

Information Technology**Course Number: 22:544:647****Course Title: Graph Methods and Network Analysis****COURSE DESCRIPTION**

Graphs arise naturally wherever pairwise interactions occur: the web, social media, communication networks, transportation networks, product purchases, financial transactions, disease transmission, protein interactions, to name a few instances. An understanding of how to utilize graphs to represent, store, process, and analyze such phenomena is necessary in a broad range of disciplines, including technology, biology, marketing, communications, finance, and many more. This course aims to introduce students to all aspects of graph analysis, starting with an introduction to basic graph concepts and theory, practical analysis techniques and tools, and moving on to advanced methods. At the end of the course, students will have a comprehensive understanding of all key aspects of working with graph data and extracting useful insights.

The course draws upon material from a number of different disciplines, including computer science, network science, and computer systems. The students will be given the opportunity to apply the techniques we cover in class on their own, via guided assignments using real-world data and Python. By the end of the class, students are also expected to complete a project which is a major part of the course and where they will propose a problem or task and then use the techniques covered in the class to tackle it.

Course Delivery Mode:

In-person and remote (via Zoom), typically on alternating weeks.

All project presentations will be in-person and require in-person attendance (dates will be agreed upon and posted by the second week of class).

Learning Management System: Canvas

Hardware and software requirements: Personal computer with modern browser (minimum). Class will use Python and you should install it on your local machine (Anaconda distribution is recommended). For assignments that may involve some programming, devcontainers on GitHub Codespaces will also be provided. However, for your course project, you are expected to use your personal computer.

For both lectures and office hours, device with Zoom. Registration links will be posted on

Canvas. Participation will require a Rutgers Zoom account; please see <https://it.rutgers.edu/zoom/knowledgebase/how-to-create-your-rutgers-zoom-account/> on how to activate, if you haven't already.

Students will also need a GitHub account. A free-tier account will be sufficient for this class.

RBS New Brunswick Students in need of financial assistance can send an email to: deanofstudents@echo.rutgers.edu

RBS Newark Students in need of financial assistance may submit their request via a form: <https://myrun.newark.rutgers.edu/care-team>

Students can also benefit from reviewing: <https://myrbs.business.rutgers.edu/students/learning-remotely>

In general, if students have any technology issues, please let them know OTIS is available to help with its extensive coverage schedule 8 am – 8 pm Mon-Fri: helpdesk@business.rutgers.edu
<https://myrbs.business.rutgers.edu/otis>

COURSE MATERIALS

- Textbook(s): [Optional but recommended; freely available online]
 - W.M. Hamilton, *Graph Representation learning*, Morgan-Claypool, 2020. https://www.cs.mcgill.ca/~wlh/grl_book/
 - A.-L. Barabási, *Network Science*, Cambridge University Press, 2016. <http://networksciencebook.com/>
- The course will mostly follow the two textbooks above (with the exception of background review). Additional suggested reference material or textbooks on specific topics will be provided on Canvas.
- Lecture slides and notes (on Canvas).

Communications and office hours:

- Check Canvas (<https://canvas.rutgers.edu/>) and your associated official Rutgers email account regularly.
- Canvas Inbox is the preferred method of communication. You may also use Rutgers email.
- For short questions/issues, the instructor will be available for at least 30min after each lecture.
- Both the instructor and TA (if one is available) will hold weekly office hours.
- All office hours will be held over Zoom. In order to best manage time, advance registration is required (links will be posted on Canvas).
- If you cannot make it to regular weekly office hours, other times/days may be arranged by appointment (please come speak to us after class).

LEARNING GOALS AND OBJECTIVES

- This course is designed to help students develop skills and knowledge in network analysis methods, data mining on graphs, and basic graph theory, as well as their applications.
 - Students who complete this course will demonstrate an understanding of the fundamental concepts and theory, as well as the ability to apply them to real-world data sets, using a language such as Python (and toolkits such as NetworkX and/or iGraph).
 - Students are expected to be self-motivated and will have the opportunity to use the techniques covered in the course through a number of guided assignments in Python.
 - Students are also expected to complete a project, working in groups, which aims to further their experience and confidence in applying what they have learned in class to real-world settings.
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PREREQUISITES

No formal prerequisites. However, students are expected to have a basic foundation in mathematics (including linear algebra, elementary probability/statistics, and calculus), and basic knowledge of data structures and algorithms (including arrays, lists, and trees; searching and sorting). Essential prerequisites will be reviewed at the beginning of the course. Students must also have some basic programming and software development background (enough to independently write short programs in a language such as Python, as well as install and use necessary development tools and libraries).

