INFORMATION FOR MS STUDENTS

IN ENGINEERING SCIENCES AND APPLIED MATHEMATICS 2019–2020

September 1, 2019

Dear Graduate Students,

This handbook is prepared to aid you in earning a Masters of Science degree in Applied Mathematics. Please read it carefully and be aware of the requirements and responsibilities described. The information contained in this handbook is more specific than that in the Graduate School Bulletin. You should also familiarize yourself with the general regulations of The Graduate School.

Please feel free to come in to see me if you have any questions, problems, or points of concern.

David Chopp, Professor and Chair

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INFORMATION FOR GRADUATE STUDENTS

Welcome to the Engineering Sciences and Applied Mathematics Department. Please keep and refer to this booklet through completion of your MS degree. Every effort has been made to anticipate your questions–from arrival through final checkout. You are responsible for knowing this material!

Key Personnel: Throughout this handbook there are references to certain administrative people. Their names and contact information are below.

Title	Name	email	phone
Department Chair	David Chopp	chopp@northwestern.edu	847-491-8391
Director of Graduate Studies	Alvin Bayliss	a-bayliss@northwestern.edu	847-491-7221
MS Student Advisor	Michael Miksis	miksis@northwestern.edu	847-491-3345
Business Administrator	Catherine Cotter	catherine.cotter@northwestern.edu	847-491-5586
Graduate Student Assistant	TBD		847-491-3345
Dept. Computing Manager	David Chopp	chopp@northwestern.edu	847-491-8391
Safety Coordinator	TBD		

The department offers two MS Options:

- MS Degree without Thesis
- MS degree with Thesis

The MS degree without Thesis option will be assumed unless the student informs the ESAM MS advisor prior to the end of the 2nd quarter of registration in the program, that he/she is selecting the Thesis option.

Disclaimer: Northwestern University reserves the right to change without notice any statement in this publication concerning, but not limited to, rules, policies, tuition, fees, curricula, and courses.

1 MS Program Mission Statement and Goals

1.1 Mission Statement

The MS program is designed to develop graduate students with a broad skill-set in mathematical modeling and analytical and computational solution methods. Upon completion, the graduate should be fully prepared to enroll in a PhD program in applied mathematics or be prepared to employ their skills in private-sector research.

1.2 Program Goals

Learning objectives	Requirement	Assessment Strategies and Criteria
Develop core applied mathematics skills	Core applied math curriculum	Demonstrate competency in differential equations, asymptotic methods, and numerical methods
Develop expertise in a single area of mathematics	Math content theme	Student must complete two courses that are related through a proposed and approved math content theme
Develop expertise in an area of application of mathematics	Math modeling theme	Student must complete three courses that are related through a proposed and approved application area theme or complete one modeling course along with an MS Thesis on an application of mathematics.

2 Course Advisor

During New Student Week, you will meet with your advisor who will assist you in selecting courses for your first quarter of study. The advisor must be consulted about course selection. The advisor will continue to be your course advisor through the completion of your MS degree. ***Responsibility for meeting published deadlines and degree requirements rests with the student.*** The Northwestern University Academic Calendar is available at http://www.registrar.northwestern.edu/calendars/index.html. The Graduate School deadlines and requirements can be found on their website at

http://www.tgs.northwestern.edu/academics/degree-requirements/index.html

Also see The Graduate School 2019 New Student Guide.

Students whose goal is to enter the PhD program at Northwestern at the end of their MS program are strongly advised to discuss this option with his or her course advisor at the first meeting as this will significantly influence course selection for the MS degree. Students pursuing this track typically take the same courses as the students in the first year PhD program and also take the Preliminary Examinations when they are offered in the Winter and Spring quarters. **Because space is limited in the PhD program, successful completion of the MS degree does not guarantee admission to the PhD program.**

3 MS DEGREE WITHOUT THESIS

3.1 Residency and Course Load

The minimum residence requirement for the MS degree is three consecutive quarters at Northwestern. **Course and 590 (research) units should total to 3-4 units each quarter to maintain full-time status. To complete the MS degree in 3 quarters, 4 units per quarter will be required.**

3.2 Course Requirements

Students must take at least twelve graded academic courses listed in the Graduate School catalog. At least nine of these twelve classes must be 400 level courses. To view available Graduate School courses, search for classes in CAESAR (http://www.northwestern.edu/caesar/) and set Course Career to the Graduate School. P/N grades are not allowed. Enrollment in the core curriculum is mandatory. In addition to five core courses, seven elective courses are required. According to University policy, students must maintain a 3.00 average to receive the MS degree. Satisfactory progress in the program is determined by department review of course grades, and faculty recommendations.

