

GRADUATE STUDIES  
IN MATHEMATICS **53**

**Spectral Methods of  
Automorphic Forms**  
Second Edition

**Henryk Iwaniec**



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# Spectral Methods Of Automorphic Forms

**SB Merriam**



## **Spectral Methods Of Automorphic Forms:**

Spectral Methods of Automorphic Forms Henryk Iwaniec, 2021-11-17 Automorphic forms are one of the central topics of analytic number theory. In fact, they sit at the confluence of analysis, algebra, geometry, and number theory. In this book, Henryk Iwaniec once again displays his penetrating insight, powerful analytic techniques, and lucid writing style. The first edition of this book was an underground classic both as a textbook and as a respected source for results, ideas, and references. Iwaniec treats the spectral theory of automorphic forms as the study of the space of  $L^2$  functions on the upper half plane modulo a discrete subgroup. Key topics include Eisenstein series, estimates of Fourier coefficients, Kloosterman sums, the Selberg trace formula, and the theory of small eigenvalues. Henryk Iwaniec was awarded the 2002 Cole Prize for his fundamental contributions to number theory.

Automorphic Forms and Zeta Functions Siegfried Böcherer, 2006 This volume contains a valuable collection of articles presented at a conference on Automorphic Forms and Zeta Functions in memory of Tsuneo Arakawa, an eminent researcher in modular forms in several variables and zeta functions. The book begins with a review of his works, followed by 16 articles by experts in the fields, including H. Aoki, R. Berndt, K. Hashimoto, S. Hayashida, Y. Hironaka, H. Katsurada, W. Kohnen, A. Krieg, A. Murase, H. Narita, T. Oda, B. Roberts, R. Schmidt, R. Schulze-Pillot, N. Skoruppa, T. Sugano, and D. Zagier. A variety of topics in the theory of modular forms and zeta functions are covered: Theta series and the basis problems, Jacobi forms, automorphic forms on  $Sp(1, q)$ , double zeta functions, special values of zeta and  $L$  functions, many of which are closely related to Arakawa's works. This collection of papers illustrates Arakawa's contributions and the current trends in modular forms in several variables and related zeta functions.

Contents: Tsuneo Arakawa and His Works; Estimate of the Dimensions of Hilbert Modular Forms by Means of Differential Operator; H. Aoki; Marsden-Weinstein Reduction, Orbits, and Representations of the Jacobi Group; R. Berndt; On Eisenstein Series of Degree Two for Squarefree Levels and the Genus Version of the Basis Problem; I. S. Böcherer; Double Zeta Values and Modular Forms; H. Gangl et al; Type Numbers and Linear Relations of Theta Series for Some General Orders of Quaternion Algebras; K. Hashimoto; Skewholomorphic Jacobi Forms of Higher Degree; S. Hayashida; A Hermitian Analog of the Schottky Form; M. Hentschel; The Siegel Series and Spherical Functions on  $O(2n, n) \times O(n, n)$ ; Y. Hironaka; Koecher-Maa Series for Real Analytic Siegel Eisenstein Series; T. Ibukiyama; A Short History on Investigation of the Special Values of Zeta and  $L$  Functions of Totally Real Number Fields; T. Ishii; Genus Theta Series; Hecke Operators and the Basis Problem for Eisenstein Series; H. Katsurada; The Quadratic Mean of Automorphic  $L$  Functions; W. Kohnen et al; Inner Product Formula for Kudla Lift; A. Murase; On Certain Automorphic Forms of  $Sp(1, q)$ ; Arakawa's Results and Recent Progress; H. Narita; On Modular Forms for the Paramodular Group; B. Roberts;  $SL(2, \mathbb{Z})$ -Invariant Spaces Spanned by Modular Units; N. P. Skoruppa; W. Eholzer; Readership: Researchers and graduate students in number theory or representation theory, as well as in mathematical physics or combinatorics.

