SC42110
Dynamic Programming and Stochastic Control
Course Information

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Please check the course information and follow the announcements posted on Brightspace!

Staff

- Lecturer:
  - Amin Sharifi Kolarijani (m.a.sharifikolarijani@tudelft.nl)
- Teaching assistants
  - Arman Sharifi Kolarijani (a.sharifikolarijani@tudelft.nl)
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You can ask your questions during lectures, tutorials, and office hours. The staff will also regularly check/answer the questions posted on the Brightspace discussion forum.

We do not answer technical questions by email.

Schedule

- Lectures and tutorials (April 22 – June 13)
  - Tuesdays, 10:45-12:45, ME - Hall F
  - Fridays, 10:45-12:45, ME - Hall E
- Exam: written, 3 hours, on-campus
  - Final: Monday, June 23, 13:30-16:30
  - Resit: Monday, July 14, 13:30-16:30
- Optional
  - Three exercise sets (May 8, May 22, June 9, 23:59)
  - Three take-home quizzes (May 12, May 29, June 11, 8:00-20:00)

Possible changes will be announced on Brightspace!

Schedule

Course structure and dates - 2024-25 Q4

Week	Date		Lecture	Tutorial	Exercise deadline	Quiz	Topic
17	Tue	22-4-2025	1				Intro & preliminaries
	Fri	25-4-2025		1			Preliminaries (Ex. Set 0)
18	Tue	29-4-2025	2				Markov chains
	Fri	2-5-2025	3				Markov chains
19	Tue	6-5-2025	4				Markov chains / Dynamic programming
	Thu	8-5-2025			1		Set 1: Markov chains
	Fri	9-5-2025		2			Markov chains (Ex. Set 1)
20	Mon	12-5-2025				1	Markov chains
	Tue	13-5-2025	5				Dynamic programming
	Fri	16-5-2025	6				Dynamic programming / Applications - LQR
21	Tue	20-5-2025	7				Applications - LQR
	Thu	22-5-2025			2		Set 2: Dynamic programming
	Fri	23-5-2025		3			Dynamic programming (Ex. Set 2)
22	Tue	27-5-2025	8				Applications - Portfolio selection
	Thu	29-5-2025				2	Dynamic programming
23	Tue	3-6-2025	9				Applications - Optimal stopping
	Fri	6-6-2025	10				Applications - Optimal stopping
24	Mon	9-6-2025			3		Set 3: Applications
	Tue	10-6-2025		4			Applications (Ex. Set 3)
	Wed	11-6-2025				3	Optimal stopping
	Fri	13-6-2025		5			Exam-like questions
26	Mon	23-6-2025	Final exam				
29	Mon	14-7-2025	Resit exam				

Optional tasks

(S) Three exercise sets (0/1)

- already posted on Brightspace
- hand-written solutions to be handed in via Brightspace by the announced deadline

(Q) Three take-home quizzes (graded)

- one exam-like question per quiz
- expected to spend at most one and a half hours per quiz
- posted at 8:00 am of the announced dates;
- hand-written solutions to be handed in via Brightspace by 8:00 pm on the same day

Optional tasks

We cannot emphasize enough how important it is to try to solve the exercises and quizzes yourself. The quizzes are particularly a great opportunity to familiarize yourself with the final exam and get feedback on your performance.
If you look at the sample exam questions (available on Brightspace), you may notice that you can already understand the questions! Moreover, after going through the course material, the provided answers come across as quite straightforward! But if you don't work out the provided exercises, quizzes, and sample exams yourself, you will most probably not pass the exam!

Grading policy

For those who only take the final exam, the optional tasks can contribute up to 15% if only they help compared to the final exam:

$$\text{Grade} = 85\%\ E + 15\%\ \max\{E,\ S \times Q\}$$

- $E \in [1, 10]$: grade of the final exam
- $S \in \{0, 1\}$: check of all exercise sets ($S = 1$ if and only if all worked-out sets are handed in by the corresponding deadline)
- $Q \in [1, 10]$: average grade of the three take-home quizzes

For those who take the resit exam, the grade will be entirely based on the resit exam:

$$\text{Grade} = 100\%\ E$$

- $E \in [1, 10]$: grade of the resit exam

Prerequisites

- Probability theory
  Familiarity with the following concepts is expected: sample space, event, random variable, probability density function, cumulative distribution function, conditional probability, independence, expected value, variance, covariance, correlation, Bayes law, law of total probability, normal distribution, binomial distribution, law of large numbers, central limit theorem, etc.
- Calculus and linear algebra
  Familiarity with the following concepts is expected: matrix manipulations, eigenvalue decomposition, etc.

Try out 'Exercise Set 0' posted on Brightspace.
The next session will be a tutorial dedicated to this exercise set.

Material

- Lecture notes/slides (available on Brightspace)

  The 'lecture notes' are the **only** material that can be used during the exam!

- Books:
  - D.P. Bertsekas and J.N. Tsitsiklis, Introduction to Probability, Athena Scientific, 2002.
    An excellent introduction to basic probability at advanced undergraduate level; two chapters on stochastic processes and Markov chains.
  - D.P. Bertsekas, Dynamic Programming and Optimal Control, 3rd edition, Athena Scientific, 2005.
    A classic textbook with two volumes on dynamic programming; the main source of this course is Chapters 1 and 4 of Volume I.
- Similar courses (which this course is also based on):
  - DP & SC, Peyman Mohajerin Esfahani, TU Delft
  - DP & SC, Dimitri Bertsekas, MIT
  - Applied Probability & Stochastic Processes, Daniel Kuhn, EPFL
  - DP & SC, Benjamin Van Roy, Stanford

Learning objectives

By the end of the course, you should be able to

- model real-world control and decision-making problems under uncertainty and in dynamic environments using the framework of discrete-time Markov decision process;
- formalize the optimal decision-making problem and derive the respective dynamic programming principle and useful properties of the desired solution;
- solve the optimal decision-making problem using the dynamic programming algorithm and a proper computational approach.

Course outline (tentative)

- Markov chains
- Markov decision processes & dynamic programming algorithm
- Applications:
  - Linear systems with quadratic cost
  - Optimal portfolio selection
  - Optimal stopping problems