

Math 466/566: Network Optimization (Fall 2022)

Time	Tue,Thu 2:55–4:10 PM
Location	Pullman: Cleveland 30; Vancouver: VECS 125
Instructor	Bala Krishnamoorthy
Office	VUB 347; Zoom
Office Hours	Tue 12–1 PM, Wed 2:30–3:30 PM
Email	kbala@wsu.edu
Course web page	http://www.math.wsu.edu/faculty/bkrishna/Math566.html
Book	Ahuja, Magnanti, and Orlin — Network Flows: Theory, Algorithms, and Applications. Prentice-Hall. ISBN: 013617549X
Options to buy	AbeBooks.com Alibris.com Amazon.com

Description of the Course

Welcome to Network Optimization! Network flow problems constitute an important class of optimization problems with applications to several areas including chemistry, computer networking, engineering, public policy, scheduling, telecommunications, transportation, big data analytics, and more. We will present an integrated view of the theory, algorithms, and applications of key network optimization problems including the shortest path, maximum flow, minimum cost flow, minimum spanning tree, and matching problems. We will present most arguments from first principles, and we will adopt a network (or graph) view point. We will use linear optimization approaches on some occasions, and will provide the necessary background so as to keep the discussion self-contained. **But previous knowledge of linear optimization (Math364 in particular) will not be required. The only (pre)requirement is mathematical sophistication and intuition.** We will emphasize powerful algorithm strategies, rigorous analysis of the algorithms, and data structures for their implementation. Apart from problems involving proofs (in homework and the midterm exam), the student will produce working implementations of some of the algorithms using Matlab (or Python, or another similar package/language). Depending on student interest, we will discuss specific applications and topics from data sciences and/or combinatorial optimization.

Organization and Grading

There will be around eleven homework assignments. Each assignment will be posted at least one week before the day on which it will be due. Dates are given in the tentative schedule (they may be subject to some changes). Some of the problems will involve writing programs in a computer package (Matlab, by default) to produce a running version of algorithms discussed in class. **All homework and project submissions should be made electronically by email.**

There will be one in-class, closed-book, midterm exam on **Thursday, October 6**. Students are encouraged to not miss the exam. Requests for taking a **make-up exam** at an alternative time could be considered under extreme circumstances. But such a make-up exam will be different from the one taken by the rest of the class at the regular time.

There will be a final course project (no final exam will be given). Students should work on the project individually. The total score for the course will be calculated using the following weights:

- homework: 55 %
- mid-term: 20 %
- project: 25 %

The least homework grade **from among those turned in** will be dropped. In each homework and in the exam, some problems will be marked as “advanced”, indicated by [G]. Students registered for Math 466 will not be responsible for solving these problems. They are strongly encouraged to attempt the advanced problems, though. Points gained on these problems by Math 466 students will be counted as extra credit.

The total score will be *rounded up* to the first decimal place, e.g., 87.42 \rightarrow 87.5, 79.91 \rightarrow 80.

Grade for the course will be determined by the total score based on the following scales.

Math 466: ≥ 92 : A; 88–91.9: A–; 83–87.9: B+; 78–82.9: B; 73–77.9: B–; 68–72.9: C+; 63–67.9: C; 58–62.9: C–; 53–57.9: D+; 45–52.9: D; and ≤ 44.9 : F.

Math 566: ≥ 92 : A; 86–91.9: A–; 80–85.9: B+; 73–79.9: B; 66–72.9: B–; 59–75.9: C+; 53–58.9: C; 48–52.9: C–; 43–47.9: D+; 38–42.9: D; and ≤ 37.9 : F.

Expectations for student effort: For each hour of lecture equivalent, students should expect to have a minimum of two hours of work outside class. Given the conjoint setting for this class, this expectation applies to students in both Math 466 and Math 566. Also see note about expected effort required for the programming assignments below (under Software).

Attendance Policy: I will not be recording your attendance. At the same time, it is essential to not miss any of the lectures if you want to do well in this course. As such, you are encouraged to attend class regularly.

