3 Opinion

Let me begin by saying that this is one of the best mathematics books that I have read recently. It is beautifully written and very well organised, the kind of book that is well within the reach of an undergraduate student, even one with little complex analysis. Indeed, a good knowledge of the analysis of real functions of one variable is probably enough for reading most of the book. Chapter one is a case apart, it is so elementary and so interesting that it should be read by anyone interested in mathematics. The other chapters are far more demanding and have to be studied carefully if one is to profit by them. However, I know of no better place to learn about Dirichlet's Theorem on arithmetic progressions or Selberg's proof of the Prime Number Theorem. And if there are two results of analytic number theory that deserve to be known to every mathematician, these are certainly they.

Since no book is perfect, there are a number of minor points that may be improved in future editions. For instance, given the technical nature of the subject matter, it is not to be expected that readers will remember previously proved results without an explicit reference. Unfortunately, the author often does not cite such results, which makes the reading a little harder than necessary. A few more brackets in some of the more complicated equations would also have helped the reader. I should also add that I have my doubts about the author's statement that

> [t]he proof [of Selberg's fundamental formula] [...] can be understood by a talented high-school student (p. 215).

But these are very minor points on an otherwise excellent book. I only wish more well-organised, clear and passionate books like this were written. Mathematics would benefit very much from it!

Review of [14]

Pioneering Women in American Mathematics: The Pre-1940 PhD's
by Judy Green and Jeanne LaDuke
345 pages, $63.00, hardcover, 2009, AMS

Review by Sorelle A. Friedler (sorelle@google.com)

1 Introduction

Pioneering Women in American Mathematics: The Pre-1940 PhD's is a comprehensive examination of the lives of all 228 women who earned PhDs in mathematics before 1940 who were US-born or earned their PhDs in the US. The first eight chapters of the book examine the themes of these women's lives with regards to family background and childhood education, undergraduate and graduate education, and career and professional opportunities and contributions. The rest of the book contains short biographies (approximately one page each) of each of the 228 women.[15] The authors focus mainly on the large set of facts they collected, much of it from first-hand data or interviews. The information is extensive, and though some themes and summaries are suggested, mostly the data is left to speak for itself.

[14]

[15] Longer biographies and more extensive references can be found on the AMS site: http://www.ams.org/bookpages/hmath-34.

2 Summary

A surprising statement sets the tone for the book; "More than 14 percent of the PhD's awarded in mathematics during the first four decades of the twentieth century went to women, a proportion not achieved again until the early 1980s."[16] The authors continue by exploring the reasons why the percentage was not higher, and begin explanation of the drop in percentage, through careful examination of the lives of the women who earned PhDs in those years. These women represented a geographically, educationally, and economically (but not racially) diverse snapshot of the United States population of the time. In addition to the plethora of facts, we are given some insight into the perseverance and spirit of these women through anecdotes about particular women.

The first woman to earn her PhD in mathematics was Christine Ladd-Franklin. She passed her dissertation defense in 1882 at Johns Hopkins University and the mathematics department agreed that she had earned a PhD. The awarding of her PhD was blocked by the university trustees because she was a woman.

> In 1926, at the fiftieth anniversary of the founding of Johns Hopkins, Ladd was offered an honorary degree as a result of her work in physiological optics. She insisted, instead, that it be the PhD she had earned forty-four years earlier or none.[17]

They agreed, and so 44 years after earning it, Ladd was awarded her PhD.

After presenting this story and giving some broad information to set the scene, the book begins by examining trends in the women's early education and family backgrounds. The authors found that there were no common trends in the early education and family backgrounds of women who earned PhDs. The women came from around the country, in numbers somewhat dependent on the availability of undergraduate education for women in their state (e.g., Southern states produced proportionally less PhDs, North Eastern states produced proportionally more). Similarly, while one might hypothesize that many of the women's parents also had advanced degrees, only a few parents did. The women's pre-college schooling was made up of about 70% public secondary schooling, with the remaining attending private schools or studying with tutors. Unfortunately, the authors do not discuss if this was true for the broader population of the time as well. Anecdotally, parents and high school teachers were described as important in leading to strong interests in mathematics.

