**University of Toronto**
**Department of Electrical and Computer Engineering**
**ECE1657 Game Theory and Evolutionary Games**
**Fall 2016-2017**

**Information Sheet**

| **Instructor** | **Email Address** | **Office** | **Phone No.** |
|---|---|---|---|
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**Lectures**: Tuesday 10-12, Room: TBD
Starts September 13, 2016.

**Outline**: This course presents a mathematical treatment of classical and evolutionary game theory. Topics covered in classical game theory: matrix games, continuous games, Nash equilibrium (NE) solution, existence and uniqueness, best-response mapping. Topics covered in evolutionary games: evolutionary stable strategy (ESS) concept, NE versus ESS, replicator dynamics (population dynamics), relation to dynamic asymptotic stability. The two areas will be connected by learning in games via imitation dynamics, fictitious play, reinforcement learning and their relation to replicator dynamics. Engineering applications to communication networks, multi-agent learning will be discussed.

**Course Notes**: There is no required textbook. You'll be able to download the course notes from the Course Documents section in the University of Toronto web portal. The notes are self-contained and serve as a textbook for this course.

As extra references, you may consider consulting [1], [3], [2], [6], [5], [4].

# References

[1] T. Basar and G. J. Olsder. *Dynamic noncooperative game theory.* SIAM Series Classics in Applied Mathematics, 2nd edition, 1999.

[2] J. Hofbauer and K. Sigmund. *Evolutionary games and population dynamics.* Cambridge University Press, 1998.

[3] G. Owen. *Game Theory.* Academic Press, 3rd edition, 1995.

[4] L. Pavel. *Game theory for control of optical networks.* Birkhäuser-Springer Science, 2012.

[5] W. H. Sandholm. *Population Games and Evolutionary Dynamics.* Cambridge University Press, 2009.

[6] J. W. Weibull. *Evolutionary game theory.* The MIT Press, 1995.

**Syllabus**:

- CHAPTER 1: Introduction to Game Theory and Evolutionary Games
  - Games in extensive and in normal form; game features;
  - Solution concepts (Minimax, Best Response, Nash Equilibrium, Pareto efficient)
- CHAPTER 2: Matrix Games: Two-Player Zero-Sum
  - Pure and mixed strategies; Minimax theorem
  - Computation of mixed-strategy equilibrium
- CHAPTER 3: Matrix Games: N-Player Non Zero-Sum
  - Bimatrix games (mixed strategies, computation of NE for $2 \times 2$ games)
  - N-Player games (pure and mixed strategies)
  - Best Response correspondence; Nash equilibria (NE) theorem
  - Characterization of Nash equilibria
- CHAPTER 4: Games with Continuous Kernel
  - Game formulations; mixed strategies
  - Nash equilibria theorem and reaction curves
- CHAPTER 5*: Continuous Games with Coupled Constraints
  - Nash equilibria and relaxation (augmented optimization)
  - Lagrangian extension in a game setup, duality extension
- CHAPTER 6,7: Evolutionary Games
  - Evolutionary (population) games; potential games
  - Symmetric matrix games and symmetric Nash equilibrium (NE)
  - Evolutionary stable strategy (ESS)
  - Replicator Dynamics (RD)
  - Stable RD equilibria vs. NE / ESS strategies via Lyapunov theorem
- CHAPTER 8: Learning in Population Games
  - Revision Protocol
  - Imitation Dynamics (ID)
  - Best Response Dynamics (BR)
- CHAPTER 9: Learning in Repeated Matrix Games
  - Repeated Games
  - Best Response Learning
  - Fictitious Play (FP) Learning
  - Reinforcement Learning (RL)