Institute Graduate Curriculum Committee
Minutes
Thursday, November 3, 2016

Present: Breedveld (ChBE), Sluss (CoB), Pikowsky (Registrar), Bafna (CoD-ARCH), Balch (CoC-IC), Chow (CoC-CSE), Cozzens (Vice Provost), Dovrolis (CoC-CS), Flowers (CoD-ARCH), Hays (CoC-IC), Jagoda (AE), Scripka (GCC Student Rep-for Jani), Jayaraman (MSE), Ries (ECON), Schmidt-Krey (BIOL), Smith (AE)

Visitors: Hodges (REG), Bamburowski (Graduate Studies), Porter (BC), White (CoC), Essa (CoC-IC), Romberg (ECE), Erera (ISyE), Castro (BC), Jacobs (CoE)

Note: All action items in these minutes require approval by the Academic Senate. In some instances, items may require further approval by the Board of Regents or the University System of Georgia. If the Regents' approval is required, the change is not official until notification is received from the Board to that effect. Academic units should take no action on these items until USG and/or BOR approval is secured. In addition, units should take no action on any of the items below until these minutes have been approved by the Academic Senate or the Executive Board. It may also be that approval of the Southern Association of Colleges and Schools is also required.

There are 24 voting members, 13 needed to reach a quorum.

All votes are unanimous except as noted.

Administrative Items:

1. David Bamburowski, Director of Graduate Studies, presented for the Committee's information a Memorandum of Understanding between GT Lorraine and Insa Toulouse Diplôme d'Ingénieur program. (France). GT-:L shall admit qualified students enrolled in INSA Toulouse Diplôme d'Ingénieur program to pursue the Master of Science degree from Georgia Tech in either Computer Science (CS), Electrical and Computer Engineering (ECE) or Mechanical Engineering (ME).

   Memorandum of Understanding – Acknowledged without Concern

Academic Matters

1. A motion was made to *approve* a request from the School of Building Construction for a new degree. This motion was seconded and approved.

New Degree – APPROVED

Master of Real Estate Development

The proposed Master of Real Estate Development (MRED) would be offered to professionals to further existing real estate careers, professionals looking to change career direction, and full time students with undergraduate degrees in real estate, construction, architecture, landscape architecture, planning, or engineering.

The MRED will be a 30 credit hour program made available to full time and post professional students, with the opportunity for full time students to complete the degree in 12 to 18 months. The likely scenario for post professional students will be 24 months. Instruction will include regular classroom courses, studio-based real estate development courses, and case studies involving real estate development projects. The studio courses will be collaborative courses involving students from various Schools within the College of Design to come together in real world project problem solving. The core courses will be taught by a blend of full time faculty and adjunct real estate development professionals in order to provide the best of the academic environment, including research, along with classroom instruction from active real estate professionals.

Students and faculty will be in a face-to-face environment; there is no distance learning element included in the initial program.

Admissions

Applicants to the MRED Program will be considered based upon two tiers of criteria. All tiers will be considered equally and independently from each other, and will require a GRE or GMAT score within the past five years in the 60th percentile or higher. The GRE or GMAT requirement may be waived on a case by case basis with appropriately documented industry experience. The goal is to provide flexibility in admissions criteria to draw a variety of students with a range of academic and work experiences related to real estate development.

<u>Tier One Criteria</u>

An undergraduate degree from an accredited program in the United States or a similarly accredited program from a foreign university in one of the following fields of study and no work experience in the real estate development industry.

- Construction Management
- Architecture
- Architecture Engineering
- Civil Engineering
- Landscape Architecture
- City Planning
- Real Estate
- GPA 3.0 or higher
- TOEFL scores of a minimum of 100

Tier Two Criteria
An undergraduate degree from an accredited program in the United States or a similarly accredited program from a foreign university in one of the following fields of study combined with at least two (2) years work experience in the real estate development industry.

- Accounting
- Finance
- Business
- Property Management
- GPA 3.0 or higher
- TOEFL scores of a minimum of 100
- Letters of recommendation from two real estate professionals specifying industry competence

Evaluation and Assessment:
MRED student learning outcomes address the knowledge required to create value through useful real estate space with associated services over time. The process demands the management of four influences that are constantly competing for dominance during the transformation of real estate from raw land to habitable space, or from a diminished value to an adaptive reuse. The four influences are the physical nature of the site, the regulatory policies, the market demands, and the financial requirements. Business management of the four influences through the creative design and construction process form the basis of the core courses, and frame the topics of elective courses. In more detail, the four influences are:

- The physical nature of the site compels the initial concept for development. Site characteristics along with available resources will drive the feasibility of sustainable land use. Planning, engineering, design and construction will all play a part in successful utilization of the land.