*Automorphic Forms And Zeta Functions - Proceedings Of The Conference In Memory Of Tsuneo Arakawa* Masanobu Kaneko, Siegfried Böcherer, Tomoyoshi

Ibukiyama, Fumihiko Sato, 2006-01-03 This volume contains a valuable collection of articles presented at a conference on Automorphic Forms and Zeta Functions in memory of Tsuneo Arakawa an eminent researcher in modular forms in several variables and zeta functions The book begins with a review of his works followed by 16 articles by experts in the fields including H Aoki R Berndt K Hashimoto S Hayashida Y Hironaka H Katsurada W Kohnen A Krieg A Murase H Narita T Oda B Roberts R Schmidt R Schulze Pillot N Skoruppa T Sugano and D Zagier A variety of topics in the theory of modular forms and zeta functions are covered Theta series and the basis problems Jacobi forms automorphic forms on  $Sp(1, q)$  double zeta functions special values of zeta and L functions many of which are closely related to Arakawa's works This collection of papers illustrates Arakawa's contributions and the current trends in modular forms in several variables and related zeta functions

, *Eisenstein Series and Automorphic L-Functions* Freydoon Shahidi, 2025-04-07 This book presents a treatment of the theory of L functions developed by means of the theory of Eisenstein series and their Fourier coefficients a theory which is usually referred to as the Langlands Shahidi method The information gathered from this method when combined with the converse theorems of Cogdell and Piatetski-Shapiro has been quite sufficient in establishing a number of new cases of Langlands functoriality conjecture at present some of these cases cannot be obtained by any other method These results have led to far reaching new estimates for Hecke eigenvalues of Maass forms as well as definitive solutions to certain problems in analytic and algebraic number theory This book gives a detailed treatment of important parts of this theory including a rather complete proof of Casselman-Shalika's formula for unramified Whittaker functions as well as a general treatment of the theory of intertwining operators It also covers in some detail the global aspects of the method as well as some of its applications to group representations and harmonic analysis This book is addressed to graduate students and researchers who are interested in the Langlands program in automorphic forms and its connections with number theory

*An Introduction to Automorphic Representations* Jayce R. Getz, Heekyoung Hahn, 2024-03-01 The goal of this textbook is to introduce and study automorphic representations objects at the very core of the Langlands Program It is designed for use as a primary text for either a semester or a year long course for the independent study of advanced topics or as a reference for researchers The reader is taken from the beginnings of the subject to the forefront of contemporary research The journey provides an accessible gateway to one of the most fundamental areas of modern mathematics with deep connections to arithmetic geometry representation theory harmonic analysis and mathematical physics The first part of the text is dedicated to developing the notion of automorphic representations Next it states a rough version of the Langlands functoriality conjecture motivated by the description of unramified admissible representations of reductive groups over nonarchimedean local fields The next chapters develop the theory necessary to make the Langlands functoriality conjecture precise Thus supercuspidal representations are defined locally cuspidal representations and Eisenstein series are defined globally and Rankin-Selberg L functions are defined to give a link between the global and local settings This preparation complete the

global Langlands functoriality conjectures are stated and known cases are discussed This is followed by a treatment of distinguished representations in global and local settings The link between distinguished representations and geometry is explained in a chapter on the cohomology of locally symmetric spaces in particular Shimura varieties The trace formula an immensely powerful tool in the Langlands Program is discussed in the final chapters of the book Simple versions of the general relative trace formulae are treated for the first time in a textbook and a wealth of related material on algebraic group actions is included Outlines for several possible courses are provided in the Preface Lectures on Linear Partial Differential Equations Grigoriĭ Il'ich Eskin, 2011 This is a reader friendly relatively short introduction to the modern theory of linear partial differential equations An effort has been made to present complete proofs in an accessible and self contained form The first three chapters are on elementary distribution theory and Sobolev spaces The following chapters study the Cauchy problem for parabolic and hyperbolic equations boundary value problems for elliptic equations heat trace asymptotics and scattering theory

