Course Information Book

Department of Mathematics

Tufts University

Fall 2016

This booklet contains the complete schedule of courses offered by the Math Department in the Fall 2016 semester, as well as descriptions of our upper-level courses (from Math 61 [formally Math 22] and up). For descriptions of lower-level courses, see the University catalog.

If you have any questions about the courses, please feel free to contact one of the instructors.

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Course Renumbering

Starting Fall, 2012, the lower level math courses will have new numbers. The matrix below gives the map between the current numbers and the new numbers. The course numbers on courses you take before Fall 2012 will not change, and the content of these courses will not change.

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* Course coordinator
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* Course coordinator
Math 61 Discrete Mathematics Fall 2016
Course Information

**Block: B**
**Instructor:** Zachary Faubion
**Email:** zachary.faubion@tufts.edu

**Block: F**
**Instructor:** Zachary Faubion
**Email:** zachary.faubion@tufts.edu

**Text:** TBA

Course description TBA
BLOCK: C
INSTRUCTOR: Robert J. Lemke Oliver
EMAIL: robert.lemke_oliver@tufts.edu
OFFICE: N/A
OFFICE HOURS: None in Spring 2016. (Feel free to email.)
PREREQUISITES: Math 32 or consent.

TEXT: TBD

COURSE DESCRIPTION:

Broadly speaking, number theory is the study of the integers. Despite having its origins in ancient Greece, it remains an active area of research, bringing together ideas from many different areas of mathematics.

Some motivating questions might be, are there infinitely many prime numbers? Of those, how many end in the digits 123456789? Is there any structure to the integer solutions to the equation \(a^2 + b^2 = c^2\), or do they occur as sporadic accidents? If \(n > 2\), are there any non-zero integer solutions to the equation \(a^n + b^n = c^n\)? Which integers can be written as the sum of two squares, or three squares, or four squares? How are prime numbers used in cryptography? In this course, we will develop the tools needed to answer (some of) these questions, making connections with some open problems along the way.

Proofs play a central role in number theory, though no prior experience will be assumed. Grades will be based on a combination of homework, exams, and a final project.
Math 70  Linear Algebra  Fall 2016

Course Information

**Block: C (TWF 9.30-10.20)**
**Instructor:** Montserrat Teixidor  
**Email:** mteixido@tufts.edu  
**Office:** Bromfield-Pearson 115  
**Office hours:** (Spr 2016) by appointment

**Block: D (M9.30-10.20, TTh 10.30-11.20)**
**Instructor:** Mary Glaser  
**Email:** Mary.Glaser@tufts.edu  
**Office:** Bromfield-Pearson 4  
**Office hours:** (Spr 16) M 10:30-11:30, W 2-4.

**Prerequisites:** Math 42, or consent of instructor.


**Course description:** Linear algebra begins the study of systems of linear equations in several unknowns. The study of linear equations quickly leads to the important concepts of vector spaces, dimension, linear transformations, eigenvectors and eigenvalues. These abstract ideas enable efficient study of linear equations, and more importantly, they fit together in a beautiful setting that provides a deeper understanding of these ideas.

Linear algebra arises everywhere in mathematics. It plays an important role in almost every upper level math course. It is also crucial in physics, chemistry, economics, biology, and a range of other fields. Even when a problem involves nonlinear equations, as is often the case in applications, linear systems still play a central role, since “linearizing” is a common approach to non-linear problems.

This course introduces students to axiomatic mathematics and proofs as well as fundamental mathematical ideas. Mathematics majors and minors are required to take linear algebra (Math 70 or Math 72) and are urged to take it as early as possible, as it is a prerequisite for many upper-level mathematics courses. The course is also useful to majors in computer science, economics, engineering, and the natural and social sciences.

The course will have two midterms and a final, as well as daily homework assignments.
Block: E+WF (Wed, Fr 10:30–11:45)
Instructor: Montserrat Teixidor
Email: mteixido@tufts.edu
Office: Bromfield-Pearson 115
Office hours: (Spring 2016), by appointment
Phone: (617) 627-2358

Prerequisite: Math 34 or Math 39, or permission of instructor. Students may count only one of Math 70 and Math 72 for credit.


Course description:

Math 72 is a proof-based introduction to linear algebra. It will stress the development of abstract concepts and the proofs of theorems, and there will be less emphasis on matrix computations than in the other linear algebra course Math 70. The course will be appropriate for those students who prefer a less computational treatment of linear algebra. It is intended for majors or minors in mathematics, computer science, science and engineering. The course will include numerous examples that will motivate and clarify the exposition as well as demonstrate the power of the abstract point of view.

It is impossible to overstate the importance of linear algebra to the entire field of mathematics, and to applications as diverse as medical imaging, operations research, internet search engine design, statistics, or signal processing. Linear algebra is a prerequisite for most upper-level mathematics courses. Therefore, it is recommended that students who are seriously interested in mathematics take linear algebra (Math 72 or 70) as soon as possible.

