

Math 401 [M]: Introduction to Analysis I

Credits	3
Section	02 (Pullman), 01 (Vancouver)
Time	Tu-Thu 12:05–1:20 PM
Location	WEBS B8 (PI) , VECS 120 (Vn), Zoom (ID: 972 9462 0925, Pw: 13059)
Instructor	Bala Krishnamoorthy
Office	VUB 347 (Vancouver), Zoom (ID: 360 546 9167, Pwd: Bala)
Office Hours	Wed 11 AM–12 PM, Thu 3–4 PM
Email	kbala@wsu.edu
Phone	360-546 9167
Course web page	http://www.math.wsu.edu/faculty/bkrishna/Math401.html
Text	Tom L. Lindstrøm Spaces An introduction to Real Analysis AMS. ISBN: 9781470440626

Description of the Course

This course offers an introduction to real analysis at the senior undergraduate level. Real analysis is a continuation of calculus, and many of the concepts we introduce in this class should be familiar from calculus, e.g., functions, continuity, convergence, etc. But we will introduce these concepts in new, more abstract, contexts. The biggest change from calculus to real analysis is a shift in emphasis from calculations to formal arguments.

We will cover Chapters 1–4 from the book (Lindstrøm: Spaces An Introduction to Real Analysis). Topics covered include preliminaries (proofs, sets, functions, etc.), completeness, basics of metric spaces, convergence, compactness, and spaces of continuous functions. Emphasis will squarely be on constructing sound mathematical arguments, i.e., proofs.

Prerequisites: A grade of C or better in Math 301 (Introduction to Mathematical Reasoning), or an equivalent class (on “Introduction to Proof Writing”).

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. Discussion of homework problems with other students is allowed and encouraged. But each person should hand in their her own hand- or type-written solutions.

There will be two exams—a midterm and a final. The dates are provided in the tentative schedule. Both will be given as take home exams. More details will be provided closer to the exams.

The total score for the course will be assigned using the following weights.

- Homework: 60 %
- midterm: 20 %
- final: 20 %

The least homework grade **from among those turned in** will be dropped.

For all graded work, you will be evaluated on

- ⇒ how well you understood the underlying mathematical concepts,
- ⇒ whether you correctly applied the concepts to come up with correct arguments/proofs, and
- ⇒ whether you provide correct and clear **exposition** and description of the above aspects, and of the responses sought in the case of each problem.

Grades for the course will be assigned according to the following scale for the total scores obtained in the course. ≥ 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.

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.

Academic Integrity: I encourage discussion of homework problems with others. But each person should submit their own (hand or type) written solutions. 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 a graded item and possibly a failing grade for the entire course.

Students with Disabilities: Reasonable accommodations are available for students with a documented disability. All accommodations **MUST** be approved by the Access Center. You are also welcome to discuss your access issues with me, but I will send you to the Access Center ultimately in most cases.

See details on COVID-19 policies, academic integrity, availability of reasonable accommodations, safety, inclement weather policy, and much more in the attached documents (end of this PDF file).

Tentative Schedule, and Topics Covered

We will cover sections from Chapters 1–4 from the book LSIRA (Lindstrøm: Spaces An Introduction to Real Analysis). Sections from LSIRA are listed. Based on how things progress, I may cover other topics not listed here (from LSIRA, or outside). Information and materials (handouts, etc.) will be provided in due course if I cover topics outside of LSIRA.

