August 2, 2001

TO: Kathy Garcia  
    Program Review Assistant  
    Office of Graduate Studies

RE: Graduate Program Bylaws and Degree Requirements - Graduate Group in Applied Mathematics

FR: Celia Davis  
    Graduate Coordinator

This is in response to Professor Calvert's request of July 9, 2001, for updated information on our bylaws and degree requirements.

Bylaws:

The attached revised bylaws were submitted to Graduate Studies (via Lee Wilce) on April 27, 2001.

Degree Requirements:

Frankly, it's hard to tell from our records when the degree requirements were last officially approved by Graduate Council. I have attached a copy of the last letter that I could find, which is dated July 20, 1988. Knowing, however, that our brochure has been updated a couple of times since then (the latest copy is attached), I find it hard to believe that we haven't officially submitted changes since 1988.

Be that as it may though, please know that the new GGAM Chair, Bruno Nachtergaele, has begun the review process of degree requirements for our new brochure. His goal is to submit a final document to the Graduate Council in early Fall 01.

ATTACHMENTS
GRADUATE GROUP IN APPLIED MATHEMATICS
UNIVERSITY OF CALIFORNIA, DAVIS

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GRADUATE GROUP IN APPLIED MATHEMATICS
UNIVERSITY OF CALIFORNIA
DEPARTMENT OF MATHEMATICS
DAVIS, CALIFORNIA  95616

Revised 7/88
I. **Information for Applicants**

**The Graduate Group in Applied Mathematics at U. C. Davis**

The University of California has eight general campuses, of which Davis is one. Davis started as an agricultural school and later established a School of Veterinary Medicine. It became a general campus in 1959. Since that time, the school has expanded from 2,000 to 19,500 students, with undergraduate and graduate programs in many different fields as well as the professional schools of Administration, Law, and Medicine. The town of Davis is located in the central California valley, about 70 miles east of San Francisco and about 100 miles from the Sierra-Nevada mountains and Lake Tahoe. Despite the size of the campus, it has retained many of the attributes of a small college, with an informal atmosphere and excellent student-faculty interaction (particularly at the graduate level).

The agricultural tradition of the Davis Campus has given it exceptional strength and emphasis in the applied sciences. Applied mathematics is an integral part of scientific research, and almost all engineering and science departments contain at least one active applied mathematician. In addition, the Mathematics Department and the Division of Statistics on the Davis Campus are particularly strong in applied areas.

The Graduate Group in Applied Mathematics was created to provide graduate students in this field with the broadest possible access to faculty support and supervision. There are approximately forty faculty members in the Graduate Group.

There are thirty-nine graduate groups on the Davis Campus, ranging from Agricultural Education to Water Science. A graduate group is an interdisciplinary collection of faculty organized as a degree granting entity. The faculty are all members of an academic department on campus, and courses in a graduate group are drawn from appropriate departmental courses throughout the campus. Graduate groups administer their own degree programs independently. Most groups are housed in a particular department which provides administrative support. The Graduate Group in Applied Mathematics is housed in the Mathematics Department.

The graduate group also enjoys a close relationship with the Institute of Theoretical Dynamics, an organized research unit that provides a focus for research collaboration among faculty and students. Members of the Institute share a common interest in dynamics, each carrying with them a special perspective arising from their individual disciplines. Among other things, the Institute sponsors visitors, meetings, and other forms of interaction among scientists and mathematicians. The Graduate Group in Applied Mathematics and the Institute of Theoretical Dynamics jointly sponsor a colloquium series that meets weekly.

**Degree Programs and Courses**

The Graduate Group offers programs leading to the M.S. and Ph.D.
degrees in Applied Mathematics. The program includes over fifty courses from more than fourteen departments on campus. In addition to formal courses, the graduate group sponsors a regular colloquium series and several seminars. The graduate group places a strong emphasis on original research, and both the M.S. and Ph.D. programs require a thesis.

Admission to the Graduate Program

1) Master's Degrees

Minimum requirements for admission are a 3.0 overall grade point average and a combined GRE score of 1100. No foreign language is required. Meeting these minimum requirements, however, does not guarantee admission. The program admits qualified students with bachelor's degree in mathematics, physics, chemistry, engineering, economics, the life sciences, or related fields. Minimum academic prerequisites for admission are undergraduate courses in linear algebra, ordinary differential equations and advanced vector calculus. Advanced calculus (introduction to real analysis) and partial differential equations are strongly recommended. Applicants should also display evidence of strong quantitative skills.

