Department of Mathematics

Field Description

Mathematics has been described as the queen of all sciences. Understanding mathematics enables one to explain and analyze not only science and nature but almost all disciplines from archeology to zoology. Most recently, mathematics has become an indispensable tool in finance and other business related areas. To ensure that mathematics is available for students with varied backgounds and different professional goals, the department offers courses at all levels. Advanced courses are designed to be taken by mathematics and actuarial science majors and those in related fields.

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The Majors

Mathematics

The major in mathematics is designed to enable the student to enter the marketplace (industrial or educational) or to pursue further studies in mathematics or allied fields at the graduate level. Interested students should meet with an advisor in the Department of Mathematics as early as possible for assistance in formulating an appropriate course of study.

A student majoring in mathematics cannot declare a second major in statistics.

Program Learning Goals

Upon completion of the two-year sequence in calculus, students will be able to:

1. Differentiate and integrate a wide variety of algebraic and transcendental functions;
2. Apply such knowledge to a variety of verbal problems in economics, physics, and related rates;
3. Develop the Taylor series expansion for functions and compute the error terms occasioned by truncation of the series to a finite number of terms;
4. Use geometric vectors to prove theorems;
5. Deal with functions and surfaces (areas, volumes) in 3-dimensional space;
6. Use other (than Cartesian) coordinate systems, especially polar coordinates, in the study of graphs and, by change of variable, to facilitate certain integrations;

7. Follow subtle lines of reasoning, detect breaches of logic and validity, write sustained logical arguments;
8. List several approaches to the real number system, such as Dedekind cuts, the Bolzano–Weierstrass property, the nested-interval property, the existence of suprema and infima of bounded sets, the convergence of Cauchy sequences.

Upon completion of our courses in analysis beyond calculus, students will be able to:

1. Point out the analogies—the interplay and interconnections—between corresponding real-valued functions of a real variable and complex-valued functions of a complex variable;
2. Highlight some of the properties that follow from analyticity of functions on various domains;
3. Perform computations with complex numbers, evaluate contour integrals, evolve Laurent series of functions;
4. Show how metric spaces endowed with Euclidean and non-Euclidean metrics are particular examples of topological spaces;
5. Present properties of metrizable and nonmetrizable topological spaces as generalizations of properties that originate in the set of real numbers;
6. Explicate properties of connectedness and compactness in topological spaces.

Upon completion of our courses in algebra, students will be able to:

1. Trace the construction of the integral domain of rational integers and the fields of rational and complex numbers by successive refinements of, and additions to, the properties of a set;
2. Show how abstract initial conditions can be used to derive facts and features of a variety of algebraic structures;
3. Apply abstract algebra, which had its origins and motivation in number theory, back to number theory, to elucidate number-theoretic properties by placing them in a general (abstract) setting;
4. Prove theorems about groups, rings, fields, and other algebraic structures;
5. Account for the advantages of abstract formulations in mathematics;
6. Define the dimension of a vector space in terms of the (unique) number of vectors in a basis, accomplish basis-to-basis transformations, compute characteristic values and vectors, and enumerate some of the profound connections among the invertibility of matrices, systems of linear equations, determinants, linear independence, spanning sets and bases, rank, orthogonality.

Upon completion of our courses in geometry, students will be able to:

1. Discourse with authority on the impact and role of initial assumptions (postulates) on the structure of a geometrical system, mainly with reference to Lobachevskian and Riemannian geometry;
2. Cite facts (theorems) of Euclidean geometry that depend on the parallel postulate and hence are absent in neutral geometry;
3. Provide examples of finite and infinite incidence geometries and their isomorphisms;
4. Trace some of the history of geometry, especially as it concerns attempts to prove Euclid's parallel axiom as a consequence of the other axioms;
5. Speak on difficulties encountered in endeavoring to establish the physical validity of a geometric theory – which the actual geometry of the universe is, given the homogeneity of space with respect to the parallel postulate; and of course
6. Compose mathematically correct proofs of geometric statements.

Upon completion of our other classes, students will be able to:

1. Solve differential equations using series expansions, Laplace transforms, and other standard techniques [differential equations];
2. Enunciate properties and applications of Eulerian, Hamiltonian, connected, cyclic, acyclic, planar, traversable, and other types of graphs [graph theory];
3. Approach combinatorics problems from two points of view which, when united, lead to solutions of problems in combinatorics using permutations, combinations, partitions, mathematical induction [combinatorics];
4. Trace the historical development of mathematics from antiquity to the present, including contributions to that cumulative subject from various cultures and countries [history of mathematics];
5. Stipulate properties and characteristics of whole numbers – divisibility, the division algorithm, Diophantine equations, unique factorization, the integers modulo *n*, Fermat's theorem, Euler's theorem, representation in different bases [theory of numbers];
6. Write computer programs in a high-level programming language to solve mathematical problems and verify their correctness, and invoke techniques of object-oriented programming to represent objects and their behaviors in code [algorithms, computers, and programming class].

