Math 486 Syllabus

Mathematical Theory of Games Summer 2022

Welcome to Math 486: Game Theory! This summer session of Math 486 is an **asynchronous online course**. My hope as the instructor is that you will find this to be an engaging online course and a supportive learning environment. My priorities are to provide the resources, the learning opportunities, and the support you need to get as much from this course as you desire.

Instructor: Dr. Russ deForest (he/him/his)

I am an assistant teaching professor in Penn State's Math Department. My research interests are in population dynamics, evolutionary game theory, partial differential equations, and the scholarship of teaching and learning mathematics. I spend a lot of time outdoors with my family hiking and mountain biking on the wonderful trails in Central Pennsylvania.

How to Contact Me: Ongoing communication in an online asynchronous course is essential. I welcome your questions and it is important to me that you feel comfortable reaching out with any concerns. You can contact me through email and through our Piazza course page.

- Piazza course page: Rapid response, best for general questions that benefit all students in the course.
- **Course email address:** deforest.math486@gmail.com Preferred email address during the semester. Response within 48 hours (usually within 24 hours).
- **Permanent email address:** rfd131@psu.edu Best email address for ongoing or follow-up communication after the course has concluded.

Most of your questions should be posted to our Piazza course page. Using Piazza allows us to respond to common questions quickly and efficiently. Piazza is frequently monitored by the instructional team and using Piazza ensures a timely response. Questions can be answered by the instructional team or other students in the course. You can post questions anonymously to the class if you wish. Please keep in mind that your posts are not anonymous to the instructional team. You can also use Piazza to make private posts to the instructional team.

While this class is running please use the following **course email address:** deforest.math486@gmail.com. This is the best way to reach me about any personal concerns related to Math 486 during the semester. You will typically receive a response within 24 hours (except on weekends) and should always expect a response within 48 hours. I will send out a general announcement if there is a reason to expect a delayed response. If you do not receive a response via email within 48 hours, please kindly send a follow-up reminder. Rest assured that I want to hear from you and help make your time in the course a rewarding and enjoyable learning experience.

Although I continue monitoring the course email address, once the semester has concluded it is best to email me at rfd131@psu.edu. I will send a reminder of this at the end of the term.

Course Overview and Description

Game Theory is a wide ranging subject. We will focus on two main areas: non-cooperative game theory and evolutionary game theory. In our study of non-cooperative game theory we will motivate concepts and ideas with basic applications, develop the abstract mathematical theory from these motivating examples, and then apply and extend the theory to additional examples. As we examine real applications we will remain mindful of the limitations of the theory.

In our coverage of evolutionary game theory we will be interested in applications to biology. This topic will require some use of modeling with differential equations. While some background in differential equations is helpful, it is not a prerequisite for the course. We will develop the material we need from differential equations as part of the course; the coverage is similar to the material on differential equations covered in Math 141B (second-semester biocalculus).

We will rely on the required text, pre-recorded lectures, some interactive components (including interactive games where extra-credit may be on the line), a discussion forum (Piazza), and supplemental materials. I hope to challenge your intuition and provide an enjoyable experience where you are motivated to learn. Your active participation is what really makes our summer semester a successful and enjoyable experience.

Please note as you review the syllabus that your written homework accounts for**a substantial** part of the overall grade. We offer weekly opportunities for homework revision so that you can revisit misunderstandings. Consistent participation, following up with these homework revision opportunities, and making use of available student hours and homework Q&A sessions are the best ways to ensure you get the most out of this course.

Class Duration: May 16 – Aug 10

Prerequisites:

Math 220 (Matrices) and Math 140 (Calculus I)

An overview of some background skills:

- Throughout the course we will develop carefully reasoned mathematical arguments. If you have taken a "proofs course", this will feel familiar, but experience in mathematical proof is not a course prerequisite. These are skills that we will promote and develop throughout the course.
- We will sometimes need to solve linear (and less frequently nonlinear) systems of equations. There are a variety of approaches to solving such systems and we assume this material is familiar or can be reviewed as needed.
- We will frequently rely on differential calculus to find maxima or minima or to determine when a function is increasing or decreasing with respect to a given variable.
- During our coverage of differential equations late in the course we will review determinants, eigenvalues, and eigenvectors of square matrices.
- You should feel welcome to ask for additional help or supporting resources for any topics that feel unfamiliar.

Instructional Team

Dr. Russ deForest is the course instructor and is an assistant teaching professor.

Sofya Bykova is the course TA and is entering her second year as a PhD student in Mathematics. She is interested in algebraic geometry and dynamics.

Russ deForest

Sofya Bykova

Required Textbook

The following textbook is *required*. You can download an electronic copy of the textbook through the Penn State Library here.