Student GPA is calculated according to the following scale: A = 4, A- = 3.7, B+ = 3.3, B = 3, B- = 2.7, C+ = 2.3, C = 2 and will appear on the graduate student transcript.

3.2.1 Core Courses in Engineering Sciences and Applied Mathematics

The following courses comprise five units of the graduate core curriculum for the MS degree in engineering sciences and applied mathematics.

ES_APPM 411-1,2	Differential Equations of Mathematical Physics (2 units)
ES_APPM 420-1	Asymptotic and Perturbation Methods in Applied Mathematics (1 units)
ES_APPM 446-1	Numerical Solution of Partial Differential Equations (1 units)
ES_APPM 448-0	Numerical Methods for Random Processes (1 units)

Waiving Core Courses:

Students who are sufficiently prepared in the subject matter of a core course may petition for a waiver from the course requirement. The instructors may require documentation, e.g. text used, course outline, lecture notes, exams, etc. The signed form should be given to the Graduate Student Assistant to be placed in

the student's file. Please note that the waiving of a course does not decrease the total number of courses required. Substitution of ES_APPM 311-1,2 in place of ES_APPM 411-1,2 may be done if recommended by your advisor and approved by the Chair.

3.2.2 Elective Courses

The remaining of the seven courses for the MS are to be selected by the student in consultation with his or her advisor and must be approved by the advisor. Of those electives one must be a course in numerical methods, three must be in mathematical modeling, and three courses must have mathematical content. More specifically:

- Numerical Elective: Students must take either ES_APPM 444 or 445 in the spring quarter to satisfy this requirement.
- Mathematical Modeling Electives: Students are expected to select 3 classes where mathematics is applied to areas of application. Courses typically taken to satisfy this requirement within ESAM are ES_APPM 421-1 and two special topics classes offered in our yearly graduate modeling sequence. If classes are taken outside of the department, the course sequence should have a theme, e.g., financial mathematics, fluid mechanics, data science, etc. Themes can be chosen from the accompanying list, or designed in consultation with the MS advisor.
- Mathematical Content Electives: Students are expected to select 3 classes where mathematics is the focus of the class. For example, within ESAM students may wish to complete the ES_APPM 411 and ES_APPM 420 sequences by taking ES_APPM 411-3, ES_APPM 420-2, and ES_APPM 412-0. If taken outside of ESAM, the classes should have a theme, e.g., stochastic methods, optimization, etc. Themes can be chosen from the accompanying list, or designed in consultation with the MS advisor.

Any courses taken for the MS must be an extension of the student's background rather than a repetition of work done as an undergraduate.

3.2.3 Timeline for Approval of Plan of Study

To ensure that students maintain a proper path toward completion of the MS degree and to remain in academic good standing, all students are required to meet with their advisor at the designated times below and have their plan of study approved. Each quarter the student's 12 course Plan of Study, including both the math modeling and math content themes, must be listed on GSTS and approved by the advisor. The Math Modeling and Math Content Themes must be entered on the bottom left of the Plan of Study page on GSTS in the Comments Section. A student's Plan of Study can evolve over the academic year but Final Approval must be given at the beginning of Spring Quarter for those students expecting to graduate in June or December 2020.

September 30: Last day to get approval for Fall classes plus the 12 proposed courses to complete the degree. The proposed modeling and math content themes and the 12 proposed courses must be entered in the GSTS Plan of Study page. All future changes to this plan of study must be approved by the MS advisor.

November 4–8: All MS students must meet with the MS advisor to review their proposed Winter schedule prior to registration. The advisor will contact all students before Winter registration begins to schedule

this meeting. Any changes to the Plan of Study must be entered on GSTS and approved by the MS advisor.

February 17–21, 2020: All students must have their Spring schedule and 12 course Plan of Study on GSTS approved by the MS advisor. This can be done by email.

April 6, 2020: Last day to get Final Approval of the Plan of Study. This plan must contain the math modeling and math content themes plus the courses to be counted to complete the themes.

4 MS DEGREE WITH THESIS

The course requirements are the same as for the MS degree without thesis option except two of the Mathematical Modeling electives are replaced by ES_APPM 590. Only one unit of 590 can be taken per quarter.

To complete the MS with thesis option, the student must identify an approved research advisor before the end of the 2nd quarter of study within the program. Otherwise the student will default to the MS Degree without thesis option. If by the end of the 3rd quarter of residence, the student has completed the necessary course requirements and maintained an adequate GPA, a MS without thesis degree will be awarded at that time.

