More Tales of Our Forefathers

Barry Simon
Mathematics and Theoretical Physics
California Institute of Technology
Pasadena, CA, U.S.A.
Some Caveats

This is not a mathematics talk

Introduction

Riemann, Euler, Gauss
Newton, Hilbert, Poincaré
Riesz², Szegő, von Neumann
Kato, Loewner, Verblunsky
Blumenthal, Pick, Tauber
Landau, König, Marcinkiewicz
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1. I am not a historian and I’ve no faith that all that I’m telling you is true. None of the stories was made up, at least by me.

2. I regret that this is mainly about forefathers and not foremothers also, although there will be one female mathematician among 22 mathematicians.
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Mostly we remember mathematicians by applying their names to theorems and to mathematical objects. In this regard, I quote The Arnold Principle. “If a notion bears a personal name, then this name is not the name of the discoverer.”
Three Great Mathematicians

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In the modern era, there is enough infrastructure that for the past 50 years, many great mathematicians quickly found important positions and lived rather dull lives (although there can be political upheavals that change that). But the lack of many university positions and limited contact between groups means that this is less true of the greats of 150-250 years ago.
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- He spent his career employed by the Academies of Science, first in St. Petersburg (1727-41), then Berlin (1741-66) and then St. Petersburg (1766-83) again.
- A remarkable thing about that is that he was totally blind from 1766 but continued to produce many papers until his death!
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Euler

Five Greatest Whatevers

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In 1801, he published his masterpiece, *Disquisitiones Arithmeticae* on number theory and also in that year gained great fame for the following:
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He spent his career as the observatory director and, in addition to his “pure mathematics”, developed techniques in magnetism, geodesy, and potential theory. Indeed, his work on Gaussian curvature and Gauss’ law (on div and integrals) had roots in this applied work.
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6 In 1827, Abel and Jacobi revolutionized the theory of elliptic integrals by understanding that their inverse functions were doubly periodic (what we now call elliptic functions). But in his notebooks starting about 1796, Gauss had this basic idea, at least for a special case called the Lemniscate integral.
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But somehow that hasn’t been enough and there have been persistent stories that his attitude is connected to the reception that his masterpiece *Disquisitiones Arithmeticae* got from the French Academy. W.W. Rouse Ball (1850-1925) claimed in a history of mathematics that Gauss submitted the manuscript in 1800 to the French Academy and they rejected it with a snide description of the work.
There is no direct evidence for this claim and some modern historians of mathematics say there is no validity to the idea.
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Here is what G. N. Watson (1886-1965) (of Whittaker-Watson and *Bessel Function* fame) had to say in his retiring presidential address of the British Mathematical Association which was entitled *The Marquis and the Land-Agent; A Tale of the Eighteenth Century.*
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So much for the impact of not publishing!
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Hilbert’s early work involved aspects of algebra – particularly, invariant theory (Hilbert basis theory) and algebraic number theory.
Introduction

Riemann, Euler, Gauss

Newton, Hilbert, Poincaré

Riesz², Szegő, von Neumann

Kato, Loewner, Verblunsky

Blumenthal, Pick, Tauber

Landau, König, Marcinkiewicz

Krein, Noether, Thomson

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"At that moment I left Caen where I then lived, to take part in a geological expedition organized by the École des Mines. The circumstances of the journey made me forget my mathematical work; arrived at Coutances we boarded an omnibus for I don’t know what journey."
Poincaré

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Introduction

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Newton, Hilbert, Poincaré

Riesz, Szegő, von Neumann

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Poincaré

He has several books about celestial mechanics and his work on the 3-body problem is what first gained him wide fame because he got a prize from the King of Sweden for it. He wrote cogently on the issues underlying statistical mechanics and, in this context, proved the celebrated Poincaré recurrence theorem that if a phase space has finite volume then the system returns arbitrarily close to its initial condition after long times.

