

Checkmate: Using Computers to Win Games of Strategy and Chance

GESM 160 (4 Units)

Description	In this course, we will deconstruct popular games of strategy and chance. We will investigate how we can use statistical analyses to make optimal decisions in these games, as well as some foundations of how a computer can be programmed to aid in this endeavor. We will also explore basic concepts in combinatorial game theory and how this may further inform player decisions. Examples will be taken from games as diverse as craps, poker, Monopoly, Scrabble, tic-tac-toe, Nim, and chess.
Objective	Upon conclusion of this course, students will have a strong grasp of all three facets of the GE-F (Quantitative Reasoning) category: <ul style="list-style-type: none">• Formal Reasoning – We will use basic forms of logic to formulate problems in a manner that we can then solve with a computer.• Abstract Representation – By necessity, computers must represent games with abstraction.• Empirical Analysis – Games of chance are built around probability. As such, this course will investigate methods for analysis of said probabilities.
Prerequisites	This course assumes no prior experience with statistics or programming, though students are expected to have completed high school Algebra II (or equivalent).
Instructor	Sanjay Madhav (madhav@usc.edu)
Office Hours	M/W 12 – 1:30PM and T/Th 2:30 – 4:30PM in OHE 530H
Lecture	Monday and Wednesday, 2:00-3:50PM in GFS 212
Course Structure	Although there will be some traditional lecture, meetings will generally also involve in-class, graded, activities. This means that attendance is extremely important.

Generally, for each game we will take a multi-step approach to learning about it:

1. In class guided analysis of the game. This will involve playing the game in a small group and performing some guided calculations of various properties of the game.
2. Discussion on some of the mathematical basis for the analysis in (1).
3. Short written homework problem sets related to (1) and (2).
4. Discussion of how we can model (1) and (2) using a computer. In the earlier parts of the semester, we will model in Excel, whereas in the latter parts of the semester, we may use the Python programming language.
5. Labs (computer-based) that synthesize everything covered in the earlier steps.

While there will be a midterm, instead of a final exam, there will be a group report. Each group of 3-4 students will select from a list of games, and write a medium-length report the mathematical analysis of the game in question. Each group will also be responsible for formulating a computer model for at least a subset of the game in question. Each group will also give a brief presentation to the class on their findings.

Required Textbook	Taylor, David. <i>The Mathematics of Games: An Introduction to Probability</i> . ISBN-13: 978-1482235432.
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Grading	<p>The course is graded with the following weights:</p> <table> <tr> <td>In-class Activities</td> <td>30%</td> </tr> <tr> <td>Problem Sets</td> <td>18%</td> </tr> <tr> <td>Labs (Computer-based)</td> <td>18%</td> </tr> <tr> <td>Midterm Exam</td> <td>19%</td> </tr> <tr> <td>Final Report</td> <td>15%</td> </tr> <tr> <td>TOTAL POSSIBLE</td> <td>100%</td> </tr> </table>	In-class Activities	30%	Problem Sets	18%	Labs (Computer-based)	18%	Midterm Exam	19%	Final Report	15%	TOTAL POSSIBLE	100%												
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Grading Scale	<p>Letter grades will be assigned according to the following scale:</p> <table> <tr> <td>93%+</td> <td>A</td> </tr> <tr> <td>90-92%</td> <td>A-</td> </tr> <tr> <td>87-89%</td> <td>B+</td> </tr> <tr> <td>83-86%</td> <td>B</td> </tr> <tr> <td>80-82%</td> <td>B-</td> </tr> <tr> <td>77-79%</td> <td>C+</td> </tr> <tr> <td>73-76%</td> <td>C</td> </tr> <tr> <td>70-72%</td> <td>C-</td> </tr> <tr> <td>69</td> <td>D+</td> </tr> <tr> <td>67-68</td> <td>D</td> </tr> <tr> <td>66</td> <td>D-</td> </tr> <tr> <td>65 and below</td> <td>F</td> </tr> </table> <p>Half percentage points will be rounded up to the next whole percentage. So for instance, 89.5% is an A-, but 89.4% is a B+.</p>	93%+	A	90-92%	A-	87-89%	B+	83-86%	B	80-82%	B-	77-79%	C+	73-76%	C	70-72%	C-	69	D+	67-68	D	66	D-	65 and below	F
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Homework	<p><i>Submission of Homework/Labs:</i> Problem sets must be turned in on paper in class. Labs must be turned in on Blackboard (further information on Blackboard will be given in class). In almost all cases, homework is due at the start of class, one week from when it is assigned.</p> <p><i>Late Assignments:</i> Homework/labs will be accepted up to four days late, with a 10% penalty per day late. No homework will be accepted more than four days late without a satisfactory (and documented) reason. In-class activities cannot be submitted late.</p>																								
Policies	<p><i>Make-up policy for exams:</i> To make up for a missed exam, the student must provide a satisfactory reason (as determined by the instructor) along with proper documentation. Make-up exams are generally only offered in emergency situations.</p> <p><i>Late policy for final report:</i> The final report will not be accepted late, as it is a group assignment. Even if one group member has an emergency, the other group members should be able to complete the report.</p> <p><i>Software:</i> The software used in this course can be installed on Macs or PCs. Students without their own computers can use the computers in any of the USC Computing Centers.</p> <p>Microsoft Office is free for USC students: https://itservices.usc.edu/officestudents/</p>																								