Major Course Requirements

Math Program Prerequisites As a preliminary requirement, students must complete the calculus prerequisite, which may be achieved by any one of the six options.		
Option 1:		**8 credits**
	Calculus AP Exam (BC) with a score of 4 or 5 (transfers to Baruch as MTH 3010 Calculus II)	4 credits
And one of the following:		
MTH 3020	Intermediate Calculus	4 credits

or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credit
	or	
Option 2:		**12 credits**
	Calculus AP Exam (AB) with a score of 4 or 5 (transfers to Baruch as MTH 2610 Calculus I)	4 credits
and		
MTH 3010	Calculus I	4 credits
And one of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
	or	
Option 3:		**12 credits**
MTH 2610	Calculus I	4 credits
and		
MTH 3010	Calculus II	4 credits
And one of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		4 credits
MTH 3050	Multi-Variable and Vector Calculus *	
	or	
Option 4:		**12-13 credits**
MTH 2205	Applied Calculus	3 credits
or		
MTH 2207	Applied Calculus and Matrix Applications	4 credits
And the following two courses:		
MTH 3006	Integral Calculus	4 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
	or	
Option 5:		**12-13 credits**

MTH 2205 *or* MTH 2206	Applied Calculus	3 credits
or		
MTH 2207	Applied Calculus and Matrix Applications	4 credits
and		
MTH 3006	Integral Calculus	4 credits
and		
MTH 3007	Infinite Series	1 credit
And one of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
	or	
Option 6:		**10 credits**
MTH 2630	Analytic Geometry and Calculus I	5 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
	* *MTH 3050 is not open to students who completed MTH 3020, MTH 3030, MTH 3035, or their equivalent.*	
Required Courses All students must take the following three courses:		
MTH 3300	Algorithms, Computers and Programming I	3 credits
MTH 4010	Mathematical Analysis I *(formerly Advanced Calculus)*	3 credits
MTH 4100	Linear Algebra and Matrix Methods	3 credits
Electives Students must complete at least 15 elective credits from the following group of courses:		
MTH 4000	Bridge to Higher Mathematics	3 credits
MTH 4009	Proof Writing for Mathematical Analysis	1 credit
MTH 4030	Topology	3 credits

MTH 4020	Advanced Calculus II	3 credits
MTH 4110	Ordinary Differential Equations	3 credits
MTH 4120	Introduction to Probability **	4 credits
MTH 4115	Numerical Methods for Differential Equations in Finance	4 credits
MTH 4125	Introduction to Stochastic Process	4 credits
MTH 4130	Mathematics of Data Analysis *(formerly Mathematics of Statistics)*	4 credits
MTH 4135	Computational Methods in Probability	3 credits
MTH 4140	Graph Theory	3 credits
MTH 4145	Mathematical Modeling *	3 credits
MTH 4150	Combinatorics	3 credits
MTH 4200	Theory of Numbers	3 credits
MTH 4210	Elements of Modern Algebra	3 credits
MTH 4220	Introduction to Modern Geometry	3 credits
MTH 4230	History of Mathematics	3 credits
MTH 4240	Differential Geometry *	3 credits
MTH 4300	Algorithms, Computers and Programming II	3 credits
MTH 4310	Methods of Numerical Analysis	3 credits
MTH 4315	Introduction to Mathematical Logic	3 credits
MTH 4320	Fundamental Algorithms	3 credits
MTH 4420	Actuarial Mathematics I	4 credits
MTH 4421	Actuarial Mathematics II	4 credits
MTH 4430	Mathematics of Inferential Statistics	4 credits
MTH 4451	Short-Term Insurance Mathematics	4 credits
MTH 4452	Short-Term Insurance Mathematics II	4 credits
MTH 4500	Introductory Financial Mathematics	4 credits
MTH 4600	Data Analysis and Simulation for Financial Engineers	4 credits
MTH 5010	Advanced Calculus III *	3 credits
MTH 5020	Theory of Functions of a Complex Variable	3 credits
MTH 5030	Theory of Functions of Real Variables*	3 credits
MTH 5100	Partial Differential Equations and Boundary Value Problems*	4 credits

MTH 5500	Stochastic Calculus for Finance	4 credits

* These courses are offered infrequently, subject to student demand.

** Students may use the combination of MTH 3120 and MTH 4119 in the place of MTH 4120 as elective credit toward the major. *MTH 4119 must be completed as an independent study (please consult the Department of Mathematics).*

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Actuarial Science

The field of actuarial science applies mathematical principles and techniques to problems in the insurance industry. Progress in the field is generally based upon completion of examination given by the Society of Actuaries. The Baruch College major is designed to prepare students to pass the P, FM, IFM (formerly MFE), LTAM (formerly MLC), and STAM (formerly C) exams offered by the Society of Actuaries. Classes are offered which fulfill current VEE (Validation by Educational Experience) requirements in economics, finance, and statistics. Students interested in this highly structured program are urged to meet with an advisor in the Department of Mathematics as early as possible for assistance in formulating an appropriate course of study.

A student majoring in actuarial science cannot minor in mathematics or declare a second major in statistics.