Women's colleges were critical to producing women with PhDs in mathematics before 1940. Among the ten schools that led in providing college educations to women who later earned PhDs, eight were women's colleges. Similarly, it is anecdotally reported that classes taught by women or supportive male faculty were very influential to the women's decisions to continue their education. Nola Anderson Haynes (PhD, University of Missouri, 1929) describes the influence a supportive chairman had on her decision to pursue a PhD as follows:

> One day... the chairman of the department asked, "Miss Anderson, what are you going to do next year?" I said, "I guess go out and get a job in a junior college," thinking I could very easily, of course. And he said, "Would you be interested in going on towards a PhD if you got a fellowship?" Well, that was an easy thing; ... I didn't have to think about getting a job, so I accepted it and went on and got my PhD.[18]

[16] Page 1.

[17] Page 5

[18] Page 60, as quoted from Smithsonian meeting tapes recorded August 31, 1981 at a luncheon for pre-World War II female American mathematics PhDs.

The authors note that while most other prominent women's colleges were among the leaders in producing future PhDs, Barnard and Radcliffe were not. "Perhaps it is noteworthy that at both Barnard and Radcliffe the undergraduate classes were taught by the male faculty of the associated men's universities."[19]

The graduate education of these 228 women included many firsts, and not just firsts for women. For example, six women were the first of any sex to be awarded a PhD in mathematics at their university.[20] Many universities were willing to admit women as graduate students long before they were willing to admit female undergraduates.

> The definiteness of aims, the increased earnestness and the more mature character which belong to the greater age of graduate students, may entirely or largely remove difficulties which are found in the way of men and women mingling in the undergraduate department. The Faculty of Yale University knows very well that to admit women to its graduate school is quite unlike opening the doors of Yale College to girls of the age of eighteen.[21]

But the most important factor in the graduate education of these women was their advisor; the eight advisors who directed the most dissertations of women in the study advised two-thirds of all women who earned PhDs at the schools in which they taught, and were the main reason why those schools were leaders in educating women at the PhD level in mathematics.[22] The University of Chicago, the leading producer of female mathematics PhDs during this period, had two advisors, L. E. Dickson and G. A. Bliss, who together advised 65% of the 46 Chicago women PhDs or 13% of the total 228 women considered in this book.[23]

After earning their PhDs, 90% of the women were employed within one year (even though many graduated during the Depression). Most of these were jobs in academia, either in teaching, research, or other associated positions. Of these, two-thirds had previous relationships with their employer, as employees or students. Half of the women's first teaching jobs were at women's colleges, most of which employed only single women. Marriage was a large factor in the employment of the women in this study, and the work patterns for women differed based on marital status.

Of the women who were married, 36% were unemployed during the time that they were married. A main cause of this unemployment was the existence of anti-nepotism laws which disproportionally affected women. 65% of these married women were married to other PhDs, and it was only them, not their husbands, who lost or were refused jobs. After World War II, the rise in undergraduate students due to the GI Bill meant that many of these women who were previously denied employment were offered jobs.

In contrast, 96% of the women studied who were single were employed, despite the Depression. Many of them were employed at women's colleges, and were promoted to full professor by the time they had retired. There were also some women who earned PhDs in this time period who were nuns. Generally, these women were encouraged by their church to pursue a PhD to satisfy the teaching needs of their order's colleges. These women had the advantage of having a guaranteed job after graduation. They frequently served in positions of administrative authority within their university or religious order.

While women's colleges and religious orders served as positive employers in terms of the promotion and advancement of their female employees, women teaching at co-ed schools often remained at the instructor level throughout their careers. At the University of Chicago, despite graduating many female PhDs, there have only been two women promoted to associate or full professor from its founding in 1892 until the writing

[19] Page 28.
[20] Page 55.
[21] Page 8, as quoted from *The College Woman* (New York: Baker and Taylor, 1894), 130-131.
[22] Page 46.
[23] Pages 44-45.

of this book in 2009.[24] Despite the professional set-backs some of these women experienced, one expressed satisfaction with her choice in earning a PhD in mathematics in a 1926 professional survey, saying:

> The freedom from monotony in the work in mathematics, the vision and grasp of fields of knowledge that may be interpreted through mathematics, the ideals of thought and of thinking, and the ability to interpret in conduct, relief from the turmoil of a crowded life, all these make the Ph.D. more valuable than any professional advantage to be derived from it.[25]