**Riemann Surfaces by Way of Complex Analytic Geometry** Dror Varolin, 2011-08-10 This book establishes the basic function theory and complex geometry of Riemann surfaces both open and compact Many of the methods used in the book are adaptations and simplifications of methods from the theories of several complex variables and complex analytic geometry and would serve as excellent training for mathematicians wanting to work in complex analytic geometry After three introductory chapters the book embarks on its central and certainly most novel goal of studying Hermitian holomorphic line bundles and their sections Among other things finite dimensionality of spaces of sections of holomorphic line bundles of compact Riemann surfaces and the triviality of holomorphic line bundles over Riemann surfaces are proved with various applications Perhaps the main result of the book is Hormander's Theorem on the square integrable solution of the Cauchy Riemann equations The crowning application is the proof of the Kodaira and Narasimhan Embedding Theorems for compact and open Riemann surfaces The intended reader has had first courses in real and complex analysis as well as advanced calculus and basic differential topology though the latter subject is not crucial As such the book should appeal to a broad portion of the mathematical and scientific community This book is the first to give a textbook exposition of Riemann surface theory from the viewpoint of positive Hermitian line bundles and Hormander bar partial estimates It is more analytical and PDE oriented than prior texts in the field and is an excellent introduction to the methods used currently in complex geometry as exemplified in J P Demailly's online but otherwise unpublished book Complex analytic and differential geometry I used it for a one quarter course on Riemann surfaces and found it to be clearly written and self contained It not only fills a significant gap in the large textbook literature on Riemann surfaces but is also rather indispensable for those who would like to teach the subject from a differential geometric and PDE viewpoint Steven Zelditch

**An Introduction to Measure Theory** Terence Tao, 2021-09-03 This is a graduate text introducing the fundamentals of measure theory and integration theory which is the foundation of modern real analysis The text focuses first on the concrete

setting of Lebesgue measure and the Lebesgue integral which in turn is motivated by the more classical concepts of Jordan measure and the Riemann integral before moving on to abstract measure and integration theory including the standard convergence theorems Fubini's theorem and the Carathéodory extension theorem Classical differentiation theorems such as the Lebesgue and Rademacher differentiation theorems are also covered as are connections with probability theory The material is intended to cover a quarter or semester's worth of material for a first graduate course in real analysis There is an emphasis in the text on tying together the abstract and the concrete sides of the subject using the latter to illustrate and motivate the former The central role of key principles such as Littlewood's three principles as providing guiding intuition to the subject is also emphasized There are a large number of exercises throughout that develop key aspects of the theory and are thus an integral component of the text As a supplementary section a discussion of general problem solving strategies in analysis is also given The last three sections discuss optional topics related to the main matter of the book [An Epsilon of Room, I: Real Analysis](#) Terence Tao, 2022-11-16 In 2007 Terry Tao began a mathematical blog to cover a variety of topics ranging from his own research and other recent developments in mathematics to lecture notes for his classes to nontechnical puzzles and expository articles The first two years of the blog have already been published by the American Mathematical Society The posts from the third year are being published in two volumes The present volume consists of a second course in real analysis together with related material from the blog The real analysis course assumes some familiarity with general measure theory as well as fundamental notions from undergraduate analysis The text then covers more advanced topics in measure theory notably the Lebesgue Radon-Nikodym theorem and the Riesz representation theorem topics in functional analysis such as Hilbert spaces and Banach spaces and the study of spaces of distributions and key function spaces including Lebesgue's  $L^p$  spaces and Sobolev spaces There is also a discussion of the general theory of the Fourier transform The second part of the book addresses a number of auxiliary topics such as Zorn's lemma the Carathéodory extension theorem and the Banach-Tarski paradox Tao also discusses the epsilon regularisation argument a fundamental trick from soft analysis from which the book gets its title Taken together the book presents more than enough material for a second graduate course in real analysis The second volume consists of technical and expository articles on a variety of topics and can be read independently [Linear Algebra in Action](#) Harry Dym, 2007 Linear algebra permeates mathematics perhaps more so than any other single subject It plays an essential role in pure and applied mathematics statistics computer science and many aspects of physics and engineering This book conveys in a user friendly way the basic and advanced techniques of linear algebra from the point of view of a working analyst The techniques are illustrated by a wide sample of applications and examples that are chosen to highlight the tools of the trade In short this is material that the author wishes he had been taught as a graduate student Roughly the first third of the book covers the basic material of a first course in linear algebra The remaining chapters are devoted to applications drawn from vector calculus numerical analysis control theory complex

analysis convexity and functional analysis In particular fixed point theorems extremal problems matrix equations zero location and eigenvalue location problems and matrices with nonnegative entries are discussed Appendices on useful facts from analysis and supplementary information from complex function theory are also provided for the convenience of the reader The book is suitable as a text or supplementary reference for a variety of courses on linear algebra and its applications as well as for self study