Program Learning Goals

Upon completion of the required core courses in actuarial mathematics, students will be able to:

1. Examine and solve problems dealing with discrete and continuous probability distributions.
2. Recognize when a specific probability distribution is applicable.
3. Determine an appropriate distribution to model a specific scenario in a risk-management context.
4. Compute equivalent interest and discount rates (both nominal and effective).
5. Write an equation of value for a set of cash flows. Estimate effective compound yield rates for the set of cash flows using a simple interest approximation.
6. Calculate present and future values for various types of annuities and perpetuities such as annuities-due, perpetuities-due, annuities-immediate, perpetuities-immediate, arithmetic or geometric annuities, and non-level annuities.
7. Determine the payment amount for a loan with a specific repayment structure.
8. Find the outstanding balance immediately after a payment on a loan.
9. Calculate the amount of principal and amount of interest in a payment for an amortized loan.
10. Perform an amortization on a coupon bond.
11. Compute yield rates for a callable bond at each of the call dates.
12. Calculate values, duration, and convexity for both zero-coupon bonds and coupon bonds.
13. Use first-order approximation methods based on duration to estimate the change in present value of a portfolio based on changes in interest rates.
14. Construct an investment portfolio to immunize a set of liability cash flows.
15. Calculate minimal variance portfolios with and without constraints.
16. Perform pricing and hedging of European and American type derivative securities in the context of one- and multi-period binomial models.
17. Construct arguments based on the no-arbitrage principle, and devise arbitrage strategies when this principle is violated.
18. Price European derivative securities in the context of the Black-Scholes model.
19. Derive a put-call parity relation, and use it for pricing and hedging.

Upon completion of elective courses in actuarial mathematics, students will be able to:

1. Find closed-form solutions to ordinary and partial differential equations derived from financial models.
2. Derive the celebrated Black-Scholes formula by solving the Black-Scholes PDE.
3. Compute values of European, American, and exotic options using finite difference numerical methods.
4. Download options market data and use it as input for codes generating implied volatility surfaces.
5. Describe and classify different kinds of short-term insurance coverage.
6. Explain the role of rating factors and exposure in pricing short-term insurance.
7. Create new families of distributions by applying the technique of multiplication by a constant, raising to a power, exponentiation, or mixing.
8. Calculate various measures of tail weight and interpret the results to compare tail weights.

9. Calculate risk measures, including Value at Risk and Tail Value at Risk, and explain their properties, uses, and limitations.
10. Calculate premiums using the pure premium and loss ratio methods.
11. Use Maximum Likelihood Estimation and Bayesian Estimation to estimate parameters for severity, frequency, and aggregate distributions for individual, grouped, truncated, or censored data.
12. Use hypothesis tests (e.g., Chi-square goodness-of-fit, Kolmogorov-Smirnov, and likelihood ratio tests) and score-based approaches (e.g., the Schwarz-Bayesian Criterion, the Bayesian Information Criterion, and the Akaike Information Criterion) to perform model selection on a collection of data.
13. Apply credibility models such as the Buhlmann and Buhlmann-Straub models, and explicate the relationship between these models and Bayesian models.
14. Explain the concepts of random sampling, statistical inference and sampling distribution.
15. State and use basic sampling distributions.
16. Describe and apply the main methods of estimation including matching moments, percentile matching, and maximum likelihood.
17. Describe and apply the main properties of estimators including bias, variance, mean squared error, consistency, efficiency, and UMVUE.
18. Construct confidence intervals for unknown parameters, including the mean, differences of two means, variances, and proportions.
19. Analyze data using basic statistical inference tools like confidence intervals and hypothesis testing for the population mean.
20. Apply tools such as analysis of variance, tests of significance, residual analysis, model selection, and predication in both the simple and multiple regression models.
21. Demonstrate proficiency in some basic programming skills in SAS and the time-series Forecasting interactive system. Perform time-series analysis using these tools.
22. Identify patterns in data such as trend or seasonality. Incorporate these patterns into the time-series analysis of the data, and perform error analysis of the data.
23. Explain K-means and hierarchical clustering, and interpret the results of a cluster analysis.

Common Objectives – Actuarial *and* Financial Mathematics

Upon completion of the required finance courses for the actuarial science and financial mathematics majors, students will be able to:

1. Expound on the governance of corporations.
2. Outline the operation of financial markets and institutions.
3. Measure corporate performance.
4. Analyze risk and return. Determine the opportunity cost of capital.
5. Perform capital budgeting using various techniques.
6. Compute the present and future values of investments with multiple cash flows.
7. Describe the mechanisms that cause fluctuation of bond yields.
8. Calculate internal rate of return.
9. Perform and interpret scenario analysis for a proposed investment.
10. Calculate financial break-even points.
11. Determine relevant cash flows for a proposed project.
12. Determine a firm's overall cost of capital.

