RUTGERS
Rutgers Business School
Newark and New Brunswick

Data Structures and Algorithms	**Dr. Shahrzad Haddadan**
22:544:613:02	
Data Structures and Algorithms (26:198:685:01)	
Fall 2024	Email: s.haddadan@rutgers.edu
518, 1 Washington Park.	office hours: Thursdays: TBD
Tuesday 1:00-3:50 PM	

COURSE DESCRIPTION

In this course, we will cover the most fundamental algorithms and the essential data structures. We will learn the basic mathematical tools necessary to analyze these algorithms. Furthermore, through homework exercises as well as leetcode and problem solving sessions we will enhance the fluency of students in algorithm design both in theory and in implementations.

Course Delivery Mode: In-person.

Learning Management System: Canvas

Instructor Dr. Shahrzad Haddadan, Assistant Professor of Management Sciences and Information Systems.
Office: Room 5142, 100 Rockafeller Road, Piscataway, NJ 08854.
Email: s.lastname@rutgers.edu

COURSE MATERIALS

Textbook: T. Corman, C. Leiserson, R. Rivest, and C. Stein "Introduction to Algorithms", MIT Press. Fourth Edition.

Software used: Python.

The following topics will be discussed in this course:

Topic 1: Basics and definitions. Asymptotic notation, simple algorithm.

Topic 2: Simple Data structures: Arrays, linked lists, stacks, queues, graphs

Topic 3: Number theoretic algorithms: Applications to random number generation, cryptography, RSA, Prime testing, Euclid's algorithm for gcd

Topic 4: Divide and Conquer paradigm: Strassen's matrix multiplication algorithm, maximum sub-array, Quick sort

Topic 5: Dynamic Programming: Simple examples, Fibonacci numbers, Dynamic programming for matrix chain products, knapsack problem

Topic 6: The Greedy Paradigm: Huffman codes**,**

Graph algorithm: Dijkstra's algorithm, improvement with heaps, Floyd-Warshal algorithm, Shortest distances as a form of matrix multiplication, minimum spanning trees and forests. Prim's and Kruskal's Greedy algorithms, the basic methods

Topic 7. Information storage and retrieval, Searching, and supporting data structures Binary search trees, red-black trees. Hash tables

Topic 8: NP-completeness and Computational intractability: SAT, reductions, Karp's np complete problems

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PREREQUISITES

There is no formal pre-requisite for this course but some familiarity with basic probability theory or statistics and linear algebra is needed. Some knowledge or experience with programming will be essential.

ACADEMIC INTEGRITY

Discussion of homework problems is allowed and encourages. However, every student must write their own homework assignment and exam individually.

Discussing homework problems are allowed and encourages, but copying solutions is a violation of the honor code. You are not allowed to seek help for doing take home exams. For group assignments you may not ask any person outside your group to write any part of your code for you.

We take the honor code very seriously and any violation will be reported to the administrations at Rutgers. *If you have any doubt about violation of honor code ask your professor.*

Use of AI tools like ChatGPT is only permitted to help you for brainstorming ideas, viewing examples, or refining your writing. All submitted material must be your original work. Any misuse of these tools will be regarded as cheating and reported to Rutgers administration.

ATTENDANCE AND PREPARATION POLICY

This course moves at a fast pace and new concepts are introduced in each lecture. These concepts are practiced in homework assignments. Regularly attending class and completely homework assignments are central for learning. If you fall behind, it may be too difficult to catch up. Your final score will be a combination of your performance on attendance, homework assignments and exams.

Regular attendance in class contributes to 5% of your final score. Anything that causes repeated disturbance in class such as late arrival, use of cellphones, chatting with peers will negatively affect your score.

- Expect me to attend all class sessions. I expect the same of you. If your absence is due to religious observance, a Rutgers-approved activity, illness, or family emergency/death <u>and</u> you seek makeup work, also send [me/TA] an email with full details and supporting documentation within two days of your first absence.

- Expect me to arrive on time for each class session. I expect the same of you.

- Expect me to remain for the entirety of each class session. I expect the same of you.

- Expect me to prepare properly for each class session. I expect the same of you. Complete all background reading and assignments. You cannot learn if you are not prepared.