- Regulatory laws and rules emanate from various levels of the public sector, and establish the framework for permissible real estate development in a particular location. The application of ethical compliance mechanisms to accomplish the private goals of the developer along with the public goals of the controlling level of government is always a component of the development process.

- The real estate market demands habitable space that satisfies current needs at a sustainable cost. Whether residential, office, retail, industrial, or mixed use, real estate supply and demand must be managed during the delivery of a product that often takes years to bring to market. Vibrant site and building design that recognizes current market demand with an eye on serving the market for many years in the future requires a unique collaboration of disciplines managed by the real estate developer.

- The majority of real estate investment is made with debt that must be serviced during use and repaid at the appropriate time. Development requires significant monetary outlays well before the property can produce revenue, and is based upon financial projections that are much more art than science. Financing can create tremendous pressure to deliver, and by doing so, often is the greatest influence on the resulting development. Every discipline that touches a real estate development is affected by finance.

Learning Objectives and Outcomes 1.0: Physical Nature of the Site

1.1. Understanding the process of site assessment relative to surface characteristics such as topography, water, and vegetation as well as subsurface characteristics such as rock and soil.
Assessment method: Exams and case studies related to BC 6175

1.2. Matching appropriate land uses to a specific site based upon physical characteristics while assessing the impact to surrounding properties.
Assessment method: Exams and projects related to ARCH 6151

1.3. Relating the subdivision of land to the physical character of the site and to surrounding land uses.
Assessment methods: Projects and case studies related to BC 6175

Learning Objectives and Outcomes 2.0: Regulatory Laws and Rules

2.1. Understanding the structure of land use controls at the federal, state, and local levels of government along with the controlling branch of government and typical departmental organization at each level.
Assessment method: Papers and exams related to BC 6350

2.2. Applying ethical compliance strategies relative to rules and regulations surrounding infrastructure design and construction along with identifying necessary consultants associated with the various regulatory areas.
Assessment method: Projects and development studios related to BC 6375

Learning Objectives and Outcomes 3.0: Real Estate Markets

3.1. Analyzing the demand drivers for various types of real estate development including residential for sale and rental, office, retail, industrial and mixed use.
Assessment method: Exams and research papers related to CP 6640

3.2. Identifying existing and proposed supply within a specifically defined market area for various types of real estate development.
Assessment method: Exams and research papers related to CP 6640

3.3. Researching public and private data sources that provide supply and demand information for real estate projects.

Assessment methods: Case studies and reports related to BC 6175

3.4. Collating market research into a viable proposal for new development in a written report and a verbal presentation.

Assessment Method: Case studies and development studios related to CP 6640

Learning Objectives and Outcomes 4.0: Financial Process

4.1. Understanding sources of acquisition, development and construction financing and typical parameters associated with real estate development financing.

Assessment Method: Exams and case studies related to BC 6575

4.2. Projecting value, cost, and absorption to determine loan structure and financing costs for various types of real estate development projects.

Assessment Method: Case studies and reports related to BC 6575

4.3. Preparing and analyzing basic financial statements for real estate projects and real estate development companies

Assessment Method: Exams and case studies related to CP 6611

Learning Objectives and Outcomes 5.0: *Business Management*

5.1. Understanding real estate business organizational structures along with the various legal structures associated with responsible real estate development.

Assessment Method: Exams and reports related to BC 6350

5.2 Creating management process of the people associated with the real estate development including public and private planners, site engineers, regulators, real estate brokers, lawyers and financial advisors and lenders.