We will begin with an introduction to abstract vector spaces, span and linear independence, basis, and dimension. We then proceed to a study of linear maps and their matrices, together with properties such as rank, nullspace, range, trace, and determinant. From this, we continue into eigenvalues and eigenvectors, diagonalizability, invariant subspaces, the Cayley-Hamilton theorem, inner product spaces, orthogonality, the adjoint, as well as orthogonal, unitary, and normal linear operators, the spectral theorem, and bilinear and quadratic forms. As time permits, we will cover characteristic and minimal polynomials of a linear operator, generalized eigenvectors, and the Jordan canonical form.

There will be two midterm exams and a final, as well as weekly assignments.
Math 87 Mathematical Modeling and Computation  Fall 2016
Course Information

BLOCK: J+TTh, Tue Thurs. 3:00 -4:15 PM  
INSTRUCTOR: James Adler  
EMAIL: james.adler@tufts.edu  
OFFICE: Bromfield-Pearson 209  
OFFICE HOURS: (Spring 2016) T 9:30-11:00am & Th 2:30-4:00pm  
PREREQUISITES: Math 34 or 39, Math 70 or 72, or consent.

TEXT: none

COURSE DESCRIPTION:
This course is about using elementary mathematics and computing to solve practical problems. Single-variable calculus is a prerequisite, as well as some basic linear algebra skills; other mathematical and computational tools, such as elementary probability, elementary combinatorics, and computing in MATLAB, will be introduced as they come up.

Mathematical modeling is an important area of study, where we consider how mathematics can be used to model and solve problems in the real world. This class will be driven by studying real-world questions where mathematical models can be used as part of the decision-making process. Along the way, we’ll discover that many of these questions are best answered by combining mathematical intuition with some computational experiments.

Some problems that we will study in this class include:

1. The managed use of natural resources. Consider a population of fish that has a natural growth rate, which is decreased by a certain amount of harvesting. How much harvesting should be allowed each year in order to maintain a sustainable population?

2. The optimal use of labor. Suppose you run a construction company that has fixed numbers of tradespeople, such as carpenters and plumbers. How should you decide what to build to maximize your annual profits? What should you be willing to pay to increase your labor force?

3. Project scheduling. Think about scheduling a complex project, consisting of a large number of tasks, some of which cannot be started until others have finished. What is the shortest total amount of time needed to finish the project? How do delays in completion of some activities affect the total completion time?

Using basic mathematics and calculus, we will address some of these issues and others, such as dealing with the MBTA T system and penguins (separately of course...). This course will also serve as a good starting point for those interested in participating in the Mathematical Contest in Modeling each Spring.
BLOCK: G+ (Mo, We 1:30-2:45)  
INSTRUCTOR: Christoph Borgers  
EMAIL: christoph.borgers@tufts.edu  
OFFICE: 215 Bromfield-Pearson Hall  
OFFICE HOURS: (Spring 2016) Tu 12–1:30, Th 12–1:30  
PHONE: (617) 627-2366

PREREQUISITES: Single-variable calculus, and one of Math 51 (for its Linear Algebra content), Math 70, or Math 72. Experience programming in a language such as C, C++, Python, or Matlab.


COURSE DESCRIPTION: Numerical analysis is the study of algorithms for mathematical problems involving real or complex numbers, for instance differentiation and integration, linear systems of equations, nonlinear algebraic equations, and differential equations.

There are many striking examples illustrating the importance of numerical algorithms to society. Here are just three of them. (1) In 1991, a Norwegian offshore oil platform called the Sleipner A sank. The resulting economic loss was estimated at $700 million. The post-accident investigation traced the problem to a faulty numerical method for predicting shear stresses. (2) At the heart of the Google search engine is an algorithm for ranking web pages by importance, called the PageRank algorithm. Fundamentally, the problem is to compute an eigenvector of an $n \times n$ matrix, where $n$ is the number of pages on the web. In January of 2016, Google estimated $n \approx 50,000,000,000$. (3) CT scanners are used throughout the world for medical diagnostics. This technology is based on numerical algorithms for the solution of certain integral equations.

This course is an introduction to the field, treating linear algebra fairly lightly, instead emphasizing non-linear equations, integration, and differential equations. (For a thorough treatment of numerical linear algebra, take Math 128/CS 128.) Computer programming will be a substantial component of the homework.
Math 135  Real Analysis I  Fall 2016
Course Information

BLOCK: D+TR (Tue Thu 12:00–1:15)
INSTRUCTOR: Fulton Gonzalez
EMAIL: fulton.gonzalez@tufts.edu
OFFICE: Bromfield-Pearson 203
OFFICE HOURS: (Spring 2016) Tue 3–5 p.m.,
Thu 3–4 p.m.
PHONE: (617) 627-2368

BLOCK: C (Tues Wed Fri 9:30–10:20)
INSTRUCTOR: Zbigniew Nitecki
EMAIL: zbigniew.nitecki@tufts.edu
OFFICE: Bromfield-Pearson 214
OFFICE HOURS: (Spring 2016) MWF 1:30-2:30 or by appointment
PHONE: (617) 627-3843

PREREQUISITES: Math 42 or 44, and 70, or consent.