The ESAM department will require a written thesis to be approved at a final examination. The thesis must be completed by the end of the Fall quarter of the second year of study in the program or the student's degree path will revert to the coursework only option. The student's Examining Committee will determine by the end of the 1st summer of study whether the student is making sufficient progress to complete the thesis by the end of the Fall quarter of the second year of study. If they do not judge that sufficient progress has been made, the student's degree path will revert to the coursework only option. The final examination shall include a presentation by the student of the thesis material and examination of this material by the Examining Committee. The Examining Committee will be comprised of at least two full-time members of the Northwestern University Faculty, who must also be members of the Graduate Faculty. At least one of the members of The Examining Committee must be an ESAM faculty member. The Examining Committee must be approved by the program advisor.

The thesis should be based on original research that is of publishable quality. It should be prepared according to the Graduate School format for PhD dissertations.

5 BS/MS Program

Students who enter the ESAM MS program via the BS/MS program at McCormick have the same requirements for the MS degree as listed above. Graduate courses taken as an undergraduate prior to entering the ESAM MS program can be applied toward the MS degree requirements with department approval. No course used to fulfill requirements to receive the BS degree may also be used toward fulfilling the MS degree. For information about this program, please contact Bruce Lindvall, Assistant Dean for Graduate Studies at McCormick.

6 Additional Information for All MS Degree Programs

6.1 Preliminary Examinations

The preliminary examinations are not required of students to complete the MS degree. However, students interested in pursuing a PhD degree at the completion of their MS degree may optionally take the preliminary examinations if approved by his or her course advisor.

There is one exam for each of the topics of advanced calculus, differential equations, linear algebra, and complex variables. The exams are based on advanced undergraduate material. Sample examinations from previous years as well as a list of textbooks that cover the topics are available upon request from the student's course advisor. They are offered within the first two weeks of the Winter quarter and are given as four separate 2-hour exams.

Students who fail one or more exams will be given an opportunity to retake a new exam on the same subject(s) within the first two weeks of the following Spring quarter. Students are required to pass all four exams before they may be allowed to enter the PhD program. **Because space is limited in the PhD program, passing the preliminary examinations as a MS student does not guarantee admission to the PhD program.**

6.2 Versant Language Examination

The Versant Language exam is not required of students pursuing the MS degree. However, it is mandatory for international students whose country of origin is not Australia, Canada, New Zealand, or United Kingdom when pursuing a PhD degree. If an international MS student is interested in pursuing a PhD at Northwestern at the completion of their MS degree, he or she may optionally take the Versant Language Examination if approved by his or her course advisor. Students in the MS program that wish to take the Versant Examination must notify his or her course advisor no later than the fifth week of the Winter quarter to be registered for the Spring testing. It is mandatory for international students to pass the Versant Language exam in order to be admitted into the ESAM PhD program from the MS program. For more information about the Versant test as well as English language tutoring resources, see the Versant testing page.

6.3 Admission into the PhD Program

MS students in good standing may wish to be considered for admission into the PHD program. Because space is limited admission is very competitive, and students should be aware of this. Students interested in pursuing the PhD are strongly encouraged to discuss this option with their MS advisor. The following is a list of necessary conditions that must be met if a student wishes to be considered for the PhD program:

1. The student must take the 1st year PhD sequence of classes. Please see the ESAM PhD Graduate Student Handbook for the list of courses.
2. The student must take the written preliminary exams, see Section 6.1 above.
3. International students must satisfy The Graduate School's spoken English proficiency requirement before the end of spring quarter of their 1st year of study, see Section 6.2 above and: http://www.tgs.northwestern.edu/funding/assistantships/graduate-and-teaching.html

4. Identify a PhD thesis advisor before the end of the Spring quarter of the 1st year of study.

Because admission is very competitive, the department recommends that MS students seeking admission pursue all their options for graduate study. This includes applying to other programs and schools, applying to other programs of study within Northwestern, and actively pursuing employment for after graduation. If the student seeks admission, he/she must inform the ESAM MS student advisor. A decision will be make before the end of the Spring Quarter.

6.4 Graduate Student Tracking System (GSTS)

Students are expected to maintain their current information in the Graduate Student Tracking System (GSTS, http://gsts.northwestern.edu). The Graduate Student Tracking System allows students to track their progress and activity in one place. Students log in with their NetID and use the tool to communicate with their program on their plan of study, coursework, milestones, and annual progress.