Assessment Method: Exams and case studies related to BC 6175

The MRED will be assessed according to the Guidelines for Academic Program Review as established by the Board of Regents and the Office of the Provost at Georgia Tech. This involves the development of a self-study and constitution of an External Review Committee every five years with the purpose of assessing the goals and direction of the program. The aforementioned learning outcomes are going to be assessed using both direct and indirect sources of evidence of student performance. Direct sources of evidence will be collected from class assignments, final presentations, and studio sessions. For collecting indirect sources of evidence of student performance, the School will conduct an annual assessment using data from the following assessment methods:

1. Exit survey data from graduating students collected by the Institute Assessment Office.
2. Exit survey data from graduating students collected by the School of Building Construction and the College of Design.
3. Alumni survey data collected by the Institute Assessment Office.
4. MRED Professional Advisory Committee, as described in 7b. below, review of curriculum and processes.

In addition to the assessment based on performance in the core curriculum, students and employers will be asked to provide input on the questions such as the following:

1. Did your studies towards the Master of Real Estate Development provide you with effective knowledge to apply to a range of real estate development projects? Range of answers: 1 (poorly) to 5 (extremely well). This bears on Learning Outcomes 1-4.

2. Did your studies towards the Master of Real Estate Development prepare you to analyze the four primary influences that impact real estate development projects? Range of answers: 1 (poorly) to 5 (extremely well). This bears on Learning Outcomes 1-4.

3. How well did your studies towards the Master of Real Estate Development prepare you to recommend for or against acquiring a specific site for a specific new development? Range of answers: 1 (poorly) to 5 (extremely well). This bears on Learning Outcome 1 and 2.

4. Was your new hire from the Georgia Tech Master of Real Estate Development program prepared to contribute to your real estate development business? Range of answers: 1 (poorly) to 5 (extremely well). This bears on Learning Outcomes 5.

5. For your next hire, will you interview graduates of the Georgia Tech Master of Real Estate Development program? Range of answers: 1 (absolutely not) to 5 (absolutely). This bears on Learning Outcomes 5.

Administration
The MRED Program will be housed in the School of Building Construction in the College of Design at the Georgia Institute of Technology, Atlanta, Georgia.

The MRED Program will be under the overall management of the Dean of the College of Design along with the Chair of the School of Building Construction in the College. Faculty resources and curricula will be reviewed and agreed on annually by the chairs of the Schools of Building Construction, Architecture and City and Regional Planning in a process coordinated by the Dean. Administrative organization and support will be provided by the School of Building Construction.

The operations of the MRED Program will be the responsibility of a Program Director appointed by the Chair of the School of Building Construction in consultation with the Dean and the Chairs of the School of City and Regional Planning and Architecture. The Program Director will work with the School Chairs, with instructional faculty, with standing faculty committees such as the Curriculum Committees of the Schools and the College, and any committees or task forces appointed by the School Chairs. Working in consultation with the three School Chairs, the Program Director will have oversight for day-to-day operations, student recruiting, admission decisions, advising, curriculum coordination and development, and supplementary projects including foreign study programs, international studio projects, lecture programs, field trips, and research initiatives. The existing Recruiter and Academic Advisor in the School of Building Construction will lead these two areas with the Academic Advisor convening regular meetings with the academic advisors in each of the three Schools to insure seamless integration of the students into appropriate courses within the individual Schools. Admission decisions and curriculum development responsibilities will be shared by the Director and the MRED faculty. Beyond the administrative responsibilities discussed here, the MRED Program will not require any additional administrative support beyond that already existing in the College of Design, including facilities management, information technology management, and similar operations.

A Professional Advisory Committee will be formed to advise the Program Director on program initiatives and curriculum matters. This group will include real estate development professionals from Atlanta firms, as well as real estate development academics from other institutions.

Accreditation

There are no accrediting bodies for real estate development programs. The College of Design programs are reviewed in accordance with Institute policy as part of the Institute's Academic Program Review (APR) process. All review materials resulting from the APR are reviewed by the Institute's faculty governing bodies and made available to the Board of Regents and the Southern Association of Colleges and Schools.