TEXT: TBD

COURSE DESCRIPTION:
Real analysis is the rigorous study of real functions, their derivatives and integrals. It provides the theoretical underpinning of calculus and lays the foundation for higher mathematics, both pure and applied. Unlike Math 32, 34, and 42, where the emphasis is on intuition and computation, the emphasis in real analysis is on justification and proofs.

Is this rigor really necessary? This course will convince you that the answer is an unequivocal yes, because intuition not grounded in rigor often fails us or leads us astray. This is especially true when one deals with the infinitely large or the infinitesimally small. For example, it is not intuitively obvious that, although the set of rational numbers contains the set of integers as a proper subset, there is a one-to-one correspondence between them. These two sets, in this sense, are the same size! On the other hand, there is no such correspondence between the real numbers and the rational numbers, and therefore the set of real numbers is uncountably infinite.

In this course, we will study the topology of the real line and Euclidean space, compactness, connectedness, continuous mappings, and uniform convergence. Along the way, we will encounter theorems of calculus, such as the intermediate-value theorem and the maximum-minimum theorem, but in a more general setting that enlarges their range of applicability.

In addition to introducing a core of basic concepts in analysis, a companion goal of the course is to hone your skills in distinguishing the true from the false and in reading and writing mathematical statements and proofs.

Math 135 is required of all math majors. A math minor must take Math 135 or 145 (or both).
BLOCK: C (TWF 9:30-10:20)
INSTRUCTOR: George McNinch
EMAIL: george.mcninch@tufts.edu
OFFICE: Bromfield-Pearson 112
OFFICE HOURS (Spring 2016): Tues and Thur 3:00-4:00, Wed 10:30-11:30

PREREQUISITES: Math 70 or 72 (Linear Algebra or Abstract Linear Algebra)


COURSE DESCRIPTION:
The study of algebra has a long history, and it remains an important part of modern mathematics. Historically, algebra was concerned with the manipulation of equations and, in particular, with the problem of finding the roots of polynomials; this is the algebra you know from high school.

Modern algebra – and this course – systematically studies the mathematical notions of groups, rings, and fields. Roughly speaking, group theory is the study of symmetry; symmetries play an important role in mathematics, but also in physics, chemistry and other physical sciences. The study of rings and fields is part of arithmetic – i.e. of number theory – and of geometry – since information about geometric objects is often encoded by the ring of functions.

The last half-century has seen some big breakthroughs in algebra and its applications, such as the solution of Fermat’s Last Theorem and the classification of finite simple groups (the building blocks of all finite groups). Algebraic topics like representation theory, algebraic geometry and number theory remain at the forefront of modern mathematics.

A main goal of Math 145-146 is to describe the beautiful connection that Galois discovered between groups and the roots of polynomials – i.e. between groups and fields. We have first to develop an understanding of – and the fundamental results for – the mathematical objects involved.
In 2010, there were 388 billionaires in the world whose combined wealth exceeded that of half the earth’s population. Today, that number is 62, and all indications are that it continues to decrease. The enormous concentration of wealth and the unchecked growth of inequality have emerged as crucial social issues of our time. To what extent can mathematics help shed light on this problem?

We will begin with definitions of money, wealth and income – concepts that are often confused in the popular literature – so that we can speak precisely about this subject. We will briefly survey historical thought on this subject from mathematical, economic and philosophical perspectives. We will then discuss how wealth distributions are quantified, and how inequality is measured. This will lead us to study the theory of distributions and density functions, histograms and kernel estimation. In turn, this will enable us to understand the history of empirical studies of wealth distribution, including the important observations of Pareto, Lorenz, Gini, Gibrat and others. Along the way, we will learn about the Lorenz-Pareto, Gini, Atkinson, and Foster-Greer-Thorbecke indices, and upward mobility measures.

Next we turn our attention to various ways of understanding wealth concentration. This will lead us to a study of random walks, the Gambler’s Ruin problem, an introduction to Markov processes, and the concept of stochastic dominance. From this viewpoint, we will study pyramid and Ponzi schemes, both from a mathematical and an ethical perspective.

