Games: Theory and Applications – COSC-6590
School of Engineering and Computing Sciences
Fall 2018

A. COURSE INFORMATION

Course number/section: COSC 6590.001
Class meeting time: Tuesdays and Thursdays: 05:30pm – 06:45pm
Class location: Lectures at Engineering Building, Room 108
Course Website: Blackboard

B. INSTRUCTOR INFORMATION

Instructor: Luis Rodolfo GARCIA CARRILLO
Office location: Engineering Building 316M
Office hours: Monday, Tuesday, and Wednesday: 08:00am – 10:00am
Telephone: 361-825-3576
e-mail: luis.garcia@tamucc.edu
Appointments: By Request

C. COURSE DESCRIPTION

Catalog Course Description
The purpose of this course is to teach students to formulate problems as mathematical games and provide the basic tools to solve them. The course covers:

- Static games, starting with two-player zero-sum games and eventually building up to n-player non-zero sum games. Saddle-points and Nash equilibria will be covered.
- Dynamic optimization (dynamic programming) for discrete and continuous time.
- Dynamic games, both open and closed-loop policies.

The intended audience includes (but is not restricted to) students in engineering and computer science. The class is heavily project-oriented and the students are strongly encouraged to choose a project that is relevant to their own area of research.

Extended Course Description
In optimization, one attempts to find values for parameters that minimize a suitably defined criterion (such as monetary cost, energy consumption, heat generated, etc.) However, in most engineering applications there is always some uncertainty as to how the selected parameters will affect the final objective. One can then pose the problem of how to make sure that the selection will lead to acceptable performance, even in the presence of some degree of uncertainty. This question is at the heart of most zero-sum games that appear in engineering applications. In fact, game theory provides the mathematical framework for robust design in engineering.

Modern game theory was born in the 30's, mostly propelled by the work of John von Neumann, further refined by Morgenstern, Kuhn, Nash, Shappley and others. Throughout most of the 40's
and 50's, Economics was its main application, eventually leading to the 1994 Nobel prize in Economic Science awarded to John Nash, John C. Harsanyi, and Reinhard Selten for their contributions to Game Theory. It was not until the 70s that it started to have a significant impact on engineering and in the late 80's it led to significant breakthroughs in control theory and robust filtering. Currently Game theory is pervasive to all areas of engineering.

D. PREREQUISITES AND COREQUISITES

Prerequisites
- Familiarity with Linear Algebra and Probability and Statistics at an undergraduate level.
- Or consent of Instructor

Corequisites
None

E. REQUIRED TEXTBOOK(S), READINGS AND SUPPLIES

Required Textbook(s)

Optional Textbook(s) or Other References

Supplies
None

F. STUDENT LEARNING OUTCOMES AND ASSESSMENT

Assessment is a process used by instructors to help improve learning. Assessment is essential for effective learning because it provides feedback to both students and instructors. A critical step in this process is making clear the course’s student learning outcomes that describe what students are expected to learn to be successful in the course. The student learning outcomes for this course are listed below. By collecting data and sharing it with students on how well they are accomplishing these learning outcomes students can more efficiently and effectively focus their learning efforts. This information can also help instructors identify challenging areas for students and adjust their teaching approach to facilitate learning.

Upon completion of this course, students should be able to:
1. - Comprehending the key principles of noncooperative game theory.
2. - Applying the Minimax Theorem and evaluating mixed saddle-point equilibria
3. - Analyzing stochastic policies for games in extensive form, and applying them to the existence and computation of saddle-point equilibria.
4. - Comprehending games with N-players.
5. - Analyzing potential games and evaluating Nash equilibria for potential games.
6. - Analyzing dynamic games: the optimal control of a dynamical system
7. - Evaluating the saddle-point equilibria of zero-sum discrete-time and continuous-time dynamic games in state-feedback policies.

G. INSTRUCTIONAL METHODS AND ACTIVITIES

Programming in Matlab, software implementation of noncooperative games.
Whenever possible, computational tools such as the MATLAB software environment will be used to solve numerical problems without being subject to a detailed treatment of numerical methods.

H. MAJOR COURSE REQUIREMENTS AND GRADING

- **Exams (30%)** - There will be three in-class exams worth 10% of the final grade each. Exams may only be made up with an approved University excuse and will be different from the in-class version of the exam. If you have a conflict with an exam date, please let me know as soon as you know about the conflict.