6.5 Academic Standing

The Graduate School details procedures for determining Good Academic Standing, Probation, and Exclusion. See the Graduate School website at:
http://www.tgs.northwestern.edu/about/policies/satisfactory-academic-progress.html.

6.6 Filing for Graduation

For graduation, the student must complete the Master's Degree Completion form in the TGS Forms section in Caesar at the beginning of the quarter the student plans to graduate. For the exact deadline date to receive a degree, see the graduate school website and the academic calendar.

6.7 Appeals Process

The faculty make every effort to ensure that each student's progress is carefully reviewed and the resulting feedback is accurate and constructive. There may be, however, instances in which a student feels that a review decision is unjust or is based on incomplete or inaccurate information. If this occurs, there are appeal channels available to the student.

First, the student should discuss his/her concerns with their advisor in order to resolve any misconception or misperception. If the advisor and the student are not able to resolve the concern, an appeal may be directed to the Department Chair. The University policy for academic-related grievances is provided in The Graduate School Catalog. For non-academic matters, such policies are provided in the Northwestern Student Handbook.

7 GENERAL INFORMATION

7.1 Pass/No-Credit Option

Students working toward an MS or a PhD in Engineering Sciences and Applied Mathematics may **not** use courses taken on a P/N basis to satisfy course requirements. Graduate students may, with the approval of their advisor, take courses on a P/N basis *after* satisfying the departmental course requirements.

7.2 Academic Honesty

All students are expected to adhere to TGS Standards of Academic Integrity. Students are strongly advised that originality is essential in all homework, projects, exams, theses, etc. associated with graduate work. Students are required to do their own work. Ideas, data, or word-for-word quotations taken from other sources **(including the work of fellow students and other group members)** must be appropriately referenced; otherwise plagiarism will have been committed. The following statements should help define what is meant by "appropriately referenced":

1. All ideas, data, mathematical expressions, and word quotes taken from the works of others should be clearly and directly referenced to the original author. This is best accomplished by listing a reference number after the material with the numbered references appearing at the end of the manuscript. The following format is also acceptable:

   "The equation can be derived following the approach of Jones[33] as follows:..."

2. Word for word quotes must have quotation marks at the beginning and end and be referenced in the manner described above.

3. Photocopied figures should be referenced as described in 1. above.

4. Redrawn figures or plots made from other people's table of data can be appropriately labeled "after Smith[43]".

5. Each person should receive proper recognition for contributions made.

Special note: group collaboration on homework assignments is at the discretion of the professor. Unless otherwise stated, students are expected to turn in their own original work.

In accordance with Graduate School regulations, "All cases of alleged academic dishonesty involving students of The Graduate School are to be referred by members of the faculty to the Dean of The Graduate School" as well as the Associate Dean of Graduate Studies of McCormick. A student found guilty of academic dishonesty runs the risk of being dismissed immediately from the graduate program.

On Being a Scientist by the Governing Board of the National Research Council is available at

http://www.nap.edu/catalog.php?record_id=12192#toc

Northwestern University's Office for Research Integrity provides guidance on ethical conduct of research. Information about research misconduct is available online at

http://www.research.northwestern.edu/ori/misconduct/

Students should be familiar with the contents of these two documents. The Department expects the highest levels of integrity from students and faculty.

7.3 Student Support and Conflict Resolution

Students should speak with the Department Chair to interact in a confidential manner when concerns arise.

7.4 Consumption of Alcoholic Beverages

Consumption of alcoholic beverages in the Technological Institute, except at official departmental functions and such recognized events as post-defense celebrations, is incompatible with sound safety and work-place practices and is therefore unacceptable. **We expect our students to abide by Illinois laws concerning all controlled substances.**

7.5 Student's File

In addition to the information contained in GSTS, folders are kept in the department offices for each student. They contain additional materials not currently maintained in GSTS such as application materials, approved study programs, grades for completed courses, records of completed examinations, names of committee members, current address, phone numbers, etc. In accordance with Government regulations a student is allowed access to his file after submitting a written request to the department. Educational records cannot be released to any outside agency without the student's written consent. Students applying for credit cards, etc., which require employment and/or salary verification by the department, must inform the department that such a request may be forthcoming. Verification of employment may also be done through NU's Employment Verification Infoline at https://www.theworknumber.com.

7.6 Change of Address

The Department Office must be notified of any change of address. Students may change their home address through the HR website https://www.northwestern.edu/myhr and also in Caesar. **Be sure to change your address in both** as the two systems are separate.

