

Economic Theory of Networks Syllabus

Department of Economics, Temple University

Econ 3522 Section 001 CRN 20391

Spring 2015

Instructor: Dr. Dimitrios Diamantaras, Associate Professor of Economics

Class meets Tuesdays and Thursdays 11:00 pm to 12:20 pm in Anderson 5

General

This course presents an overview of networks with emphasis on social networks, online and offline. Students will learn the basic mathematical techniques for representing networks as well as techniques from game theory and economics for the analysis of network structure and evolution.

Office Hours and Contact Information

My office is in Ritter Annex 813. I will hold office hours there every Monday from 1:00 pm to 2:00 pm and every Tuesday and Thursday from 1:00 pm to 2:00 pm, excepting Martin Luther King day and the Monday and Thursday that fall in Spring Break. Office hours may be preempted by meetings; I will announce such events ahead of time on Blackboard and offer alternative times. Students can request to meet with me outside my office hours. Such requests should be submitted via email to dimitrios.diamantaras@temple.edu at least 48 hours in advance of the desired time. My office phone number is 215-204-8169, but you have a far better chance to reach me quickly via email than via phone.

Disability Statement

This course is open to all students who meet the academic requirements for participation. Any student who has a need for accommodation based on the impact of a disability should contact the instructor privately to discuss the specific situation as soon as possible. Contact Disability Resources and Services at [215-204-1280](tel:215-204-1280) in 100 Ritter Annex to coordinate reasonable accommodations for students with documented disabilities.

Statement on Academic Freedom

Freedom to teach and freedom to learn are inseparable facets of academic freedom. The University has adopted a policy on Student and Faculty Academic Rights and Responsibilities (Policy # 03.70.02) which can be accessed at <http://goo.gl/aZBTa>.

Prerequisites

Econ 1102, Principles of Microeconomics, or Econ 1902 (honors version). There is no formal mathematical prerequisite; the necessary mathematical tools will be explained in the course. However, a willingness to think with logical rigor for sustained periods of time will be essential.

Textbook

The textbook for this course is *Networks, Crowds, and Markets*, by David Easley and Jon Kleinberg, Cambridge University Press 2010. The book is available online as chapter-by-chapter PDF files at <http://goo.gl/omWV> and the printed book can be purchased from the Temple bookstore on the Main campus. The course is modeled after a course offered at Cornell University by the authors of the textbook. You can find the latest syllabus for that course at https://courses.cit.cornell.edu/info2040_2014fa/ and the edX on-line version of the course as of Spring 2014 is at <https://courses.edx.org/courses/CornellX/INFO2040x/1T2014/info>. I recommend signing up for the latter (even though it is too late to get credit for it) for different presentations of this material than mine, and for additional practice problems.

Grading

Student progress will be evaluated on the basis of attendance (5%), contributions to a class blog (15%), homework assignments (20%, the two worst assignment grades are dropped from the calculation), two in-class midterm examinations, and an in-class final examination. The weights of the exams are as follows, where E1 stands for the exam where a student earned the highest exam score among the student's three exam scores (as percentages), E2 for the student's second-highest exam score, and E3 for third: 30% for E1, 20% for E2, 10% for E3. A document with detailed instructions on how to register for the class blog will be available on Blackboard at the start of the semester.

There will be 7 homework sets, each consisting of problems designed to help the student practice network analysis along the lines of the material covered in the most recent class meetings. Each assignment will be due by Monday of the week after the class meetings which covered the material included in the assignment.

The class blog will be open to every student, who will be expected to *make at minimum one blog post every two weeks, and one comment to another student's post every two weeks*. Each post should discuss how a news item is relevant to the material covered in the course or some new development in the theory of networks that the student making the post has discovered. In order to consider your blog posts and comments for grading I **must** receive an email with the link to each one of them.

Blog posts and comments will be graded on relevance to the course material, coherence, clarity, and incisiveness. Homework assignments and exams will be graded for correctness and clarity. Letter grades will be given according to the following scale: A: 93-100; A-: 90-92; B+: 87-89; B: 83-86; B-: 80-82; C+: 77-79; C: 73-76; C-: 70-72; D+: 67-69; D: 63-66; D-: 60-62; F: 0-59.

The midterm exams and the final will be held as shown in the course outline below. The final exam will be held as scheduled by the University during exam week; please do not ask me to change its date. All exams are closed-book. There is no opportunity for extra credit.

Course Policies

Class *attendance* is required. Students who know they will miss class, come late, or leave early, are requested to let me know in advance. I will not count up to two absences against your attendance grade.

Missing an exam is not acceptable except if (1) you have a very serious reason (such as being treated in a hospital at the time of the exam) **and** (2) you notify as early as possible and at the latest before the start time of the exam. If, and only if, both conditions (1) and (2) are met, I will offer you a make-up exam, upon seeing credible proof of the condition that necessitated missing the exam.

Academic dishonesty is reprehensible and I will punish it severely by referring the student for University disciplinary action **and** giving a zero grade for the exam or assignment involved. Please refer to the *Student Code of Conduct*, which can be found at <http://goo.gl/BbtriN>, and to the Student Responsibilities document for details about academic dishonesty, which can be found at <http://goo.gl/gjKwP>.

Course Outline

Week 1, 1/13, 1/15. Chapters 1, 2.