- **Project (30%)** – The students are strongly encouraged to choose a project that is relevant to their own area of research.
The following three types of projects are possible in this course:
  1. Solution of a research problem relevant to the student's area of research
  2. Software implementation of an automated player for board game
  3. Independent study of a topic not covered in class (e.g., reading a paper or book chapter).
Possible topics include:
   a. N-person games in extensive form (Sec 3.5 of [2])
   b. Static infinite games (Ch. 4 of [2])
   c. Learning and evolution in repeated games (pp. 23-29 of [3])
   d. Markov games
   e. Computer network games (security, resource management)
   f. Pursuit-evasion (Ch. 8 of [2])
   g. Cooperative games
The projects are individual work. A one-page project proposal is due on **October 1**. Every student is expected to meet the instructor at least once before the project presentations. The project evaluations will be based on your class presentations

- **Homework (30%)** – 6 Homeworks total, at 5% each

- **Quizzes (10%)** – Quizzes will count for a portion of the class participation grade. Either in hardcopy, or on the course Blackboard page.

- Grade Scale: A (90-100%) B (80-89%) C (70-79%) D (60-69%) F (<60%)
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<thead>
<tr>
<th>ACTIVITY</th>
<th>% of FINAL GRADE</th>
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<tr>
<td>Exams</td>
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I. COURSE CONTENT/SCHEDULE

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<tr>
<th>DATE (BY DAY OR WEEK)</th>
<th>TOPIC</th>
<th>HOMEWORK</th>
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<tr>
<td>08/27 Week 01</td>
<td>1.- Introduction to Noncooperative games</td>
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<td>2.- Actions and Policies</td>
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<td>09/03 Week 02</td>
<td>Review: Probability and Statistics</td>
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<td>Review: Optimization</td>
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<td>09/10 Week 03</td>
<td>3.- Zero-sum matrix games</td>
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<td>4.- Mixed policies</td>
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<td>09/17 Week 04</td>
<td>5.- Minimax Theorem</td>
<td>HW01</td>
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<td>6.- Computation of mixed saddle-point equilibrium policies</td>
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<td>09/24 Week 05</td>
<td>7.- Games in extensive form</td>
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<td>8.- Stochastic policies for games in extensive form</td>
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<td>10/01 Week 06</td>
<td>9.- Two-player games</td>
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<td>10.- Computation of Nash equilibria for bimatrix games</td>
<td>HW02</td>
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<td>10/08 Week 07</td>
<td>11.- N Player Games</td>
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<td>12.- Potential games</td>
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<td>10/15 Week 08</td>
<td>13.- Classes of Potential Games</td>
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<td>14.- Dynamic Games</td>
<td>HW03</td>
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<td>10/22 Week 09</td>
<td>15.- One player Dynamic Games</td>
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<td>16.- One Player Differential Games</td>
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<td>10/29 Week 10</td>
<td>Overview: Games and Programing Languages</td>
<td>HW04</td>
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<td>11/05 Week 11</td>
<td>17.- State-Feedback Zero Sum</td>
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<td>11/12 Week 12</td>
<td>18.- Dynamic Games</td>
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<td>State Feedback Zero-Sum Differential Games</td>
<td>HW05</td>
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<td>11/19 Week 13</td>
<td>Thanksgivings</td>
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<td>11/26 Week 14</td>
<td>Project Presentations</td>
<td>HW6</td>
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<td>12/03 Week 15</td>
<td>Project Presentations</td>
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Note: Changes in this course schedule may be necessary and will be announced to the class by the Instructor. The assignments and exams shown are directly related to the Student Learning Outcomes described in Section F.

J. COURSE POLICIES

Attendance/Tardiness
- Students are expected to be in attendance, punctual, and prepared for class.

Late Work and Make-up Exams
- Late work is not going to be accepted. Make-up Exams are only arranged with 1 week prior notice. No make-up exam will be arranged after each exam.

Extra Credit
- Extra Credit questions/problems will be given in some of the tests and homework.

Cell Phone Use
- Please refrain from the use of electronic devices during class, as it is distracting to not only you, but also to your instructor and peers. Silence your phones and put them away so you are not tempted to stray off task.

Laptop Use
- Laptops will be permitted for particular activities as deemed appropriate.