Core Courses

BC 6175 Real Estate Development and Construction (3-0-3)

Provides an overview of the history of land, the real estate development process, the professionals involved in the process, and the integration of the process and people

BC 6575 Real Estate Production Finance (3-0-3) **

Business model and financing process required to produce new real estate developments through an investigation of land acquisition, development and construction financial management

BC 6350 Design and Construction Law (3-0-3)

Overview of real estate law and legal issues encountered by real estate developers, contractors and designers including federal, state, and local laws and regulations

CP 6640 Applied Real Estate Development Methods (3-0-3)

Application of market and feasibility analyses and public policy requirements to the development process across various land use types

ARCH 6151 Theories of Urban Design (3-0-3)

Introduction of urban design ideas, research, and practice, examining traditional qualities of the American city and their possible applications to the contemporary city

BC 6875 Real Estate Development Capstone Project (2-3-3)

Culminating application of program knowledge to a real estate project researched and proposed by the student

** CP 6611 Principles of Real Estate Finance and Development can be substituted.

Elective Courses

BC 6375 Trends and Policies for Development (3-0-3)

Overview of development in the United States along with current trends and the impact of public policy of the development process to provide context for ethical real estate development

BC 6675 Residential Design and Construction (3-0-3)

Examination of the application of market, community, and regulatory factors to residential design and construction, and the management process associated with sustainable development delivery

ARCH 6226 Green Construction (3-0-3)

A focus on the means, methods, strategies, and technologies to improve the energy efficiency and performance of buildings thereby reducing environmental impact

CP 6016 Growth Management Law and Implementation (3-0-3)

Overview of various legal tools applied to the management of real estate development by state and local government

CP 6105 Land Conservation (3-0-3)

Examination of the distinctive American view of land, the history of the conservation movement, and the why and how of modern land conservation

CP 6112 Introduction to Land Use Planning (3-0-3)

Introduction to land use planning, the basic rationale for land use planning, and its form in different states

CP 6611 Principles of Real Estate Finance and Development

Introduction to principles of real estate finance, focusing on the role the public sector plays in making development projects financially feasible

CP 6233 Sustainable Urban Development (3-0-3)

Exploration of the principles and practice of sustainable urban development and the role of planning

MGT 6082 Fundamentals of Real Estate Development (3-0-3)

Overview of the real estate development process from concept through design and construction to ultimate sale or permanent financing.

Additional courses from the Schools of Building Construction, City and Regional Planning, and Architecture as approved by the Program Chair in conjunction with the School Chairs and professors.

Notes: The Committee requested the pre-requisites for the Capstone course (BC 6875) be updated to pre-requisites only instead of pre-requisites with concurrency. There was question if it remained as such that students could technically enroll in the Capstone in their first terms of the program which is not the intent.

The Committee also followed up on a question from the presentation of the prospectus of the degree in regards to securing enough tenure-track faculty to sustain the program. The unit explained that other instructors from programs such as the Professional Master's in Occupational Safety and Health could instruct the capstone course and the faculty listed only represented faculty for the core courses as the elective courses are existing taught outside of the MRED program.

The Committee inquired about when the program would see that it's suitable to waive the GRE/GMAT for a student. The unit stated the students would need extensive industry experience and it was confirmed it would not be a petitioned item in such cases.

A motion was made to approve a request from the School of Building Construction for a new course. This motion was seconded and approved.

New Course – APPROVED with edits

BC 6875: Real Estate Development Capstone Project (2-3-3)

Note: Per the Committee's request, the NCP Box 7 (pre-requisites) will be updated to state that the pre-requisites are stand alone and not pre-requisites with concurrency.

2. A motion was made to *approve* a request from the College of Computing, the College of Engineering, and the College of Sciences for a new degree. This motion was seconded and approved.

New Degree – APPROVED
Doctor of Philosophy with a major in Machine Learning

The ML PhD program has the following principal objectives, each of which supports an aspect of the Institute's mission:

1. Create students that are able to advance the state of knowledge and practice in machine learning through innovative research contributions.
2. Create students who are able to integrate and apply principles from computing, statistics, optimization, engineering, mathematics and science to innovate, and create machine learning models and apply them to solve important real-world data intensive problems.
3. Create students who are able to participate in multidisciplinary teams that include individuals whose primary background is in statistics, optimization, engineering, mathematics and science.
4. Provide a high quality education that prepares individuals for careers in industry, government (e.g., national laboratories), and academia, both in terms of knowledge, computational (e.g., software development) skills, and mathematical modeling skills.
5. Foster multidisciplinary collaboration among researchers and educators in areas such as computer science, statistics, optimization, engineering, social science, and computational biology.
6. Foster economic development in the state of Georgia.
7. Advance Georgia Tech's position of academic leadership by attracting high quality students who would not otherwise apply to Tech for graduate study.

Curriculum

Program of Study

The central goal of the PhD program is to train students to perform original, independent research. The most important part of the curriculum is the successful defense of a PhD Dissertation, which demonstrates this research ability. The academic requirements are designed in service of this goal.