Moreover, students are generally expected to possess a level of maturity that corresponds to the level of the course. General expectations include:

- Motivated and self-driven; able to ask good questions; participate and contribute to class.
 - Able to program and learn necessary tools (e.g., Python and necessary libraries, Jupyter, etc) largely independently.
 - Clear communication skills (which follows from clear thinking process).
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ACADEMIC INTEGRITY

I do NOT tolerate cheating. Students are responsible for understanding the RU Academic Integrity Policy (<http://academicintegrity.rutgers.edu/>). I will strongly enforce this Policy and pursue *all* violations. On all examinations and assignments, students must sign the RU Honor Pledge, which states, “On my honor, I have neither received nor given any unauthorized assistance on this examination or assignment.” [I will screen all written assignments through *SafeAssign* or *Turnitin*, plagiarism detection services that compare the work against a large database of past work.] Don’t let cheating or plagiarism destroy your hard-earned opportunity to learn and advance. See business.rutgers.edu/ai for more details.

You do not have permission to distribute my course materials to any other person or republish any of my content to a third-party platform like Course Hero, Quizlet, etc.

Guidance on the use of AI at Rutgers

As noted in [Rutgers Academic Integrity Policy 10.2.13](#), the principles of academic integrity require that students make sure that all submitted coursework be “the student’s own and created without the aid of impermissible technologies, materials, or collaborations.

ATTENDANCE AND PREPARATION POLICY

- I expect you to attend all classes, pay attention, and actively participate. You cannot learn if you do not pay attention or if you only passively listen. It is your responsibility to keep up with everything covered in class.

- Attendance will be recorded using Qwickly Attendance (via Canvas); a checkin code will be provided at the beginning of each lecture. A minimum of five absences will be automatically excused; please use this “absence credit” wisely. If for whatever reason you cannot check in during the beginning of the class, please come up immediately after the end of the lecture and let me know. I will *not* be able to edit your checkin once the lecture is over (no exceptions).

EXAM DATES AND POLICIES

There are no exams in this course.

CLASS PROJECTS

Students will have to complete a class project, which aims to further their experience and confidence in applying what they have learned in class to real-world settings, as well as successfully presenting their work to others.

- Students will work in groups of up to three people; students can choose their own groups and should do so in the first two weeks of the class.
- Students will have to formulate a problem or task in graph analysis; some suggestions will be provided, but students are encouraged to come up with their own ideas, drawing from their interests and experience.
- Students will have to successfully give a short (3-5 minute) pitch to the class, in which they explain and justify the problem, it’s importance, their goals, and their plan to achieve them. This will happen approximately half-way through the semester. Students will receive feedback from the instructor as well as the class and, after any adjustments

to their proposal, they should write a short (up to 1 page) summary.

- Students will have to complete the tasks outlined in their proposal and prepare a final presentation (10-15 minutes) which they will give in class, as well as a final report (up to 5 pages) which outlines their approach, methods, and results. The final presentations will be given during the last class and the final report will be due after that.

GRADING POLICY

Course grades are determined as follows:

- 60% project
 - 15% proposal (writeup & short presentation)
 - 15% final presentation
 - 30% technical merit
 - 30% homework assignments
 - 10% attendance
- No extra credit or make-up work is available; no exceptions. The only ways to earn credit in the class are those listed above.
 - Scores of individual coursework components are not adjusted in any way. Grades may be curved at the end (i.e., just before assigning letter grades). Any curving shall only decrease score cutoffs from standard values (i.e., it can only improve your letter grade).
 - No pre-grading of homework assignments; of course are always welcome to seek help and ask specific technical questions.
 - Grades will be assigned objectively (based on *technical* arguments) and consistently (using the *same* criteria for *all* students). Consequences, such as hurt pride, lost scholarships, lost tuition reimbursement, lost job opportunities, or dismissals will not (and cannot) affect your grade in any way.
 - Re-grading requests will be considered for grade discrepancies that are *only* due to either (i) factual/technical errors, or (ii) consistency errors in applying grading criteria across students. During re-grading, we will re-examine your *entire* work (not select fragments), as well as that of possibly other students, if presented as evidence for (ii).

COURSE TOPICS

Topics covered include:

1. An introduction to basic graph models and theory, and the different kinds of graphs that arise in various phenomena.
2. Practical analysis of graphs, including how to retrieve and extract graph data using web APIs, and analyze them using Python and popular tools such as NetworkX and/or iGraph.
3. Link analysis, which can help understand and quantify the relative importance of links and nodes in a graph.
4. Community discovery, which can help understand the overall structure of a graph.

5. Random graph models, which can help understand the processes by which real-world graphs arise and evolve.
6. Large-scale graph systems, which can help store, manage, and analyze graphs with millions of nodes and billions of edges.
7. Advanced methods for classification and clustering in graphs, including kernel-based methods and deep learning.
8. Dynamic graph models, which can help process and understand graphs that change over time.

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]

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](#)

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.]
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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](#).

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.