2) Ph.D.

The minimum admission requirements for the Ph.D. are the same as for the Master of Science. Applicants for the Ph.D. program may be admitted either into the M.S. program, or, if the applicant shows exceptional promise, directly into the Ph.D. program. Admission decisions are made by the Committee on Admissions and Advising of the Graduate Group.

II. Financial Aid Information

Most graduate students in good standing receive some form of financial aid. Opportunities for financial aid include:

<table>
<thead>
<tr>
<th>Position</th>
<th>Salary</th>
<th>How To Apply</th>
<th>Application Deadline</th>
<th>Awards Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>T.A.</td>
<td>$1,181</td>
<td>Obtain application from Mathematics Department and return to Math. Department</td>
<td>Feb. 1</td>
<td>March 15</td>
</tr>
<tr>
<td>Math. Dept.</td>
<td>for 9 months</td>
<td>(w/transcripts and letters of recommendation)</td>
<td></td>
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<tr>
<td>Readerships</td>
<td>$8.13/hr.</td>
<td>As soon as you arrive in Davis</td>
<td></td>
<td>1st day of class</td>
</tr>
<tr>
<td>Fellowships</td>
<td>Variable</td>
<td>Obtain application and return to Graduate Div.</td>
<td>Jan. 15 (w/transcripts and letters of recommendation)</td>
<td>March 15</td>
</tr>
<tr>
<td>Research</td>
<td>Variable</td>
<td>Through a faculty member with sponsored research</td>
<td></td>
<td>Variable</td>
</tr>
</tbody>
</table>

Variable
III. General Program Requirements

Each graduate student is assigned a graduate adviser to help the student design a program and to guide progress toward a stated goal. New students must consult with their graduate adviser during the week preceding the start of classes to discuss their proposed program, and continuing students must consult with their adviser every quarter. Every program and any changes in the program must have the approval of the adviser. Failure to have such approval may mean that credit toward the degree will not be received for courses taken and normal progress therefore delayed.

Foreign Language Requirements

There is no foreign language requirement for the M.S. degree. For the Ph.D. degree the candidate must translate a passage of mathematical prose from French, German, or Russian into English with the aid of a dictionary. The length of the passage shall be about two pages, and the translation must be accomplished in two hours or less. The passage will be selected, and the translation approved, by a faculty member selected by the Committee on Admissions and Advising.

Seminars and Colloquia

The Graduate Group, in cooperation with the Institute for Theoretical Dynamics, runs a colloquium series that meets on a weekly basis. Students are encouraged to attend all colloquia in the series. Students are required to take the "student seminar" for one unit of credit each quarter.

IV. The Graduate Programs

M.S. in Applied Mathematics

1. Course requirements

The M.S. program contains five specific fields of emphasis: applied algebra and combinatorics; optimization and control; differential equations; probability and statistics; and numerical analysis and computation. Each student is required to complete satisfactorily six units of approved courses in each of two of these fields.

A list of currently approved courses is contained in the Appendix. Students who wish to complete a course not on the current list of approved courses may petition the Committee on Admissions and Advising to have the course included in the list. In addition, each student must complete nine units in a specific area of application (e.g. chemistry, population genetics, etc.) The nine units completed in the application area must be a coherent program related to the student's thesis. Each student must also take the courses Math 119 (or graduate level differential equations), Math 203ABC, and Math 204. Courses that satisfy these requirements cannot be taken on a S/U basis.
2. Unit requirements.

The student must complete a minimum of 36 units, at least 18 of which must be at the graduate level. Students whose cumulative GPA falls below 3.3 may be subject to dismissal (a GPA of 3.3 must also be maintained in Math 203ABC and Math 204). The units must be subdivided as follows:

- Math 119, 203ABC, 204: 15 units
- Six units in each of two fields of emphasis: 12 units
- Field of application: 9 units

Note: There is no exam (written or oral) for the M.S. degree. However, those M.S. students planning to pursue a Ph.D. should take the Ph.D. preliminary exam no later than the winter quarter of their second year.

3. Thesis and/or Dissertation

Each student will complete a master’s thesis on a topic selected by the student under the guidance of his or her thesis adviser. Students are expected to select a thesis adviser during their first year. The adviser also recommends a program of study in the student’s selected area of application.

The master’s thesis will normally consist of the solution of a problem or problems, using modern methods of applied mathematics, from the student’s selected area of specialization.