Software

Students will be asked to implement several of the algorithms discussed in class. This implementation/programming part will be an integral part of the learning process in this course.

Programming assignments could be done using Matlab (or another package or language of your choice, e.g., Python). WSU has a systemwide Matlab license, using which students could get Matlab on their PC (see the Matlab Portal for more info). You will not need powerful computers— an ordinary laptop or desktop could be used to run Matlab.

Students should expect to spend a nontrivial amount of time on programming assignments, especially if they are doing such programming for the first time. It is highly recommended that each student installs Matlab and gets familiar with basic commands early in the semester.

Academic Integrity: I encourage discussion of homework problems with others. But each student should submit their own (hand or type) written solutions and/or computer programs (codes). You might search the internet for finding materials to enhance your understanding. If you use such material to assist in your homework submission, you **should** cite the relevant sources. Plagiarism or cheating will **not** be tolerated. In particular, do not copy blindly from internet sources! Such behavior is easy to detect, and will result in a zero grade for the item in question and possibly a failing grade for the entire course.

Tentative Schedule for Math 466/566 (Fall 2022)

Week	Lec #	Date	Details
1	1	Tue, Aug 23	syllabus, logistics, intro to network models
	2	Thu, Aug 25	various network optimization problems
2	3	Tue, Aug 30	network representations, data structures
	4	Thu, Sep 1	network representations, data structures [HW 1 Due]
3	5	Tue, Sep 6	transformations and flow decompositions
	6	Thu, Sep 8	computational complexity, search algorithms [HW 2 Due]
4	7	Tue, Sep 13	breadth- and depth-first search, intro to shortest paths
	8	Thu, Sep 15	shortest paths (SP): label setting algos [HW 3 Due]
5	9	Tue, Sep 20	label setting algos, label correcting algos
	10	Thu, Sep 22	complexity, implementation of SP algos [HW 4 Due]
6	11	Tue, Sep 27	more on SP algos
	12	Thu, Sep 29	all-pairs shortest paths [HW 5 Due]
7	13	Tue, Oct 4	review for mid-term
	14	Thu, Oct 6	MIDTERM
8	15	Tue, Oct 11	maximum flow, augmenting paths (AP)
	16	Thu, Oct 13	max-flow min-cut (MFMC), shortest AP (SAP) algo [HW 6 Due]
9	17	Tue, Oct 18	more on SAP, excess scaling algo
	18	Thu, Oct 20	preflow-push algorithms [HW 7 Due]
10	19	Tue, Oct 25	more on preflow-push algos
	20	Thu, Oct 27	min-cost flows (MCF), residual network for MCF [HW 8 Due]
11	21	Tue, Nov 1	MCF optimality conditions
	22	Thu, Nov 3	cycle canceling algo for MCF [HW 9 Due]
12	23	Tue, Nov 8	successive SP algo, complementary slackness
	24	Thu, Nov 10	minimum spanning trees (MST) [HW 10 Due]
13	25	Tue, Nov 15	Kruskal's and Prim's algo for MST
	26	Thu, Nov 17	matching problems, assignment problems
		Tue, Nov 22	<i>No class: thanksgiving</i>
		Thu, Nov 24	<i>No class: thanksgiving</i>
14	27	Tue, Nov 29	stable marriage problem, non-bipartite matching
	28	Thu, Dec 1	augmenting paths, more on matching [HW 11 Due]
15	29	Tue, Dec 6	combinatorial optimization/other topics
	30	Thu, Dec 8	combinatorial optimization/other topics
16		Thu, Dec 15	[Project due] by 5:00 p.m.

Student Learning Outcomes (SLOs) and Assessment

Quantitative skills: A student completing this course should be able to do the following tasks.

- Formulate problems in application domains as appropriate network flow problems;
- employ existing, or devise new efficient, algorithms to solve the network flow problems;
- prove results on the finiteness and efficiency of these algorithms; and
- produce working implementations of several algorithms in a software package.

