Combinatorial Games and Puzzles
Math 1038
Winter Term 2011
Course Description

Instructor: John Schmitt
Office: Warner 311, Ext. 5952
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Office Hours: Monday, Wednesday and Thursday 9-10:30am, or by arrangement.
Course web-page available via my home-page: http://www.middlebury.edu/~jschmitt/

Meeting Times and Location:
Monday, Tuesday, Wednesday, Thursday 10:30am-12:30pm, Warner 506
First day: Monday, January 3rd
Last day: Thursday, January 27th

Textbooks:
Elwyn Berlekamp, *The Dots and Boxes Game: Sophisticated Child's Play*, (Natick, Mass: AK Peters 2000).
Cameron Browne, *Hex Strategy: Making the Right Connections*, (Natick, Mass: AK Peters 2000).
Michael Albert, Richard Nowakowski, David Wolfe *Lessons in Play*, (Wellesley, MA: AK Peters 2007)/. The web-page for this text is:
http://homepages.gac.edu/~wolfe/lessonsinplay/.

Please note that the publishing company AK Peters has recently been purchased by the Taylor Francis Group.

Attendance: Due to the nature of this course your attendance is of the utmost importance. Only one absence is permitted (none is preferred). For each additional unexcused absence 5 percentage points will be deducted from your final grade. It is your responsibility to sign the attendance sheet each day.

Materials:

Many of the games that we'll want to play need a modicum of materials to play. Some basic suggested materials to have at your disposal:

- Pens/pencils of several different colors.

- 50 counters of one color, 50 of another (can use beans, coins, skittles)

- Dominos

- Blank white paper

- Straightedge/ruler

- Chessboard (paper one is fine)

- Graph paper

Special Needs: If you require special arrangements for class or during tests/exams please talk to me as soon as possible to make such arrangements.

Honor Code: The Honor Code will be observed throughout this class and for all examinations. If you have a question about how the Honor Code applies to this class please ask.

Paper on a Combinatorial Game or Puzzle (35 Percent of Grade)

Approval of topic (including references) date: January 10th (Submit a short description, which includes a game description, and preliminary bibliography.)

Due Date: January 24th

Goal of Paper: Identify a combinatorial game, conduct research on the game and write an expository paper about this game. The choice of the game is up to you, but must meet with my approval by the date indicated above.

Points that MUST be addressed in the paper include:

- Conduct a MathSciNet search about the game (go to www.ams.org/mathscinet). Check materials on reserve. Search the QA listings of the library and bibliographies of articles and texts we've read.

- Discuss rules of game and how to play - conciseness and accuracy are important.

- Show that the game satisfies the definition of a *combinatorial game.*

- Discuss the order and size of game graph.

- Discuss opening strategy and end strategy.

- Discuss how mathematics informs play.

- Discuss attributes of an evaluation function.

- Include relevant diagrams, figures and calculations.

- Include open problems/questions (if appropriate).

- You must have AT LEAST two mathematical sources. Print sources preferred.

- Create a set of *original* problems and their solutions in the combinatorial game you have chosen to research to include in your paper. The problems (game positions) should illustrate the inherent nature of a "good" combinatorial game. The solution might illustrate a useful technique or strategy in the game. An indication of an "amateur" move for each problem should be given. You will obtain these "amateur" moves by playing your class-mates and keeping a record of their moves. Solutions should be included in an appendix.

- Double-spaced, minimum of 8 pages (excluding diagrams), maximum of 10 pages (excluding diagrams).

- Please submit a hard-copy and an electronic-copy (via e-mail).

The level of mathematical sophistication will contribute to the grade.

Homework and quizzes(10 percent of grade):

Homework will be given on a daily basis. Some will be in-class, some to solve on your own outside of class time. You may consult with classmates, but the **write-up of these problems must be done on your own!** These will be derived from reading, class discussion and the skills you develop in your playing. BE PREPARED to share your solutions in class! Quizzes will be occasional, unannounced and cover the previous night's reading.

Hex tournament play (10 percent of grade):

Games are often competitive, here is no exception. Towards the end of the class, we will hold a double-elimination tournament or Swiss-style tournament. The winner will receive the full portion of possible points (and a special prize), otherwise tournament ranking will determine portion of the grade.

Dots-and-boxes tournament play (10 percent of grade):

Ditto.

In-class participation (15 percent of Grade):

The content of this course is best learned by *PLAYING*. You will be judged upon your participation in games, class discussion, presentations given, questions given, answers offered, and how well you remain involved (particularly when you might be waiting for a new opponent). I **require you to play with classmates** and with others outside of class-time in order to develop your skills and understanding of combinatorial games and puzzles.

Exam (20 percent of grade)

Date of Exam: January 27th

Goal: A final exam will cover all reading assignments, lectures, films and games covered. It will mostly consist of short-answer type questions.