Ph.D. in Applied Mathematics

1. Course requirements.

Each student must complete a program of advanced study approved by the Committee on Admissions and Advising. This program must include Math 201 (real & complex analysis); one of the following sequences Math 202 (functional analysis), Math 213 (stochastic dynamics & applications), Math 218 (partial differential equations), Math 219 (ordinary differential equations), Math 228 (numerical solution of differential equations), Math 229 (numerical methods in linear algebra), Math 235 (probability theory), or Math 240 (differential geometry), and three quarters in a field of specialization (normally taken outside the Mathematics Department) beyond the field of specialization requirement of the Master’s degree.

2. Unit requirements.

Each student must complete at least six advanced courses with a grade of A or A-. Students whose cumulative GPA falls below 3.3 may be subject to dismissal.
3. **Ph.D. Preliminary Examination.**

The Ph.D. preliminary exam consists of two parts: (1) a written exam covering Math 119, Math 203ABC, and Math 204, and (2) an oral exam.

The oral exam will be on material from Math 119, 203ABC and 204; and in addition, topics from an area in which the student expects to write the M.S. thesis. This exam should be taken no later than the winter quarter of the second year. The results of these exams will go to the Admissions Committee which will decide if the student is allowed to enter the Ph.D. program.

4. **Qualifying Examination.**

Each candidate must pass a two-part qualifying oral examination. The examination will be administered by a committee of five faculty recommended to the Graduate Division by the Committee on Admissions and Advising, in consultation with the student and his or her thesis adviser. The student's thesis adviser may not serve on this committee. The first part of the examination will consist of material from the advanced courses in mathematics and in the student's area of specialization. The second part of the examination will be concerned with the student's proposed doctoral dissertation. Prior to this part of the examination the student must submit to the Committee on Admissions and Advising a written Dissertation Proposal. During the examination the committee members will question the student on this proposal and on related material.

5. **Dissertation.**

The doctoral dissertation is the main part of this program. A topic will be selected by the student under the advice and guidance of his or her thesis committee. Students will be expected to begin some research activity during the first year of their Ph.D. program.

The dissertation presented to the thesis committee must contain an original contribution in applied mathematics. In some cases the dissertation will expand the knowledge of some area of applied mathematics. In other cases methods of applied mathematics may be used to solve some substantial problem in an applied discipline such as engineering, biology, economics, the physical sciences, or the agricultural sciences.

6. **Thesis Defense**

The student must give a one hour seminar, open to the public, on the subject of his or her thesis. After the seminar, the student's thesis committee will meet privately with the student to discuss the contents of the thesis.
v. Progress Toward the Degrees.

While students proceed with varying speeds towards their goal, a schedule for normal progress is given below.

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<thead>
<tr>
<th>POSTGRADUATE YEAR</th>
<th>QUARTER</th>
<th>M.S.</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Complete courses 119, 203A, and one elective. Begin consideration of possible thesis topics.</td>
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<tr>
<td>1</td>
<td>2</td>
<td>Complete course 203B and two electives.</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>Complete course 203C, and two electives. Begin work on M.S. thesis during summer.</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Complete Course 204 and two electives.</td>
</tr>
<tr>
<td>2</td>
<td>2,3</td>
<td>Complete requirements for the M.S. degree.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POSTGRADUATE YEAR</th>
<th>QUARTER</th>
<th>Ph.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>Pass Ph.D. Preliminary Exam</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Complete course requirements for M.S. degree, if necessary.</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Complete coursework for the Ph.D. Pass the qualifying examination. Begin or continue work on Ph.D. thesis.</td>
</tr>
<tr>
<td>4,5</td>
<td></td>
<td>Complete requirements for the Ph.D. degree.</td>
</tr>
</tbody>
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Teaching Assistantships (T.A.):

Teaching Assistantships are 1/2-time positions involving, at most, 20 hours per week. Students may apply for teaching assistantships in the Mathematics Department or in their thesis adviser's department. Duties may include problem-solving sessions and office hours for students' questions, and grading exams. Experienced Teaching Assistants may be assigned to teach a class. Teaching Assistants who have performed satisfactorily and are making normal academic progress towards stated degree objectives have preference for renewal of the position for the next year. The mathematics departmental course load requirement for a Teaching Assistant is at least 2 graduate courses per quarter or 1 graduate and 1 undergraduate course per quarter. The load may vary in other departments.
Readerships in the Mathematics Department

Readers in the Mathematics Department grade homework in undergraduate classes and may hold an appointment as a Reader for a maximum of 19 hours a week. Graduate students are usually given preference for these positions. Assignments are awarded according to experience.