Major Course Requirements

Math Program Prerequisites

Based on placement, follow one of the following preliminary calculus options below:

Option 1:		**8 credits**
	Calculus AP Exam (BC) with a score of 4 or 5 (transfers to Baruch as MTH 3010 Calculus II)	4 credits
And one of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
	or	
Option 2:		**12 credits**
	Calculus AP Exam (AB) with a score of 4 or 5 (transfers to Baruch as MTH 2610Calculus I)	4 credits

and		
MTH 3010	Calculus II	4 credits
And <u>one</u> of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
or		
<u>Option 3</u>:		**12 credits**
MTH 2610	Calculus I	4 credits
and		
MTH 3010	Calculus II	4 credits
And <u>one</u> of the following:		
MTH 3020	Intermediate Calculus	4 credits
or		
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
or		
<u>Option 4</u>:		**12-13 credits**
MTH 2205/ MTH 2206	Applied Calculus	3 credits
or		
MTH 2207	Applied Calculus and Matrix Applications	4 credits
And the following two courses:		
MTH 3006	Integral Calculus	4 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
or		
<u>Option 5</u>:		**12-13 credits**
MTH 2205/ MTH 2206 *or* MTH 2207	Applied Calculus Applied Calculus and Matrix Applications	3 credits 4 credits
<u>And</u>		

MTH 3006 *and* MTH 3007	Integral Calculus Infinite Series	4 credits 1 credit
Plus <u>one</u> of the following:		
MTH 3020	Intermediate Calculus	4 credits
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
	or	
<u>Option 6</u>:		**10 credits**
MTH 2630	Analytic Geometry and Calculus I	5 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
NOTE: * MTH 3050 is not open to students who completed MTH 3020, MTH 3030, MTH 3035, or their equivalents.		
Business Program Prerequisites		
ACC 2101	Principles of Accounting	3 credits
BUS 1000	Introduction to Business **	3 credits
or		
BUS 1011	Business Fundamentals: The Contemporary Business Landscape **	3 credits
CIS 2200	Introduction to Information Systems and Technologies **	3 credits
ECO 1001	Micro-Economics	3 credits
ECO 1002	Macro-Economics	3 credits
STA 2000	Business Statistics I **	3 credits
FIN 3000	Principles of Finance	3 credits
FIN 3610	Corporate Finance	3 credits
NOTES: ** Students who have completed MTH 4120 or both MTH 3120 and MTH 4119, may have the following FIN 3000 prerequisites waived: BUS 1000/ BUS 1011; CIS 2200; and STA 2000. Please consult the Weissman Associate Dean's Office (WSAS.AssocDean@baruch.cuny.edu; 646-312-3890; Vertical Campus, room 8-265) to request registration permission.		

Required Courses		
MTH 3300	Algorithms, Computers, and Programming I	3 credits
MTH 4120	Introduction to Probability ***	4 credits
MTH 4410	Theory of Interest	4 credits
Students must also complete three of the following five courses:		
MTH 4420	Actuarial Mathematics I	4 credits
MTH 4421	Actuarial Mathematics II	4 credits
MTH 4451	Short-Term Mathematics	4 credits
MTH 4452	Short-Term Mathematics II	4 credits
MTH 4500	Introductory Financial Mathematics	4 credits
*** Students who have completed MTH 3120 cannot enroll in MTH 4120. They must satisfy the probability requirement by registering for MTH 4119 as an independent study (please consult the Department of Mathematics).		
Electives In addition, one course must be chosen from the following list of electives:		
MTH 4115	Numerical Methods for Differential Equations in Finance	4 credits
MTH 4125	Introduction to Stochastic Processes	4 credits
MTH 4130	Mathematics of Data Analysis *(formerly Mathematics of Statistics)*	4 credits
MTH 4135	Computational Methods in Probability	3 credits
MTH 4420	Actuarial Mathematics I	4 credits
MTH 4421	Actuarial Mathematics II	4 credits
MTH 4430	Mathematics of Inferential Statistics	4 credits
MTH 4451	Short-Term Mathematics	4 credits
MTH 4452	Short-Term Mathematics II	4 credits
MTH 4500	Introductory Financial Mathematics	4 credits
MTH 4600	Data Analysis and Simulation for Financial Engineers	4 credits
MTH 5500	Stochastic Calculus for Finance	4 credits

The following courses are recommended, but not required. They are not applicable toward the major.		
ECO 3100	Intermediate Micro-Economics	3 credits
ECO 3200	Intermediate Macro-Economics	3 credits

Financial Mathematics

This major is first and foremost a course of study in mathematics, with a focus on the computational tools and techniques needed to thrive in the financial engineering industry. In today's specialized world, a sophisticated level of mathematical understanding is an essential competitive edge. As this program includes courses in Economics and Finance, students who would usually not consider a traditional mathematics major will find this program especially attractive. Interested students are urged to contact the Department of Mathematics as early as possible. The student will be assigned an advisor who will aid in formulating an appropriate course of study.

A student majoring in financial mathematics cannot minor in mathematics or declare a second major in statistics.