- Expect me to participate fully in each class session. I expect the same of you. Stay focused and involved. You cannot learn if you are not paying attention.

EXAM DATES AND POLICIES

There are 2 midterms and 1 final exam in this course. The midterms will be during the class tentatively on week 7 and 12 of the course, and the final exam is TBD.

GRADING POLICY

Course grades are determined as follows:

Regular attendance (5%) in class contributes to 5% of your final score. Anything that causes repeated disturbance in class such as late arrival, use of cellphones, chatting with peers will negatively affect your score.

Homework assignments (40%) There will be 10 homework assignments in this course which constitute 40% of the final grade.

Homework assignment are both in written form and some are coding problems which will be completed on datacamp.

Quizzes (20%): There will be three quizzes in this course which will contribute to 20% of the final score

Leetcode and problem-solving sessions (20%): There will be four leetcode and problem solving sessions during the course. Being absent at these sessions means you have to make up for it or you will lose the points.

Final exam (15%): In person final exam will be in written form and will include problems from all the topics discussed in the course.

Late policy: Late homework submissions will be penalized; for any late day you will lose 5% of that homework assignment's score.

Group work: The students are encouraged to brainstorm and study together specially with their group members while respecting the honor code.

TENTATIVE COURSE SCHEDULE

	Topics and reading assignments from [1]	Homework
Week 1 (09/03)	Algorithm analysis (Section 2.1, 2.2) Asymptotic analysis (3.1,3.2)	HW1: **Due:** Midnight 09/09
Week 2 (09/10)	Asymptotic notation (3.1, 3.2, 3.3) Analysis of recursive algorithms(4.3,4.4,4.5) Divide and conquer strategy (chapter 4)	HW2: **Due:** Midnight 09/16
Week 3 (9/17)	Simple Data Structures (10.1,10.2,10.3) --- - **Leetcode/ problem solving session 1 on simple data structures and divide and conquer**	HW3: **Due:** 09/30 midnight
Week 4 (9/24)	**Quiz 1(take home): simple data structures, divide and conquer**	No homework
Week 5 (10/01)	Graph algorithms: BFS (20.1,20.2) Graph algorithms: DFS (20.3) Topological sort (20.4) Strongly connected components (20.5)	HW 4: **Due:** 10/07 midnight
Week 6 (10/08)	More on divide and conquer paradigm (4.1,4.2) --- -- **Leetcode/ problem solving session 2 on simple graph algorithms**	HW5 Due: Midnight 10/21

Week 7 (10/15)	Greedy algorithms **Quiz 2 (in class): simple graph algorithms / divide and conquer**	no homework
Week 8 (10/22)	Greedy algorithms	HW6: **Due:** 10/28 midnight
Week 9 (10/29)	Dynamic programming	HW 7: **Due:** 10/11 midnight
Week 10 (11/05)	Dynamic programming --- **Leetcode and problem solving session 3 for greedy algorithms and dynamic programming**	No homework
Week 11 (11/12)	Complex data structures --- **Quiz 3 (in class) dynamic programming, greedy algorithms**	HW 8: **Due:** 10/18 midnight
Week 12 (11/19)	Advanced graph algorithms: shortest path algorithms Minimum spanning tree	HW 9: **Due:**12/03 midnight
(11/26)	Thanks giving	
Week 13 (12/03)	NP-hardness --- **Leetcode and problem solving session 4 for complex data structures, advanced graph algorithms**	HW 10: **Due:** 12/09 midnight Practice problems for final
Week 14 (12/10)	NP- hardness Final Q& A	

Exam date: TBD

SUPPORT SERVICES

If you need accommodation for a *disability*, obtain a Letter of Accommodation from the Office of Disability Services. The Office of Disability Services at Rutgers, The State University of New Jersey, provides student-centered and student-inclusive programming in compliance with the Americans with Disabilities Act of 1990, the Americans with Disabilities Act Amendments of 2008, Section 504 of the Rehabilitation Act of 1973, Section 508 of the Rehabilitation Act of 1998, and the New Jersey Law Against Discrimination. More information can be found at ods.rutgers.edu.
[Rutgers University-New Brunswick ODS phone (848)445-6800 or email dsoffice@echo.rutgers.edu]
[Rutgers University-Newark ODS phone (973)353-5375 or email ods@newark.rutgers.edu]