These skills will be evaluated through the student's responses to problems—both proof-type as well as computational ones involving software programming—in homework assignments and the midterm exam. Implementations of algorithms will be assessed also as part of the final project.

Written communication skills: A student completing this course should be able to

- provide sound mathematical arguments including proofs,
- justify choices of network models used for problems in a logically clear manner, and
- write a cohesive report for the final project in the form of a short research paper.

These skills will be evaluated through the student's responses to problems in homework assignments and the midterm exam as well as the report for the final project.

WSU Systemwide Policies and Statements

Reasonable Accommodation

Reasonable accommodations are available for students with documented disabilities or chronic medical or psychological conditions. If you have such a condition and need accommodations to fully participate in this class, please visit your campus' Access Center/Services website to follow published procedures to request accommodations. Students may also contact their campus offices to schedule an appointment with an Access Advisor. All disability related accommodations are to be approved through the Access Center/Services on your campus. It is a university expectation that students connect with instructors (via email, Zoom, or in person) to discuss logistics within two weeks after they have officially requested their accommodations.

For more information, contact an Access Advisor on your home campus:

- Pullman, WSU Global Campus, Everett, Bremerton, and Puyallup: 509-335-3417 Access Center (<https://www.accesscenter.wsu.edu>) or email at access.center@wsu.edu
- Vancouver: 360-546-9739 Access Center (<https://studentaffairs.vancouver.wsu.edu/access-center>) or email van.access.center@wsu.edu.

Religious Accommodation

Washington State University reasonably accommodates absences allowing for students to take holidays for reasons of faith or conscience or organized activities conducted under the auspices of a religious denomination, church, or religious organization. Reasonable accommodation requires the student to coordinate with the instructor on scheduling examinations or other activities necessary for course completion. Students requesting accommodation must provide written notification within the first two weeks of the beginning of the course and include specific dates for absences. Approved accommodations for absences will not adversely impact student grades. Absence from classes or examinations for religious reasons does not relieve students from responsibility for any part of the course work required during the period of absence. Students who feel they have been treated unfairly in terms of this accommodation may refer to Academic Regulation 104 – Academic Complaint Procedures.

Academic Integrity

All members of the university community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Students are responsible for understanding the full [Academic Integrity Statement](#). Students who violate WSU's Academic Integrity Policy (identified in [WAC 504-26-010\(3\) and -404](#)) will receive a failing grade for the assignment or for the whole course, will not have the option to withdraw from the course pending an appeal, and will be reported to the Center for Community Standards. If you have any questions about what is and is not allowed in this course, ask your course instructor.

Safety and Emergency Notification

Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the "Alert, Assess, Act," protocol for all types of emergencies and the "[Run, Hide, Fight](#)" response for an active shooter incident. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way to assure your own safety (and the safety of others if you are able). Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, please view the FBI's [Run, Hide, Fight video](#) and visit the [WSU safety portal](#).

Full details can be found at <https://provost.wsu.edu/classroom-safety/>.

Severe Weather

For severe weather alerts, see <http://alert.wsu.edu/> and <https://oem.wsu.edu/emergency-procedures/severe-weather/>. In the event of severe weather affecting university operations, guidance will be issued through the alert system.

WSU Vancouver Statement: In the event that an adverse weather event (e.g., snow or ice) or natural hazard that poses a safety risk occurs, you should take personal safety into account when deciding whether you can travel safely to and from campus, taking local conditions into account. If campus remains open and your instructor decides to cancel the face-to-face meeting and substitute an alternative learning activity, you will be notified by your instructor via email or through Blackboard within a reasonable time after the decision to open or close campus has been made. Instructions regarding any alternative learning options or assignments will be communicated in a timely manner. If travel to campus is not possible due to adverse regional conditions, allowances to course attendance policy and scheduled assignments, including exams and quizzes, will be made. Students who attempt to gain advantage through abuse of this policy (e.g., by providing an instructor with false information) may be referred to the Center for Community Standards for disciplinary action. If a student encounters an issue with an instructor, the student should first talk with the instructor. If the issue cannot be resolved, the student should follow the reporting violations of policies outlined on the student affairs website.