The curriculum for the PhD in Machine Learning is truly multidisciplinary, containing courses taught in eight schools across three colleges at Georgia Tech: the Schools of Computational Science and Engineering, Computer Science, and Interactive Computing in the College of Computing; the Schools of Industrial and Systems Engineering, Electrical and Computer Engineering, and Biomedical Engineering in the College of Engineering; and the School of Mathematics in the College of Science.

The academic requirements for the PhD in Machine Learning consist of 10 courses, passing the qualifying examination, and successfully defending a PhD thesis. Five of the courses are designated as "core"; students are expected to take these courses in their first two years in the program. The five remaining courses are chosen from a long, diverse list of electives. The qualifying examination consists of a focused literature review that takes place over the course of a semester, for which the student receives course credit.

Almost all of the courses in both the core and elective categories are already taught regularly at Georgia Tech. However, two core courses (designated in the next section) are being developed specifically for this program. The proposed outlines for these courses can be found in the Appendix in Proposal 5142 on the IGCC site. Students who complete these required courses as part of a master's program will not need to repeat the courses if they are admitted to the ML PhD program.

Summary of General Requirements for a PhD in Machine Learning

- Core curriculum (5 courses, 15 hours).
- Area electives (5 courses, 15 hours).
- Responsible Conduct of Research (RCR) (1 course, 1 hour, pass/fail). Georgia Tech requires that all PhD students complete an RCR requirement that consists of an online component and in-person training. The online component is completed during the student's first semester enrolled at Georgia Tech. The in-person training is satisfied by taking PHIL 6000 or their associated academic program's in-house RCR course.
- Qualifying examination (1 course, 3 hours). This consists of a one-semester independent literature review followed by an oral examination.
- Doctoral minor (3 courses, 9 hours).
- Research Proposal. The purpose of the proposal is to give the faculty an opportunity to give feedback on the student's research direction, and to make sure they are developing into able communicators.
- PhD Dissertation.

Core Curriculum Courses

Machine Learning PhD students will be required to complete courses in five different areas. With the exception of the Foundations course, each of these area requirements can be satisfied using existing courses from the College of Computing or Schools of ECE, ISyE, and Mathematics.

Mathematical Foundations of Machine Learning. This will be a new course cross-listed between the College of Computing (CS) and Schools of ECE and ISyE. This required course is the gateway into the program, and will cover the key subjects from applied mathematics needed for a rigorous graduate program in ML. Particular emphasis will be put on advanced concepts in linear algebra and probabilistic modeling. A formal course proposal will be submitted to the graduate curriculum committee after it has been taught as Special Topics to request a permanent number as CS/CSE/ECE/ISYE 7740.

Intermediate Statistics. The purpose of this requirement is to expose students to the main concepts in mathematical statistics. It can be met through any one of the three courses listed below. While these courses emphasize different material, they are all centered on mathematical analysis of fundamental problems in statistics.

- ISYE 6412, Theoretical Statistics
- ECE 7251, Signal Detection and Estimation
- MATH 6262, Statistical Estimation

Machine Learning: Theory and Methods. This course serves as an introduction to the foundational problems, algorithms, and modeling techniques in machine learning. Each of the courses listed below treats roughly the same material using a mix of applied mathematics and computer science, and each has a different balance between the two.

- CS 7616, Pattern Recognition
- CSE/ISYE 6740, Computational Data Analysis
- ECE 6254, Statistical Machine Learning
- ECE 6273, Methods of Pattern Recognition with Applications to Voice

Probabilistic Graphical Models and ML in High Dimensions. This will be a new course cross-listed between the College of Computing (CS) and schools of CSE and ECE. The course will provide students with an introduction to the theory and practice of graphical models, one of the most dominant frameworks in machine learning and artificial intelligence. Similar courses have been taught as special topics courses in the School of CSE, including CSE 8803ML (Machine Learning II: Advanced Topics) and CS 8803PGM (Introduction to Probabilistic Graphical Models). A formal course proposal will be submitted to the graduate curriculum committee after it has been taught as Special Topics to request a permanent number of CS/CSE/ECE 7741.

Optimization. Optimization plays a crucial role in both developing new machine learning algorithms and analyzing their performance. The three courses below all provide a rigorous introduction to this topic; each emphasizes different material and provides a unique balance of mathematics and algorithms.