Program Learning Goals

Upon completion of the major in Financial Mathematics, students will be able to:

1. Perform linear algebraic calculations such as matrix multiplication and inversion, solving systems of linear equations, Gram-Schmidt orthogonalization, Cholesky decomposition, computation of eigenvalues and eigenvectors.
2. Obtain exact and numerical solutions to differential equations arising in finance such as the Black-Scholes model and its corresponding partial differential equation.
3. Compute implied asset price volatilities for European and American options from options market data.
4. Compute empirical volatilities from asset price time series using GARCH-type models.
5. Apply the fundamental notions of probability theory – including continuous and discrete random variables, expected value and variance, conditional expectation, multivariate distributions, the law of large numbers, the central limit theorem, and moment-generating functions – to settings in finance where randomness arises, such as in the modelling of asset prices and interest rates.
6. Apply the basic properties of martingales.
7. Calculate minimum variance portfolios in a Markowitz and CAPM setting.
8. Calculate call and put stock option values using a binomial model.
9. Calculate call and put option values using the Black-Scholes model.
10. Compute expectation for random variables and probabilities of events pertaining to Brownian motion.
11. Compute expectations of functions of Ito processes using the Ito formula.
12. Apply stochastic calculus to financial situations.
13. Apply the theory of Markov chains to appropriate settings. Examples include: the computation of invariant distributions, the implementation of the Hastings-Metropolis algorithm, and Gibbs sampling.
14. Apply the theory of arrival processes to settings such as corporate default models.
15. Apply the theory of Brownian motion and related continuous-time stochastic processes such as the Ornstein-Uhlenbeck process to model the evolution of correlated asset values over time as well as the evolution of the Treasury yield curve over time.
16. Use tools of statistical inference in the context of financial data. These tools include Bayesian estimation, maximum likelihood estimation, multiple regression analysis, confidence intervals, the t- and F-distributions for determining statistical significance, and analysis of variance.
17. Implement Black-Karasinski and Hull-White and related lattice-based interest rate models to value fixed-income derivative securities like options on bonds, interest rate swaps, caps, floors, and swaptions.
18. Build simulative interest-rate models based on continuous-time stochastic processes to value fixed-income derivative securities.
19. Build elementary computer programs in Python and C++ to simulate stochastic processes.
20. Use these models to calculate a fixed-income security's duration, convexity, and key-rate duration for hedging purposes.

Common Objectives – Actuarial *and* Financial Mathematics

Upon completion of the required finance courses for the actuarial science and financial mathematics majors, students will be able to:

1. Expound on the governance of corporations.
2. Outline the operation of financial markets and institutions.
3. Measure corporate performance.
4. Analyze risk and return. Determine the opportunity cost of capital.
5. Perform capital budgeting using various techniques.
6. Compute the present and future values of investments with multiple cash flows.

7. Describe the mechanisms that cause fluctuation of bond yields.
8. Calculate internal rate of return.
9. Perform and interpret scenario analysis for a proposed investment.
10. Calculate financial break-even points.
11. Determine relevant cash flows for a proposed project.
12. Determine a firm's overall cost of capital.

Major Course Requirements

NOTE: Depending on a student's starting mathematics proficiency, this program may require more than 120 credits to complete.		
Mathematics Program Prerequisites:		
As a preliminary requirement, students must complete the calculus requirement, which may be achieved by any one of the following six methods:		
Option 1:		
	Calculus AP Exam (BC) with a score of 4 or 5 *(transfers to Baruch as MTH 2610 and MTH 3010)*	8 credits
MTH 3050	Multi-Variable and Vector Calculus	4 credits
	or	
Option 2:		
	Calculus AP exam (AB) with a score of 4 or 5 *(transfers to Baruch as MTH 2610)*	4 credits
MTH 3010	Calculus II	4 credits
MTH 3050	Multi-Variable and Vector Calculus	4 credits
	or	
Option 3:		
MTH 2610	Calculus I	4 credits
MTH 3010	Calculus II	4 credits
MTH 3050	Multi-Variable and Vector Calculus	4 credits
	or	
Option 4:		
MTH 2205/ MTH 2206	Applied Calculus	3 credits
or		
MTH 2207	Applied Calculus and Matrix Applications	4 credits
***and* the following three courses:**		
MTH 3006	Integral Calculus	4 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits

MTH 3035	Vector Calculus *	1 credit
	or	
<u>Option 5</u>:		
MTH 2205/ MTH 2206	Applied Calculus	3 credits
MTH 2207	Applied Calculus and Matrix Applications	4 credits
***and* the following three courses:**		
MTH 3006	Integral Calculus	4 credits
MTH 3007	Infinite Series	1 credit
MTH 3050	Multi-Variable and Vector Calculus *	4 credits
	or	
<u>Option 6</u>:		
MTH 2630	Analytic Geometry and Calculus I	5 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
MTH 3035	Vector Calculus *	1 credit
Each option also requires:		
MTH 4000 *	Bridge to Higher Mathematics	4 credits

*** NOTES:**

1. **At least an overall B+ average is required for the calculus courses preceding MTH 3020, MTH 3030 or MTH 3050 in each of the above options.**
2. **MTH 3050 may be replaced with MTH 3020 and MTH 3035 in any of the above options.**
3. **At least a B or better is required in: MTH 3050; or MTH 3020 and MTH 3035; or MTH 3030 and MTH 3035 as appropriate.**
4. **To gain official admission to the program students must complete MTH 4000 with a minimum grade of B.**

Business Program Prerequisites:		
ACC 2101	Principles of Accounting	3 credits
ECO 1001	Micro-Economics	3 credits
ECO 1002	Macro-Economics	3 credits

BSFM students are not required to complete the following FIN 3000 course prerequisites: BUS 1000/1011; CIS 2200; and STA 2000. Please consult the Weissman Associate Dean's Office (WSAS.AssocDean@baruch.cuny.edu; 646-312-3890; VC 8-265) to request registration permission.