Grading Percentages:

Homework and quizzes	10
Paper on a combinatorial game	35
Tournament play	20
In-class participation	15
Final exam	20

Assignment of Grades:

The assignment of grades will follow the scheme below.

90 and above	A
80 - 89	B
70 - 79	C
60 -69	D
below 60	F

Plus and minus will be assigned at my discretion. Any person(s) proving a conjecture or providing a solution to an unsolved problem given in a published mathematical article/text will automatically recieve an A for the course. Any person finding a previously undiscovered error in *Lessons in Play* will receive an additional one percentage point to the final average.

References on Reserve in Library:

1. Michael Albert, Richard Nowakowski, David Wolfe *Lessons in Play*, (Wellesley, MA: AK Peters 2007).

2. Elwyn Berlekamp, *The Dots and Boxes Game: Sophisticated Child's Play*, (Natick, Mass: AK Peters 2000).

3. Elwyn R. Berlekamp, John H. Conway and Richard K. Guy, *Winning Ways for Your Mathematical Plays*, Second Edition, A.K. Peters, Natick MA, Volume 1, 2001; Volume 2: 2003; Volume 3: 2003; Volume 4: 2004.

4. Jörg Bewersdorff (translated by David Kramer), *Luck , Logic and White Lies*, (Wellesley, MA: AK Peters 2005).

5. Cameron Browne, *Hex Strategy: Making the Right Connections*, A.K. Peters, Natick, MA, 2000.

6. Cameron Browne, *Connection Games: Variations on a Theme.* A.K. Peters, Wellesley, MA, 2005.

7. John H. Conway, *On Numbers and Games*, Academic Press, London, 1976.

8. Imma Curiel, *Cooperative Game Theory and Applications: Cooperative Games Arising from Combinatorial Optimization Problems*, Kluwer Academic Publishers, Dordrecht, Netherlands, 1997.

9. Martin Gardner, *Mathematical Puzzle Tales*, Mathematical Association of America, Washington, DC, 2000.

10. Richard J. Nowakoski, *Games of No Chance*, Cambridge University Press, Cambridge, England, 1998. (See electronic link below.)

11. Richard K. Guy (editor), *Combinatorial Games*, American Mathematical Society, 1991.

12. Richard J. Nowakowski, *More Games of No Chance*, Cambridge University Press, Cambridge, England, 2002. (See electronic link below.)

13. Jonathan Schaeffer, *One jump ahead: challenging human supremacy in checkers*, Springer, NY, 1997.

Film:

14. *Śatarnja ke khilari (The Chess Players)* produced by Suresh Jindal ; screenplay, music/direction, Satyajit Ray, New York : Kino on Video, [2006].

15. *War games*, Hollywood, CA : United Artists, 1983.

    CD:

16. Martin Gardner, *Martin Gardner's Mathematical Games*, Mathematical Association of America (MAA), 2005.

Online Resources:

Journals and texts:

1. *Integers: Electronic Journal of Combinatorial Number Theory*, www.integers-ejcnt.org (See the games section of the journal.)

2. http://www.msri.org/publications/books/Book29/contents.html. Most of the contents of *Games of No Chance* is available here.

3. http://www.msri.org/communications/books/Book42/contents.html. Most of the contents of *More Games of No Chance* is available here.

4. http://www.math.ucla.edu/~tom/Game_Theory/Contents.html

   Games to play (there are countless more):

5. www.mazeworks.com/hex7.htm. This is a 7×7 version of hex.

6. http://home.earthlink.net/~vanshel/. Play Hex against a computer program.

7. http://www.cs.ualberta.ca/~chinook/. THE website for computer checkers program.

8. http://www.math.ucla.edu/~tom/Games/CONTENTS.html. To play Chomp, Fibonacci Nim, Moore's Nim, Dawson's Chess, Dots and Boxes, and Dominition.

   Gamers:

9. http://www.mscs.dal.ca/%7Erjn/. The home-page of Richard Nowakowski, an avid combinatorial game theorist.

10. http://www.wisdom.weizmann.ac.il/%7Efraenkel/. The home-page of A. Fraenkel, an avid combinatorial game theorist.

11. http://math.berkeley.edu/~berlek/index.html. The home-page of Elwyn Berlekamp, an avid combinatorial game theorist.

12. http://www.ics.uci.edu/~eppstein/cgt/. The home-page of David Eppstein, an avid combinatorial game theorist.

13. http://compgeom.cs.uiuc.edu/~jeffe/mathgames.html. The home-page of Jeff Erickson, an avid combinatorial game theorist.

14. Homepage of Robert R. Snapp, U. Vermont, www.cs.uvm.edu/∼snapp (Click on CS32)

15. Homepage of Tom Ferguson at UCLA, http://www.math.ucla.edu/∼tom/