Poincaré was the founder of modern algebraic topology. Following up on work of Schwarz and Klein, he formalized the theory of covering spaces and defined the fundamental group. He invented Homology theory, proved Poincaré duality and stated the Poincaré conjecture (originally as a theorem with an incorrect proof).
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He also said “We have seen a rabble of functions arise whose only job, it seems, is to look as little as possible like decent and useful functions. No more continuity, or perhaps continuity but no derivatives...
He also said “We have seen a rabble of functions arise whose only job, it seems, is to look as little as possible like decent and useful functions. No more continuity, or perhaps continuity but no derivatives. . . Yesterday, if a new function was invented it was to serve some practical end; today they are specially invented only to show up the arguments of our fathers, and they will never have any other use.”
Hungary

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Introduction

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Newton, Hilbert, Poincaré
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Picking only three mathematicians isn’t easy but the deepest ones, at least from the first half of the last century, are clearly Riesz, Szegő and von Neumann. Of course, there were Riesz brothers so I get to discuss four and up the total number to 22. Remarkably, F. Riesz was a student with Lipót Fejér (1880–1959) but the other three – M. Riesz, Szegő and von Neumann – were all students of Fejér.
Frigyes Riesz (1880–1956) was a Jewish–Hungarian mathematician whose students included Horvath, Radó, Rényi and Sz-Nagy.
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Riesz and his brother as well as Haar, König and Fejér never married and he told his student Kalmar that he shouldn’t marry but instead devote his life to science. As one of Riesz’ students reports: “However, Kalmar did get married. This made Riesz lose his temper to some extent. For a while he was nervous and impatient to Kalmar.”
Then he calmed down. Kalmar’s wife was also an able mathematician, and Riesz liked her, as all of us did.
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This would lead to disconcerting results for the collaborator, who was perpetually out of step. An example was told me by Tibor Rado, his ex-assistant. During the academic year, Riesz would lecture on measure theory and functional analysis. Rado would take copious notes.
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“Oh, very good, very good. Yes, this is very nice, really nice. But let me tell you. During the summer I had an idea. We will do it all another way. You will see as I give the course. You will like it.”
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10. Definition of Hardy spaces ($H^p$) and Riesz factorization
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- Riesz Products
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19 Orthogonal Projections by Minimization
F. Riesz

20  Definition and basic theory of subharmonic functions
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20. Definition and basic theory of subharmonic functions
21. Riesz decomposition of subharmonic functions
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22 Projections associated to components of spectrum
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23 Riesz Spaces (vector lattices) and their duality
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F. Riesz

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24 Polar Decomposition Proof of Spectral Theorem
25 Riesz Sunshine Lemma
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27 HL Maximal Inequality \Rightarrow \text{ Lebesgue Differentiation}
## F. Riesz

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János was Johann when he worked in Germany and after coming to the United States became John, universally called Johnny. Johnny was a child prodigy and his father arranged tutoring—the stories say that both Szegő and Fekete tutored him and both were very impressed. He was the ultimate double major. He registered as a math student in Budapest and at the same time studied chemistry, first in Berlin and later in Zürich, returning to Budapest only to ace his math exams. And he didn't hesitate to discuss math, for example, with Weyl in Zürich when he was officially a chemistry student.
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I want to end my discussion of von Neumann with some fascinating history behind the von Neumann and Birkhoff ergodic theorems. In early 1931, Bernard Osgood Koopman (1900–81) published a short note that explained that measure-preserving dynamics induced unitary operators on $L^2(\Omega, d\mu)$ and suggested that the newly discovered (by Stone and von Neumann) spectral resolution and eigenvectors/eigenvalues might be significant, but he didn’t do anything further with this.
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At the beginning of October 1931, von Neumann, then in Princeton, went to New York where Koopman was on the Columbia faculty and told Koopman of his result to confirm that Koopman had not found it independently.
Koopman was enthusiastic and suggested that von Neumann publish his result in the Proceedings of the National Academy of Sciences (PNAS), where Koopman’s note had appeared.
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Still later in October, Koopman and George David Birkhoff (1884-1944) came to Princeton for the opening of (old) Fine Hall. There, Koopman and von Neumann told Birkhoff of von Neumann’s result, knowing of Birkhoff’s long interest in the quasi-ergodic hypothesis.
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The issue is that while Birkhoff was clearly motivated by von Neumann, who was first, Birkhoff was more senior, a member of the National Academy, and a good friend of the managing editor of the PNAS (who held the post for almost fifty years!), Harvard chemist, E. B. Wilson.
And Wilson arranged for Birkhoff’s paper to jump the queue and appear in the 1931 volume rather than the 1932 volume and with an earlier communication date! While Birkhoff mentioned von Neumann, the implication is that von Neumann’s work was at best independent and possibly later.
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von Neumann