Required Finance Courses:

FIN 3000	Principles of Finance	3 credits
FIN 3610	Corporate Finance	3 credits
Required Upper-level Mathematics Courses:		
MTH 3300	Algorithms, Computers, and Programming I	3 credits
MTH 4100	Linear Algebra	3 credits
MTH 4115	Numerical Methods for Differential Equations	4 credits
MTH 4120	Introduction to Probability *	4 credits
MTH 4125	Introduction to Stochastic Processes	4 credits
MTH 4130	Mathematics of Data Analysis *(formerly Mathematics of Statistics)*	4 credits
MTH 4300	Algorithms, Computers, and Programming II	3 credits
MTH 4500	Introductory Financial Mathematics	4 credits
MTH 4600	Data Analysis and Simulation for Financial Engineers	4 credits
MTH 5500	Stochastic Calculus for Finance	3 credits

*** Students who have completed MTH 3120 cannot enroll in MTH 4120. They must satisfy the probability requirement by registering for MTH 4119 as an independent study (please consult the Department of Mathematics).**

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The Minor

The minor in mathematics provides students with a background in the various theories and uses of mathematics. The minor requires the completion of MTH 3006, MTH 3010, MTH 3020, MTH 3030, or MTH 3050, and any other 3- or 4- or 5-credit mathematics course numbered 3000 or higher with the exception of MTH 4005 and MTH 4410 (which are not applicable toward the minor). Students must then complete a capstone course consisting of any mathematics course at the 4000-level or higher with the exceptions of MTH 4005, MTH 4009, MTH 4119, and MTH 4410 (which may not be used as a capstone course).

This minor is not open to students who are pursuing a major in statistics.

Required Course All students must take one of the following courses:		
MTH 3006	Integral Calculus	4 credits
MTH 3010	Calculus II	4 credits
MTH 3020	Intermediate Calculus	4 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits

MTH 3050	Multi-variable and Vector Calculus	4 credits
Electives		
Students must take any two other courses from the following list, with at least one of the courses being a 4000-level or higher capstone course:		
MTH 3020	Intermediate Calculus	4 credits
MTH 3030	Analytic Geometry and Calculus II	5 credits
MTH 3050	Multi-variable and Vector Calculus	4 credits
MTH 3120	Elementary Probability	3 credits
MTH 3300	Algorithms, Computers and Programming I	3 credits
MTH 4000	Bridge to Higher Mathematics	3 credits
MTH 4010	Mathematical Analysis I (formerly Advanced Calculus)	3 credits
MTH 4020	Advanced Calculus II	3 credits
MTH 4030	Topology	3 credits
MTH 4100	Linear Algebra and Matrix Methods	3 credits
MTH 4110	Ordinary Differential Equations	3 credits
MTH 4115	Numerical Methods for Differential Equations in Finance	4 credit
MTH 4120	Introduction to Probability	4 credits
MTH 4125	Introduction to Stochastic Process	4 credits
MTH 4130	Mathematics of Data Analysis *(formerly Mathematics of Statistics)*	4 credits
MTH 4135	Computational Methods in Probability	3 credits
MTH 4140	Graph Theory	3 credits
MTH 4145	Mathematical Modeling *	3 credits
MTH 4150	Combinatorics	3 credits
MTH 4200	Theory of Numbers	3 credits
MTH 4210	Elements of Modern Algebra	3 credits
MTH 4220	Introduction to Modern Geometry	3 credits
MTH 4230	History of Mathematics	3 credits
MTH 4240	Differential Geometry *	3 credits
MTH 4300	Algorithms, Computers and Programming II	3 credits
MTH 4310	Methods of Numerical Analysis	3 credits
MTH 4315	Introduction to Mathematical Logic	3 credits

MTH 4320	Fundamental Algorithms	3 credits
MTH 4420	Actuarial Mathematics I	4 credits
MTH 4421	Actuarial Mathematics II	4 credits
MTH 4430	Mathematics of Inferential Statistics	4 credits
MTH 4451	Short-Term Insurance Mathematics	4 credits
MTH 4452	Short-Term Insurance Mathematics II	4 credits
MTH 4500	Introductory Financial Mathematics	4 credits
MTH 4600	Data Analysis and Simulation for Financial Engineers	4 credits
MTH 5010	Advanced Calculus III *	3 credits
MTH 5020	Theory of Functions of a Complex Variable	3 credits
MTH 5030	Theory of Functions of Real Variables*	3 credits
MTH 5100	Partial Differential Equations and Boundary Value Problems*	4 credits
MTH 5500	Stochastic Calculus for Finance	4 credits
* These courses are offered infrequently, subject to student demand.		