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* <https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct/>.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* <http://equity.usc.edu/> or to the *Department of Public Safety* <http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us>. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* <http://dornsife.usc.edu/ali>, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* <http://emergency.usc.edu/> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.

Course Outline

W	Date	Topic(s)	Reading/Problems/Labs
1	8/24	Introduction; Activity: M&M Distribution	
	8/26	Activity: Coins and Dice; Independent events	Ch. 1; <i>PS #1 Assigned</i>
2	8/31	Activity: Roulette; Expected value	Ch. 2 (pp. 25-29)
	9/2	Activity: More Roulette; Excel I	Appendix B; <i>Lab #1 Assigned</i>
3	9/7	<u>No class – Labor Day holiday</u>	
	9/9	Activity: Craps	Ch. 2 (pp. 30-end); <i>PS #2 Assigned</i>
4	9/14	Activity: Poker; Combinations; Excel II	Ch. 3 (pp. 49-60)
	9/16	Bluffing; Activity: Texas Hold 'em	Ch. 3 (pp. 61-end); <i>Lab #2 Assigned</i>
5	9/21	Activity: Blackjack; Binomial distribution	Ch. 4 (pp. 81-85)
	9/23	Card counting; Activity: More Blackjack; Excel III	Ch. 4 (pp. 85-end); <i>PS #3 Assigned</i>
6	9/28	Activity: Slot machines	
	9/30	Midterm review	
7	10/5	<u>Midterm Exam</u>	
	10/7	Activity: Yahtzee; Permutations	Ch.5 (pp. 113-138); <i>PS #4 Assigned</i>
8	10/12	Activity: Snakes and Ladders; Transition matrices	Ch. 6 (pp. 167-184)
	10/14	Activity: Monopoly; Transition matrices in Excel	Ch. 6 (pp. 184-end); <i>Lab #3 Assigned</i>
9	10/19	Activity: Scrabble	
	10/21	Activity: Lottery; Programming basics	Ch. 8 (pp. 251-258); <i>PS #5 Assigned</i>
10	10/26	Activity: Monte Carlo simulations	
	10/28	Activity: Logic; Decision-making	<i>Lab #4 Assigned</i>
11	11/2	Activity: Nim; Combinatorial game theory	Appendix C
	11/4	Activity: Game trees; Gambit	<i>Lab #5 Assigned</i>
12	11/9	Activity: Tic-Tac-Toe; More game trees	
	11/11	Activity: Chess; Modeling minimax	<i>Lab #6 Assigned</i>
13	11/16	Activity: More Chess; Abstraction	
	11/18	Activity: Final report	<i>PS #6 Assigned</i>
14	11/23	Activity: Final report	
	11/25	<u>No class – Thanksgiving holiday</u>	
15	11/30	Activity: Final report	
	12/2	Group Presentations	