Scholarships and Fellowships:

The Graduate Fellowship Program is administered through the Graduate Division. Specifics of eligibility are enclosed in the Application for Admissions and Fellowship (prospective students) and in the Fellowship Brochure (continuing students). Applications and all supporting documentation must be on file by January 15.

Research Assistantships:

Often a student doing M.S. or Ph.D. research can be supported by his or her adviser, if the research is sponsored through a grant or contract.

Out-of-State-Fee Fellowships:

If you are not a California resident, you may apply for an out-of-state fee fellowship. (Consult the Graduate Announcement for details.) However, if you become eligible but do not apply for California residency, you are not entitled to an out-of-state fee fellowship.

Compliance Statement

In accordance with applicable Federal laws and University policy, the University of California does not discriminate in any of its policies, procedures, or practices on the basis of race, color, national origin, religion, sex, sexual orientation, age or handicap. Inquiries regarding the University's equal opportunity policies may be directed to the Vice Chancellor—Affirmative Action Officer and Title IX Coordinator, 521 Mrak Hall, (916-752-2070). Speech and hearing impaired persons may dial 752-6TTY for assistance.

Department of Mathematics
Graduate Division
July 1988
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The following is a list of faculty members of the Graduate Group, together with a brief statement of their research interests. Students who are interested in a more complete description of a particular faculty member's research interests are encouraged to write directly to the faculty member in care of his or her department.

**DALLAS O. BANKS**, Mathematics. Mathematical modeling of physical and engineering processes, including fine particle collection processes.

**LOUIS W. BOTSFORD**, Wildlife and Fisheries Biology. Stability and control of populations that reflect age, size, or stage structure; population dynamics and management of fisheries and aquatic populations.

**JOHN W. BREWER**, Mechanical Engineering. Analysis and simulation of dynamic systems; the growth of populations in age, space, and time; computer-aided simulation of economic and demographic systems; the bond graph method; automatic control.

**MICHAEL BUONOCORE**, Radiology (UCD Medical Center). Medical imaging, specifically research in image reconstruction algorithms, numerical simulation of x-ray, ultrasonic, and nuclear magnetic resonance processes, numerical simulation of blood flow, NMR and ultrasound inverse scattering theory.

**TIM E. CARPENTER**, Epidemiology and Preventive Medicine. Epidemiologic and economic impact of diseases in livestock, including optimization and simulation modeling; microeconomic decision analysis and project evaluations.

**TSU-SHIAN CHANG**, Electrical and Computer Engineering. Dynamic optimization problems and applications, flow control and routing in computer network, path planning and obstacle avoidance, and robotics.


**RICHARD GROTHAAN**, Land, Air and Water Resources. Numerical modeling of geophysical flows, especially atmospheric circulation modeling; linear instability analysis and nonlinear evolution of flows; applications of new numerical techniques to geophysical problems; advanced graphical display of data including computer animation; evaluation of finite difference scheme errors.
MOHAMED HAFEZ, Mechanical Engineering. Transonic acrodynamics, computational fluid dynamics; numerical solutions of partial differential equations.

ALAN H. HASTINGS, Mathematics and Division of Environmental Studies. Theoretical population biology including mathematical ecology and mathematical genetics; qualitative theory of differential equations, differential-delay equations, bifurcation theory.

LEONARD HERMANN, Civil Engineering. Theory and application of finite element methods, modeling of structural composites and properties of engineering material.

BRIAN G. HIGGINS, Chemical Engineering. Theoretical fluid mechanics, hydrodynamic stability theory, and computational fluid mechanics.

FREDERICK A. HOBBS, Mathematics. Singularly perturbed differential equations, mathematical fluid dynamics, quantum field theory.

RICHARD HODGE, Agricultural Economics. Optimization and control of economic systems; estimation theory; bioeconomics.

T. C. HSIA, Electrical Engineering & Computer Science. Least squares parameter estimation, system identification and control, adaptive systems theory, signal processing, and robotics.

MONT HUBBARD, Mechanical Engineering. Applications of system theory, control, parameter identification and estimation to dynamical systems including internal combustion engines, vehicle suspensions, vibration control, biomechanics, flywheel energy storage, passive solar heating systems.

ANIL K. JAIN, Electrical and Computer Engineering. Image processing techniques, including fast algorithms for image analysis and stochastic models for images.

DAVID K. KATZ, Obstetrics and Gynecology. Sperm transport to the egg and fertilization; biofluid dynamics; fertility, infertility, and contraception.

