

Math 10A/10B

This document describes a new first-year math curriculum for biology majors at UC Berkeley. It is divided into two single semester courses, whose design requires that they be taken in the order described in this document. The title for the combined courses is “Mathematics and Statistics for the Biomedical Sciences”.

- [Jump to Semester One](#) Course Outline
- [Jump to Semester Two](#) Course Outline
- [Jump to Frequently Asked Questions](#) ***Updated 6/21/12

Title: Math 10A: Methods of Mathematics: Calculus, Statistics, and Combinatorics

Days/Times: MWF 2-3p + discussion

Course Control Number: 53622

Final Exam Group: 15, Thursday, December 19, 3-6 pm

Textbook: No specific textbook is assigned to the course; instructor will provide lecture notes and assignments.

Course Website: TDB

The syllabi are listed week-by-week with notes following the description of each week (in italics). Mathematics and statistics topics are drawn from the current courses Math 1A/B, 16A/B, Math 55 and Stat 20 with a bit of material from Math 54 and CS 70. Although the first semester focuses on calculus, and the second semester on discrete mathematics, there is a mixture of topics in both; for example, differential equations are taught in the second semester. This organization was required in order to teach the mathematics together with statistics, and it results in the courses having to be taken sequentially.

USE OF BIOLOGY IN THIS COURSE

Biological examples will be limited to a single theme, that of cancer biology. The first semester will emphasize examples related to disease progression where mathematical modeling and statistical analysis of tumor growth (possibly in the context of therapy) are key issues. The second semester will emphasize the molecular basis of cancer, with topics from elementary genetics. The reason for limiting the scope of the biology examples is to enable the students to focus on the mathematics principles they are learning without the distraction of having to learn a lot of new biology as well. However the topic of cancer biology should appeal to students and throughout the year they will learn about the different quantitative aspects of studying it, thus enriching their biology education as well.

HOW TOPICS WERE CHOSEN

Topics were selected based on recommendations of recent panels studying mathematics education for biologists (e.g. CRAFTY, AAMC), and recommendations of a large group of faculty from the departments of mathematics, statistics, molecular and cell biology, environmental sciences policy and management, and integrative biology. The deans of Letters and Sciences and of Biological Sciences have been overseeing the development of the course while providing valuable guidance in shaping the syllabi.

FIRST SEMESTER OF THE COURSE

Details on the first semester course: the first semester course is most similar to Math 1A and 16A, although it includes a week of Math 16B and approximately 3 weeks of Stat 20. It also has a different order of topics, focused on teaching the statistics concurrently with the math. This comes at the expense of some of the techniques for integration, and with the removal of examples from the physical and social sciences. Instead, there will be time for biology examples, and for a probability theory and statistics theme throughout the semester. The integration of probability theory and statistics with the calculus course is a key recommendation of the CRAFTY report and was also emphasized by a number of faculty.

SECOND SEMESTER OF THE COURSE

Details on the second semester course: the second semester course is most similar to Math 55, however all of the number theory/logic in Math 55 has been removed from the course and replaced by more statistics and a bit of linear algebra (essentially the first two weeks of Math 54). Another important change is the introduction of differential equations (two weeks of Math 16B) following difference equations.

LOOKING FORWARD

The series of Math 10A/10B or Math 1A/1B are now required for either MCB majors or IB majors. In the case of IB majors, this new year-long requirement will be in effect for freshmen admitted to Cal in fall 2012. (Any IB major who was admitted earlier will still have the requirement of Math 16A.)

In the long term, it is expected that the new year-long sequence will become the required math for freshmen biology majors (including the MCB and IB majors). In the case of IB it has meant the current 16A requirement to a year-long requirement (and different course). Other majors, such as Chemical Biology may also wish to change their requirement from Math 1A/1B to the new course.

Furthermore, the new sequence will serve as a sufficient prerequisite for Math 53 and Math 54, so that students who have those courses as requirements for their biology major will have the opportunity to take the new course instead of Math 1A/B. In fact, the course already contains 2 weeks from Math 54 so students who take the new sequence may even be at an advantage. Furthermore, the new courses do not replace dedicated statistics courses that some biology majors currently take, and biology majors will continue to be encouraged to take additional statistics, even if not required to do so by their major.

With the exception of IB majors, who will be required to take an extra semester of math under the new plan, the introduction of the new courses results in a transition of requirements for students, but not an increase in required math. Transfer students will not be required to take the new course.