In addition to academic employment, about two dozen women chose industry, military, or other non-academic careers. One of the most notable of these women was Grace Murray Hopper. She graduated from Vassar College in 1928 and from Yale with a PhD in mathematics in 1934. In 1941 she was an assistant professor at Vassar when she took a leave of absence to join WAVES, a female branch of the US Naval Reserve. From that time forward she had an ongoing involvement with the military, though she was not always on active duty. She also worked at Harvard, the University of Pennsylvania, George Washington University, and many computer companies. During her career she wrote code for the Mark I computer and worked on the UNIVAC and developed its first compiler. She is best known for developing the first English-language programming language, FLOW-MATIC, and for her work as one of the leading developers on its successor, COBOL. When she was forced to retire from the navy in 1986, she had reached the rank of rear admiral (lower half).[26]

Hopper's contributions, though non-academic, could be considered to be the most influential produced by the women in this book. Many research and other professional contributions were made by the women. As a group, these women published almost 400 papers. With 14 papers presented at the meetings of the AMS between 1914 and 1930, Olive C. Hazlett was among the top 10% of all math researchers of the time.[27] Many women also contributed professionally through math education publications and professional organizations and, of course, through the students they taught.

In the final chapter before the bibliographic entries, the authors suggest possible reasons for the decline of women as a percentage of mathematics PhD earners after 1939. The main reason suggested is a demographic one - after World War II, the GI Bill provided the means by which many more men could enter college and graduate school. The number of male students increased dramatically, thus decreasing the percentage of women to about 5 percent in the 1950s. For example, the University of Chicago, one of the leading graduate schools for women in mathematics in the 1930s, graduated a total of 88 students in the 1930s, 24 of whom were women, and a total of 102 students in the 1950s, only 3 of whom were women.[28] While there were circumstances specific to the University of Chicago that contributed to the precipitous decline (most notably, the retirement of some professors especially supportive to women students), the trend was nationwide. "By the 1950s the number and percent of women earning PhD's in mathematics were so low that women in mathematics were effectively invisible."[29]

[24] Page 88. It appears from the university's website that this is still the case.
[25] Page 96, as quoted from Hutchinson, *Women and the Ph.D.*, page 101.
[26] Pages 205-206.
[27] Pages 98-99.
[28] Page 116.
[29] Page 118.

3 Opinion

Pioneering Women in American Mathematics presents an extensive history of the 228 American women who earned PhDs in mathematics before 1940. While the book does summarize the data collected in its introductory chapters, its purposeful lack of broad thematic description results in a dry, though important, collection of the facts. The first such comprehensive investigation into the lives of these 228 women, perhaps the book will serve as the foundation for future understanding of the trends and anomalies in these women's lives. It would be especially interesting to see more instances in which the experiences and lives of these women are compared proportionally to equivalent experiences of all mathematics PhDs from the time.

The main takeaway message, if trying to use this history to understand how to support women PhDs in mathematics and computer science today, is the import of teachers and advisors. As mentioned earlier, supportive undergraduate faculty were influential in these women's decisions to pursue a PhD, and two professors were single-handedly responsible for supervising the dissertations of 13% of these women. Though the number of students has increased, professors today should not underestimate the impact they can have on the total number of female PhDs simply by supporting the efforts of the ones who arrive in their department.

For readers interested in research on women in mathematics, this book is a fundamental source. For the average reader, I recommend skimming the first eight chapters and using the bibliographic entries and embedded tables as an important reference. If you are interested in the specific history of your university, the book contains an extensive index.

Review[30] of
A Guide to Elementary Number Theory
Author of book: Underwood Dudley
Publisher: MAA, 2009, 141 pages, hardcover
$50.00
Reviewed by Song Yan `syan@math.harvard.edu`

1 Introduction

Number theory, in mathematics, is the study of the properties of integers. It used to be the purist of the pure branch of mathematics. With the advent of modern computers and digital communications, it is now also a very applied subject of mathematics, with applications particularly in cryptography and Internet security. A traditional introductory book in elementary number theory such as [1] would include theories of divisibility, congruences, continued fractions, arithmetic functions and Diophantine equations, whereas a modern introductory book such as [2] would also include some materials in the theory of elliptic curves (the revised sixth edition of [1] also included a chapter on elliptic curves at the end of the book), and some applications of number theory to e.g., coding and/or cryptography.

2 Overview

As the author claimed, this is not a textbook in elementary number theory, it is written for someone who wants to know e.g., which integers are the sum of two squares, or someone who once knew but has forgotten. However, the author did write a text in elementary number theory 42 years ago [3].

[30]