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Two years earlier, as a graduate student, he had published fundamental work on eigenvalue perturbation recovering and extending earlier work of Rellich. He was only a graduate student at age 32 because he had spent much of the War years in the countryside under bad conditions that caused him to contract tuberculosis.
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Loewner

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Loewner’s remarkable theorem on matrix monotone functions has gotten a growing fan club.
Loewner

(and I joked it was meant to be Schramm’s Lovely Evolution). Since Schramm’s untimely death it has stood for Schramm–Loewner Evolution.

Loewner’s remarkable theorem on matrix monotone functions has gotten a growing fan club. For example, I am writing a monograph on the subject which I describe as a love poem to Loewner’s Theorem.
I conclude the discussion of Loewner with a wonderful quote from his student Lipman Bers: “Loewner was a man whom everybody liked, perhaps because he was a man at peace with himself.”
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Verblunsky

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It was hard going, but as I absorbed the papers, it became clear that there was an enormous number of ideas in these papers that had become important, but then forgotten and later rediscovered!
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Since then there are more than 110 MathSciNet references to Verblunsky’s Theorem or Coefficients. So I guess not only is Verblunsky a personal favorite of mine, I must be personal favorite of his.
Nazi Mayhem

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Nazi Mayhem

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Pick is best known for solving the problem $f(z_j) = w_j$ for Herglotz functions from which we get Pick functions, Pick’s Theorem, Pick matrix and Pick interpolation.
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Alfred Tauber

Tauber was born in Bratislava but spent most of his adult life in Vienna. Unable to find an academic position, he worked from 1892 until 1908 for an insurance company and then spent the rest of his career as a Professor of Actuarial Science. He was arrested on June 28, 1942 and the death date of July 26, 1942 is not certain.
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Starting 15 years later, Hardy and Littlewood proved numerous theorems where one showed a converse of an easy result under additional conditions by the name “Tauberian theorem”. In his great 1932 paper that has his Tauberian theorem, Wiener remarked: “I feel it would be far more appropriate to term these theorems Hardy–Littlewood theorems, were it not that usage has sanctioned the other appellation.”
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Landau submitted his thesis in analytic number theory to the University of Berlin in 1899 although his formal advisor Fröbenius frowned on the subject. He was privatdozent at Berlin from 1899 until 1909 when he moved to Göttingen after the sudden death of Minkowski. The final choice for Minkowski’s successor was between Oskar Perron (1880-1975) and Landau and Felix Klein made the choice saying “Oh, Perron is such a wonderful person. Everybody loves him. Landau is very disagreeable, very difficult to get along with. But we, being a group as we are, it is better that we have a man who is not easy.” In any event Landau was arrogant which will be significant shortly – as a historian wrote: “Landau was also something of a cynical snob. The story is well known that he used to tell people who would ask for his address in Göttingen, You’ll find it easily; it’s the most splendid house in the city.”
Landau's first major result was his 1903 proof of the prime number theorem, first proven by Hadamard and de la Vallée-Poussin independently in 1896.
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Returning to Germany at the end of 1928 was not such a wise move. Hitler came to power on Jan. 30, 1933 and by April 7, there was a law in place allowing the removal of Jewish teachers from Universities. On Nov. 2, 1933, Landau tried to give his first lecture of the fall quarter. Teichmüller objected to the teaching of Jewish calculus rather than Aryan calculus and organized student members of the SA who prevented any students from entering the lecture hall.
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Among the other German Jewish mathematicians fired from their jobs and unable to find suitable jobs outside Germany (although both emigrated to Palestine) were Schur and Toeplitz.
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Friedrich Hartogs (1874-1943), a founding father of the theory of several complex variables and Felix Hausdorff (1868-1942), the founder of point set topology and Hausdorff dimension also committed suicide rather than get shipped off to camps (both by overdoses of barbiturates).
Marcinkiewicz

