Math 55

Subjects: Others
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Math 55 is a two-semester long first-year undergraduate mathematics course at Harvard University, founded by Lynn Loomis and Shlomo Sternberg. The official titles of the course are Honors Abstract Algebra (Math 55a) and Honors Real and Complex Analysis (Math 55b). Previously, the official title was Honors Advanced Calculus and Linear Algebra.

Keywords: mathematics course ; analysis ; shlomo

1. Description

The Harvard University Department of Mathematics describes Math 55 as "probably the most difficult undergraduate math class in the country."[1] Formerly, students would begin the year in Math 25 (which was created in 1983 as a lower-level Math 55) and, after three weeks of point-set topology and special topics (for instance, in 1994, *p*-adic analysis was taught by Wilfried Schmid), students would take a quiz. As of 2012, students may choose to enroll in either Math 25 or Math 55 but are advised to "shop" both courses and have five weeks to decide on one.[2] Depending on the professor teaching the class, the diagnostic exam may still be given after three weeks to help students with their decision.

In 1994, 89 students took the diagnostic exam: students scoring more than 50% on the quiz could enroll in Schmid's Math 55 (15 students), students scoring between 10 and 50% could enroll in Benedict Gross's Math 25: Theoretical Linear Algebra and Real Analysis (55 students), and students scoring less than 10% were advised to enroll in a course such as Math 21: Multivariable Calculus (19 students).[3]

A take-home final ends the class.[4]

1.1. Historical Retention Rate

In 1970, Math 55 covered almost four years worth of department coursework in two semesters, and subsequently, it drew only the most diligent of undergraduates. Of the 75 students who enrolled in the 1970 offering, by course end, only 20 remained due to the advanced nature of the material and time-constraints under which students were given to work.[5] David Harbater, a mathematics professor at the University of Pennsylvania and student of the 1974 Math 55 section at Harvard, recalled of his experience, "Seventy [students] started it, 20 finished it, and only 10 understood it." Scott D. Kominers, familiar with the stated attrition rates for the course, decided to keep an informal log of his journey through the 2009 section: "...we had 51 students the first day, 31 students the second day, 24 for the next four days, 23 for two more weeks, and then 21 for the rest of the first semester after the fifth Monday" (the beginning of the fifth week being the drop deadline for students to decide whether to remain in Math 55 or transfer to Math 25).[6] In 2006, the class was 45 percent Jewish (5 students), 18 percent Asian (2 students), 100 percent male (11 students).[7]

2. Course Content

Through 2006, the instructor had broad latitude in choosing the content of the course.[8] Though Math 55 bore the official title "Honors Advanced Calculus and Linear Algebra," advanced topics in complex analysis, point set topology, group theory, and differential geometry could be covered in depth at the discretion of the instructor, in addition to single and multivariable real analysis as well as abstract linear algebra. In 1970, for example, students studied the differential geometry of Banach manifolds in the second semester of Math 55.[5] In contrast, Math 25 was more narrowly focused, usually covering real analysis, together with the relevant theory of metric spaces and (multi)linear maps. These topics typically culminated in the proof of the generalized Stokes' theorem, though, time permitting, other relevant topics (e.g., category theory, de Rham cohomology) might also be covered.[9] Although both courses presented calculus from a rigorous point of view and emphasized theory and proof writing, Math 55 was generally faster paced, more abstract, and demanded a higher level of mathematical sophistication.

Loomis and Sternberg's textbook *Advanced Calculus*,[10] an abstract treatment of calculus in the setting of normed vector spaces and on differentiable manifolds, was tailored to the authors' Math 55 syllabus and served for many years as an assigned text. Instructors for Math 55[11] and Math 25[9] have also selected Rudin's *Principles of Mathematical Analysis*,[12]

Spivak's *Calculus on Manifolds*,[13] Axler's *Linear Algebra Done Right*,[14] and Halmos's *Finite-Dimensional Vector Spaces*[15] as textbooks or references.

From 2007 onwards, the scope of the course (along with that of Math 25) was changed to more strictly cover the contents of four semester-long courses in two semesters: Math 25a (linear algebra) and Math 122 (group theory) in Math 55a; and Math 25b (calculus, real analysis) and Math 113 (complex analysis) in Math 55b. The name was also changed to "Honors Abstract Algebra" (Math 55a) and "Honors Real and Complex Analysis" (Math 55b). Fluency in formulating and writing mathematical proofs is listed as a course prerequisite for Math 55, while such experience is considered "helpful" but not required for Math 25.[1] In practice, students of Math 55 have usually had extensive experience in proof writing and abstract mathematics, with many being the past winners of prestigious national or international mathematical olympiads (such as USAMO or IMO). Typical students of Math 25 have also had previous exposure to proof writing through mathematical contests or university-level mathematics courses.

3. Notable Alumni

Problem sets are expected to take from 24 to 60 hours per week to complete,[1] although some claim that it is closer to 20 hours.[16] Many of those who are able to handle the workload and complete the course become professors in quantitative fields;[5] alumni of Math 55 include Harvard mathematics professors Benedict Gross and Joe Harris as well as Harvard physics professor Lisa Randall,[17] Harvard economics professors Andrei Shleifer and Eric Maskin, and Berkeley economics professor Brad DeLong.[18] Contrary to a 2006 article in *The Harvard Crimson* which alleged that only 17 women completed the class between 1990 and 2006,[6] 39 women completed 55a and 26 completed 55b.[19] Math 25 has more women: in 1994–95, Math 55 had no women, while Math 25 had about 10 women in the 55-person course.[3]

Past students of Math 55 also include Bill Gates,[20] Richard Stallman,[5] and Simpsons executive producer Al Jean.[21]

Demographics of students taking this course over the years have been used to study the causes of gender and race differences in the fields of mathematics and technology.[22]

4. Historical Instances of Math 55

Year	Instructor	Course materials
1996–1997	**Alexander Polishchuk**	
1997–1999	**Pavel Etingof**	
1999-2000	**Noam Elkies**	
2000–2001	**Wilfried Schmid**	
2002–2003	**Noam Elkies**	**55a,[23] 55b[24]**
2003–2004	**Yum-Tong Siu**	**55a[25]**
2004–2005	**Wilfried Schmid**	
2005–2006	**Noam Elkies**	**55a,[26] 55b**
2008–2009	**Curtis T. McMullen**	**55a,[27] 55b[28]**
2009–2010	**Curtis T. McMullen**	**55a,[29] 55b[30]**
2010–2011	**Noam Elkies**	**55a,[31] 55b[32]**
2011–2012	**Yum-Tong Siu**	
2013–2015	**Dennis Gaitsgory**	
2015–2016	**Yum-Tong Siu**	
2016-2018	**Noam Elkies**	**55a[33]**
2018-2020	**Joe Harris**	
2020–2021	**Denis Auroux**	**55a,[34] 55b[35]**

5. Fictional References

Math 55, along with several other high-level mathematics courses, was brought up by Dr. Spencer Reid in a 2015 episode of *Criminal Minds* entitled "Mr. Scratch." However, graduates of the class are not forced to join the NSA, as the show states.[36]

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catalog as "probably the most difficult undergraduate math class in the country." It is legendary among high school math prodigies, who hear terrifying stories about it in their computer camps and at the Math Olympiads. Some go to Harvard just to have the opportunity to enroll in it. Its formal title is "Honors Advanced Calculus and Linear Algebra," but it is also known as "math boot camp" and "a cult." The two-semester freshman course meets for three hours a week, but, as the catalog says, homework for the class takes between 24 and 60 hours a week."

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