Chapter 1

Brief overview of networks and the theories that have been developed by mathematicians, game theorists, and economists to analyze networks. Introduction of the main topics of the course: markets and games on networks, information networks, and network dynamics.

Chapter 2

Basics of graph theory as needed for the analysis of networks: edges and nodes on graphs; paths; connectivity; graph components; network distance; the small worlds phenomenon; six degrees of Kevin Bacon and Erdős numbers; network data set sources.

Week 2, 1/20, 1/22. Chapters 3, 5.

Chapter 3

Strong and weak ties; the strength of weak ties; strength and network structure in large data sets; strength, social media, and passive engagement; closure, structural holes, and social capital.

Chapter 5

Structural balance; structure of balanced networks; applications of structural balance to international relations, trust and online ratings; weak form of structural balance.

Homework assignment 1 due on 1/27

Week 3, 1/27, 1/29. Chapter 6.

Chapter 6

Introduction to games; how to reason about behavior in a game; best responses and dominant strategies; Nash equilibrium; multiple equilibria and coordination games; multiple equilibria and the hawk-dove game; mixed strategies; Pareto optimality and social optimality.

Week 4, 2/3, 2/5. Chapters 7, 8.

Chapter 7

Evolutionary game theory: fitness as a result of interaction, evolutionarily stable strategies; relationship of Evolutionary and Nash equilibria; evolutionarily stable mixed strategies.

Chapter 8

Modeling network traffic with game theory: traffic at equilibrium; Braess's paradox (adding more roads may increase congestion); social cost of traffic at equilibrium.

Homework assignment 2 due 2/10

Week 5, 2/10, 2/12. Chapter 9.

Chapter 9

Auctions: types of auctions; relationships between auction formats; second-price auctions and truthful bidding; first-price auctions and other auction formats; common values and the winner's curse.

Week 6, 2/17, 2/19. Midterm 1 (2/17; covers chapters 1, 2, 3, 5, 6, 7, 8) and Chapter 10.

Chapter 10

Matching markets: bipartite graphs and perfect matchings; valuations and optimal assignments; prices and market clearing; constructing a set of market-clearing prices; relation to single-item auctions.

Week 7, 2/24, 2/26. Chapter 11.

Chapter 11

Network models of markets with intermediaries: price setting in markets; modeling trade on networks; equilibria in trading networks; auctions and ripple effects; trader profits.

Homework assignment 3 due 3/10

Spring Break

Week 8, 3/10, 3/13. Chapters 12, 13.

Chapter 12

Bargaining and power in networks: power in social networks; experiments on power and exchange; connection to buyer-seller networks; Nash bargaining solution; ultimatum game; stable outcomes; balanced outcomes.

Chapter 13

The structure of the Web: World Wide Web; information networks, hypertext, associative memory; the Web as a directed graph; the bow-tie structure of the Web; Web 2.0 emerging.

Week 9, 3/17, 3/20. Chapters 14, 15.

Chapter 14

Link analysis and Web search: the problem of ranking; hubs and authorities; PageRank; applying link analysis in modern Web search; applications beyond the Web (scientific citation analysis, U.S. Supreme Court Citation analysis).

Chapter 15

Sponsored search markets: advertising based on search behavior; advertising as a matching market; encouraging truthful bidding in matching markets with the Vickrey-Clarke-Groves principle; truth-telling as a dominant strategy in the VCG mechanism; the generalized second-price auction and its equilibria; ad quality; complex queries and interactions among keywords.

Homework assignment 4 due 3/24

Week 10, 3/24, 3/26. Chapter 16.

Chapter 16

Information cascades: following the crowd; a herding experiment; Bayes's rule; Bayes's rule in the herding experiment; a simple, general cascade model; sequential decision making and cascades; lessons from cascades.

Week 11, 3/31, 4/2. Midterm 2 (3/31; covers chapters 9, 10, 11, 12, 13, 14, 15) and Chapter 17.

Chapter 17

Network effects: network effects as externalities; the economy without network effects; the economy with network effects; stability, instability, and tipping points, dynamic view of the market; industries with network goods; mixing individual effects with population-level effects.

Homework assignment 5 due 4/7

Week 12, 4/7, 4/9. Chapters 18, 19.

Chapter 18

Power laws and rich-getting-richer: popularity as a network phenomenon; power laws; rich-get-richer models; the unpredictability of rich-get-richer effects; the long tail; the effect of search tools and recommendation systems.

Chapter 19

Cascading behavior in networks: diffusion in networks; modeling diffusion through a network; cascades and clusters; diffusion, thresholds, and weak ties; extensions of the basic cascade model; knowledge, thresholds, and collective action.

Homework assignment 6 due 4/14

Week 13, 4/14, 4/16. Chapters 20, 21.

Chapter 20

The small-world phenomenon: six degrees of separation; structure and randomness; decentralized search; modeling the process of decentralized search; empirical analysis and generalizations; core-periphery structures and difficulties in decentralized search.

Chapter 21

Epidemics: diseases and their transmission networks; branching processes; the SIR epidemic model; the SIS epidemic model; synchronization; transient contacts and the dangers of concurrency; genealogy, genetic inheritance, and mitochondrial Eve.

Homework assignment 7 due 4/21

Week 14, 4/21, 4/23. Review and synthesis.

**Week 15. FINAL EXAM on Tuesday, May 5, 2015, 10:30 am to 12:30 pm.
Covers chapters 16, 17, 18, 19, 20, 21.**