The US Citizenship & Immigration Services (USCIS) requires every international student and scholar to report a change of address within 10 days of their move. It is critical for F-1 and J-1 students to update their address in CAESAR immediately upon their relocation. For J-1 and H-1 scholars they will need to inform the international office as soon as possible. All F-1 students, J-1 students and scholars, and H-1B scholars will also need to complete a change of address form (AR-11) available on the USCIS website at: http://uscis.gov/. Failure to do so will be a violation of their F-1 or J-1 status and could result in severe consequences for them and their dependent(s)!

7.7 International Students

Upon arrival all international students must register immediately with the International Student Office, 630 Dartmouth Place, Evanston Campus, who will act as advisor on all matters concerning employment practice, visa renewals, etc. International students interested in pursuing the Ph.D. degree are required to pass the Versant English Test in order to fulfill The Graduate School's spoken English proficiency requirement http://www.tgs.northwestern.edu/funding/assistantships/graduate-and-teaching.html , also see http://groups.linguistics.northwestern.edu/esl/versant.htm.

7.8 Colloquium Series

The Department organizes the colloquium series that generally meets on Mondays at 4pm. Its primary purpose is to broaden the education of each graduate student by bringing to campus the leaders in our field. Attendance is recommended for all graduate students.

7.9 Safety

The department has taken a number of steps to help provide a safe environment for your research. In the event of an alarm requiring evacuation of the building, all members of the department are expected to evacuate to the department rally point in the lobby of the Catalysis Center, which is located at the end of the bridge on the second floor of the K wing on the south side of Tech. When you arrive at the rally point, report to the Safety Coordinator so we can ensure everyone's safe exit from the building.

7.10 Computing Facilities

Linux computers are available for general academic and research use in the student offices. Not all computers in student offices are for general use, but are for specific research projects. Contact the Department Computing Manager if you have any questions about which computers are available for general use. New students are assigned a user ID based on their NU net ID that allows them to log in to any of the department Linux computers, and also allots storage space that is on a shared server that can be accessed from any of the Linux computers. The Manager must be consulted prior to addition or deletion of any software or hardware on these systems, or in the event of system malfunctions. **Important: The department linux computers are backed up nightly, so they must be left on and connected to the network at all times.** Please check beforehand with the Manager if a computer must be disconnected for any reason.

Students may also access the department network via their own personal computer. To obtain access, send an email to the Graduate Student Assistant with: Name, office #, operating system, whether it is a laptop or desktop, and the Ethernet MAC address. An Ethernet connection is required to use the department printers, wireless connections are not on our local subnet, and hence will not allow access to the printers.

7.11 Student Lounge

The graduate student lounge is located in room M443. It is managed by the ESAM graduate student leadership. All students are expected to comply with the rules set by the graduate student leadership to

keep the lounge as a pleasant place for students to gather. Access to the student lounge is by an access code for a numeric pad on the door. Contact the Graduate Student Assistant if you do not know the access code. Please do not share the access code with non-ESAM people. Use of the lounge is intended only for ESAM students, faculty, and staff.

7.12 Telephone, Fax, Mail, Photocopying, and Printing

Telephones. Telephones are provided in all student offices, however, their use should be limited to university business only. **Personal calls should be made on cell phones**. Long distance calls require an access code. Persons who may have occasion to call you for business purposes from outside the University should be given the telephone number of the main Department office (847)-491-3345. **Collect calls are not acceptable, by Northwestern regulations.**

Postal Service. Mail is delivered once a day to the Department Office. The student mailboxes are in M426; you will find your mail and messages in your assigned box above your name label. It is advisable to check your mailbox daily. Use of the University mailing address for personal mail is not allowed by NU regulations.

Photocopying, Copy Cards, and Faxing. A photocopying machine for research and teaching related copying is available in the Department Office. Copy cards for use in copying machines at the library are available through the Wildcard Office or Main Library. Photocopying services are also located at Norris Center and 2020 Ridge for large orders. Personal copying should be kept to a minimum on the department machine. A fax machine is located in the Department Office. Long distance faxes require an access code. See the department for personal faxes.

Printing. A black and white and printer is provided in the Student Lounge, M443. A color printer is provided in the main office, M426. The black and white printer should be used, with duplexing turned on to save paper, unless color is **absolutely necessary**. Use of the printers is for academic and research purposes only, and not for personal use. Information about accessing the printers from the Department provided computers or your personal computer can be found on the Department website under student resources.