- ECE 8823, Convex Optimization: Theory, Algorithms, and Applications
- ISYE 6661, Linear Optimization
- ISYE 6663, Nonlinear Optimization
- ISYE 6669, Deterministic Optimization
- ISYE 7683, Advanced Nonlinear Programming

Electives

In addition to meeting the five core area requirements, each student is required to complete five elective courses. These courses are required for getting a complete breadth in ML. These courses must be chosen from at least two of the five subject areas listed below.

Statistics and Applied Probability: To build breadth and depth in the areas of statistics and probability as applied to ML.

- AE 6505, Kalman Filtering
- BMED 6700, Biostatistics
- ECE 6558, Stochastic Systems
- ECE 6601, Random Processes
- ECE 6605, Information Theory
- ISYE 6404, Nonparametric Data Analysis
- ISYE 6413, Design and Analysis of Experiments
- ISYE 6414, Regression Analysis
- ISYE 6416, Computational Statistics
- ISYE 6420, Bayesian Statistics
- ISYE 6761, Stochastic Processes I
- ISYE 6762, Stochastic Processes II
- ISYE 7400, Adv Design-Experiments
- ISYE 7401, Adv Statistical Modeling
- ISYE 7405, Multivariate Data Analysis
- MATH 6263, Testing Statistical Hypotheses
- MATH 6266, Statistical Linear Modeling
- MATH 6267, Multivariate Statistical Analysis
- MATH 7244, Stochastic Processes and Stochastic Calculus I
- MATH 7245, Stochastic Processes and Stochastic Calculus II

Advanced Theory: To build a deeper understanding of foundations of ML.

- CS 7280, Network Science
- CS 7510, Graph Algorithms
- CS 7520, Approximation Algorithms

- CS 7530, Randomized Algorithms
- CS 7535, Markov Chain Monte Carlo Algorithms
- CS 7540, Spectral Algorithms
- CS 7545, Machine Learning Theory
- ECE 6283, Harmonic Analysis and Signal Processing
- ECE 6555, Linear Estimation
- ISYE 7682, Convexity
- MATH 6112, Advanced Linear Algebra
- MATH 6221, Advanced Classical Probability Theory
- MATH 6580, Introduction to Hilbert Space
- MATH 7338, Functional Analysis
- MATH 7586, Tensor Analysis
- MATH 88XX, Special Topics: Mathematical Foundations of Learning Theory
- MATH 88XX, Special Topics: High Dimensional Probability and Statistics

Applications: To develop a breadth and depth in variety of applications domains impacted by/with ML.

- AE 6373, Advanced Design Methods
- AE 8803, Machine Learning for Control Systems
- AE 8803, Nonlinear Stochastic Optimal Control
- BMED 6780, Medical Image Processing
- BMED 8813BHI, Biomedical and Health Informatics
- BMED 8813MHI, mHealth Informatics
- BMED 8813MLB, Machine Learning in Biomedicine
- BMED 8823ALG, OMICS Data and Bioinformatics Algorithms
- CS 6440, Introduction to Health Informatics
- CS 6465, Computational Journalism
- CS 6474, Social Computing
- CS 6475, Computational Photography
- CS 6476, Computer Vision
- CS 6601, Artificial Intelligence
- CS 7450, Information Visualization
- CS 7476, Advanced Computer Vision
- CS 7630, Autonomous Robots
- CS 7636, Computational Perception
- CS 7646, Machine Learning for Trading
- CS 7650, Natural Language Processing
- CSE 6141, Massive Graph Analysis
- CSE 6240, Web Search and Text Mining
- CSE 6242, Data and Visual Analytics
- CSE 6301, Algorithms in Bioinformatics and Computational Biology
- ECE 4580, Computational Computer Vision
- ECE 6255, Digital Processing of Speech Signals
- ECE 6258, Digital Image Processing
- ECE 6260, Data Compression and Modeling
- ECE 6273, Methods of Pattern Recognition with Application to Voice
- ECE 6550, Linear Systems and Controls

- ECE 8813, Network Security
- ISYE 6421, Biostatistics
- ISYE 6810, Systems Monitoring and Prognosis
- ISYE 7201, Production Systems
- ISYE 7204 Info Prod & Ser Sys
- ISYE 7203, Logistics Systems
- HS 6000, Healthcare Delivery
- MATH 6759, Stochastic Processes in Finance
- MATH 6783, Financial Data Analysis

Computing and Optimization: To provide more breadth and foundation in areas of math, optimization and computation for ML.

