

Syllabus analysis II spring 2024.

Course Title is

Analysis II

MATH:6210:0001 *Prerequisites:* MATH:6200

Start and end times: 2:30P - 3:20P MWF 113 [MLH](#)

Instructors: Palle Jorgensen (Primary Instructor)

Sem. Hrs: 3 .In-Person. This course section will be held face-to-face in a physical instructional space, 2:30P - 3:20P MWF 113.

Admin: College of Liberal Arts and Sciences

Admin Home: MATH:6210 .

Time and Location. Start and end times: 2:30P - 3:20P MWF 113 [MLH](#)

Instructor: Palle Jorgensen, Professor .

Palle Jorgensen, palle-jorgensen@uiowa.edu **Office Hours: MWF 1-2 pm, or by appointment, office** MLH 25b, ph 319 3350782.

DEO Contact Information:

[Ryan D Kinser](#) Department Chair (DEO)

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General Catalog <https://catalog.registrar.uiowa.edu/liberal-arts-sciences/mathematics/>

From the catalogue: “Hilbert space, Banach space techniques; Hahn-Banach theorem, open mapping theorem, principle of uniform boundedness; reflexivity, H-p spaces, Paley-Wiener theorem, space of functions that are analytic on the open unit disk.”

Topics and aim. I stress that this course can be tailored to the needs of students registered in the class.

The course covers central and core topics in analysis, concentrating on complex analysis, but also a variety of related topics, both pure and applied. See also the TOC below.

Includes key tools in **complex analysis** (analytic functions in one and in several variables), and with an emphasis on applications, both to related areas within math such as harmonic analysis, complex geometry, and complex dynamics (e.g., Julia set algorithms), and PDE; as well areas of engineering, e.g., filters and algorithms used in signal/image processing, and in systems theory.

The level will be adjusted to the students who register.

If you have questions or suggestions, email me: palle-jorgensen@uiowa.edu

In class, will begin with a review (even though the fundamentals of analytic function theory are covered in a 5000 course), and I adjust topic-selection to students who are signed up; so flexible about prerequisites.

Text: The primary book for the course will be *the second half of W. Rudin*, Real and Complex Analysis, 3rd ed, chapters 10 through 20. (**You need not be already familiar with chs 1-10.**) (The same book we used in Analysis I.) In addition, we will supplement with current research texts; tailored to specific student needs.

I will also supplement with other books and topics of interest to students in the class. As you know, the 6000 level courses are typically helpful when you think about PhD-thesis research.

Key course topics: One and several complex variables, contour integrals, conformal maps, Riemann surfaces, complex manifolds, conformal geometry, harmonic analysis (especially H^p spaces), functional and harmonic analysis, Hilbert spaces arising from analytic continuation of Fourier transforms (many important applications, e.g., signals and frequency bands), approximation by polynomials and by rational functions. Also covered will be connections to neighboring areas, e.g., to PDEs, to geometry, numerical analysis, functional analysis, and operator theory. An exciting new direction: complex dynamics, see e.g., L.

Carleson and J. Milnor: <https://www.amazon.com/Complex-Dynamics-Universitext-Lennart-Carleson/dp/0387979425> and

https://www.amazon.com/Dynamics-One-Complex-Variable-AM-160/dp/0691124884/ref=sr_1_3?crid=16J60HG5SSZB4&dchild=1&keywords=john+milnor&qid=1608314326&s=books&prefix=john+milnor%2Cstripbooks%2C150&sr=1-3

PS: Even though the course is called Analysis II, *the topics from Analysis I are not prerequisites*, and the extent to which stuff from Analysis I will be needed, I will supply the necessary review.

Fyi about the course, in more detail.

The course will be about central topics in analysis, concentrating on complex analysis, and related.

The level will be adjusted to the students in the class. Even though the fundamentals of analytic function theory are covered in an analysis 5000 course, I will begin with a review, and will be able to adjust the selection of topics to students who are signed up. I am flexible about prerequisites. Even though the course is called Analysis II, *the topics from Analysis I are not prerequisites*, and the extent to which stuff from Analysis I will be needed, I will supply the necessary review.

Grading policy: participation 25%, homework 30%, midterms 25%, final 20%.

Homework is assigned weekly, and due every Wednesday. You may hand in in class, or via ICON uploads.

Text: Rudin: The primary book for the course will be the second half of W. Rudin, Real and Complex Analysis, 3rd ed, chapters 10 through 20. (You need not be already familiar with chs 1-10.) But we will also have supplements.

