Advanced Stochastic Systems ISyE 4232 , Spring 2017

Instructor: Dr. David Goldberg (a.k.a. Professor Goldberg, Professor)david.goldberg@isye.gatech.edu
Instructor office hours (in 437 Groseclose): By appointment, feel free to send an e-mail
Instructor review sessions before learning assesments: To be announced (TBA)
TA: Ruitu Xu (email TBA)
TA Office hours: Monday 7 - 8, Wednesday 1 - 2, Friday 3 - 4, Location TBA
TA review sessions before learning assessments: TBA
Classes: T/R 9:35 am - 10:55 am in Instr Center 209

Course description. This is an introductory course to stochastic optimization and control with applications to stochastic systems and operations research, as well as the fundamentals of recursion and dynamic programming (which are foundational to optimizing and controlling stochastic systems). The objective of this course is to: understand recursion in algorithms and dynamic programs, and understand the basic theory of (stochastic) control and its application to stochastic models and operations research.

Textbook. There is no required textbook for this class. I will be regularly posting notes on T-Square through the semester, which will act as our course text. These notes will have practice problems and practice learning assessments. There are also many, many great resources online related to the topics covered in this class (for example MIT opencourseware), which you should feel free to explore. Another good reference for the foundational topics of recursion and dynamic programming is Thomas H.. Cormen, Leiserson, C. E., Rivest, R. L., and Stein, C. Introduction to algorithms. Cambridge: MIT press.

Course goals.

- Understand how recursion can be used in the design of algorithms
- Understand how to analyze recursion in algorithms
- Understand how dynamic programming can be used to design algorithms
- Understand how to analyze algorithms based on dynamic programming
- Understand the applications of dynamic-programming based algorithms
- Understand how to formulate control problems as dynamic programs
- Understand how to formulate stochastic control problems as dynamic programs
- Understand how to connect stochastic control problems to Markov decision processes
- Understand how to solve Markov decision processes
- Understand applications of Markov decision processes to stochastic models and operations research

Outline of topics. The topics covered in this course (time permitting) include, but are not limited to:

- **Fundamentals of recursion and algorithms**: Pseudo-code, arrays, runtime analysis of algorithms, searching, sorting, greatest common divisor, general examples of recursion (pros and cons)
- **Dynamic programming**: Why dynamic programming helps algorithmically and its connection to recursion; classical examples of dynamic programming including: combinatorial optimization, optimal subsequences and edit distance, and shortest paths; applications to transportation, biology, and other domains; general methodology of dynamic programming

- **Deterministic control**: Formulation of general deterministic control problems using dynamic programming and backwards induction, cost-to-go functions, and applications
- **Stochastic control**: Formulation of general stochastic control problems using dynamic programming and backwards induction, cost-to-go functions, formulation as Markov Decision Processes, application to inventory theory, queueing control, and machine learning

Office hours policy. Professor Goldberg's office hours are by appointment. Feel free to send him an e-mail asking to meet and discuss any topics from class. In the e-mail, please include at least two different times that work for you to meet. Also, please make the subject heading as descriptive as possible, and put 4232 and your name in the subject heading.

Learning assesments. There will be 5 learning assesments (l.a., also known as quizzes), and one end-of-the-year l.a. (also known as final exam). Each of the five l.a. will contribute 15% to your overall l.a. score (a.k.a. final grade). The end-of-the-year l.a. will contribute 25% to your overall l.a. score.

Homework: There is no homework in this class. You will be given practice problems, both to solve together in class and as extra examples in the notes, but these will not be collected and graded.

Learning Assesments: L.a. will be given in class, starting exactly 5 minutes after the start of class (9:40 am), and lasting the entire class. Different l.a. may have different formats (multiple choice, short answer, etc.) Practice l.a. will be posted to T-Square before each actual l.a., and the actual l.a. will be of a format similar to the corresponding practice l.a.

L.a. will be given on the following dates:

L.a. #	Date
Learning assesment 1	2/7
Learning assesment 2	2/28
Learning assesment 3	3/16
Learning assesment 4	4/4
Learning assesment 5	4/20

end-of-the-year learning assesment (i.e. final): The end-of-the-year learning assesment will be given on the date specified by the registrar , namely May 2 (Tuesday) 2:50pm - 5:40pm , in the regular classroom.

Review sessions for assesments: The Professor and TA will hold review sessions before each assesment, time and location TBA before each assesment.