**Automorphic Representations and L-Functions for the General Linear Group: Volume 1** Dorian Goldfeld, Joseph Hundley, 2011-04-21 This graduate level textbook provides an elementary exposition of the theory of automorphic representations and L functions for the general linear group in an adelic setting Definitions are kept to a minimum and repeated when reintroduced so that the book is accessible from any entry point and with no prior knowledge of representation theory The book includes concrete examples of global and local representations of  $GL_n$  and presents their associated L functions In Volume 1 the theory is developed from first principles for  $GL_1$  then carefully extended to  $GL_2$  with complete detailed proofs of key theorems Several proofs are presented for the first time including Jacquet's simple and elegant proof of the tensor product theorem In Volume 2 the higher rank situation of  $GL_n$  is given a detailed treatment Containing numerous exercises by Xander Faber this book will motivate students and researchers to begin working in this fertile field of research

**Functional Analysis** Yuli Eidelman, Vitali D. Milman, Antonis Tsoolomitis, 2004 Introduces the methods and language of functional analysis including Hilbert spaces Fredholm theory for compact operators and spectral theory of self adjoint operators This work presents the theorems and methods of abstract functional analysis and applications of these methods to Banach algebras and theory of unbounded self adjoint operators

[A Course on the Web Graph](#) Anthony Bonato, 2008 A Course on the Web Graph provides a comprehensive introduction to state of the art research on the applications of graph theory to real world networks such as the web graph It is the first mathematically rigorous textbook discussing both models of the web graph and algorithms for searching the web After introducing key tools required for the study of web graph mathematics an overview is given of the most widely studied models for the web graph A discussion of popular web search algorithms e.g PageRank is followed by additional topics such as applications of infinite graph theory to the web graph spectral properties of power law graphs domination in the web graph and the spread of viruses in networks The book is based on a graduate course taught at the AARMS 2006 Summer School at Dalhousie University As such it is self contained and includes over 100 exercises The reader of the book will gain a working knowledge of current research in graph theory and its modern applications In addition the reader will learn first hand about models of the web and the mathematics underlying modern search engines Publisher's description

*$C^*$ -Algebras and Finite-Dimensional Approximations* Nathanial P. Brown, Narutaka Ozawa, 2025-01-16  $C^*$  approximation theory has provided the foundation for many of the most important conceptual breakthroughs and applications of operator algebras This book systematically studies most of the numerous types of approximation properties that have been important in recent years

nuclearity exactness quasidiagonality local reflexivity and others Moreover it contains user friendly proofs insofar as that is possible of many fundamental results that were previously quite hard to extract from the literature Indeed perhaps the most important novelty of the first ten chapters is an earnest attempt to explain some fundamental but difficult and technical results as painlessly as possible The latter half of the book presents related topics and applications written with researchers and advanced well trained students in mind The authors have tried to meet the needs both of students wishing to learn the basics of an important area of research as well as researchers who desire a fairly comprehensive reference for the theory and applications of  $C^*$  approximation theory

**Topics in Random Matrix Theory** Terence Tao, 2023-08-24 The field of random matrix theory has seen an explosion of activity in recent years with connections to many areas of mathematics and physics However this makes the current state of the field almost too large to survey in a single book In this graduate text we focus on one specific sector of the field namely the spectral distribution of random Wigner matrix ensembles such as the Gaussian Unitary Ensemble as well as iid matrix ensembles The text is largely self contained and starts with a review of relevant aspects of probability theory and linear algebra With over 200 exercises the book is suitable as an introductory text for beginning graduate students seeking to enter the field

