Beyond Math 1:
Which math course is for you?
(2023-2024)

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 of Math 18a, 19a, 18b/19b, 21a, 21b, 22a, 25a, 55a. You can also take Math 101 concurrently with any of Math 18-21. (The School of Engineering and Applied Sciences also offers Applied Math 22a,b which covers much the same topics from Math 21a,b but in different order.) This pamphlet describes the Mathematics Department's offerings and should help you decide which course is for you.

• Math 18a: This course is taught in the fall only. Math 18a covers the concepts and techniques of multivariable calculus most useful to those studying the social sciences, particularly economics. The course also serves as an introduction to mathematical modeling in the social sciences and economics. Math 18a should not be taken in addition to Math 21a, but Math 19b or Math 21b may be taken before or after Math 18a.

• Math 19a: Math 19a is given in just the fall; it teaches multivariable calculus and differential equations for applications to the life sciences. It is recommended by those taking the Life Science 1a,b courses and by the life science concentrations (this means Biological Anthropology, Chemical and Physical Biology, Human Evolutionary Biology, Molecular and Cellular Biology, Neurobiology, Organismic and Evolutionary Biology, and Social and Cognitive Neuroscience.) In particular, the focus in Math 19a is on differential equations, both linear and non-linear in one or more variables. Math 19a has a second focus which is mathematical modeling for life science problems. This course is preferable to Math 21a for those majoring in a life science except for students who plan to take Physics 11/12 or 15/16.

• Math 18b/19b: This one course is given only in the spring semester. Math 18b/19b is a follow-on course for both Math 18a and Math 19a. It is for people interested in life sciences or social sciences or economics. The course teaches linear algebra with enough probability and statistics to forgo the beginning statistics courses such as Stat 100, 102. Some programming will also be taught. All of the linear algebra in Math 21b is taught; The differential equations in Math 21b is traded for probability and statistics.

∗ NOTE: Math 21b can be taken after Math 19a; and Math 18b/19b can be taken after Math 21a. But Math 18a and Math 21a can't both be taken. Likewise, Math 18b/19b and Math 21b can't both be taken.

• Math 21a: This course covers the basics of multivariable calculus in two and three dimensions: Curves and surfaces, functions and their derivatives, the calculus of variations, multi-variable integration,

integration on curves and surfaces, multivariable generalizations of the fundamental theorem of calculus. In short: Math 21a teach the tools and intuition for dealing with basic multivariable problems. Math 21a is given in both the fall and spring semester.

• Math 21b: This course covers the basics of linear algebra in dimensions 2, 3 and higher. A significant part of the course uses the linear algebra to study ordinary and partial differential equations. Math 21a and Math 21b can (in principle) be taken in either order, but most students take Math 21a first.

 • Math 22a,b: This course covers multivariable calculus and linear algebra for students interested in theoretical sciences. It covers the same topics as Math 21a,b but with more rigor. Students are taught techniques of proof and mathematical reasoning. The workload and content is comparable with the 21 sequence. But unlike in the latter, the linear algebra and calculus are more interlinked. Math 22b cannot be taken after Math 21a; and Math 21b cannot be taken after Math 22a

• Math 25 and 55: These are theory courses that should be elected only by those students who have a particular interest in and enjoyment of abstract mathematics, as well as a solid understanding of one-variable calculus. (Even so, these courses are not just for people planning for the Mathematics concentration; many of the students in these courses go on to concentrate in other sciences.) These courses assume a willingness to think rigorously and abstractly about mathematics; and they require a willingness to work hard. Both courses study multivariable calculus and linear algebra plus many very deep, related topics. These courses come with an iron clad guarantee that you will be challenged by the mathematics.

∗ CHOOSING BETWEEN MATH 22, 25 OR 55: Math 25 differs from Math 22 and by virtue of the work load in Mathematics 25 being significantly more; but then Mathematics 25 covers more material. Even so, any given course that asks for Math 25 as a prerequisite accepts Math 22 as well. Mathematics 55 differs from Mathematics 25 in that the former assumes an extremely strong proof oriented mathematics experience. Entrance into Mathematics 55 requires the consent of the instructor.

∗ SKIPPING MATH 25/55: Every so often, a first year person with an advanced background wants to skip Math 25 and Math 55 and start with a 100- or 200- level course. Based on many years of experience, we discourage this. Here is why: These courses teach more than just a body of mathematics; they teach 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 first year student would best serve your needs, you should speak to the Director of Undergraduate Studies in Mathematics.

• Applied Math 22: The Applied Math 22a,b sequence is like Math 21a,b with regards to content (although the material is presented in a different order: Applied Math 22a is similar to Math 21b whereas Applied Math 22b is more like Math 21a. Math 22a,b is also taught from a somewhat more applied point of view. Both Applied Math 22a and Applied Math 22b are taught in a single lecture hall, whereas Math

21a.b are taught in small sections that are designed to maximize student/ teacher interactions. (Mathematics concentrators can use Applied Math 22a,b as related field courses for concentration credit if they do not also take Math 21a,b or Math 22a,b. Applied Math concentrators can take Applied Math 22a,b or Math 21a,b or one of Math 22-55.)

OTHER COURSES:

• Math 101: Math 101 (offered both fall and spring semesters) is designed to give people with a Math 1b level background and with interest in mathematics a taste of what modern mathematics is all about. This course can be taken concurrently with Math 21a or 21b. It is not to be taken with Math 25 or 55 (without special permission). Math 101 also gives a good background for writing and following mathematical proofs. This skill will be needed for most higher level math courses. This skill is also taught in Math 22 and Math 25, and in a few other 100 level courses.