JOEL KEIZER, Institute of Theoretical Dynamics. Nonequilibrium thermodynamics; molecular fluctuations in chemistry, physics, and biophysics; electrochemical oscillations; nonequilibrium statistical mechanics; theory of diffusion controlled chemical reactions.

ARTHUR J. KRISER, Mathematics. Systems and control theory; applied geometry; stochastics, particularly stochastic differential equations of the second order.

BRUCE LABROCK, Civil Engineering. Finite element method applied to fluid mechanics problems, including turbulence modeling, stratified flow, mass transport, and free surface flows.

CHUNG KI NG LAU, Mechanical Engineering. Combustion theory.


HEINER LIEHN, Department of Environmental Horticulture. Mathematical models of crops at the plant and crop level. Ecological modeling, biometrics, crop ecology, application of modeling techniques to horticulture.

PETER LINZ, Computer Science. Numerical analysis, including integral equations and ill-posed problems; programming languages, including vector-programming languages and their use in computational mathematics, and functional languages.

MARC MANGEL, Mathematics, Agricultural Economics and Entomology. Operations research with applications in resource management; search theory; stochastic differential equations.

MIGUEL A. MARINO, Land, Air, and Water Resources and Civil Engineering. Subsurface hydrology and pollution; optimization and simulation of water resource systems; irrigation planning, design, and operation models; hydrologic forecasting.

NORMAN MATLOFF, Statistics and Electrical and Computer Engineering. Regression analysis, stochastic processes, probabilistic modeling of computer systems, computer simulation.

DONALD McCUTCHEON, Chemistry. Application of statistical mechanics and stochastic processes to chemical and biophysical systems.

KIM MISH, Civil Engineering. Theory and application of finite elements models in applied mechanics.

RICHARD E. PLANT, Mathematics and Entomology. Applications of operations research in agricultural and resource management; mathematical population biology.

ROBERT POWELL, Chemical Engineering. Continuum mechanics, rheology, mechanics of viscoelastic fluids and solids.

CARLOS E. PUENTE, Land Air and Water Resources. General surface hydrology; rainfall-runoff modeling; forecasting of river flows; quantification of spatial variation; sampling of hydrologic processes; applications of stochastic processes, operations research and nonlinear science techniques to hydrologic problems.
DAVID M. ROBINS, Graduate School of Administration. Statistics, including time series analysis and forecasts, design and analysis of experiments, robust statistical methods.

JOHN E. ROEMER, Economics. Economic theory, Marxian economics.

ROBERT SHINNAY, Statistics. Pattern recognition problems; signal detection and estimation for time series with stationary errors.

WENDY K. SILK, Land, Air and Water Resources. Plant growth and development; mathematical models for morphogenesis.


CRAIG A. TRACY, Mathematics. Statistical mechanics; the theory of exactly solvable models, completely integrable systems.

MICHAEL TURELLI, Genetics. Deterministic and stochastic models in population genetics, quantitative genetics, and ecology.

ROGER J-B. WEETS, Mathematics. Deterministic and stochastic optimization, numerical procedures, modeling and theory; approximation schemes for variational problems.

STEPHEN WHITAKER, Chemical Engineering. Theoretical fluid dynamics, multiphase systems, applications of perturbation methods in fluid mechanics.

WILLIAM A. WILLIAMS, Agronomy and Range Science. Dynamic simulation of range and crop plant behavior; multivariate analysis in agricultural research; linear programming applications.
APPENDIX

Approved courses for the Master of Science program.

ALGEBRA AND APPLIED COMBINATORICS

APPLIED SCIENCE

111 Introduction to Foundations of Computing
211 Automata Theory and Formal Language

ELECTRICAL AND COMPUTER ENGINEERING

120 Automata Theory and Formal Languages
122 Algorithm Design and Analysis
171 Introduction to Computer Architecture
176 Digital Systems
221 Formal Language Theory
222A Design and Analysis of Algorithms
222B Advanced Design and Analysis of Algorithms
266 Information Theory and Coding

MATHEMATICS

139A,B Introduction to Algebra
151A,B,C Algebra
167 Linear Algebra and Applications

MECHANICAL ENGINEERING

224 Kinematic Design of Mechanisms

PHYSICS

223 Group-Theoretical Methods of Physics
DIFFERENTIAL EQUATIONS

ATMOSPHERIC SCIENCE
121A,B  Atmospheric Dynamics
158     Boundary Layer Meteorology
200     Atmospheric Processes
221     Advanced Atmospheric Dynamics
223     Advanced Boundary Layer Meteorology