- *Game Theory in Action* by Steve Schecter and Herbert Gintis. 2016. Princeton University Press. ISBN: 978-1400880881

The textbook is also available through the Penn State Bookstore and online sellers.

Optional Textbooks/Additional Resources

Material and examples may also be drawn from other texts, including:

- *Game Theory Evolving: A Problem Centered Introduction to Modeling Strategic Interaction* by Herbert Gintis 2nd ed. 2009. Princeton University Press. ISBN: 978-0691140513
- *Game Theory: A Multi-leveled Approach* by Hans Peters, available for free via Penn State Library here.
- *Twenty Lectures on Algorithmic Game Theory* by Tim Roughgarden, Cambridge University Press. ISBN: 978-1-316-62479-1

Course Format

The course outline will generally follow the required textbook. Each week contains the following elements:

1. **Pre-recorded Lectures:** These are recorded videos of your instructor covering material and solving relevant examples.
2. **Written Homework:** Each lesson includes a written homework. Each homework includes a short set of exercises and problems. Exercises are intended to provide practice working with definitions and concepts. Problem sets will require you to extend and apply the material covered and are usually more involved than the exercises. These assignments are submitted in Gradescope.
3. **Concept Checks (Online Quizzes):** Online quizzes will be posted weekly on Gradescope. Each quiz will be made available from Thursday afternoon until the following Tuesday night at 11:59 pm EDT (i.e. State College time) and will cover material from that Lesson. Each quiz provides problems that can help you think about the relevant material covered.
4. **Online Students Hours and Homework Q & A Sessions** Drop in to student hours via zoom to ask questions about course content or to chat about game theory and topics related to the course. The Homework Q&A sessions will be more specific to homework that is coming due. Times for these sessions will be determined during the first week of the course.
5. **Piazza:** Piazza is an online discussion board where students can ask and answer questions. Posting (and answering) questions about the material will help both you and your peers. You can access Piazza through Canvas or via https://piazza.com.
6. **Interactive Participation:** In addition to live Q&A Sessions, and student hours, the course involves opportunities for interaction with your peers through discussion and through participation in **Interactive Games**.
    - **Question Assignments** are weekly assignments. Formulating questions about the material facilitates your learning. These questions give your instructor the opportunity to provide personalized feedback and helps the instructor prioritize material for review through video responses and Piazza posts.
    - **Interactive games** involve choosing a strategy in some game via an online webform. Some games will involve being randomly paired with another member of the class; other games will involve interacting with the entire class. Part of your class grade will involve participating in these games.

Written Homeworks

- There are 10 written homework assignments at 20 points each, for 200 out of 400 total course points.
- Written Homeworks are due every Tuesday night throughout the semester (except Week 7, when midterms are due instead).
- Homeworks are graded for correctness and for full credit must also follow the Homework submission guidelines posted on Canvas.
- **Late Homeworks** are accepted until 48 hours past the due date (Thursday night each week) for 80% credit.
- **Homework Revisions:** Following the grading of each Written Homework, you will be able to submit a Homework Revision (guidelines are posted on Canvas). A homework revision will allow you to earn back up to 50% of any points lost on the homework assignment. As an example if you score 10 of 20 points on a Written Homework, you can increase that score to 15 of 20 by submitting a homework revision following the guidelines on Canvas. If the original assignment was submitted late, you earn 80% of the revised score.
- Opportunities for revision are available provided you have submitted the original assignment (but see the **exception**).
- **Exception:** Your have **one exception** per semester. Using your exception allows you to submit a written homework assignment as a revision and still earn full credit for that written homework. What does this mean? Suppose you aren't able to complete the Lesson 6 Written Homework on time (you do not need a reason). You can let us know that you wish to use your exception. This allows you to miss the due date, and complete the homework at a later date (after video solutions become available). You will submit the completed homework as a revision for full credit. Note that the exception does not mean you get to skip out on this homework completely.
- **Using your Exception:** To use your exception, you will need to notify us that you intend to use your exception before the due date on that assignment passes. There is a Google Form available in Canvas for this purpose. An unused exception will be converted to 5 points extra credit at the end of the semester.

Exams

We have two "take-home" exams.

- Midterm: Thursday June 30 – Tuesday July 5th
- Final Exam: Thursday Aug 4 – Tuesday Aug 9

Each exam is an unproctored "take-home" exam and will be similar to a longer written homework that reviews material of the course. **Be mindful of the relative importance of Homework assignments in the overall grade**. Focus your efforts on consistent work on homework and participation assignments throughout the course. This is the best way to support your own learning and ensure the outcome you hope for in the course.