Overall learning assesment score (also known as final grade):

Final weighted average	Overall learning assesment score
≥ 90	A
$80 - 89$	B
$70 - 79$	C
$50 - 69$	D
< 50	F

Collaboration policy on learning assesments: There is absolutely no collaboration, of any sort, allowed on any learning assesments. No outside sources or technologies may be used, no notes may be used, and no calculators or laptops or cellphones or related technologies can be used for any purpose during the assesment.

Policy on missed assesments: Any learning assessment which is missed without an advanced warning and agreed upon or documented excuse will be given a score of 0. An advanced warning and agreed upon excuse is one in which the student has contacted me at least 72 hours prior to the end of the scheduled class on which the student has an issue, and I responded saying that the excuse was acceptable. This is intended for planned absences due to serious illness, family situations, and official activities organized by Georgia tech (for example conferences and sporting events). If I am uncertain of the legitimacy of such an excuse, I will follow up with the Dean of Students office, and will likely follow up with the Dean of Students office in all cases. If the student does not give me at least 72 hours advanced notice of such a situation, then documentation is required from the Dean of Students office. I understand that in the case of an emergency it may be impossible to get the proper documentation prior to the relevant class day, but I will definitely follow up with the Dean of Students, and documentation will ultimately have to be provided.

If your reason for missing the assesment is covered by the above two scenarios, your final grade will be calculated as follows. The percentage of the final score which would have been used for any such l.a. will be shifted to the final l.a. Thus if you miss 1 l.a. for the above excused reasons, your final l.a. will count for $25 + 15 = 40$ % of your final score. If you miss 2, your final l.a. will count for $25 + 2 \times 15 = 55\%$.

Any missed assesments not excused by either of the above situations will be given a score of 0. If you show up late to class on the day of an assesment, and the l.a. has not yet ended, you may begin the assesment at the time you arrive to class, but must turn in the assesment the same time as the other students. Namely, you will not get extra time on an assesment if you show up late.

Policy on students with special circumstances: If you have special circumstances (e.g. you must travel and/or miss work for college-related activities, or you require special accomodations through the ADAPTS office), please send me an e-mail to set up an appointment, and I will work with you.

Partial credit and regrade policy: Different assesments will have different numbers of questions, with each question worth a different number of points, and the point values will be specified on the given assesment. Limited partial credit may be given at the discretion of myself or the TAs, but do not assume that any given partial or incorrect answer will receive any partial credit. Fairness will always be a major consideration when making such decisions.

Attendance and class cancellation policy: Although attendance is not strictly required, it is very important to succeeding in this class. The class will be very interactive, involving a great deal of group work. Since there is no graded homework, solving problems together in class will be very important to succesfully learning the course material. Many of the examples done in class will appear in the course notes and on the learning assesments. Also, class will be fun!
A situation may arise in which I have a personal situation or emergency which requires me to miss class. In this case, the class will receive an e-mail prior to class about how to proceed (for example class cancelled, or class taught by a different professor or TA that day). I will make every effort to give the class as advanced warning as possible about such matters. For a list of school holidays, see the registrar's website.

Content of particular classes and quizzes: Class will be a combination of myself lecturing, the class working together in groups to solve problems, and doing various other learning activities. I will encourage the various groups to keep a record of their ideas and solutions, and incorporate all of this (my own lectures, the group ideas, etc.) into the the class notes that I post on T-Square. As it is hard to predict the pace that works best for any given group of students, I am not dictating that we absolutely must cover any particular material on any particular lecture or assesment. At the end of the class immediately preceeding an assesment, I will remind the class of the topics to be covered on that assesment. The default should be to assume that an assesment covers all material discussed in class since the previous assesment. Of course, since the ideas build on one another, questions on any previous topics may also appear. The end-of-the-year assesment will be comprehensive.

Violations of the honor code and/or student / faculty expectations agreement. The Georgia Tech honor code and the student-faculty expectations agreement may be found on Georgia Tech's website. Students are expected to read and abide by both the Georgia Tech honor code and the Georgia Tech student-faculty expectations agreement in this class. Any violations of the honor code and/or student / faculty expectations agreement will be taken very seriously, and could lead to harsh consequences. Please do not violate the Georgia Tech honor code and/or student / faculty expectations agreement in this class.

Changes to the syllabus. The educational experience is dynamic, and thus nothing can be set in stone. New situations always arise, emergencies happen, etc. This syllabus is subject to change, but every effort will be made to give the class as advanced warning as possible about such changes.