7.13 Kitchen, Large Conference Room, and Supply Cabinet

Kitchen. Kitchen use is restricted to ESAM department members. Please comply with the kitchen rules that are posted. Do not leave personal items in the kitchen. After washing your dishes, be sure to dry them and remove them promptly. The microwave and toaster oven should not be left unattended while in use. Clean up any food that splatters, drips or spills. Remember, it is easier to clean up the mess when it is still fresh. As a courtesy to other department members, please only take tea and other supplies on a single-use basis. Finally, to prevent flooding, make sure the hot water dispenser is completely turned off after use. There is no janitorial service to clean up this space, so it is your responsibility to keep the area clean and clear of personal belongings.

Large Conference Room (M416). If you need to enter/exit the conference room, please do so through the Tech hallway, not the department office. The conference room should be left in the condition that it is found. If chairs or other furniture are moved, they should be returned to their original position. Do not leave food in the room; properly dispose of any garbage. This room acts as a classroom and event space, and should be kept tidy at all times.

Supply Cabinet (M426). Limited supplies (pens, notebooks, etc.) are available for research purposes.

These supplies are not for personal or class use. Please only take one of each item at a time.

7.14 Automobile Regulations

The University Police Parking Division controls the NU parking lots. Students requiring a sticker that will enable them to park in the various University parking lots should obtain an application from the Parking Office located at 1841 Sheridan Road, Evanston (open Monday through Friday, 8:00 A.M. to 4:00 P.M.). Applications are issued upon presenting your University I.D. card, driver's license and payment of a fee. Additional information can be found at http::/www.northwestern.edu/up/parking. For your information, all students who park cars on campus are required to register the car with the Parking Office. Bicycles should also be registered.

7.15 The SIAM Student Group

The Northwestern Student chapter of SIAM (Society for Industrial and Applied Mathematics) was established in 2011. Each year (usually at the end of the Spring Quarter) an election is held to fill the offices of President, Vice President, Secretary/Treasurer, Activities Chairman, and Faculty Representative. The Officers serve as liaison to the Faculty and Department administration in representing the students' interests. They also organize various social and professional activities throughout the year. Students are automatically members and are encouraged to participate. For international students the club provides valuable interaction for the development of English proficiency.

7.16 Bike Riding and Skateboarding

For obvious safety reasons, bike riding and skate boarding are prohibited in the corridors of Tech. **In addition, bikes may not be stored in public spaces in the building, in particular the stairwells where they can pose an evacuation hazard.**

Example Modeling Themes

Theme	Suggested Courses (Choose 3 from the list)
Finance	ECON 308, ECON 310, ECON 311, ECON 349, ECON 360, ECON 362, ECON 383, ECON 410-1, ECON 411, IEMS 405, FINC 485-1, STAT 365, IEMS 326
Data/Machine Learning	ES_APPM 495, ES_APPM 421-1, ELEC_ENG 435, ELEC_ENG 475, COMP_SCI 349, COMP_SCI 469, DATA_SCI 422, DATA_SCI 423, STAT 301
Mechanics	ES_APPM 495, MECH ENG 417, MECH ENG 495
Financial Engineering	FINC 485-1, IEMS 326, IEMS 373, IEMS 473, STAT 365
Economics	ECON 308, ECON 310, ECON 311, ECON 360, ECON 381, ECON 383, ECON 410-1, ECON 410-2, FINC 485-1, ECON 362
Applied Multivariate Analysis	STAT 348-0, ES_APPM 495, ES_APPM 421-1

Example Math Content Themes

Theme	Suggested Courses (Choose 3 from the list)
Applied Analysis	ES_APPM 322, ES_APPM 411-1, ES_APPM 411-3, ES_APPM 420-2, ES_APPM 412
Statistics	ES_APPM 412, ES_APPM 420-2, IEMS 303, IEMS 304, IEMS 315, IEMS 401, IEMS 435, IEMS 460, IEMS 461, IEMS 462-1, STAT 350, STAT 439, STAT 455, ECON 480
Optimization	ES_APPM 311-3, IEMS 310, IEMS 450-1, IEMS 450-2, IEMS 451, IEMS 452
Predictive Analytics	ES_APPM 420-2, ES_APPM 412, IEMS 462-1
Linear Programming	IEMS 450-1, ES_APPM 322, ES_APPM 411-1
Operations Research	ES_APPM 421-1, ES_APPM 495, IEMS 310, IEMS 450
Statistical Dynamics	ES_APPM 322, MECH ENG 460-2, OPNS 516