The centerpiece of this course will be an introduction to dynamical models, especially agent-based models, with particular emphasis on asset-exchange models, especially the Yard-Sale Model. We will show how such simple models of agent transactions at the microeconomic level can be used to derive dynamical equations for the wealth distribution. Along the way, we will learn about strong and weak forms of conservation laws, multi-agent distributions and density functions, the random-agent approximation leading to the Boltzmann equation, and the small-transaction approximation leading to the Fokker-Planck equation for the wealth distribution. We will study the phenomenology exhibited by these equations, including a phase transition discovered by Bouchaud and Mézard in 2000 called wealth condensation, which is thought to explain the origin of oligarchy.

The course will finish with a litany of state-of-the-art results and outstanding problems, with particular emphasis on that of reconciling asset-exchange models with neoclassical microeconomics. Toward this end, we will review the latter subject, beginning with the notion of utility as understood by Bentham and Walras, introducing the notion of Pareto efficiency, and leading up to a mathematical description of General Equilibrium theory. We will review some of the assumptions built into this line of thinking, and some of the known problems with those assumptions, including asymmetric information, irrational expectations, behavioral economic effects, and stochasticity. In particular, we will highlight some of Akerlof’s recent work on asymmetric information.

Some description will be given of available databases for the study of wealth distribution, including that maintained by the Federal Reserve and the U.S. Census Bureau, as well as international data available, for example from the World’s Top Incomes Database.

Multivariable calculus is a prerequisite. Courses in differential equations and linear algebra would be helpful, but are not necessary. No prior background in economics is assumed. There will be weekly problem sets, at least one midterm and a final exam.
Math 150-02 Nonlinear Dynamics and Chaos
Course Information
Fall 2016

BLOCK: E (Mo, We, Fr 10:30–11:20)
INSTRUCTOR: Christoph Börgers
EMAIL: christoph.borgers@tufts.edu
OFFICE: 215 Bromfield-Pearson Hall
OFFICE HOURS: (Spring 2016) Tu 12–1:30, Th 12–1:30
PHONE: (617) 627-2366

PREREQUISITES: Math 51 or consent.


COURSE DESCRIPTION: This is primarily a course on ordinary differential equations with emphasis on qualitative, geometric aspects of the subject; however, there is also some material on iterated maps — that is, on dynamical systems in which time ticks discretely instead of flowing continuously. Applications in physics, biology, chemistry, and engineering will be discussed in detail.

We will discuss coupled systems of $n$ differential equations describing $n$ quantities $x_i(t)$, $i = 1, ... , n$. (Here $t$ is time and $x_i(t)$ is a real number.) Following the book, the course has three parts: $n = 1$, $n = 2$, and $n > 2$.

Even the case $n = 1$ has very interesting aspects. We will discuss bifurcations in a single differential equation for a single time-dependent unknown quantity, with applications to lasers, the motion of a bead on a rotating hoop immersed in molasses (we have to immerse it in molasses in part 1, otherwise $n = 2$ for this problem), insect outbreaks, and the simplest mathematical caricature of excitable cells (nerve and muscle).

Systems with $n = 2$ allow oscillatory behavior. (Systems with $n = 1$ do not.) We will study the classification of fixed points, phase portraits, limit cycles (that is, persistent oscillations), and bifurcations in two dimensions. There is an abundance of applications of these subjects: the pendulum (first without drive, then the driven pendulum), predator and prey populations, oscillating chemical reactions, nerve cells, and the bead on the hoop without the molasses.

Systems with $n > 2$ allow “chaos”. We will study the famous Lorenz equations (one of the first systems of differential equations in which chaotic behavior was discovered), chaos in iterated one-dimensional maps, fractals, and strange attractors.

This course is suitable for upper level undergraduate and beginning graduate students from Mathematics, Engineering, Biology, Chemistry, and Physics.
BLOCK: F
INSTRUCTOR: TBA

Course description TBA
Block: F+ MWF
Instructor: TBA

Prerequisites: Math 42 or consent.

Text: TBA

Course description:
Many things we experience in the real world are unpredictable. Consider flipping a coin. Can we predict if it will land heads or tails? If the exact position of your finger, the composition of the table, and the air currents were known, then we could predict the outcome of the coin flip. However, due to the lack of information, we cannot predict the result. This lack of information is explained as being due to “randomness.” In this course, we will study the probability distributions of outcomes of random experiments.

In this course, we will cover sample spaces associated with a random experiment, the axioms of probability, combinatorics, conditional probability, independence of events, discrete and continuous random variables, joint probability distributions, the central limit theorem, and the law of large numbers. The probability distributions that we will cover include geometric, binomial, uniform, exponential, poisson, gamma, and the normal distribution. Knowledge of single and multivariable calculus is required for this course.
BLOCK: J+ (Tue Thu 3:00 – 4:15 p.m.)
INSTRUCTOR: Fulton Gonzalez
EMAIL: fulton.gonzalez@tufts.edu
OFFICE: Bromfield-Pearson 203
OFFICE HOURS: (Spring 2016) Tuesdays 3:00 – 5:00 p.m.; Thursdays 3:00 – 4:00 p.m.
PHONE: 617 627 2368

PREREQUISITES: Math 135 or equivalent, Math 136 is recommended.