*Modern Geometric Structures and Fields* Сергей Петрович Новиков, Искандер Асанович Тайманов, 2006 Presents the basics of Riemannian geometry in its modern form as geometry of differentiable manifolds and the important structures on them This book shows that Riemannian geometry has a great influence to several fundamental areas of modern mathematics and its applications

**Training Manual on Transport and Fluids** John C. Neu, 2009-11-30 I have learned a lot from John Neu over the past years and his book reflects very well his sense of style and purpose Walter Craig McMaster University Hamilton Ontario Canada and Fields Institute for Research in Mathematical Sciences Toronto Ontario Canada John Neu's book presents the basic ideas of fluid mechanics and of the transport of matter in a clear and reader friendly way Then it proposes a collection of problems starting with easy ones and gradually leading up to harder ones Each problem is solved with all the steps explained In the course of solving these problems many fundamental methods of analysis are introduced and explained This is an ideal book for use as a text or for individual study Joseph B Keller Stanford University This book presents elementary models of transport in continuous media and a corresponding body of mathematical technique Physical topics include convection and diffusion as the simplest models of transport local conservation laws with sources as the general framework of continuum mechanics ideal fluid as the simplest model of a medium with mass momentum and energy transport and finally free surface waves in particular shallow water theory There is a strong emphasis on dimensional analysis and scaling Some topics such as physical similarity and similarity solutions are traditional In addition there are reductions based on scaling such as incompressible flow as a limit of compressible flow and shallow water theory derived asymptotically from the full equations of free surface waves More and deeper examples are presented as problems including a series of problems that model a tsunami approaching the shore The



problems form an embedded subtext to the book Each problem is followed by a detailed solution emphasizing process and craftsmanship The problems express the practice of applied mathematics as the examination and re examination of simple but essential ideas in many interrelated examples

**Mapping Degree Theory** Enrique Outerelo, Jes s M. Ruiz, 2009-11-12  
This textbook treats the classical parts of mapping degree theory with a detailed account of its history traced back to the first half of the 18th century After a historical first chapter the remaining four chapters develop the mathematics An effort is made to use only elementary methods resulting in a self contained presentation Even so the book arrives at some truly outstanding theorems the classification of homotopy classes for spheres and the Poincare Hopf Index Theorem as well as the proofs of the original formulations by Cauchy Poincare and others Although the mapping degree theory you will discover in this book is a classical subject the treatment is refreshing for its simple and direct style The straightforward exposition is accented by the appearance of several uncommon topics tubular neighborhoods without metrics differences between class 1 and class 2 mappings Jordan Separation with neither compactness nor cohomology explicit constructions of homotopy classes of spheres and the direct computation of the Hopf invariant of the first Hopf fibration The book is suitable for a one semester graduate course There are 180 exercises and problems of different scope and difficulty

**Differential Algebraic Topology** Matthias Kreck, 2010 This book presents a geometric introduction to the homology of topological spaces and the cohomology of smooth manifolds The author introduces a new class of stratified spaces so called stratifolds He derives basic concepts from differential topology such as Sard s theorem partitions of unity and transversality Based on this homology groups are constructed in the framework of stratifolds and the homology axioms are proved This implies that for nice spaces these homology groups agree with ordinary singular homology Besides the standard computations of homology groups using the axioms straightforward constructions of important homology classes are given The author also defines stratifold cohomology groups following an idea of Quillen Again certain important cohomology classes occur very naturally in this description for example the characteristic classes which are constructed in the book and applied later on One of the most fundamental results Poincare duality is almost a triviality in this approach Some fundamental invariants such as the Euler characteristic and the signature are derived from co homology groups These invariants play a significant role in some of the most spectacular results in differential topology In particular the author proves a special case of Hirzebruch s signature theorem and presents as a highlight Milnor s exotic 7 spheres This book is based on courses the author taught in Mainz and Heidelberg Readers should be familiar with the basic notions of point set topology and differential topology The book can be used for a combined introduction to differential and algebraic topology as well as for a quick presentation of co homology in a course about differential geometry

## The Enigmatic Realm of **Spectral Methods Of Automorphic Forms**: Unleashing the Language is Inner Magic

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