Grades

Grades will be calculated from a total of 400 points, distributed as follows:

Weekly Quizzes	50 points
Homeworks	200 points
Midterm	50 points
Final Exam	50 points
Participation	50 points
Extra Credit	Up to 20 points
Total	**400 points**

Final course grades will be assigned as follows:

Grade	Raw Score	Percent Score
A	372–400 points	93% – 100%
A-	360–371 points	90% – 92%
B+	348–359 points	87% – 89%
B	332–347 points	83% – 86%
B-	320–331 points	80% – 82%
C+	308–319 points	77% – 79%
C	280–307 points	70% – 76%
D	240–279 points	60% – 69%
F	0 – 239 points	0% – 59%

Schedule of Topics (tentative)

Lesson	Content
Lesson 1	Introduction and Overview Backward Induction, Extensive and Normal Form Games Textbook Sections 1.1–1.8 and lecture notes.
Lesson 2	Continuous Strategy Games, Stackelberg Duopoly Dominated Strategies, Prisoner's Dilemma Textbook Sections 1.9–1.13 and 2.1–2.4
Lesson 3	Auctions, Iterated Elimination of Dominated Strategies, Textbook Sections 2.5–2.13
Lesson 4	Nash equilibrium, Cournot Duopoly, Applications Textbook Sections 3.1–3.11
Lesson 5	Lotteries, Incomplete Information Mixed Strategies Textbook Sections 4.1–4.6 and 5.1–5.2
Lesson 6	Mixed Strategy Nash Equilibria, Applications Textbook Sections 5.1–5.11
Lesson 7	Subgame Perfect Equilbria, Bargaining, Repeated Games Textbook Sections 6.1–6.11
Lesson 8	Introduction to Evolutionary Games, Evolutionary Stability 8.1, 8.3–8.5
Lesson 9	Differential Equations and Evolutionary Dynamics Textbook Sections: 9.1–9.5
Lesson 10	Evolutionary Dynamics Textbook Sections 10.1–10.11

Academic Integrity

Academic dishonesty is not limited to simply cheating on an exam or assignment. The following is quoted directly from the "PSU Faculty Senate Policies for Students" regarding academic integrity and academic dishonesty:

> "Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students."

All University and Eberly College of Science policies regarding academic integrity/academic dishonesty apply to this course and the students enrolled in this course. Refer to the following URL for further details on the academic integrity policies of the Eberly College of Science: https://science.psu.edu/current-students/integrity/policies.

Statement of student responsibility:

- In submitting any assignment in this course you acknowledge unequivocally that the work is your own and does not violate Penn State's Academic Integrity policies.
- Uploading questions or content from Homeworks, Quizzes, or Exams to online sites including, but not limited to "Chegg" is a direct violation of academic integrity.
- **You are responsible for solutions that are copied from online sites**, regardless of whether you copy directly from an unauthorized online site or receive such solutions through another individual, including other students enrolled in this course.

Nondiscrimination

The University is committed to equal access to programs, facilities, admission and employment for all persons. It is the policy of the University to maintain an environment free of harassment and free of discrimination against any person because of age, race, color, ancestry, national origin, religion, creed, service in the uniformed services (as defined in state and federal law), veteran status, sex, sexual orientation, marital or family status, pregnancy, pregnancy-related conditions, physical or mental disability, gender, perceived gender, gender identity, genetic information or political ideas. Discriminatory conduct and harassment, as well as sexual misconduct and relationship violence, violates the dignity of individuals, impedes the realization of the University's educational mission, and will not be tolerated. Direct all inquiries regarding the nondiscrimination policy to the Affirmative Action Office, The Pennsylvania State University, 328 Boucke Building, University Park, PA 16802-5901, Email: aao@psu.edu, Tel (814) 863-0471.

Disability Accommodation

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus (http://equity.psu.edu/sdr/disability-coordinator).

For further information, please visit Student Disability Resources website (http://equity.psu.edu/sdr/).

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling and Psychological Services

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

- Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
- Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

Educational Equity

Penn State University has adopted a *Protocol for Responding to Bias Motivated Incidents* that is grounded in the policy that the *University is committed to creating an educational environment which is free from intolerance directed toward individuals or groups and strives to create and maintain an environment that fosters respect for others.* That policy is embedded within an institution traditionally committed to academic freedom. Bias motivated incidents include conduct that is defined in University Policy AD 91: Discrimination and Harassment, and Related Inappropriate Conduct. Students, faculty, or staff who experience or witness a possible bias motivated incident are urged to report the incident immediately by doing one of the following:

- Submit a report via the Report Bias webpage (http://equity.psu.edu/reportbias/)
- Contact one of the following offices:
  - University Police Services, University Park: 814-863-1111
  - Multicultural Resource Center, Diversity Advocate for Students: 814-865-1773
  - Office of the Vice Provost for Educational Equity: 814-865-5906
  - Office of the Vice President for Student Affairs: 814-865-0909
  - Affirmative Action Office: 814-863-0471