If you are *pregnant*, the Office of Title IX and ADA Compliance is available to assist with any concerns or potential accommodations related to pregnancy.
[Rutgers University-New Brunswick Title IX Coordinator phone (848)932-8200 or email jackie.moran@rutgers.edu]
[Rutgers University-Newark Office of Title IX and ADA Compliance phone (973)353-1906 or email TitleIX@newark.rutgers.edu]

If you seek *religious accommodations*, the Office of the Dean of Students is available to verify absences for religious observance, as needed.
[Rutgers University-New Brunswick Dean of Students phone (848)932-2300 or email deanofstudents@echo.rutgers.edu]
[Rutgers University-Newark Dean of Students phone (973)353-5063 or email DeanofStudents@newark.rutgers.edu]

If you have experienced any form of *gender or sex-based discrimination or harassment*, including sexual assault, sexual harassment, relationship violence, or stalking, the Office for Violence Prevention and Victim Assistance provides help and support. More information can be found at http://vpva.rutgers.edu/.
[Rutgers University-New Brunswick incident report link: http://studentconduct.rutgers.edu/concern/. You may contact the Office for Violence Prevention and Victim Assistance at (848)932-1181]
[Rutgers University-Newark incident report link: https://cm.maxient.com/reportingform.php?RutgersUniv&layout_id=7 . You may also contact the Office of Title IX and ADA Compliance at (973)353-1906 or email at TitleIX@newark.rutgers.edu. If you wish to speak with a staff member who is confidential and does **not** have a reporting responsibility, you may contact the Office for Violence Prevention and Victim Assistance at (973)353-1918 or email run.vpva@rutgers.edu]

If students who have experienced a temporary condition or injury that is adversely affecting their ability to fully participate, you should submit a request via https://temporaryconditions.rutgers.edu .

If you are a military *veteran* or are on active military duty, you can obtain support through the Office of Veteran and Military Programs and Services. http://veterans.rutgers.edu/

If you are in need of *mental health* services, please use our readily available services.
[Rutgers University-Newark Counseling Center: http://counseling.newark.rutgers.edu/]
[Rutgers Counseling and Psychological Services–New Brunswick: http://rhscaps.rutgers.edu/]

If you are in need of *physical health* services, please use our readily available services.
[Rutgers Health Services – Newark: http://health.newark.rutgers.edu/]
[Rutgers Health Services – New Brunswick: http://health.rutgers.edu/]

If you are in need of *legal* services, please use our readily available services:
http://rusls.rutgers.edu/

Students experiencing difficulty in courses due to *English as a second language (ESL)* should contact the Program in American Language Studies for supports.
[Rutgers–Newark: PALS@newark.rutgers.edu]
[Rutgers–New Brunswick: eslpals@english.rutgers.edu]

If you are in need of additional *academic assistance*, please use our readily available services.
[Rutgers University-Newark Learning Center: http://www.ncas.rutgers.edu/rlc
[Rutgers University-Newark Writing Center: http://www.ncas.rutgers.edu/writingcenter]
[Rutgers University-New Brunswick Learning Center: https://rlc.rutgers.edu/]

[Optional items that many faculty include:
  - Students must sign, date, and return a statement declaring that they understand the RU Academic Integrity Policy.
  - Students must sign, date, and return a statement declaring that they understand this syllabus.]

CODE OF PROFESSIONAL CONDUCT

[If you prefer to direct students to the conduct policy online instead, please use the following link and place it beneath the header above:
https://myrbs.business.rutgers.edu/students/code-professional-conduct]

Rutgers Business School is recognized for its high-quality education. To that end, maintaining the caliber of classroom excellence, whether in person or online, requires students to adhere to the same behaviors expected in professional career environments. These include the following principles:

Discussion and Correspondence
- Each student is encouraged to participate actively in class discussions and exercises. Substantive dialogue requires a degree of mutual respect, willingness to listen, and tolerance of opposing points of view. Disagreement and the challenging of ideas must happen in a supportive and sensitive manner. Hostility and disrespectful behavior will not be tolerated.