Week	Lec #	Date	Details
1	1	Tue, Aug 24	syllabus, etc. proofs (1.1)
	2	Thu, Aug 26	sets (1.2), families of sets (1.3)
2	3	Tue, Aug 31	functions (1.4), relations (1.5)
	4	Thu, Sep 2	relations (1.5) [HW 1 Due]
3	5	Tue, Sep 7	countability (1.6), ϵ - δ arguments (2.1)
	6	Thu, Sep 9	ϵ - δ stuff (2.1), completeness (2.2) [HW 2 Due]
4	7	Tue, Sep 14	completeness (2.2), *-value theorems (2.3)
	8	Thu, Sep 16	theorems (2.3) [HW 3 Due]
5	9	Tue, Sep 21	metric spaces: definitions (3.1)
	10	Thu, Sep 23	convergence (3.2) [HW 4 Due]
6	11	Tue, Sep 28	open and closed sets (3.3)
	12	Thu, Sep 30	complete spaces (3.4) [HW 5 Due]
7	13	Tue, Oct 5	more on complete spaces (3.4)
	14	Thu, Oct 7	catch up; review for mid-term
8	15	Tue, Oct 12	Midterm: Due by 10 PM 11:59 PM
	16	Thu, Oct 14	compact sets (3.5)
9	17	Tue, Oct 19	compact sets (3.5), compactness (3.6)
	18	Thu, Oct 21	completion of metric spaces (3.7) [HW 6 Due]
10	19	Tue, Oct 26	modes of continuity (4.1) and convergence (4.2)
	20	Thu, Oct 28	convergence (4.2), calculus with sequences (4.3) [HW 7 Due]
11	21	Tue, Nov 2	calculus with sequences (4.3), power series (4.4)
	22	Thu, Nov 4	power series (4.4), bounded function spaces (4.5) [HW 8 Due]
12	23	Tue, Nov 9	bounded continuous function spaces (4.6)
		Thu, Nov 11	<i>No class: Veteran's Day</i> [HW 9 Due on Friday, Nov 12]
13	24	Tue, Nov 16	applications to differential equations (4.7)
	25	Thu, Nov 18	compact sets of continuous functions (4.8) [HW 10 Due]
14		Tue, Nov 23	<i>No class; thanksgiving</i>
		Thu, Nov 25	<i>No class; thanksgiving</i>
14	26	Tue, Nov 30	more differential equations (4.9)
	27	Thu, Dec 2	Weierstrass' theorem (4.10) [HW 11 Due]
15	28	Tue, Dec 7	Stone-Weierstrass theorem (4.11)
	29	Thu, Dec 9	catch up; review for final
16		Wed, Dec 15	[Final Exam] due by 11:59 PM

Student Learning Outcomes and Assessment

A student completing this course will achieve the following learning goals.

- **Depth, breadth, and integration of learning:**
 - Develop a thorough understanding of basic concepts from the field of mathematics of **real analysis**.
 - Develop skills and aptitude to construct mathematically sound proofs for basic and some advanced results in real analysis.
- **Creative and Critical thinking:**
 - **Acquire** the necessary **competencies** for **solving mathematical problems** in real analysis. This goal would often require the **innovative use** of the fundamental mathematical concepts for constructing proofs.
 - Be able to **critically evaluate** the relative merits of various relevant approaches to solve problems in real analysis, e.g., different proofs for a result on metric spaces or continuity of functions.
- **Quantitative Reasoning:**
 - Acquire the skills to **construct mathematically sound proofs** for results in real analysis. Become well versed in assessing the correctness of such proof arguments.
 - Acquire the skills to **test** the relevant **assumptions** based on which the various results in real analysis are presented.
- **Communication skills (written and oral):**
 - Provide sound mathematical arguments including proofs in the homework assignments.
 - Participate in discussion during lecture in class.

Most of these goals will be assessed in an integrated fashion throughout the course. Relevant activities for the **assessment** of specific learning goals are tabulated below. **Evaluation** of each learning goal will be performed through **grading** the homework assignments and exams.

Learning goal	relevant activities
Depth, breadth, and integration of learning	all lectures, homework, exams
Information literacy	all homework, exams
Creative and critical thinking	all homework, exams
Quantitative reasoning	proof problems in homework, exams
Communication skills (written)	homework submissions, exams
Communication skills (oral)	in-class participation

WSU Systemwide Policies and Statements

Reasonable Accommodation

Students with Disabilities: 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 a Disability Specialist. 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 a Disability Specialist 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.

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.

COVID-19

Per the proclamation of Governor Inslee on August 18, 2021, masks that cover both the nose and mouth must be worn by all people over the age of five while indoors in public spaces. This includes all WSU owned and operated facilities. The state-wide mask mandate goes into effect on Monday, August 23, 2021, and will be effective until further notice.

Public health directives may be adjusted throughout the year to respond to the evolving COVID-19 pandemic. Directives may include, but are not limited to, compliance with WSU's COVID-19 vaccination policy, wearing a cloth face covering, physically distancing, and sanitizing common-use spaces. All current COVID-19 related university policies and public health directives are located at <https://wsu.edu/covid-19/>. Students who choose not to comply with these directives may be required to leave the classroom; in egregious or repetitive cases, student non-compliance may be referred to the Center for Community Standards for action under the Standards of Conduct for Students.

Discrimination and Harrassment

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).

Accommodation for Religious Observances or Activities

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.

Classroom Safety

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 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 Office of Student Conduct 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. Finally, in case of class cancellation campus-wide, please check local media, the WSU Vancouver web page (<https://www.vancouver.wsu.edu>) and/or <https://www.flashalert.net/>. Individual class cancellations may be made at the discretion of the instructor.

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 Chromebook loaner program will continue in Fall 2021. 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>.