COURSE DESCRIPTION: Define the function \( f(x) \) on the interval \([0, 1]\) by

\[
\begin{cases}
1 & \text{if } x \text{ is rational,} \\
0 & \text{if } x \text{ is irrational.}
\end{cases}
\]

It is easy to see that the Riemann integral\(^1\) of \( f(x) \), defined as the limit of Riemann sums, does not exist. However, since almost all; i.e., all except a countable number of; real numbers are irrational, one would, in a sense, want the integral of \( f(x) \) to exist and be equal to zero. Lebesgue’s theory of integration, which first appeared in his famous 1904 book [Lecons sur integration et la recherche des fonctions primitives, Gauthier-Villars, Paris, 1904; second edition, 1928] treats discontinuous functions as “natural” objects to integrate and paves the way for integration on spaces besides Euclidean space (e.g. topological groups). It is immediate from Lebesgue’s construction that the integral of \( f(x) \) exists and equals zero.

In this course, we will introduce measure theory and the tools needed to define abstract integrals, and in particular the Lebesgue integral on \( \mathbb{R}^n \). We will explore important concepts such as the great convergence theorems (i.e., under what conditions is \( \lim \int f_n = \int \lim f_n \)?), \( L^p \) spaces, Banach and Hilbert spaces, complex measures, and various ways of differentiating measures, including the Radon-Nikodym Theorem. Finally, we study Fourier transforms and some applications. The course will roughly follow the first eight chapters of Rudin’s book.

There will be two exams - a midterm and a final - as well as weekly problem sets.

\(^1\)Which was actually formally defined by Cauchy.
Course Information

Block: G+TR, Tue Thu 1:30-2:45 PM
Instructor: Kim Ruane
Email: kim.ruane@tufts.edu
Office: 574 Boston Avenue 211 I
Office hours: (Spring 2016) M 9:30-12:30, Tu 3:15-4:15, Th 12-1

Prerequisites: Math 146 or equivalent


Course description:
Algebra is the study of patterns and structures. For this reason, it is the underpinning of many areas of mathematics. This course concentrates on four basic algebraic structures: groups, rings, modules, and fields. Since one of the purposes of the course is to prepare the students for the algebra qualifying exam, we will follow closely the syllabus for that exam reproduced below.

1. Generalities: Quotients and isomorphism theorems for groups, rings, modules.

2. Groups:
   - The action of a group on a set; applications to conjugacy classes and the class equation.
   - The Sylow Theorems; simple groups.
   - Simplicity of the alternating group $A_n$ for $n \geq 5$.

3. Rings and Modules:
   - Polynomial rings, Euclidean domains, principal ideal domains.
   - Unique factorization; the Gauss lemma and Eisenstein’s criteria for irreducibility.
   - Free modules; the tensor product.
   - Structure of finitely generated modules over a PID; applications (finitely generated abelian groups, canonical forms for linear transformations).

4. Fields:
   - Algebraic, transcendental, separable, and Galois extensions, splitting fields.
   - Finite fields, algebraic closures.
   - The Fundamental Theorem of Galois theory for a finite extension of a field of arbitrary characteristic.

Many of these topics are covered in Math 145 and 146, but we will study them in greater depth. Students planning to take the algebra qualifying exam may need to do some additional study on their own if we do not cover all of these topics in one semester. The course is suitable for undergraduates who have done very well in Math 145 and/or 146, especially those wishing to attend graduate school in Mathematics.
Block: 4F
Instructor: Genevieve Walsh
Email: genevieve.walsh@tufts.edu

Text: TBA

Course description: TBA
Block: B+ (TR 08:05-09:20)  
Instructor: Bruce Boghosian  
Email: bruce.boghosian@tufts.edu  
Office: Bromfield-Pearson 211  
Office hours: TBA  
Prerequisites: Math 135 or consent

Text: *Partial Differential Equations, Second Edition* by Lawrence C. Evans (American Mathematical Society, 2010), and instructor’s notes

Course description:
Partial differential equations (PDEs) are the principal language of mathematical science, and this course will provide the student with a working knowledge of that language. We shall derive and analyze the important prototypical linear PDEs for potential theory, heat transfer and wave motion. We shall learn how to classify PDEs as elliptic, parabolic or hyperbolic, and how to represent their solutions. We shall study well posedness of PDEs, and early attempts at finding conditions for the existence and uniqueness of their solutions, including the Cauchy-Kovalevskaya Theorem, and Tychonoff’s solution of the heat equation.