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Repeat for Mastery (Precalculus) and Calculus Prerequisite Changes

This pilot program, which consists of two parts, will run as an experiment for academic years 2018-2019 and 2019-2020.

The first part is to allow any student who earns grades of C-, D, or D+ to retake precalculus to achieve greater mastery.

MTH 2003 and MTH 2009 (a new course effective spring 2019) are Baruch's precalculus courses; MTH 2000 and MTH 2001 are the precalculus courses for which transfer students receive credit. By allowing students to repeat the course, they are provided with an opportunity to improve both their course mastery and grade. Students may also repeat e-permit courses per the host college's policies. In order to repeat any precalculus course, students must apply through the Office of the Registrar (151 East 25th Street, Room 850).

Please note:

- **Students will only receive credit for precalculus once**.
- **This proposal does not affect college policy of allowing students to take the course a maximum of three times. The policy on repeating courses covers any combination of MTH 2003 and MTH 2009, e.g., one course taken three times, or a one-and-two combination. All combinations will be treated identically as three attempts.**
- **A repeat for mastery course will not be eligible for TAP or Excelsior.**
- **Students who earn grades of C or better in the repeated precalculus course may replace their previous passing grades in the calculation of the overall GPA.** The precalculus repeat for mastery option is part of college's existing 16-credit maximum for grade replacements. It will not retroactively effect a student's pre-existing academic status. The following points should be noted:
    - **A maximum of 16 credits of failing and/or repeat for mastery grades may be deleted from the calculation of the cumulative GPA during an undergraduate's enrollment in CUNY.** Whether students remain at a single college or transfer from one CUNY college to another, no more than 16 credits of grades can be replaced in the calculation of the cumulative GPA. Should the 16-credit limit be reached at a college other than Baruch, a student will not be permitted to replace credits at Baruch.

- **For a grade of C or better to replace a grade of C-, D, or D+ in the calculation of the cumulative GPA, the repeated course must be taken at Baruch.** Students may repeat precalculus for mastery on permit to another institution, but the original grade will not be replaced. If a student retakes precalculus on permit at another CUNY campus, both the original and the new grade will be calculated in the overall GPA. If a student takes precalculus on permit at a non-CUNY institution, only the original grade will be calculated in the overall GPA.
- **If a student has more than one repeatable precalculus grade and subsequently earns a grade of C or better in the course, the previous grades will be deleted from the calculation of the GPA, *subject to the 16-credit limit.***
- **If a student earns less than a C grade when the course is repeated *or* has exceeded the 16 credit limit, both grades earned will be factored into the student's GPA.**
- **The cumulative GPA calculated on the basis of this policy is to be used for purposes of retention and graduation from the College and the admission to and continuance in a major or specialization.** It will not be used to calculate the GPA for graduation honors or the Dean's List.

The second part of the proposal is to include a precalculus grade prerequisite in MTH 2205 and MTH 2207.

Effective fall 2018, the prerequisites for MTH 2205 and MTH 2207 are as follows:

MTH 2205 Applied Calculus *Prerequisite: MTH 2003 or MTH 2009 with a grade of C- or better.*

MTH 2207 Applied Calculus and Matrix Applications *Prerequisite: Placement or grade of C- or better in MTH 2000 or 2001 or the equivalent.*

Courses in Mathematics (MTH)

MTH 1023	Intermediate and College Algebra	4.5 hours; 2 credits
MTH 1030	College Algebra	4 hours; 2 credits
MTH 2003	Pre-calculus and Elements of Calculus	4 hours; 3 credits
MTH 2009	Precalculus	4.5 hours; 3 credits
MTH 2120	Mathematics Appreciation	3 hours; 3 credits
MTH 2140	Mathematics and Quantitative Reasoning	4 hours; 3 credits
MTH 2160	Ideas in Mathematics and Their Applications	4 hours; 3 credits
MTH 2205	Applied Calculus	4 hours; 3 credits
MTH 2206	Applied Calculus	3 hours; 3 credits
MTH 2207	Applied Calculus and Matrix Applications	4 hours; 4 credits
MTH 2301	Concepts of Discrete Mathematics	3 hours; 3 credits
MTH 2610	Calculus I	4 hours; 4 credits
MTH 2630	Analytic Geometry and Calculus I	5 hours; 5 credits
MTH 3006	Integral Calculus	4 hours; 4 credits
MTH 3007	Infinite Series	1 hour; 1 credit
MTH 3010	Elementary Calculus II	4 hours; 4 credits