- In correspondence and in the classroom, students should demonstrate respect in how they address instructors. Students should use proper titles unless there is an explicit understanding that the instructor accepts less formal alternatives. Similarly, appropriate formatting in electronic communication and timely responsiveness are all expectations in every professional interaction, including with instructors. Everything said and written should demonstrate respect and goodwill.

Punctuality and Disruption
- Class starts and ends promptly at the assigned periods. Students are expected to be in their seats or present online and ready to begin class on time.

  - Take your responsibility to attend class seriously. Your attendance is a critical element of the learning experience for in-person classes. Failure to show up disrupts your learning and signals disrespect to your peers and instructors. (Of course, illness is a legitimate exception requiring advanced reporting to the University and your instructors.)

  - Barring emergencies and within reason, students are expected to remain in their seats for the class duration. In person, packing belongings before the end of class disturbs both other students and the instructor. Online, attending to other tasks is distracting. In addition, even if webcams are not required in your course, your attention is fundamentally lacking if you are engaged in multiple tasks simultaneously.

Technology
- The use of technology is sanctioned only as permitted by the course instructor. As research on learning shows, peripheral use of technology in classes negatively impacts the learning environment in three ways:

  1. Individual learning and performance directly suffer, resulting in the systemic lowering of grades earned.

  2. In the classroom, one student's use of technology automatically diverts and captures other people's attention, thus impeding their learning and performance. Moreover, even minor infractions have a spillover effect and result in others doing the same.

  3. Subverting this policy (e.g., using a phone during class, even if hidden below the table or out of sight from your webcam; tapping on a smartwatch; using a laptop for non-course related matters) is evident to the course instructor and offensive to the principles of decorum in a learning environment.

- Networking, computing, and associated resources in the trading rooms, advanced technology rooms, and general classrooms are to be used in the manner intended.

- Sharing links to private online classes, attempting to join an online class you are not enrolled in, or posting disruptive content during these sessions are strictly prohibited and may lead to disciplinary action.

- For more instructions on information technology resources at Rutgers University, please refer to the [Acceptable Use Policy for Information Technology Resources](#).

Misappropriating Intellectual Property
- Almost all original work is the intellectual property of its authors. These works may include syllabi, lecture slides, recorded lectures, homework problems, exams, and other materials, in either printed or electronic form. The authors may hold copyrights in these works, which U.S. statutes protect. Copying this work or posting it online (on sites such as Chegg or Course Hero) without the author's permission may violate the author's rights. More importantly, these works are the product of the author's efforts; respect for these efforts and the author's intellectual property rights are important values that members of the university community take seriously.

- For more instructions on copyright protections at Rutgers University, please refer to the [Rutgers Libraries](#).
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Bias incidents

- An act – either verbal, written, physical, or psychological that threatens or harms a person or group on the basis of actual or perceived race, religion, color, sex, age, sexual orientation, gender identity or expression, national origin, ancestry, disability, marital status, civil union status, domestic partnership status, atypical heredity or cellular blood trait, military service or veteran status.

Bias incidents can be reported online at:
[New Brunswick Bias Incident Report Form](#)
[Newark Bias Incident Report Form](#)

Rutgers Business School is committed to the highest standards of integrity. We value mutual respect and responsibility, as these are fundamental to our educational excellence inside and outside the classroom.

CV

NAME

Dr. Shahrzad Haddadan

EDUCATION

Doctor of Philosophy in Computer Science   2010 – 2016
Dartmouth College, Hanover, NH
Dissertation title: "algorithmic problems arising in posets and permutations", Thesis Advisor: Prof. Peter Winkler.