We shall then learn how to find classical or strong solutions of PDEs by mastering a variety of techniques, including: Separation of variables, eigenfunction expansions, Sturm-Liouville problems, special functions, Laplace’s method, Fourier series and integral transforms, and Green’s functions. All of this material will be introduced from a functional analytical perspective, and the student will gradually become conversant with Schwartz function spaces $S$, the Lebesgue spaces $L^p$, and the Sobolev spaces $H^k$. An introduction to the calculus of variations will be provided, weak and strong maximum principles will be formulated, and existence and uniqueness of classical solutions will be proven.

Distribution theory will next be introduced, including both classical and singular distributions. We will then turn our attention to generalized or weak solutions of partial differential equations, and their relevance to theory, applications, and numerical methods. Finally, we will study theorems for the existence and uniqueness of weak solutions, as well as regularity theorems, including unresolved questions about boundary regularity of elliptic PDEs.

An undergraduate course in Real Analysis, similar to Tufts MA 135, is a prerequisite. There will be weekly problem sets, at least one midterm and a final exam. This course concentrates on the theory of linear PDEs; the study of nonlinear PDEs is left to the follow-on course MA 252, usually offered in the semester immediately following MA 251. The course meets during a + block because of the considerable amount of material that must be covered.
# MATHEMATICS MAJOR CONCENTRATION CHECKLIST
For students matriculating Fall 2012 and after (and optionally for others)
(To be submitted with University Degree Sheet)

<table>
<thead>
<tr>
<th>Name:</th>
<th>I.D.#:</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Mail Address:</td>
<td>College and expected graduation semester/year:</td>
</tr>
</tbody>
</table>

Other Major(s):
(Note: Submit a signed checklist with your degree sheet for each major.)

Please list courses by number. For transfer courses, list by title, and add “T”. Indicate which courses are incomplete, in progress, or to be taken.

Note: If substitutions are made, it is the student’s responsibility to make sure the substitutions are acceptable to the Mathematics Department.

Ten courses distributed as follows:

I. Five courses required of all majors. (Check appropriate boxes.)
If “in progress” or future semester, note semester.

<table>
<thead>
<tr>
<th>Grade:</th>
<th>Grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 70: Linear Algebra or Math 72: Abstract Linear Algebra</td>
<td>5. Math 136: Real Analysis II or Math 146: Abstract Algebra II</td>
</tr>
</tbody>
</table>

We encourage all students to take Math 70 or 72 before their junior year. To prepare for the proofs required in Math 135 and 145, we recommend that students who take Math 70 instead of 72 also take another course above 50 (in the new numbering scheme) before taking these upper level courses.

II. Two additional 100-level math courses.

<table>
<thead>
<tr>
<th>Grade:</th>
<th>Grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. __________________</td>
<td>2. __________________</td>
</tr>
</tbody>
</table>

III. Three additional mathematics courses numbered 50 or higher (in the new numbering scheme); up to two of these courses may be replaced by courses in related fields including:
Chemistry 133, 134; Computer Science 15, 126, 160, 170; Economics 107, 108, 154, 201, 202; Electrical Engineering 18, 107, 108, 125; Engineering Science 151, 152; Mechanical Engineering 137, 138, 150, 165, 166; Philosophy 33, 103, 114, 170; Physics 12, 13 any course numbered above 30; Psychology 107, 108, 140.

<table>
<thead>
<tr>
<th>Grade:</th>
<th>Grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. __________________</td>
<td>3. __________________</td>
</tr>
<tr>
<td>2. __________________</td>
<td></td>
</tr>
</tbody>
</table>

Student’s signature: ___________________________ Date: ____________
Advisor’s signature: __________________________ Date: ____________
Chair’s signature: __________________________ Date: ____________

Note: It is the student’s responsibility to return completed, signed degree sheets to the Office of Student Services, Dowling Hall.
(form revised September 2, 2015)
# APPLIED MATHEMATICS MAJOR CONCENTRATION CHECKLIST
(To Be Submitted with University Degree Sheet)

<table>
<thead>
<tr>
<th>Name:</th>
<th>I.D.#:</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Mail Address:</td>
<td>College and expected graduation semester/year:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Major(s):</th>
<th>(Note: Submit a signed checklist with your degree sheet for each major.)</th>
</tr>
</thead>
</table>

Please list courses by number. For transfer courses, list by title, and add “T”. Indicate which courses are incomplete, in progress, or to be taken.

*Note: If substitutions are made for courses listed as “to be taken”, it is the student’s responsibility to make sure the substitutions are acceptable.*

## Thirteen courses beyond Calculus II. These courses must include:

### I. Seven courses required of all majors. (Check appropriate boxes.)

If “in progress” or future semester, note semester.

If substitutions are made for courses listed as “to be taken”, it is the student’s responsibility to make sure the substitutions are acceptable.