- CS 6505, Computability and Algorithms
- CS 6550, Design and Analysis of Algorithms
- CSE 6140, Computational Science and Engineering Algorithms
- CSE 6643, Numerical Linear Algebra
- CSE 6644, Iterative Methods for Systems of Equations
- CSE 6710, Numerical Methods I
- CSE 6711, Numerical Methods II
- ISYE 6645, Monte Carlo Methods
- ISYE 6662, Discrete Optimization
- ISYE 6664, Stochastic Optimization
- ISYE 6679, Computational methods for optimization
- ISYE 7686, Advanced Combinatorial Optimization
- ISYE 7687, Advanced Integer Programming

Platforms: To provide breadth and depth in computing platforms that support ML and Computation.

- CS 6421, Temporal, Spatial, and Active Databases
- CS 6430, Parallel and Distributed Databases
- CS 6290, High-Performance Computer Architecture
- CSE 6220, High Performance Computing
- CSE 6230, High Performance Parallel Computing

Qualifying Examination

The purpose of the Qualifying Examination is to judge the candidate's potential as an independent researcher.

The Ph.D. qualifying exam consists of a focused literature review that will take place over the course of one semester. At the beginning of the second semester of their second year, a qualifying committee consisting of three members of the ML faculty will assign, in consultation with the student and the student's advisor, a course of study consisting of influential papers, books, or other intellectual artifacts relevant to the student's research interests. The student's focus area and current research efforts (and related portfolio) will be considered in defining the course of study.

At the end of the semester, the student will submit a written summary of each artifact which highlights their understanding of the importance (and weaknesses) of the work in question and the relationship of this work to their current research. Subsequently, the student will have a closed oral exam with the three members of the committee. The exam will be interactive, with the student and the committee discussing and criticizing each work and posing questions related the students current research to determine the breadth of student's knowledge in that specific area.

The success of the examination will be determined by the committee's qualitative assessment of the student's understanding of the theory, methods, and ultimate impact of the assigned syllabus.

The student will be given a passing grade for meeting the requirements of the committee in both the written and the oral part. Unsatisfactory performance on either part will require the student to redo the entire qualifying exam in the following semester. Each student will be allowed only two attempts at the exam.

Students are expected to perform the review by the end of their second year in the program.

Doctoral Dissertation

The primary requirement of the PhD student is to do original and substantial research. This research is reported for review in the PhD dissertation, and presented at the final defense.

As the first step towards completing a dissertation, the student must prepare and defend a Research Proposal. The proposal is a document of no more than 20 pages in length that carefully describes the topic of the dissertation, including references to prior work, and any preliminary results to date. The written proposal is submitted to a committee of three faculty members from the ML PhD program, and is presented in a public seminar shortly thereafter. The committee members provide feedback on the proposed research directions, comments on the strength of writing and oral presentation skills, and might suggest further courses to solidify the student's background. Approval of the Research Proposal by the committee is required at least six months prior to the scheduling of the PhD defense. It is expected that the student complete this proposal requirement no later than their fourth year in the program.

The PhD thesis committee consists of five faculty members: the student's advisor, three additional members from the ML PhD program, and one faculty member external to the ML program. The committee is charged with approving the written dissertation and administering the final defense. The defense consists of a public seminar followed by oral examination from the thesis committee.

Minor

The minor will follow the standard Georgia Tech requirement: 9 hours outside the student's home unit, with a GPA in those courses of at least 3.0. These courses are in addition to the other core and elective requirements. The courses for the minor should form a cohesive program of study, outside the area of ML, that is approved by the Faculty Advisory Committee. Typical programs will consist of three courses from the same school (any school at the Institute) or three courses from the same elective area in the courses listed above.

Admissions criteria

Students will enroll through one of the participating units (the College of Computing or the Schools of ISYE, ECE, BME, and Math). They will indicate that they are applying for the ML program by checking a box on the application. The applicant must meet all admissions standards (including requirements on the minimum GPA, minimum GRE/TOEFL scores) of their home unit. After an initial review, the school's representative to the ML PhD Faculty Advisory Committee will submit their candidates to the program; the final admission decision will be made by the committee.