I expect to also supplement with several other books and topics of interest to students in the class. The 6000 level courses are typically helpful to students who think about their PhD research.

Key math:6210-course topics: Required book: Rudin, Real & Complex Analysis, 3rd ed, second half of the book):

TOC Rudin.

In class we cover material from chapters 10-20 in **Rudin, Real & Complex**, supplemented with current and related topics.

Course plan: Ch10, holomorphic functions; ch 11 harmonic functions, ch 12 harmonic analysis, ch 13 rational functions and their limits, ch 14 conformal theory, ch 15 Zeros of Holomorphic Functions, ch 16 Analytic Continuation, ch 17 spaces of holomorphic functions, ch 18 Banach Algebras, ch 19 Holomorphic Fourier Transforms and applications, ch 20 Uniform Approximation. Supplements include material on complex geometry from Lenard Carleson and John Milnor.

Chapter 10 Elementary Properties of Holomorphic Functions 196

Complex differentiation 196

Integration over paths 200

The local Cauchy theorem 204

The power series representation 208

The open mapping theorem 214

The global Cauchy theorem 217

The calculus of residues 224.

Chapter 11 Harmonic Functions 231

The Cauchy-Riemann equations 231

The Poisson integral 233

The mean value property 237

Boundary behavior of Poisson integrals 239

Representation theorems 245.

Chapter 12 The Maximum Modulus Principle 253

Introduction 253

The Schwarz lemma 254

The Phragmen-Lindelof method 256

An interpolation theorem 260

A converse of the maximum modulus theorem 262.

Chapter 13 Approximation by Rational Functions 266

Preparation 266

Runge's theorem 270

The Mittag-Lerner theorem 273
 Simply connected regions 274.
Chapter 14 Conformal Mapping 278
 Preservation of angles 278
 Linear fractional transformations 279
 Normal families 281
 The Riemann mapping theorem 282
 The class $[I'$ 285
 Continuity at the boundary 289
 Conformal mapping of an annulus 291.
Chapter 15 Zeros of Holomorphic Functions 298
 Infinite products 298
 The Weierstrass factorization theorem 301
 An interpolation problem 304
 Jensen's formula 307
 Blaschke products 310
 The Miintz-Szasz theorem 312.
Chapter 16 Analytic Continuation 319
 Regular points and singular points 319
 Continuation along curves 323
 The monodromy theorem 326
 Construction of a modular function 328
 The Picard theorem 331.
Chapter 17 HP-Spaces 335
 Subharmonic functions 335
 The spaces HP and N 337
 The theorem of F. and M. Riesz 341
 Factorization "theorems 342
 The shift operator 346
 Conjugate functions 350.
Chapter 18 Elementary Theory of Banach Algebras 356
 Introduction 356
 The invertible elements 357
 Ideals and homomorphisms, Gelfand theory 362
 Applications 365.
Chapter 19 Holomorphic Fourier Transforms 371
 Introduction 371
 Two theorems of Paley and Wiener 372
 Quasi-analytic classes 377
 The Denjoy-Carleman theorem 380.

Chapter 20 Uniform Approximation by Polynomials 386
 Introduction 386
 Some lemmas 387
 Mergelyan's theorem 390.

The combined list of course-topics is flexible, as per student requests, and it includes: One and several complex variables, contour integrals, conformal maps, Cauchy's theorems, conformal geometry, Riemann mapping, Riemann surfaces, complex manifolds, harmonic analysis (especially H^p spaces), analytic continuation of the Fourier transform, Hilbert spaces arising from analytic continuation of Fourier transforms (many important applications), Reproducing Kernel Hilbert Spaces(RKHS) of analytic functions, and their applications, approximation by polynomials and by rational functions. Also covered will be connections to neighboring areas, e.g., to PDEs, to geometry, operator theory, spectral theory, numerical analysis, functional analysis. New directions include: complex dynamics, see e.g., <https://www.amazon.com/Complex-Dynamics-Universitext-Lennart-Carleson/dp/0387979425>

Dates for midterms and the final exam will be announced in class and in ICON. Weekly homework due on Wednesdays. Palle Jorgensen, palle-jorgensen@uiowa.edu .

Recommendation. Get used to MathSciNet.