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Jósef Marcinkiewicz (1910–1940), a Polish mathematician, a student of Antoni Zygmund (1900–1992), is best known for the Marcinkiewicz interpolation theorem. It was announced in 1939. Before he could publish the details, the Second World War broke out. Marcinkiewicz was a Polish nationalist and, despite the fact that his colleagues in England, where he was working, urged him to stay, he returned to Poland to take up his commission as an officer in the Polish army reserves.
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My final trio is a bonus selection. I start with a bonus personal hero:

Mark Grigorievich Krein (1907–1989) was a Jewish Ukrainian mathematician born in Kiev. In 1924, he ran away to the University in Odessa and except for a brief period of evacuation during the Second World War, spent the rest of life in Odessa, a town on the Black Sea. His students include Berezansky, Glazman, Gohberg (but see below), Milman, Naimark, Rutman and Sakhnovich. He got his degree in 1929 and in the 1930's, he ran a world center of functional analysis out of the University of Odessa collaborating often with his friend Naum Akhiezer (1901-1980) who was based in Kharkiv.
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One day, Gohberg met Sahknovich, another of Krein’s students who asked him “How is the book going?” “Well, it is 85 percent ready,” Gohberg replied. “Then why do you look so sad? That is wonderful.” “Yes,” Gohberg answered, “but if you had asked me yesterday I would have said it was 95 percent ready.”

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Emmy Noether (1882–1935) was a German Jewish mathematician. Her great–grandfather, Elias Samuel, was forced to change his name by a Napoleonic edict and her grandfather’s name changed from Hertz Samuel to Hermann Nöther. Later her father, Max, changed the spelling to Noether.
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She continued to write papers in Erlangen with no official connection to the University until 1916 when she was invited to Göttingen.
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It must be emphasized that this idea has been a touchstone of modern theoretical physics. Once quantum mechanics was discovered and Poisson brackets were replaced by commutators, the theorem shone even brighter and symmetry became a basic building block of new discoveries in particle physics. As one physicist put it: “Noether’s theorem to me is as important a theorem in our understanding of the world as the Pythagorean theorem.”
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This brings me to the period of her contributions to Algebra which make her one of the greatest mathematicians of the 20th century. Together with Brauer and Artin, two younger mathematicians greatly affected by her, she pioneered the idea of algebra as abstractly defined structures.
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Here is what Alexandroff said about her in a memorial address:

"Such was Emmy Noether, the greatest of women mathematicians, a great scientist, an amazing teacher, and an unforgettable person... True, Weyl has said that 'the Graces did not stand at her cradle,' and he is right, if one has in mind the generally known heaviness of her appearance. But here Weyl is speaking of her not only as a great scholar, but also as a great woman. And she was that—her femininity appeared in that gentle and subtle lyricism which lay at the heart of the far-flung but never superficial concerns which she maintained for people, for her profession, and for the interests of all mankind. She loved people, science, life, with all the warmth, all the cheerfulness, all the unselfishness, and all the tenderness of which a deeply sensitive—and feminine—soul is capable."
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Thomson