<table>
<thead>
<tr>
<th>Course</th>
<th>Grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 42: Calculus III or Math 44: Honors Calculus III</td>
<td></td>
</tr>
<tr>
<td>Math 70: Linear Algebra or Math 72: Abstract Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>Math 51: Differential Equations</td>
<td></td>
</tr>
</tbody>
</table>

### II. One of the following:

1. ___________________________ Grade: ________

   - Math 145: Abstract Algebra I
   - Math 61/Comp 61: Discrete Mathematics
   - Comp 15: Data Structures
   - Math/Comp 163: Computational Geometry

### III. One of the following three sequences:

1. ___________________________ Grade: ________

   - Math 126/128: Numerical Analysis/Numerical Algebra
   - Math 151/152: Applications of Advanced Calculus/Nonlinear Partial Differential Equations
   - Math 161/162: Probability/Statistics

### IV. An additional course from the list below but not one of the courses chosen in section III:

1. ___________________________ Grade: ________

   - Math 126
   - Math 128
   - Math 151
   - Math 152
   - Math 161
   - Math 162

### V. Two electives (math courses numbered 61 or above are acceptable electives. With the approval of the Mathematics Department, students may also choose as electives courses with strong mathematical content that are not listed as Math courses.)

1. ___________________________ Grade: ________ 2. ___________________________ Grade: ________

---

**Student’s signature:** ___________________________ **Date:** ____________

**Advisor’s signature:** ___________________________ **Date:** ____________

**Chair’s signature:** ___________________________ **Date:** ____________

*Note: It is the student’s responsibility to return completed, signed degree sheets to the Office of Student Services, Dowling Hall.*

(form revised September 2, 2015)
### MATHEMATICS MINOR CONCENTRATION CHECKLIST

In addition to this form, students must complete the “Declaration of Major(s)/Minor/Change of Advisor for Liberal Arts Students” form.

<table>
<thead>
<tr>
<th>Name:</th>
<th>I.D.#:</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Mail Address:</td>
<td>College and expected graduation semester/year:</td>
</tr>
<tr>
<td>Major(s):</td>
<td></td>
</tr>
<tr>
<td>Faculty Advisor for Minor (please print)</td>
<td></td>
</tr>
</tbody>
</table>

Please list courses by number. For transfer courses, list by title and add “T”. Indicate which courses are incomplete, in progress, or to be taken.

**Courses numbered under 100 will be renumbered starting in the Fall 2012 semester. Courses are listed here by their new number, with the old number in parentheses.**

*Note: If substitutions are made for courses listed as “to be taken”, it is the student’s responsibility to make sure that the substitutions are acceptable.*

### Six courses distributed as follows:

#### I. Two courses required of all minors. (Check appropriate boxes.)

If “in progress” or future semester, note semester.

<table>
<thead>
<tr>
<th>Grade:</th>
<th>Grade:</th>
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</thead>
</table>

#### II. Four additional math courses with course numbers Math 50 or higher (in the new numbering scheme).

*These four courses must include Math 135: Real Analysis I or 145: Abstract Algebra (or both). Note that Math 135 and 145 are typically only offered in the fall.*

<table>
<thead>
<tr>
<th>Grade:</th>
<th>Grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ___________</td>
<td>3. ___________</td>
</tr>
<tr>
<td>2. ___________</td>
<td>4. ___________</td>
</tr>
</tbody>
</table>

**Student’s signature:** ____________________________________  **Date:** __________

**Advisor’s signature:** ____________________________________  **Date:** __________

*Note: It is the student’s responsibility to return completed, signed degree sheets to the Office of Student Services, Dowling Hall.*

(form revised September 2, 2015)
**Jobs and Careers**

The Math Department encourages you to discuss your career plans with your professors. All of us would be happy to try and answer any questions you might have. Professor Quinto has built up a collection of information on careers, summer opportunities, internships, and graduate schools and his web site ([http://equinto.math.tufts.edu](http://equinto.math.tufts.edu)) is a good source.

Career Services in Dowling Hall has information about writing cover letters, resumes and job-hunting in general. They also organize on-campus interviews and networking sessions with alumni. There are job fairs from time to time at various locations. Each January, for example, there is a fair organized by the Actuarial Society of Greater New York.

On occasion, the Math Department organizes career talks, usually by recent Tufts graduates. In the past we had talks on the careers in insurance, teaching, and accounting. Please let us know if you have any suggestions.

**The Math Society**

The Math Society is a student run organization that involves mathematics beyond the classroom. The club seeks to present mathematics in a new and interesting light through discussions, presentations, and videos. The club is a resource for forming study groups and looking into career options. You do not need to be a math major to join! See any of us about the details. Check out [http://ase.tufts.edu/mathclub](http://ase.tufts.edu/mathclub) for more information.