Master of Science in Computer Science   2007 – 2010
Sharif University of Technology, Tehran, Iran

Bachelor of Science in Computer Science   2003 – 2007
Sharif University of Technology, Tehran, Iran

ACADEMIC, GOVERNMENT, MILITARY AND PROFESSIONAL POSITIONS

Assistant Professor at Rutgers Business School   September 2022 – Present
Department of Management Sciences and Information Systems (MSIS)

Postdoctoral Researcher at Brown University   March 2020 – August 2022
Department of Computer Science & Data Science Initiative (DSI)
Supervisor: Prof. Eli Upfal

Guest Reseacher Max-Planck Institute of Informatics   October 2019 – February 2020

Postdoctoral Researcher at La Sapienza   October 2016 – September 2019
Dipartimento di Informatica
Supervisor: Prof. Flavio Chierichetti

JOURNAL PUBLICATIONS (PEER-REVIEWED)

1.Reducing polarization and increasing diverse navigability in graphs by inserting edges and swapping edge weights, Shahrzad Haddadan, Cristina Menghini, Matteo Riondato, Eli Upfal
Journal of Data Mining and Knowledge Discovery
    Volume. 36
    Issue 6
    Pages 2334-2378

Publication date 2022/11

2. The Wedge Picking Model: A Theoretical Analysis of Graph Evolution Caused by Triadic Closure and Algorithmic Implications, Sara Ahmadian, Shahrzad Haddadan
Journal of Strategic Innovation and Sustainability
       Volume 16
       Issue 3
       Pages 74-93
       Publisher North American Business Press

3. Some Instances of Homomesy Among Ideals of Posets, Shahrzad Haddadan
The Electronic Journal of Combinatorics
       Volume 28
       Issue 1
       Publication date 2021/3

4. Mixing time bounds for graphlet random walks, Matteo Agostini, Marco Bressan, Shahrzad Haddadan
Information Processing Letters
       Volume 152
       Pages 105851
       Publish date: 2019/12/1
       Publisher Elsevier

5. Mixing of Permutations by Biased Transpositions, Shahrzad Haddadan, Peter Winkler.
Theory of Computing Systems
       Volume: 63
       Pages 1068–1088
       Publish date: 28 November 2018
       Doi: https://doi.org/10.1007/s00224-018-9899-5

6. The expected jaggedness of order ideals, Melody Chan, Shahrzad Haddadan, Sam Hopkins, Luca Moci
Forum of Mathematics, Sigma
       Volume 5
       Publish date: 2017
       Publisher: Cambridge University Press
       Doi:10.1017/fms.2017.5

PROCEEDINGS (PEER-REVIEWED)

7. Optimally Improving Cooperative Learning in a Social Setting, Shahrzad Haddadan, Cheng Xin, Jie Gao. In the 41st International Conference on Machine Learning, **ICML 2024.**

8.DeMEtRIS: Counting (near)-Cliques by Crawling, Suman K. Bera, Jayesh Choudhari, Shahrzad Haddadan, Sara Ahmadian. To appear in the 16th ACM International on Web Search and Data mining, **WSDM 2023**.

9. The Drift of #MyBodyMyChoice Discourse on Twitter, Cristina Menghini, Justin Uhr, Shahrzad Haddadan, Ashley Champagne, Bj̈orn Sandstede, Sohini Ramachandran. In the 14th International ACM Conference on Web Science, **WebSci 2022**. (Runner up for best paper award).

10. Fast Doubly-Adaptive MCMC to Estimate the Gibbs Partition Function with Weak Mixing Time Bounds, Shahrzad Haddadan, Yue Zhuang, Cyrus Cousins, Eli Upfal. In the 35th Conference on Neural Information Processing Systems, **NeurIPS 2021**.

11. RePBubLik: Reducing polarized bubble radius with link insertions, Shahrzad Haddadan, Cristina Menghini, Matteo Riondato, Eli Upfal. In the 14th ACM International on Web Search and Data mining, **WSDM 2021**. (Best paper honorable mention).

12. A theoretical analysis of graph evolution caused by triadic closure and algorithmic implications, Sara Ahmadian, Shahrzad Haddadan. In the IEEE International Conference on Big Data, **IEEE Big data 2020.** (Accepted for long presentation).

13. Mallows models for top-k lists, Flavio Chierichetti, Anirban Dasgupta, Shahrzad Haddadan, Ravi Kumar, Silvio Lattanzi, In Proceedings of the 32nd Conference on Neural Information Processing Systems, **NeurIPS 2018.**

14. On the complexity of sampling nodes uniformly from a graph, Flavio Chierichetti, Shahrzad Haddadan. In Proceedings of the 45th International Colloquium on Automata, Languages, and Programming, **ICALP 2018.**

15. Mixing of permutations by biased transposition, Shahrzad Haddadan, Peter Winkler. At 34th Symposium on Theoretical Aspects of Computer Science, **STACS 2017**. (Invited to special issue of Theory of Computing Systems).