Discrimination and Harassment

Discrimination, including discriminatory harassment, sexual harassment, and sexual misconduct (including stalking, intimate partner violence, and sexual violence) is prohibited at WSU (See [WSU Policy Prohibiting Discrimination and Harassment](#) (Executive Policy 15) and [WSU Standards of Conduct for Students](#)). If you feel you have experienced or have witnessed discriminatory conduct, you can contact the WSU Compliance & Civil Rights (CCR) and/or the [WSU Title IX Coordinator](#) at 509-335-8288 to discuss resources, including confidential resources, and reporting options. (Visit ccr.wsu.edu for more information). Most WSU employees, including faculty, who have information regarding sexual harassment or sexual misconduct are required to report the information to CCR or a designated Title IX Coordinator or Liaison. (Visit ccr.wsu.edu/reporting-requirements for more info).

Lauren's Promise

I will listen and believe you if someone is threatening you. Lauren McCluskey, a 21-year-old honors student athlete, was murdered on Oct. 22, 2018, on the University of Utah campus by a man she briefly dated. *We must all take actions to ensure that this never happens again.*

If you are in immediate danger, call 911.

If you are experiencing sexual assault, domestic violence, stalking, discrimination or harassment, you have support and options. If you share information with me, please know that I am required to reach out to the Title IX Coordinator in WSU Compliance and Civil Rights (CCR), and CCR will reach out to you with information about on and off campus reporting options and resources. CCR is a system-wide resource (all campuses) which is available for intake consultations for you to learn more about available support. You can reach them directly at 509-335-8288, ccr@wsu.edu, or report online (anonymous reports accepted).

You can also speak to a victim advocate, a medical provider, or counselor confidentially about your concerns. Advocates help survivors of crime determine their own needs in regards to their physical and emotional health, reporting options, and academic concerns. At no cost, advocates connect survivors to campus and community services, and provide accompaniment to important appointments (court, hospital, and police) and support throughout the process. For a list of confidential victim advocates and medical providers, please visit CCR Resources.

WSU Police Department (WSU PD) officers and campus security will treat victims of sexual assault, domestic violence, stalking, hate crimes, and other crimes with respect and dignity. WSU PD, campus security departments, CCR, and victim advocates can also help you with safety planning.

Resources for Students

In Pullman

- Student Care Network: studentcare.wsu.edu
- Cougar Transit: 978 267-7233
- WSU Counseling and Psychological Services (CAPS): 509 335-2159
- Suicide Prevention Hotline: 800 273-8255
- Crisis Text Line: Text HOME to 741741
- WSU Pullman Police: 509 335-8548
- Pullman Police (Non-Emergency): 509 332-2521
- WSU Office of Civil Rights Compliance & Investigation: 509 335-8288
- Alternatives to Violence on the Palouse: 877 334-2887
- Pullman 24-Hour Crisis Line: 509 334-1133

In Vancouver

- Students may apply for grant assistance to cover technology or COVID-19 related educational costs through the Student Emergency Funding request form: <https://studentaffairs.vancouver.wsu.edu/financial-aid>
- The Laptop Loaner Program will continue in Spring 2022. To apply, students should visit: <https://www.vancouver.wsu.edu/information-technology/new-student-tech-guide>
- Tech Help for Students: <http://wsuvtech4students.org/>
- Access Campus Software Remotely with AppStream: <https://www.vancouver.wsu.edu/information-technology/access-campus-software-remotely-appstream>
- Cougar Food Pantry: We know that it can be hard for students to make ends meet when paying for college and living on a tight budget. The Cougar Food Pantry can help. The pantry provides free, nonperishable food items for WSU Vancouver students in need. The process is simple, anonymous and judgement-free. Learn more and request food at <https://studentaffairs.vancouver.wsu.edu/cougar-food-pantry>.