<https://mathscinet.ams.org/mathscinet/> [log in with your university ID.](#)

[MathSciNet - The University of Iowa](#)

<http://purl.lib.uiowa.edu/mathscinet>

Academic Calendar

- January 15 Martin Luther King, Jr. Convocation--All Classes Suspended; Offices Closed
- January 16 **Opening of Classes**
- March 10 - 17 Spring Break
- March 18 Classes resume
- May 3 Close of Classes
- May 6 - 10 Final Examination Week
- May 9 - 12 Commencement ceremonies. Visit the [Commencement website](#) for more information.

For the list of CLAS policies for grad courses, see below.

Graduate seminars, fyi.

Often graduate students in our Analysis 6000 sequence also attend weekly seminars. The Math Dept website maintains and updates a website with all the seminars that run during the semester. Relevant to students in Analysis II, we have two standing seminars with analysis topics, they take place on Tuesdays every semester, spring or fall.

Last semester they happened via zoom links, and I expect that we will also be virtual in the spring 21 semester. If we manage to go hybrid, I will update you. The classroom we have used for a long time is in the physics building, VAN 309.

The seminars are timed as follows, Tuesdays 1:30 Operator Theory, and 2:30 Mathematical Physics.

The title of the seminars, OT (Operator theory), and MP (Math physics), are to be understood in the broad sense, and we always have a lot of analysis topics. In fact, a diverse areas of math, of physics, and their interconnections.

What is even better is that **graduate students are encouraged to suggest topics, and also to present, in the seminars.** The organizational meeting for the combined pair of seminars will be Tuesday 1/26 at 1:30 pm. If you might be interested in presenting, just send me an email. More fyi to follow. From ICON:

Organization. we will the seminars every Tuesday in person in VAN 309 (VAN is the physics building), and also make the zoom link be available for anyone who is interested in our seminars. For example, we want to make sure that this access is not restricted to folks who are registered in the ICON system.

We welcome everyone to our seminars. The idea is that we offer students choices, for example, to take one or both of our seminars as a grad course, or alternatively just attend seminars as part of your thesis research. Also an opportunity for you to expand your research horizons. If you go to one or more seminars, you may also select to go to some but not all talks.

COLLEGE OF LIBERAL ARTS AND SCIENCES (CLAS)

Graduate Course Syllabus Insert. Spring 2024.

ATTENDANCE AND CLASSROOM EXPECTATIONS.

Students are responsible for attending class and for knowing an instructor's attendance policies, which vary by course and content area. All students are expected to attend class and to contribute to its learning environment in part by complying with University-policies and directives regarding appropriate classroom behavior or other matters.

ABSENCES.

Students are responsible for communicating with instructors as soon they know that an absence might occur or as soon as possible in the case of an illness. Delays in communication could result in a forfeit of what otherwise might be an excused absence.

ABSENCES: ILLNESS, UNAVOIDABLE CIRCUMSTANCES, AND UNIVERSITY

SPONSORED ACTIVITIES.

Students who are ill, in an unavoidable circumstance affecting academic work, or who miss class because of a University-sponsored activity are allowed by UI policy to make up a missed exam. Documentation is required by the instructor except in the case of a brief illness. Students are responsible for communicating with instructors as soon as the absence is known (<https://opsmanual.uiowa.edu/students/absences-class#8.1>).

ABSENCES: HOLY DAYS.

The University is prepared to make reasonable accommodations for students whose religious holy days coincide with their classroom assignments, test schedules, and classroom attendance expectations. Students must notify their instructors in writing of any such Religious Holy Day conflicts or absences within the first few days of the semester or session, and no later than the third week of the semester. If the conflict or absence will occur within the first three weeks of the semester, the student should notify the instructor as soon as possible. See Operations Manual 8.2 Absences for Religious Holy Days for additional information.

ABSENCES: MILITARY SERVICE OBLIGATIONS.

Students absent from class due to U.S. veteran or U.S. military service obligations (including military service-related medical appointments, military orders, and National Guard Service obligations) must be excused without penalty.

Instructors must make reasonable accommodations to allow students to make-up exams or other work. Students must communicate with their instructors about the expected possibility of missing class as soon as possible. (For more information, see <https://opsmanual.uiowa.edu/iv-8-absences-class%C2%A0-0>).

ACADEMIC MISCONDUCT.

Plagiarism and the process for addressing academic misconduct of graduate students are defined in Section IV, Article F

“Plagiarism by Graduate Students” of the UI Graduate College Manual of Rules and Regulations. Please contact the CLAS Associate Dean for Graduate Education for any necessary assistance in navigating the process mandated by the Graduate College.