The course has been under preparation for two years with intensive development of curriculum and materials primarily undertaken by Prof. Lior Pachter together with graduate students Rob Bayer (mathematics) and Brianna Heggeseth (statistics). During this time Professors Craig Evans and Deb Nolan have served as advisors from the departments of mathematics and statistics respectively.

SYLLABUS FOR A NEW SEQUENCE OF MATH COURSES FOR FIRST YEAR BIOLOGY MAJORS

Semester 1

Week:

1. Functions- an introduction to linear and quadratic functions, the quadratic formula, exponents and power functions. The exponential and logarithm functions.

This material constitutes approximately 1 week of Math 16A and 2 weeks of Math 1a. We will introduce the exponential and logarithm functions, rather than delaying those until later (they typically constitute 1.5 weeks of 16A later in the semester after differentiation). In turn, there will be less emphasis on trigonometric functions.

2. Data- the use of histograms, scatterplots pie-charts and log-log plots to represent data. Basic numerical and graphical summaries. The normal distribution.

This material constitutes approximately 1 week of Stat 20. The goal will be to introduce the overarching biological topic of the course (cancer) with examples of the type of data to be encountered in studying it. It will also serve as an outline for the course, encouraging students to think about the ways in which the data can be informative, thereby setting the stage for the mathematics topics to be studied.

3. Integration I. Introduction to integration

This material constitutes approximately 1 week of Math 1A or 16A. Introduction to Integrals, the Riemann integral. Approximating integrals with the Trapezoid rule. Definition of a probability distribution function.

4. Derivatives I. Introduction to differentiation.

This material (weeks 3 and 4) constitute approximately 2 weeks of Math Math 1A or 16A,

and will similarly encompass two weeks (weeks 3 and 4) of this course. Introduction to derivatives, slope derivative of a function. Elementary rules, the product rule, trig functions.

5. Derivatives II. Rules of differentiation, rates of change.

This will be a continuation of the previous week, with time for students to grasp a key concept of calculus. The topic has been placed early in the first semester because it is likely to be encountered in other courses taken concurrently. Additional topics include implicit differentiation.

6. Applications of derivatives.

This material constitutes 1 week of Math 1A or 16A, and is the third week of derivatives in this course. Graph sketching: general principles, critical points, asymptotes. Introduction to function approximation and motivation for infinite series.

7. Infinite series and Taylor series.

This week (and part of week 8) focus on Taylor series and its applications. Taylor series will be presented as a useful tool for approximation (linearization) to be seen later as crucial for the approximate computation of integrals. It will also be emphasized for its value as a mathematical modeling paradigm.

8. Introduction to statistical models.

This material constitutes approximately 1 week of Stat 20/135. The main goal will be to explain the notion of a statistical model, and why parameter estimation reduces to a calculus problem (to be connected to applications of differentiation in weeks 7/8).

9. Testing and confidence intervals.

This week will focus on hypothesis testing, with the single concrete example of the t-test. It will follow week 7 when students have learned about statistical models, and they will have already seen the normal distribution. The material constitutes approximately 1 week of Stat 20/135.

10. Maximum likelihood estimation and tests of significance.

This material draws on both calculus and statistics. Maximum likelihood will be explained and the methods used will draw on optimization (using derivatives and the calculation of critical points of functions)

11. Goodness of fit and likelihood ratio tests.

This week culminates the statistics introduction of previous weeks focusing on key aspects of statistics for biology.

12. Fundamental theorem of calculus and integration

This material constitutes approximately 1 week of Math 1A or 16A. We develop more deeply the theory of integration and focus on methods for computing integrals.

13. Integration II.

Continuation of methods of integration.

14. Applications

The final week of the first semester focuses on applications, specifically mathematical and statistical modeling for biology based on the tools learned during the semester.

Semester 2

Week:

1. **Finite sets, functions and balls & boxes (the 12-fold way).**

This material constitutes 1 week of Math 55.

2. **Counting, permutations, binomial coefficients**

This material constitutes 1 week of Math 55.

3. **Discrete probability theory, conditional probability, random variables.**

This material constitutes 1 week of Math 55.

4. **The Poisson approximation to the binomial distribution and Poisson random variables.**

The Poisson distribution will be emphasized during this week, both for its value in approximating the binomial distribution (thus building on topics taught in weeks 2 and 3) and also for its importance in modeling biological processes such as mutation. It will also be connected with the topic of enumeration (for example via Dobinski's formula).

5. **Difference equations, recursion.**

This material constitutes 1 week of Math 55, although Math 55 focuses on connections to generating functions, whereas this course will focus on difference equations and applications to modeling mutation.