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Thomson published over 600 papers, was elected to the Royal Society in 1851 (when he was 27) and served as its President from 1890-1895. Naming harmonic functions is kinda neat and he sounds like he had impressive credentials but you may be puzzled why I picked as my final choice someone you’ve probably never heard of and who doesn’t seem in a league with the other 21.
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Final Thoughts

I hope you’ve learned that our forefathers are fascinating as people and that you’ll consider using Mr. Google and Ms. Wikipedia to look up the names you find on theorems.
A Comprehensive Course in Analysis by Poincaré Prize winner Barry Simon is a five-volume set that can serve as a graduate-level analysis textbook with a lot of additional bonus information, including hundreds of problems and numerous notes that extend the text and provide important historical background. Depth and breadth of exposition make this set a valuable reference source for almost all areas of classical analysis.

Part 1 is devoted to real analysis. From one point of view, it presents the infinities of the twentieth century with the ultimate integral calculus (measure theory) and the ultimate differential calculus (distribution theory). From another, it shows the triumph of abstract spaces: topological spaces, Banach and Hilbert spaces, measure spaces, Riesz spaces, Polish spaces, locally convex spaces, Fréchet spaces, Schwartz space, and $L^p$ spaces. Finally, it is the study of big techniques, including the Fourier series and transform, dual spaces, the Baire category, fixed point theorems, probability ideas, and Hausdorff dimension. Applications include the constructions of nowhere differentiable functions, Brownian motion, space-filling curves, solutions of the moment problem, Haar measure, and equilibrium measures in potential theory.
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Part 2A is devoted to basic complex analysis. It interweaves three analytic threads associated with Cauchy, Riemann, and Weierstrass, respectively. Cauchy’s view focuses on the differential and integral calculus of functions of a complex variable, with the key topics being the Cauchy integral formula and contour integration. For Riemann, the geometry of the complex plane is central, with key topics being fractional linear transformations and conformal mapping. For Weierstrass, the power series is king, with key topics being spaces of analytic functions, the product formulas of Weierstrass and Hadamard, and the Weierstrass theory of elliptic functions. Subjects in this volume that are often missing in other texts include the Cauchy integral theorem when the contour is the boundary of a Jordan region, continued fractions, two proofs of the big Picard theorem, the uniformization theorem, Ahlfors’s function, the sheaf of analytic germs, and Jacob, as well as Weierstrass, elliptic functions.
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Part 2B provides a comprehensive look at a number of subjects of complex analysis not included in Part 2A. Presented in this volume are the theory of conformal metrics (including the Poincaré metric, the Ahlfors-Robinson proof of Picard’s theorem, and Bell’s proof of the Painlevé smoothness theorem), topics in analytic number theory (including Jacobi's two- and four-square theorems, the Dirichlet prime progression theorem, the prime number theorem, and the Hardy-Littlewood asymptotics for the number of partitions), the theory of Fuchsian differential equations, asymptotic methods (including Euler’s method, stationary phase, the saddle-point method, and the WKB method), univalent functions (including an introduction to SLE), and Nevanlinna theory. The chapters on Fuchsian differential equations and on asymptotic methods can be viewed as a minicourse on the theory of special functions.
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Part 3 returns to the themes of Part 1 by discussing pointwise limits (going beyond the usual focus on the Hardy-Littlewood maximal function by including ergodic theorems and martingale convergence), harmonic functions and potential theory, frames and wavelets, H^p spaces (including bounded mean oscillation (BMO)) and, in the final chapter, lots of inequalities, including Sobolev spaces, Calderon-Zygmund estimates, and hypercontractive semigroups.
Part 4 focuses on operator theory, especially on a Hilbert space. Central topics are the spectral theorem, the theory of trace class and Fredholm determinants, and the study of unbounded self-adjoint operators. There is also an introduction to the theory of orthogonal polynomials and a long chapter on Banach algebras, including the commutative and non-commutative Gel’fand-Naimark theorems and Fourier analysis on general locally compact abelian groups.