Food in Class
- No food or drinks are allowed during class.

Missed Project/Exam
- If you have a conflict with an project/exam date, please let me know as soon as you know about the conflict.

Participation
- In-group and individual activities on a regular basis will count towards final grade

Others
- All work submitted for grading must be the student's own work. Plagiarism will result in a score of 0 (zero) for the work or dismissal from the course and the Dean of Students office will be notified. No copying from another student's work of any type is allowed. It is the student's duty to allow no one to copy his or her work.

K. COLLEGE AND UNIVERSITY POLICIES

- Academic Integrity (University)
University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one’s own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in a failing grade.

- **Classroom/Professional Behavior**
  Texas A&M University-Corpus Christi, as an academic community, requires that each individual respect the needs of others to study and learn in a peaceful atmosphere. Under Article III of the Student Code of Conduct, classroom behavior that interferes with either (a) the instructor’s ability to conduct the class or (b) the ability of other students to profit from the instructional program may be considered a breach of the peace and is subject to disciplinary sanction outlined in article VII of the Student Code of Conduct. Students engaging in unacceptable behavior may be instructed to leave the classroom. This prohibition applies to all instructional forums, including classrooms, electronic classrooms, labs, discussion groups, field trips, etc.

- **Statement of Civility**
  Texas A&M University-Corpus Christi has a diverse student population that represents the population of the state. Our goal is to provide you with a high quality educational experience that is free from repression. You are responsible for following the rules of the University, city, state and federal government. We expect that you will behave in a manner that is dignified, respectful and courteous to all people, regardless of sex, ethnic/racial origin, religious background, sexual orientation or disability. Behaviors that infringe on the rights of another individual will not be tolerated.

- **Deadline for Dropping a Course with a Grade of W (University)**
  I hope that you never find it necessary to drop this or any other class. However, events can sometimes occur that make dropping a course necessary or wise. Please consult with your academic advisor, the Financial Aid Office, and me, before you decide to drop this course. Should dropping the course be the best course of action, you must initiate the process to drop the course by going to the Student Services Center and filling out a course drop form. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. Please consult the Academic Calendar (http://www.tamucc.edu/academics/calendar/) for the last day to drop a course.

- **Grade Appeals (College of Science and Engineering)**
  As stated in University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures, a student who believes that he or she has not been held to appropriate academic standards as outlined in the class syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is upon the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade
is encouraged to first discuss the matter with the instructor. For complete details, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, see University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures. These documents are accessible through the University Rules website at http://www.tamucc.edu/provost/university_rules/index.html, and the College of Science and Engineering Grade Appeals webpage at http://sci.tamucc.edu/students/GradeAppeal.html. For assistance and/or guidance in the grade appeal process, students may contact the chair or director of the appropriate department or school, the Office of the College of Science and Engineering Dean, or the Office of the Provost.

- **Disability Services**

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please call (361) 825-5816 or visit Disability Services in Corpus Christi Hall 116.

If you are a returning veteran and are experiencing cognitive and/or physical access issues in the classroom or on campus, please contact the Disability Services office for assistance at (361) 825-5816. http://disabilityservices.tamucc.edu/

- **Statement of Academic Continuity**

In the event of an unforeseen adverse event, such as a major hurricane and classes could not be held on the campus of Texas A&M University–Corpus Christi; this course would continue through the use of Blackboard and/or email. In addition, the syllabus and class activities may be modified to allow continuation of the course. Ideally, University facilities (i.e., emails, web sites, and Blackboard) will be operational within two days of the closing of the physical campus. However, students need to make certain that the course instructor has a primary and a secondary means of contacting each student.

L. **OTHER INFORMATION**

- **Academic Advising**

The College of Science & Engineering requires that students meet with an Academic Advisor as soon as they are ready to declare a major. The Academic Advisor will set up a degree plan, which must be signed by the student, a faculty mentor, and the department chair. Meetings are by appointment only; advisors do not take walk-ins. Please call or stop by the Advising Center to check availability and schedule an
appointment. The College’s Academic Advising Center is located in Center for Instruction 350 or can be reached at (361) 825-3928.

GENERAL DISCLAIMER

I reserve the right to modify the information, schedule, assignments, deadlines, and course policies in this syllabus if and when necessary. I will announce such changes in a timely manner during regularly scheduled lecture periods.