The committee's decision to admit will be based on (1) prior academic performance of the applicant in a B.S. or M.S. program at a recognized institution, including coursework and independent research projects, (2) prior work experience relevant to ML, (3) the applicant's statement of purpose, and (4) the letters of support.

Evaluation and assessment

The Graduate Studies Committee (GSC) detailed below in Section 7, will oversee the assessment of the students, to make sure that the desired learning outcomes are being achieved, while the FAC will oversee the external assessment of the program in coordination with the director. Learning outcomes and their assessments will be reported annually to the Georgia Tech Office of Assessment through its OATS system.

The following are the desired student learning outcomes, and how they will be assessed.

1. Knowledge of core concepts in Machine Learning. This will be assessed through their grades in the core courses, with a minimum GPA required for student advancement.
2. Advanced knowledge in area of specialization. Each student must take at least courses in two areas of specialization, and will be assessed through the Qualifying Exam.
3. Ability to communicate to both a specialized and general audience. This will be assessed through an evaluation of the student's oral presentations for the PhD proposal and defense.

4. Ability to perform independent research. This will be assessed with the PhD dissertation.

The GSC will also measure how well the program prepared students for their subsequent careers. This assessment plan in this regard consists of the following:

- We will conduct an exit interview with every graduating student. Among the areas to be covered include the effectiveness of the program relative to students' career objectives, skills and knowledge acquired while in the program, and the relevance and satisfaction of courses. Students will be asked to suggest areas where the program could be improved.
- We plan to track where graduates are employed and in what positions.
- We will conduct surveys of alumni and employers after graduation. The surveys will evaluate how well the students were able to apply their skills and knowledge to professional positions. The results of the survey will be used to continuously update and improve the program.
- Records will be kept concerning the completion rate and time to completion of students admitted to the program.

A strategic evaluation of the proposal ML PhD program will take place every five years in accordance with the University System of Georgia's guidelines for Academic Program Review. The review will involve the preparation of a program self-study, a visit and report by an external review committee, and an annual progress report on actions taken since the last review. The reports will go to the deans of the CoE, CoC, and CoS; to the Institute Graduate Curriculum Committee and the Provost; and to the University System of Georgia.

The output of the self-study is a report on the viability and productivity of the program, the quality of the research and scholarship of the PhDs, and a report on where students have gone after leaving GT.

Administration of the program

Home Unit Requirements. In order to seek uniformity with other programs in their unit, each home unit can, together with the ML Faculty Advisory Council (FAC), impose additional program requirements for their home unit students. These requirements if impacting the curricular changes must be approved by the Institute Graduate Curriculum Committee (IGCC). Furthermore, any changes can only be applied to new students, not retroactively to continuing students, and require a year and half lead-time to be imposed.

Note: The units addressed questions from the pre-proposal:

- **Qualifying exam:** students are able to take the exam a second time if not passed at first attempt.
- **Cohesiveness:** The units explained that students would form more of a cohort from events, seminars, and other avenues outside of being in class together.

It was recommended that on page 17 of the proposal under Home Unit Requirements that qualifying exams be mentioned as a part of the curriculum that may be changed by home units.

A request from the College of Computing, the College of Engineering, and the College of Sciences for new courses was withdrawn.

New courses – Requests Withdrawn

CS 7740: Mathematical Foundations in Machine Learning	(3-0-3)
CS 7741: Probabilistic Graph Models	(3-0-3)
CSE 7740: Mathematical Foundations in Machine Learning	(3-0-3)
CSE 7741: Probabilistic Graph Models	(3-0-3)
ECE 7740: Mathematical Foundations in Machine Learning	(3-0-3)
ECE 7741: Probabilistic Graph Models	(3-0-3)
ISYE 7740: Mathematical Foundations in Machine Learning	(3-0-3)

Note: It was noted by the Committee that typically the only exceptions made to creating new courses without them being taught as Special Topics for at least two terms are for Capstone courses. The units agreed this would be the best course of action to offer the courses as Special Topics and bring them back to IGCC for permanent number requests in one year. The units will note that the numbers listed above will be the ones requested when the NCPs come back for review.

The degree proposal was edited to reflect that the courses would be offered as Special Topics during this time.

Adjourned,

Reta Pikowsky,
Secretary