SYLLABUS

MATHEMATICS OF COMPETITIVE BEHAVIOR
CTY Summer Session 2017
Princeton, NJ

INSTRUCTOR: Ben Cohen
TEACHING ASSISTANT: Cara Xiao

Textbook: Straffin, Phillip. *Game Theory and Strategy*. Washington, D.C.: Mathematical Association of America, 1993.

A calculator is necessary for this course. Although a graphing calculator may be helpful for a few activities, a scientific calculator is sufficient.

Mathematics of Competitive Behavior includes some probability and statistics content, but the primary focus is the mathematical theory of games. Formally, game theory is the study of rational behavior in social decision-making. While it includes traditional games such as tic-tac-toe and matching pennies, the real value of game theory is in its real-world applications. Students will play games, analyze their play, and develop successful strategies. They will frequently present their findings to other class members, and will explore applications to social interaction, politics and voting, business strategies, biology, and anthropology.

COURSE SCHEDULE

WEEK ONE

DAY	TOPICS AND ACTIVITIES
1	*Morning:* • Introductions • Pretest • Course and topic overview • Historical introduction to probability (The Unfinished Game) *Afternoon:* • Introduction to probability: dependent and mutually exclusive events; expected value; class lottery • Probability with permutations and combinations • "The Birthday Problem" *Evening:* • Practice with probability and expected value
2	*Morning:* • Expected value • "A Fascinating Game" • Introduction to games and payoff matrices • Two-person *N*-strategy zero-sum games; saddle points • Dominance and IESDS *Afternoon:* • "Matching Pennies"

	• Oddments and mixed strategies; importance of unpredictability *Evening:* • "Solving 2x2 Zero-Sum Games" handout • Read Straffin ch. 2, exercises #2-5
3	*Morning:* • Graphical solution to M x 2 or 2 x N games • Jamaican fisherman problem • Two Envelopes Problem: "The Other Person's Envelope Is Always Greener" • Algebraic solution to 3 x 3 games *Afternoon:* • The Umbrella Problem • Games against nature • Bayes' theorem • Newcomb's Problem *Evening:* • Bayes' theorem worksheet • Read Straffin ch. 3, exercises #3-6, 8
4	*Morning:* • Quiz #1 • Utility theory *Afternoon:* • 2-person non-zero-sum games • Pure strategy Nash equilibrium • Pareto optimality • Payoff polygons • Battle of the Sexes *Evening:* • Solving Non-Zero-Sum Games worksheet • Read Straffin ch. 4, exercises #1, 2; read ch. 6, exercise #2a
5	*Morning:* • Group project research (computer lab) • Mixed strategy Nash equilibrium • SSS games *Afternoon:* • Rock-paper-scissors tournament and importance of unpredictability • Unexpected Hanging Paradox *Evening (Sunday):* • Read Straffin ch. 11, exercises #1, 2a-c, 3, 4a; read ch. 9-10; "Card Bingo"

WEEK TWO

DAY	TOPICS
6	*Morning:* • Monty Hall Problem • Prisoner's Dilemma interrogation and discussion • Extensive form of a game • Backward induction *Afternoon:* • Group project research (computer lab) *Evening:* • Read Straffin ch. 7, exercises #2, 5, 6a-c
7	*Morning:* • Group project presentations • Mutually assured destruction *Afternoon:* • Evolutionarily stable strategies (ESS) • Probability challenge problems *Evening:* • Midterm exam
8	*Morning:* • Chicken and stag hunt • Strategic moves • Introduction to fair division: "Divide the Chip" and Pirate Game *Afternoon:* • Introduction to differential calculus: slope as a rate of change • Application: Monopoly • Application: Cournot and Stackelberg duopolies *Evening:* • Read Straffin ch. 15, exercises #4, 6; read ch. 12, exercise #2; read ch. 13
9	*Morning:* • Individual project preparation (computer lab) • Trust, suspicion, and the F-scale: "split or steal?" *Afternoon:* • Trust Game • Centipede Game *Evening:* • Read and respond to NY Times article on North Korea strategies • Read Straffin ch. 14, exercises #1, 3a-e; read ch. 8, exercises #1, 2
10	*Morning:* • Application: Bertrand duopoly • "Noblesse Oblige"

	• Individual project preparation (computer lab)
	Afternoon: • *n*-person games
	Evening: • Read Straffin ch. 18; read ch. 19, exercises #1-3 • Final Jeopardy! strategies worksheet

WEEK THREE

DAY	TOPICS
11	*Morning:* • Individual project presentations • "Pimsler's Dementia" • Tragedy of the Commons *Afternoon:* • Voting games and methods: majority, plurality, runoff, sequential runoff, Borda count, pairwise comparisons • Arrow's Impossibility Theorem *Evening:* • Voting exercises handout • Read and respond to Tragedy of the Commons article
12	*Morning:* • eBay auction strategies • Voting power and the Banzhaf index • Case study: Supreme Court nominations • Case study: Nassau County Board of Supervisors • Apportionment and the Alabama Paradox • Video: "Nice Guys Finish First" *Afternoon:* • Estate division by sealed bids • Continuous fair division: divider-chooser, last diminisher • Case study: NFL Draft *Evening:* • Fair division activity • Read Straffin ch. 20, exercises #1-3; read ch. 21, exercises #1, 3a-b
13	*Morning:* • Case study: Bankruptcy law • Auctions: Vickrey auction, English auction, Dutch auction • Proof that sincere bidding is best in a Vickrey auction • Dollar auction • John Nash's "hex" game *Afternoon:*

	• Video: "A Brilliant Madness," discussion • Review for final exam *Evening:* • Final exam
14	*Morning:* • Case study: Tacit collusion and OPEC • Coalitions game, round 1 • Proof by mathematical induction *Afternoon:* • Course evaluations • Class auction • Three-way duel • Video: "Dr. Strangelove," discussion
15	*Morning:* • Coalitions game, round 2 • Course wrap-up • Game theory: What is it good for?

PRESENTATIONS:

There will be two presentations in the class. For the first, students will work in groups of three and select a topic from a list provided by the instructor. The students will then conduct research using the Internet and print materials and make a 15-minute presentation to the class describing their findings. For the second, students will work individually and make a five-minute presentation to the class describing their findings. Four hours of research time will be provided for each.

EVALUATION:

There will be two tests during the course: a midterm and a comprehensive final exam. Evaluation of student performance and achievement will be based on completion and accuracy of written assignments and tests, active participation in class discussions, and presentations of projects.