# 300-Level Math Courses

### Math 250: Elementary Differential Equations

A differential equation is an equation relating an unknown function to one or more of its derivatives; for instance, f' = f is a differential equation characterizing functions which equal their own derivatives. To solve a differential equation means to find all functions satisfying that equation. This course focuses on first- and second-order ordinary differential equations and on systems of linear ordinary differential equations. Here, "ordinary" refers to the fact that only single-variable functions are considered. (Note: this is not a 300-level course, but provides background necessary to take Math 351.)

### Math 300: Foundations of Higher Mathematics

This course introduces the logic, proof techniques, set theory and function theory used again and again in higher-level mathematics. The emphasis is on gaining exposure to proof-writing and on developing the type of mathematical intuition and reasoning abilities later courses require.

### Math 306: Combinatorics and Discrete Mathematics

Discrete mathematics studies "discrete" as opposed to "continuous" objects. For instance, problems dealing with integers are usually discrete in nature, whereas the kinds of things you did in a calculus course are more "continuous". Combinatorics in particular is devoted to questions which arise from counting problems, where the focus is not only on being able to perform said counts but also on recognizing how one counting problem can be reformulated in terms of another.

### Math 308: Graph Theory

A graph is a collection of dots (i.e. vertices) and lines (i.e. edges) connecting them, and is often used to indicate certain relationships between different pieces of data. For instance, hyperlinks between different webpages can be modeled

using a graph. This course is devoted to studying graphs as mathematical objects in their own right and the types of situations in which they arise.

**Math 310-1,2,3: Probability and Stochastic Processes**

This is a course in probability, covering foundational material and more advanced topics. A stochastic process is the probabilistic analog of a deterministic process; in a deterministic process the long-term behavior of a system is fully determined from some initial conditions (for instance, the types of systems modeled by differential equations are deterministic), but in a stochastic processes multiple long-term behaviors are possible due to the fact that we can only probabilistically characterize what will happen at each step.

**Math 311-1,2,3: MENU Probability and Stochastic Processes**

This is the MENU version of Math 310, which covers similar topics only in more depth, at a quicker pace, and in more generality.

**Math 320-1,2,3: Real Analysis**

Real analysis is essentially the study of functions on the set of real numbers, with things like continuity, differentiability, and integrability being the key properties of interest. This course develops all of calculus and multivariable calculus from the ground up, giving precise definitions of all concepts and rigorously understanding why things in calculus work the way they do. An important aspect is in understanding precisely what properties of the set of real numbers allow for the theory to develop.

**Math 321-1,2,3: MENU Real Analysis**

This is the MENU version of Math 320, which covers similar topics only in more depth, at a quicker pace, and in more generality.

**Math 325: Complex Analysis**

Complex analysis focuses on doing calculus with functions defined on the set of complex numbers, where the concepts of differentiation and integration of such functions are the keys one. Many aspects of calculus in the complex setting are similar to calculus in the real setting, but new and surprising behavior also arises.

**Math 327: Mechanics for Mathematicians**

Mechanics is the area of physics which describes how a physical object moves or evolves under the action of some force. This course in particular focuses on the mathematical aspects of the resulting theory, and on the different ways of formulating the applicable concepts.

**Math 330-1,2,3: Abstract Algebra**

Abstract algebra studies the types of structures which arise when imposing some "addition" and/or "multiplication" operation on a set. They key objects of study are what are called groups, rings, and fields, all of which are sets equipped with a certain type of algebraic operation. The subject arose historically from the problem of developing a "quintic formula" for polynomials of degree 5 analogous to the well-known "quadratic formula" for polynomials of degree 2; it turns out the one can recast the problem of finding such a formula in terms of properties of certain groups.

**Math 331-1,2,3: MENU Abstract Algebra**

This is the MENU version of Math 330, which covers similar topics only in more depth, at a quicker pace, and in more generality.

**Math 334: Linear Algebra, Second Course**

This course covers the same type of material seen in a lower-level linear algebra course such as Math 240, only from a much more general perspective. The key objects of study are vector spaces and linear transformations, which are general-

izations of $\mathbb{R}^n$ and matrices respectively. Concepts such as linear independence, bases, and eigenvectors are covered from a more abstract point of view.

**Math 336-1,2: Introduction to the Theory of Numbers**

Number theory studies problems involving integers, such as searching for integer solutions of polynomial equations. A key concept is that of modular arithmetic, which concerns and addition and multiplication taken modulo certain remainders. This has wide applications, such as to cryptography, which is a topic covered in the second quarter of the course.

**Math 340: Geometry**

This course studies geometry in a broad sense, focusing on the aspects which different types of "geometries" have in common. After starting with some basic constructions in Euclidean geometry, the focus shifts to projective geometry and then non-Euclidean geometry, which is a type of geometry where Euclid's parallel postulate fails.

**Math 342: Introduction to Differential Geometry**

Differential geometry uses ideas from calculus to study geometric aspects of curves and surfaces in 2- and 3-dimensions. A key notion is that of curvature, which describes the extent to which curves surface "bend".

**Math 344-1,2: Introduction to Topology**

Topology is a topic which provides a general setting in which to talk about continuity, based on having a notion of what it means for points to be "close" to one another. Length and distance, however, are not concepts which belong to the realm of topology, so the focus is instead placed on the concept of an "open" set.

**Math 351: Fourier Analysis and Boundary Value Problems**

Fourier analysis is a subject which grew out of the notion of a Fourier series, which is a type of series obtained by adding together infinitely many trigonometric functions. This has numerous applications to the study of partial differential equations, or in other words differential equations which involve partial derivatives of multivariable functions. A key question in this area is to understand solutions of a partial differential equation given information about the values of a function on the boundary of a certain region.

**Math 353: Qualitative Differential Equations**

Many types of differential equations cannot be solved explicitly, meaning that the exact functions satisfying said equations are not possible to describe concretely. Rather, this course focuses on understanding the qualitative nature of such solutions, and in particular in seeing what types of properties of the unknown solutions can be derived from properties of the differential equations alone.

**Math 354: Chaotic Dynamical Systems**

A dynamical system is a system (in a broad sense) where the time-dependence of a point in space can be characterized by a function and other information. The goal is to understand how the system "evolves" as time moves on. Chaos theory in particular is concerned with dynamical systems where even a small change in an initial condition can cause a drastic change in the long-term behavior of the system.

**Math 360-1,2: MENU Applied Analysis**

This is the MENU version of Math 250 and Math 351 combined, which covers similar topics only in more depth, at a quicker pace, and in more generality.

**Math 366: Mathematical Models in Finance**

This course covers the mathematics which goes into the modeling of financial markets and related notions.

**Math 368: Introduction to Optimization**

Optimization is concerned with understanding the extreme behavior of a function subject to some possible constraints. This notion comes in calculus courses when finding maxima and minima of function, or in understanding the method of Lagrange multipliers, and this course goes into these topics in more depth.

**Math 370: Mathematical Logic**

This course is concerned with the study of logic as a subject in its own right, and not necessarily with an eye towards applying logic elsewhere. The idea is to develop mathematical tools which allow one to formalize various logical notions and to understanding the strength and limitations of logic itself.

**Math 395: Undergraduate Seminar**

Undergraduate seminars are devoted to studying topics which go beyond the standard curriculum. The topics vary year-to-year, depending on the faculty member teaching the course. Students are expected to take part in the presentation of the material itself.