ACADEMIC ACCOMMODATIONS.

The University is committed to providing an educational experience that is accessible to all students. If a student has a

diagnosed disability or other disabling condition that may impact the student’s ability to complete the course requirements as stated in the syllabus, the student may seek accommodations through Student Disability

Services (SDS). SDS is responsible for making Letters of Accommodation (LOA) available to the student. The student must provide a LOA to the instructor as early in the semester as possible, but requests not made at least two weeks prior to the scheduled activity for which an accommodation is sought may not be accommodated. The LOA will specify what reasonable course accommodations the student is eligible for and those the instructor should provide. Additional information can be found on the SDS website. Note that accommodations are not granted retroactively but from the time of the student’s request to the instructor onward. Graduate students serving as Teaching Assistants, Research

Assistants, or Fellows must contact Faculty and Staff Disability Services (<https://hr.uiowa.edu/support/faculty-and-staff-disability-services>) for assistance with accommodations.

COMMUNICATION: UI EMAIL

Students are responsible for all official correspondences sent to their UI email address (uiowa.edu) and must use this address for any communication with instructors or staff in the UI community (Operations Manual, III.15.2). Emails should be respectful and brief, with complex matters addressed during the instructor's drop-in hours, for example.

Faculty are not expected to answer email after business hours or during the weekends.

FREE SPEECH AND EXPRESSION.

The University of Iowa supports and upholds the First Amendment protection of freedom of speech and the principles of academic and artistic freedom. We are committed to open inquiry, vigorous debate, and creative expression inside and outside of the classroom. Visit Free Speech at Iowa for more information on the University's policies on free speech and academic freedom: <https://freespeech.uiowa.edu/>.

COMPLAINTS ABOUT ACADEMIC MATTERS.

Students with a complaint about a grade or a related academic matter should first visit with the instructor and then with the course supervisor (if applicable), and finally with the director of the school, department, or program offering the course. If a graduate student has not been able to resolve the issue through the director of the school, department, or program, they should contact the associate dean for graduate education in the College of Liberal Arts and Sciences.

FINAL EXAMINATION POLICIES.

The final exam schedule is published during the fifth week of the fall and spring semesters or on the first day of summer classes; students are responsible for knowing the date, time, and place of their final exams. Students should not make travel plans until knowing this information. A student with exams scheduled on the same day and time or who have more than two final exams on the same day should visit this page for how to resolve these problems by the given deadline (<https://registrar.uiowa.edu/makeup-final-examination-policies>). No exams are allowed the week before finals, but with some exceptions made for labs, language courses, and off-cycle courses (<https://registrar.uiowa.edu/final-examination-scheduling-policies>).

HOME OF THE COURSE.

The College of Liberal Arts and Sciences (CLAS) is the home of this course, and CLAS governs the policies and procedures for its courses. Graduate students, however, must adhere to the academic deadlines set by the Graduate College. See <https://grad.uiowa.edu/academics/deadlines> .

NON-DISCRIMINATION STATEMENT.

The University of Iowa prohibits discrimination in employment, educational programs, and activities on the basis of race, creed, color, religion, national origin, age, sex, pregnancy, disability, genetic information, status as a U.S. veteran, service in the U.S. military, sexual orientation, gender identity, associational preferences, or any other classification

that deprives the person of consideration as an individual. The university also affirms its commitment to providing equal opportunities and equal access to university facilities. For additional information on nondiscrimination policies, contact the Director, Office of Institutional Equity, the University of Iowa, 202 Jessup Hall, Iowa City, IA 52242-1316, 319-335-0705, oi-e-ui@uiowa.edu . Students may share their pronouns and chosen/preferred names in MyUI, which is accessible to instructors and advisors.

SEXUAL HARASSMENT.

The University of Iowa prohibits all forms of sexual harassment, sexual misconduct, and related retaliation. The Policy on Sexual Harassment and Sexual Misconduct governs actions by students, faculty, staff and visitors. Incidents of sexual harassment or sexual misconduct can be reported to the Title IX and Gender Equity Office or to the Department of Public Safety. Students impacted by sexual harassment or sexual misconduct may be eligible for academic supportive measures and can learn more by contacting the Title IX and Gender Equity Office. Information about confidential resources can be found here. Watch the video for an explanation of these resources.