Beyond Math 1:
Which math course is for you?
(2015-2016)

If you have completed the Math 1a/1b sequence at Harvard or if you have had the equivalent material elsewhere, you may be wondering which course is for you. The mathematics department provides a variety of options which you should consider based on your academic interests and your background. With exceedingly rare exceptions, students in your position are advised to take one (or more) of Math 18, 19a, 19b, 21a, 21b, 23a, 25a, 55a, or 101. (The School of Engineering and Applied Sciences also offers Applied Math 21a,b which covers selected topics from Math 21.) This pamphlet describes the Mathematics Department's offerings and should help you decide which course is for you.

Math 18 focuses on concepts and techniques of multivariable calculus most useful to those studying the social sciences, particularly economics: functions of several variables: partial derivatives; directional derivatives and the gradient: constrained and unconstrained optimization, including the method of Lagrange multipliers. Covers linear and polynomial approximation and integrals for single variable and multivariable functions: modeling with derivatives.

Math 19a and 19b are courses that are designed for students concentrating in the life sciences. (These courses are recommended over Math 21a,b by the various life science concentrations.) Math 19a is taught in the fall and repeated in the spring; it focuses on differential equations, related techniques and modeling. Math 19b teaches linear algebra, probability and statistics; it is offered only in the spring. Both courses focus on applications and examples from the life sciences. If you passed Mathematics 1b (or have the permission of the instructor), you can take Mathematics 19a,b.

Math 21a,b is the standard second-year calculus and linear algebra sequence. It is normally taken by those students who intend to concentrate in the physical sciences or mathematics and who have had a solid first year calculus course. Math 21 emphasizes computational techniques and applications. It seeks to develop tools and intuition rather than spend time proving the results used. Math 21 is given in semester-long halves which may be taken in either order or concurrently. Math 101 can be taken concurrently with either Math 21a or 21b. The material in Math 21a/b is presented, where feasible, in correlation with Physics 15/16.

Math 21a covers multivariable calculus, while Math 21b is a one-semester introduction to linear algebra and differential equations. First-year students who had an equivalent of Math 21a in high school often take this course in the fall of their freshman year. The students with such background who intend to major in math or theoretical physics should also look into Math 23, Math 25, or Math 55. Those who are considering a concentration in mathematics may want to take Math 101 concurrently with either Math 21a or b.

Math 101 is a one-semester introduction to the three main branches of modern mathematics (algebra, analysis, and geometry) and to the methodology used in higher mathematics. It has no official prerequisites. In this course students learn to write rigorous proofs and encounter fundamental concepts which are further developed in other 100-level courses. Math 101 is intended both for those who wish to concentrate in mathematics and for those in other fields (related or not) who have an interest in learning what higher math is all about. Students often take it concurrently with or right after Math 21. Those who are taking or have taken Math 23, 25, or 55 should not take 101. In 2015-16, Math 101 will be given in the spring, but not in the fall semester.

Math 23 is an advanced version of the 21 sequence designed for students with strong math interest. This course develops theories of functions of several variables and linear algebra. Students in this course will learn to write rigorous proofs and encounter some of the beauty and elegance of modern mathematics. Math 23 offers a theoretical understanding of the mathematical concepts which are taught in Math 21. Please note that Math 23 *may not* correlate with the Physics 15/16 sequence. Also note that all 100 level Math courses which accept Math 25 or 55 as a prerequisite also accept Math 23. Math 23 should not require an unusual out of class time commitment.

Math 25 and 55 are both full-year advanced courses designed for students with a very strong interest in theoretical mathematics. Each covers multivariable calculus, linear algebra, and some additional topics from a rigorous and advanced point of view. The students in these courses are frequently committed to concentrating in mathematics and are asked to put in extensive work outside the classroom. Many have had more than one year of college mathematics while in high school or have participated in various summer math programs. However, it is not necessary to have had multivariable calculus before taking 25 or 55. Although the syllabus of Math 25 is similar to that of Math 23, students will usually have had more preparation in math.

Math 55 is a faster paced course and covers topics more deeply. It is designed for students who arrive at Harvard with an extensive background in college level math. Math 25 and 55 differ from Math 23 in the level of outside work required: homework assignments in Math 25 and 55 are typically very time consuming. Math 23, 25 or 55 all provide an excellent foundation for further study of mathematics.

Skipping Math 25 and 55: Every year a few freshmen want to skip the Math twenty/fifty level all together and start with a 100- or 200- level course. The Department, based on many years of experience, *strongly discourages* this. You may learn more advanced material in higher level courses, but never at the same speed and intensity as in Math 25 or 55. Moreover, you are learning more than just a body of mathematics in these courses. You are also learning how to 'be' a research mathematician (as opposed to one who only does well in Math courses). If, in spite of this warning, you think that taking a higher level course as a freshman would best serve your needs, you should speak to the Director of Undergraduate Studies of the Mathematics Department, Professor Jacob Lurie (lurie@math).