16. Evaluation of background subtraction methods, Soraya Panahi, Samira Sheikhi, Shahrzad Haddadan, Niloofar Gheissari. In the IEEE proceeding, Digital Image Computing Technique and Application, **DICTA 2008.**

PRESENTATIONS

1. Making mean-estimation more efficient using an MCMC trace variance approach: DynaMITE April 2024 Rutgers Electrical Engineering Department (Signal Processing Seminar) & Rutgers Business School (MSIS Seminar)
2. Estimating the parameters of a graph by crawling February 2023 Rutgers Computer Science Department (Theory Seminar)
3. Reducing polarization in graphs by inserting edges and swapping edge weights November 2022 Rutgers Business School (MSIS seminar)

4. Reducing polarization in graphs by inserting edges and swapping edge weights, November 2021 Google New York (algorithms seminar)
5. RePBubLik: Reducing polarized bubble radius with link insertions April 2021 University of California, Santa Cruz (theory reading group)
6. Algorithms for top-k lists and Social Network December 2019 Institut de Recherche en Informatique Fondamentale (IRIF)
7. Random Walks & Application in Exploring Networks and Ranking Objects September 2019 Max-Planck-Institut f¨ur Informatik, Saarbr¨ucken, Germany
8. Random Walks & Application in Exploring Networks and Ranking Objects August 2019 Indian Institute Of Technology Gandhinagar
9. The Markov chain Monte Carlo method (A short course) March 2017 Sharif University of Technology, Tehran, Iran
10. Permutations and Spin Systems January 2015 Joint Mathematics Meetings, San Antonio, TX, USA

AWARDS / HONORS

Research Awards:

- Runner up for best paper award in the 14th International ACM Conference on Web Science in 2022 (WebSci'22)
- Best paper honorable mention, the 14th ACM International on Web Search and Data mining, WSDM 2021.
- Best talk award, annual research symposium of Computer Science Department, Dartmouth College, 2015.
- Runner up for best talk award, annual research symposium of Computer Science Department, Dartmouth College, 2012.
- Runner up for best poster award, annual research symposium of Computer Science Department, Dartmouth College, 2011.

Fellowships and Travel awards:

- SIAM early career travel award, for SDM 2021.
- FSMP postdoctoral laureate; awarded by the Foundation Sciences Math´ematiques de Paris, 2020.

Ranked second among B.Sc Computer Science students of Sharif University, and M.Sc entrance exam waived, 2003 – 2007.

SERVICE TO THE PROFESSION *(must include Start/End Date)*

Leadership Roles

MSIS Weekly seminars   January 2023- present
Rutgers Business school

Fair February symposium   February 2022
Brown university (DSI)

Fair February symposium   February 2021
Brown university (DSI)

The annual research symposium of computer science   September 2014
Dartmouth College (CS dept.)

Session Chair

Session chair at the SIAM International Conference on Data Mining April 29 – May 1, 2021
Session: Foundations of Data Science @ SDM 2021

Paper Reviewer

- o Program Committee of the ACM International Conference on Web Search and Data Mining, WSDM 2023.
- o Program Committee of short paper track on the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases: ECMLPKDD 2022.
- o Program Committee of the research paper track on Social Network Analysis and Graph Algorithms at The Web Conference a.k.a. WWW 2022. (Best reviewer honorable mention).
- o Program Committee of the research paper track on Social Network Analysis and Graph Algorithms at The Web Conference a.k.a. WWW 2021.
- o Program Committee of the SIAM International Conference on Data Mining: SDM 2021.

Reviewer/sub-reviewer
   The ACM-SIAM Symposium on Discrete Algorithms SODA: 2022, 2021, 2018
   The Web Conference a.k.a WWW: 2020
   The ACM SIGKDD Conference on Knowledge Discovery & Data Mining KDD: 2020
   The European symposium on algorithms ESA: 2019, 2018
   The International Conference on Complex Networks and their Applications: 2018