MTH 3020	Intermediate Calculus	4 hours; 4 credits
MTH 3030	Analytic Geometry and Calculus II	5 hours; 5 credits
MTH 3035	Vector Calculus	1 hour; 1 credit
MTH 3040	Actuarial Seminar: R for Actuaries	2 hours; 2 credits
MTH 3050	Multi-Variable and Vector Calculus	4 hours; 4 credits
MTH 3100	Selected Topics in Discrete Mathematics	3 hours; 3 credits
MTH 3120	Elementary Probability	3 hours; 3 credits
MTH 3300	Algorithms, Computers, and Programming I	4 hours; 3 credits
MTH 3901	Actuarial Science Internship	1 hour; 1 credit
MTH 3902	Actuarial Science Internship	1 hour; 1 credit
MTH 3903	Actuarial Science Internship	1 hour; 1 credit
MTH 3904	Actuarial Science Internship	1 hour; 1 credit
MTH 3905	Math Internship	1 hour; 1 credit
MTH 3906	Math Internship	1 hour; 1 credit
MTH 3907	Math Internship	1 hour; 1 credit
MTH 3908	Math Internship	1 hour; 1 credit
MTH 3909	Financial Mathematics Internship	1 hour; 1credit
MTH 3910	Financial Mathematics Internship	1 hour; 1credit
MTH 3911	Financial Mathematics Internship	1 hour; 1credit
MTH 3912	Financial Mathematics Internship	1 hour; 1credit
MTH 4000	Bridge to Higher Mathematics	4 hours; 3 credits
MTH 4005	Problem-Solving Seminar	3 hours; 3 credits
MTH 4009	Proof Writing for Mathematical Analysis *(formerly Proof Writing for Advanced Calculus)*	1 hour; 1 credit
MTH 4010	Mathematical Analysis I	3 hours; 3 credits
MTH 4020	Advanced Calculus II	3 hours; 3 credits
MTH 4030	Topology	3 hours; 3 credits
MTH 4100	Linear Algebra and Matrix Methods	3 hours; 3 credits
MTH 4110	Ordinary Differential Equations	3 hours; 3 credits
MTH 4115	Numerical Methods for Differential Equations in Finance	4 hours; 4 credits

MTH 4119	Multivariate Probability Distributions	1 hour; 1 credit
MTH 4120	Introduction to Probability	4 hours; 4 credits
MTH 4125	Introduction to Stochastic Processes	4 hours; 4 credits
MTH 4130	Mathematics of Data Analysis *(formerly Mathematics of Statistics)*	4 hours; 4 credits
MTH 4135	Computational Methods in Probability	4 hours; 3 credits
MTH 4140	Graph Theory	3 hours; 3 credits
MTH 4145	Mathematical Modeling	3 hours; 3 credits
MTH 4150	Combinatorics	3 hours; 3 credits
MTH 4200	Theory of Numbers	3 hours; 3 credits
MTH 4210	Elements of Modern Algebra	3 hours; 3 credits
MTH 4215	Finite Fields, Algebraic Curves, and Applications	3 hours; 3 credits
MTH 4230	History of Mathematics	4 hours; 4 credits
MTH 4240	Differential Geometry	3 hours; 3 credits
MTH 4300	Algorithms, Computers, and Programming II	4 hours; 3 credits
MTH 4310	Methods of Numerical Analysis	3 hours; 3 credits
MTH 4315	Introduction to Mathematical Logic	4 hours; 3 credits
MTH 4320	Fundamental Algorithms	4 hours; 3 credits
MTH 4340	Switching Theory	3 hours; 3 credits
MTH 4395	Special Topics in Computer Science	3 hours; 3 credits
MTH 4400	Finite Differences	4 hours; 4 credits
MTH 4410	Theory of Interest	4 hours; 4 credits
MTH 4420	Actuarial Mathematics I	4 hours; 4 credits
MTH 4421	Actuarial Mathematics II	4 hours; 4 credits
MTH 4430	Mathematics of Inferential Statistics	4 hours; 4 credits
MTH 4451	Short-Term Insurance Mathematics *(formerly Risk Theory)*	4 hours; 4 credits
MTH 4452	Short-Term Insurance Mathematics II	4 hours; 4 credits
MTH 4500	Introductory Financial Mathematics	4 hours; 4 credits
MTH 4600	Data Analysis and Simulation for Financial Engineers	4 hours; 4 credits
MTH 5000	Independent Study I	Hours and credits to be arranged
MTH 5001	Independent Study II	Hours and credits to be arranged

MTH 5002	Independent Study III	Hours and credits to be arranged
MTH 5003	Independent Study IV	Hours and credits to be arranged
MTH 5004	Independent Study V	Hours and credits to be arranged
MTH 5010	Advanced Calculus III	3 hours; 3 credits
MTH 5020	Theory of Functions of a Complex Variable	3 hours; 3 credits
MTH 5030	Theory of Functional of Real Variables	3 hours; 3 credits
MTH 5100	Partial Differential Equations and Boundary Value Problems	4 hours; 4 credits
MTH 5500	Stochastic Calculus for Finance	4 hours; 4 credits
MTH 6001H	Honors in Mathematics I	Hours and credits to be arranged
MTH 6002H	Honors in Mathematics II	Hours and credits to be arranged
MTH 6003H	Honors in Mathematics III	Hours and credits to be arranged

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