**The SIAM Student Chapter**

Students in the Society for Industrial and Applied Mathematics (SIAM) student chapter organize talks on applied mathematics by students, faculty and researchers in industry. It is a great way to talk with other interested students about the range of applied math that’s going on at Tufts. You do not need to be a math major to be involved, and undergraduates and graduate students from a range of fields are members. Check out [https://sites.google.com/site/tuftssiam/](https://sites.google.com/site/tuftssiam/) for more information.
# BLOCK SCHEDULE

<table>
<thead>
<tr>
<th>50 and 75 Minute Classes</th>
<th>Mon</th>
<th>Mon</th>
<th>Tue</th>
<th>Tue</th>
<th>Wed</th>
<th>Wed</th>
<th>Thu</th>
<th>Thu</th>
<th>Fri</th>
<th>Fri</th>
<th>150/180 Minute Classes and Seminars</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:05-9:20 (A+,B+)</td>
<td>A+</td>
<td>0+</td>
<td>B+</td>
<td>1+</td>
<td>A+</td>
<td>2+</td>
<td>B+</td>
<td>3+</td>
<td>B+</td>
<td>4+</td>
<td>8:30-11:30 (0+,1+,2+,3+,4+)</td>
</tr>
<tr>
<td>8:30-9:20 (A,B)</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>9-11:30 (0,1,2,3,4)</td>
</tr>
<tr>
<td>9:30-10:20 (A,C,D)</td>
<td>D</td>
<td>0</td>
<td>C</td>
<td>1</td>
<td>C</td>
<td>2</td>
<td>A</td>
<td>3</td>
<td>C</td>
<td>4</td>
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</tr>
<tr>
<td>10:30-11:20 (D,E)</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D+</td>
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<td>D+</td>
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<tr>
<td>10:30-11:45 (D+,E+)</td>
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<td>12:00-12:50 (F)</td>
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<td>F</td>
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<td>F</td>
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<td>F+</td>
<td>1:30-4:00 (5,6,7,8,9)</td>
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<tr>
<td>12:00-1:15 (F+)</td>
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<td>F+</td>
<td>1:20-4:20 (5+,6+,7+,8+,9+)</td>
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<tr>
<td>1:30-2:20 (G,H)</td>
<td>G</td>
<td>5</td>
<td>H</td>
<td>6</td>
<td>G</td>
<td>7</td>
<td>H</td>
<td>8</td>
<td>G</td>
<td>9</td>
<td></td>
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<tr>
<td>1:30-2:45 (G+,H+)</td>
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<tr>
<td>2:30-3:20 (H on Fri)</td>
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<tr>
<td>3:00-3:50 (I,J)</td>
<td>I</td>
<td>I+</td>
<td>J</td>
<td>J+</td>
<td>I</td>
<td>J+</td>
<td>I</td>
<td>J+</td>
<td>I</td>
<td>J+</td>
<td>1:30-4:00 (5,6,7,8,9)</td>
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<tr>
<td>3:00-4:15 (J+,I+)</td>
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<tr>
<td>3:30-4:20 (I on Fri)</td>
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<tr>
<td>4:30-5:20 (K,L)</td>
<td>K</td>
<td>L+</td>
<td>K</td>
<td>L+</td>
<td>K</td>
<td>L+</td>
<td>K</td>
<td>L+</td>
<td>K</td>
<td>L+</td>
<td>1:30-4:00 (5,6,7,8,9)</td>
</tr>
<tr>
<td>4:30-5:45 (K+,L+)</td>
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<tr>
<td>6:00-6:50 (M,N)</td>
<td>M</td>
<td>M+</td>
<td>N</td>
<td>N+</td>
<td>M</td>
<td>M+</td>
<td>N</td>
<td>N+</td>
<td>M</td>
<td>M+</td>
<td>6:00-9:00 (10+,11+,12+,13+)</td>
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<td>6:00-7:15 (M+,N+)</td>
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<td>6:30-9:00 (10,11,12,13)</td>
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<td>7:30-8:15 (P,Q)</td>
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<td>6:30-9:00 (10+,11+,12+,13+)</td>
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<td>7:30-8:45 (P+,Q+)</td>
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**Notes:**
- A plain letter (such as B) indicates a 50 minute meeting time.
- A number (such as 2) indicates a 150 minute class or seminar. A number with a + (such as 2+) indicates a 180 minute meeting time.
- Lab schedules for dedicated laboratories are determined by department/program.
- Monday from 12:00-1:20 is departmental meetings/exam block.
- Wednesday from 12:00-1:20 is the AS&E-wide meeting time.
- If all days in a block are to be used, no designation is used. Otherwise, days of the week (MTWRF) are designated (for example, E+MW).
- Roughly 55% of all courses may be offered in the shaded area.
- Labs taught in seminar block 5+-9+ may run to 4:30. Students taking these courses are advised to avoid courses offered in the K or L block.