

# Economic Algorithms

School of Computer Science

Computer Science Department

Course no.: 2-7062310-1

Degree: B.A. , M.A.

# Schedule

3rd year, 2nd semester.

# Lecturer

Prof. Erel Segal-Halevi, 58.3.26, 09-7431290, davidesh@ariel.ac.il.

Office hours: Sunday 11:00-13:00, upon appointment.

# Teaching assistant/tutor

# None

# Course goal

# The course teaches algorithms for allocating scarce resources, such as land, commodities, course seats, or donated organs. These algorithms receive as input the preferences of different agents regarding the resources and have to compute an allocation that satisfies such properties as: fairness, efficiency, and truth-telling.

# Prerequisites

\* Passing grades in Algorithms 1 and Algorithms 2. You need to know how to prove correctness and analyze the run-time complexity of algorithms, and how to solve new problems using reductions to known problems.

\* Probability 1 must be studied in parallel.

# Method of Instruction

# A weekly lecture, given frontally in class, and simultaneously broadcast in Zoom. The lecture consists of two parts: In the first part, selected students present their solutions to last week’s assignment; in the second part, new material is taught.

# Course plan

The plan is tentative and subject to change.

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| Lesson unit | Subject | Lesson # |
| 1 | Fair allocation of cakes and land | 1 |
| 2 | Pareto-efficient allocation of commodities | 2 |
| 3 | Approximately fair allocation of indivisible items | 3 |
| 4 | Egalitarian-optimal allocation | 4 |
| 5 | Fair allocation with minimal sharing | 5 |
| 6 | Monetary transfers: fair allocation of rent and rooms. | 6 |
| 7 | Truthful algorithms: auctions for items and ads | 7 |
| 8 | Participatory budgeting | 8 |
| 9 | Budget proposal aggregation | 9 |
| 10 | Coordinating donations | 10 |
| 11 | Exchange algorithms: top trading cycles | 11 |
| 12 | Kidney exchange algorithms | 12 |
| 13 | Conclusion & rehearsal for exam | 13 |

# Course requirements:

# Assignment, given each week, for submission one day before the next lecture. All 12 assignments are obligatory and should be submitted individually. Course grading: 88% - Final exam; 12% - weekly assignments (1% per assignment). Bonus points will be given for successful presentations in class.

# Learning Outcomes:

By the end of the course, you will be able to:

1. Give precise mathematical definitions to notions of fairness, efficiency and truthfulness.

2. Identify the properties relevant to the given resource allocation problems.

3. Apply economic algorithms to solve resource allocation problems.

4. Provide formal proofs for properties guaranteed by various economic algorithms.

5. Develop economic algorithms for solving new allocation problems.

6. Implement economic algorithms in Python.

# Main textbook and additional textbooks:

1. Lecture notes from previous years (in Hebrew) are available at GitHub:  
<https://github.com/erelsgl-at-ariel/algorithms-5785>

2. Video recordings of lectures from 2023 (in Hebrew) are available at YouTube:

<https://www.youtube.com/playlist?list=PLM9fKcsATjxgK9M_SyJr3mYdsxKqvl7Cz>

3. Tim Roughgarden: “***Twenty Lectures on Algorithmic Game Theory*”, Cambridge University Press,** 2016. Video recordings of lectures from 2013 (in English) are available at YouTube: <https://www.youtube.com/watch?v=TM_QFmQU_VA&list=PLEGCF-WLh2RJBqmxvZ0_ie-mleCFhi2N4>

4. Felix Brandt, Vincent Conitzer, Ulle Endriss, Jerome Lang, Ariel Procaccia: “*Handbook of Computational Social Choice*”. Cambridge University Press, 2016.

5. Steven J. Brams: “*Mathematics and Democracy*”. Princeton University Press, 2008.

6. Hervé Moulin: “*Fair Division and Collective Welfare*”. MIT Press, 2004.

# Required material for the examination

# All material taught during class, including student presentations, and all assignments.