica* 54(2):425–427.
- ○ Roth, Alvin E. 2003. The Origins, History, and Design of the Resident Match. *JAMA* 289(7):909–912.

[19] November 2 / Midterm Exam.

The exam is closed-book. Non-graphing/non-programmable calculators are permitted.

[20] November 7 / Exchange Mechanisms 1: Trading Cycles.

- ○○ Shapley, Lloyd S., and Herbert Scarf. 1974. On Cores and Indivisibility. *Journal of Mathematical Economics* 1(1):23–37.
- ○ Abdulkadiroğlu, Atila, and Tayfun Sönmez. 1999. House Allocation with Existing Tenants. *Journal of Economic Theory* 88(2):233–260.
- ○ Balbuzanov, Ivan, and Maciej H. Kotowski. 2019. Endowments, Exclusion, and Exchange. *Econometrica* 87(5):1663–1692.
- ○ Balbuzanov, Ivan, and Maciej H. Kotowski. 2021. Economies with Complex Property Rights: The Role of Exclusion. *ACM SIGecom Exchanges* 19(1):30–44.
- ○ Haeringer, Chapter 11.

[21] November 9 / Exchange Mechanisms 2: Trading Cycles (con't).

[22] **November 14** / Application: Transplant Organs.

- National Academy of Science. "The Matchmaker: An Economist Tackles Kidney Exchange." *YouTube.* Video File [5:51]. November 30, 2016. ⟨https://youtu.be/TJio37FoOBQ⟩
- Roth, Alvin E., Tayfun Sönmez, and M. Utku Ünver. 2004. Kidney Exchange. *Quarterly Journal of Economics* 119(2):457–488.
- ◦ Haeringer, Chapters 16.

[23] **November 16** / Application: School Assignment Mechanisms.

- Abdulkadiroğlu, Atila, and Tayfun Sönmez. 2003. School Choice: A Mechanism Design Approach. *American Economic Review* 93(3):729–747.
- ◦ Haeringer, Chapters 13 and 14.

[24] **November 21** / Application: Auctions of Radio Spectrum.

- McMillan, John. 1994. Selling Spectrum Rights. *Journal of Economic Perspectives* 8(3):145–162.
- Leyton-Brown, Kevin, Paul Milgrom and Ilya Segal. 2017. Economics and computer science of a radio spectrum reallocation. *Proceedings of the National Academy of Sciences* 114(28):7202–7209.
- ◦◦ Coase, R. H. 1959. The Federal Communications Commission. *Journal of Law and Economics* 2:1–40.
- ◦ Haeringer, Chapter 6.
- ◦ Klemperer, Part D.
- ◦ Milgrom, Paul, and Ilya Segal. 2020. Clock Auctions and Radio Spectrum Reallocation." *Journal of Political Economy* 128(1):1–31.
- ◦ Milgrom, Paul. 2017. *Discovering Prices: Auction Design in Markets with Complex Constraints.* New York: Columbia University Press.

[25] **November 28** / Application: Electricity Markets.

- Cramton, Peter. 2017. Electricity Market Design. *Oxford Review of Economic Policy* 33(4):589–612.
- ◦ Wilson, Robert. 2002. Architecture of Power Markets. *Econometrica* 70(4):1299–1340.

[26] November 30 / Application: Feeding America.

- Prendergast, Canice. 2017. How Food Banks Use Markets to Feed the Poor. *Journal of Economic Perspectives* 31(4):145–162.

○○ Hylland, Aanund, and Richard Zeckhauser. 1979. The Efficient Allocation of Individuals to Positions. *Journal of Political Economy* 87(2):293–314.

○ Prendergast, Canice. 2022. The Allocation of Food to Food Banks. *Journal of Political Economy* 130(8):1993–2017.

○ Haeringer, Chapter 1.

[27] December 5 / Application: Bitcoin, Blockchain, and Cryptocurrencies.

- 3Blue1Brown. "But how does bitcoin actually work?" *YouTube.* Video File [26:20]. July 7, 2017. ⟨https://youtu.be/bBC-nXj3Ng4⟩

○ Budish, Eric. 2022. The Economic Limits of Bitcoin and Anonymous, Decentralized Trust on the Blockchain. Becker Friedman Institute Working Paper No. 2022-83.

○ Halaburda, Hanna, Guillaume Haeringer, Joshua Gans, and Neil Gandal. 2022. The Microeconomics of Cryptocurrencies. Mimeo.
⟨http://dx.doi.org/10.2139/ssrn.3274331⟩

[28] December 7 / Two-Sided Markets and Reputation Systems / Course Wrap-Up.

- Resnick, Paul, Richard Zeckhauser, Eric Friedman, and Ko Kuwabara. 2000. Reputation systems. *Communications of the ACM* 43(12):45–48.

- Tadelis, Steven. 2016. Reputation and Feedback Systems in Online Platform Markets. *Annual Review of Economics* 8:321–40.

○ Einav, Liran, Chiara Farronato, and Jonathan Levin. 2016. Peer-to-Peer Markets. *Annual Review of Economics* 8:615–35.