6. **Algorithms and dynamic programming.**

This material will be based on CS 70. It will build on recursion to introduce the notion of an algorithm with dynamic programming as the example. A simple and important application is to the edit distance between sequences (sequence alignment). This material from the first 5 weeks constitute a cohesive set of topics suitable for testing on a midterm.

7. **Differential equations I**

This material constitutes approximately 1 week of Math 1B or 16B. It follows naturally from difference equations.

8. **Differential equations II**

This material constitutes approximately 1 week of Math 1B or 16B. Time permitting, Euler's method will be introduced, especially in light of the recursive algorithms taught in weeks 4/5. However 2nd order differential equations as covered in Math 1B will not be covered.

9. **Inference for discrete distributions.**

This material constitutes approximately 1 week of Stat 20. The purpose of this week will be to introduce the important χ^2 test.

10. **Least squares and correlation.**

This material constitutes approximately 1 week of Math 16B/Stat 20. The problem will be formulated rigorously (to be followed by the mathematics solution in weeks 9 and 10) and will serve as a simple example of linear regression.

11. **Linear equations.**

This material constitutes approximately 1 week of Math 54, and follows naturally from the least squares week where a concrete example will introduced serve as the backdrop for this week.

12. **Matrix algebra.**

This material constitutes approximately 1 week of Math 54. The focus will be on demonstrating Gaussian elimination for solving systems of linear equations.

13. **Relations and partially ordered sets.**

This material constitutes 1 week of Math 55. The focus will be on partially ordered sets and their utility in modeling ontologies. Mathematically, relations are a natural precursor to

graphs.

14. Graphs, trees and phylogenetics.

This material constitutes 2 weeks of Math 55. Rather than discussing graphs in full generality, the focus will be on the trees viewed as special cases of graphs. Many of the mathematics and statistics topics from the entire 2 semester sequence can be tied together with this topic, and it also serves to highlight evolution as a unifying theme in biology- a fitting final message for the end of the course.

□ FREQUENTLY ASKED QUESTIONS

As new questions come up, we will be updating this list.

1. Will this course count as a prerequisite for the Physics 8 series?

Yes! The Physics Department has reviewed course content and determined that Math 10A is the prerequisite for Physics 8A and Math 10B is the prerequisite for Physics 8B. The Physics 7 series is significantly more math intensive, and requires Math 1A, 1B, 53, and 54 as you progress through the sequence.

2. I already signed up for Math 1A or I am on the waiting list for Math 1A. Do I have to wait until Phase II to add this course?

Yes. In general, freshmen will begin their Phase II appointments July 19. The way that Tele-BEARS works is that all students are assigned a Phase I appointment time and a Phase II appointment time. Once your Phase I appointment has come and gone, you can always adjust your schedule until the last day of Phase I during open hours. After that, you must wait until your Phase II appointment begins before you can log back into Tele-BEARS. [Remember that once your Phase II appointment is over, you can go in to Tele-BEARS during open hours.](#)

3. What if I drop Math 1A and then I don't get a spot in Math 10A?

Do not drop Math 1A until you've already added Math 10A! You want to be sure that you have secured a spot, not just gotten on the waiting list, before you give up your seat in Math 1A.

4. If I take Math 1A in the fall, can I take Math 10B in the spring?

No. Math 10 is a year long series that begins fall and ends spring. Math 1A will not serve as the pre-requisite for the second semester of Math 10B. If you take Math 10A in fall, be prepared to complete the series in spring.

5. Will Math 10A/B count toward requirements for other majors?

The only departments that have unequivocally approved the Math 10 series for its major are Molecular & Cell Biology and Integrative Biology. While we hope other majors will follow suit, we cannot guarantee that. If you are concerned, please enroll in Math 1A or Math 16A.

6. Math 16A and Math 1A are full. Should I enroll in Math 10A instead?

No, you should enroll in Math 10A if you're planning on pursuing a major in MCB or IB and you're interested in the material being taught and you like math.

The Math Department may open up more seats for Math 1A and Math 16A. Please place yourself on the wait list and keep checking on your status. The department will have a better chance of getting rooms if there is proven demand.

7. Math 10A is full and I am on the waitlist. Will I get into the class?

The Math Department will not be opening up any more sections of Math 10A for fall 2012. However, the professor for the courses expects that some students will drop the course during the first week. If you are interested in taking the course, plan to attend the first couple of classes to see if you can secure a space.

8. What will the textbook be for the course?

Professor Patcher has indicated that there will not be a specific textbook for the course. Instead he will be distributing notes and assignments during the course. Several textbooks will be recommended but not required. Information about these resources will be available at the start of the class.