APPLIED SCIENCE
205A,B,C Mathematical Methods
234A,B,C Electromagnetic Theory
255     Classical Mechanics
256     Continuum Mechanics
257     Magnetohydrodynamics
280A,B  Plasma Physics and Controlled Fusion
285A,B,C Advanced Plasma Dynamics

CHEMICAL ENGINEERING
150A,B  Chemical Engineering Fluid Mechanics
153     Chemical Engineering Heat Transfer
154A     Mass Transfer
159     Chemical Engineering Analysis
253A     Advanced Fluid Mechanics
253B     Advanced Heat Transfer
253C     Advanced Mass Transfer
259     Advanced Chemical Engineering Analysis
262     Transport Phenomena in Multiphase Systems

CHEMISTRY
210B     Advanced Physical Chemistry: Quantum Chemistry

CIVIL ENGINEERING
201     Introduction to Theory of Elasticity
203     Inelastic Behavior of Solids: Plasticity
204     Viscous Behavior of Solids
205     Continuum Mechanics
277     Unsteady Flow in Open Channels
278     Hydrodynamics
279     Advanced Mechanics of Fluids
ECOLOGY

232  Theoretical Ecology

ELECTRICAL AND COMPUTER ENGINEERING

130A,B  Introductory Electromagnetics
131A,B,C  Electromagnetic Fields and Waves
230  Electromagnetic Waves
231  Electromagnetic Theory

GENETICS

205  Theoretical Population Genetics

MATHEMATICS

118A,B  Partial Differential Equations
119  Theory of Ordinary Differential Equations
218A,B  Partial Differential Equations
219A,B  Ordinary Differential Equations
221A,B  Mathematical Fluid Dynamics
240A,B,C  Differential Geometry

MECHANICAL ENGINEERING

210A  Fundamentals of Fluid Mechanics and Heat Transfer
210B  Advanced Fluid Mechanics and Heat Transfer
215  Gas Dynamics
222  Advanced Dynamics

PHYSICS

105A,B  Analytical Mechanics
105C  Continuum Mechanics
110A,B,C  Electricity and Magnetism
115A,B  Introduction to Quantum Mechanics
200A-D  Theory of Mechanics and Electromagnetics
215A,B,C  Quantum Mechanics

WILDLIFE AND FISHERIES BIOLOGY

222  Advanced Population Dynamics
OPTIMIZATION AND CONTROL

AGRICULTURAL ECONOMICS

100A,B Intermediate Microeconomics
253 Optimization Techniques with Economic Applications
254 Dynamic Optimization Techniques for Economic Systems with Applications

ADMINISTRATION

283 Optimization Theory and Applications

CHEMICAL ENGINEERING

157 Process Dynamics and Control

CIVIL ENGINEERING

146 Water Resources Simulation
153 Analytical Methods in Planning
273 Water Resource Systems Engineering

ECONOMICS

200M Optimization in Economics

ELECTRICAL AND COMPUTER ENGINEERING

151 Discrete Time Systems
157A,B Control Systems
251 Nonlinear Control Systems
253 Adaptive Systems
254 Digital and Sampled-Data Control Systems
258 Optimization Techniques with Applications
259 Optimization of Dynamic Systems

MATHEMATICS

168 Mathematical Programming
270 Foundations of Optimization
271 Dynamical Optimization
272 Numerical Optimization
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>171</td>
<td>Analysis, Simulation, and Design of Dynamic Systems</td>
</tr>
<tr>
<td>172</td>
<td>Automatic Control of Engineering Systems</td>
</tr>
<tr>
<td>271</td>
<td>Design of Multivariable Control Systems</td>
</tr>
<tr>
<td>272A</td>
<td>Mathematical Foundations of System and Control Theory</td>
</tr>
<tr>
<td>272B</td>
<td>Multivariable Feedback Control and Estimation Theory</td>
</tr>
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<td></td>
<td><strong>WATER SCIENCE</strong></td>
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<tr>
<td>154</td>
<td>Water and Related Resource Allocation From Economic Principles</td>
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<tr>
<td>206</td>
<td>Water Resource Systems Analysis</td>
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<tr>
<td>Administration</td>
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<tr>
<td>241</td>
<td>Managerial Decision Making</td>
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<td>284</td>
<td>Applied Linear Models for Management</td>
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<td>285</td>
<td>Time Series Analysis and Forecasting</td>
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<tr>
<td>[ \text{AGRICULTURAL ECONOMICS} ]</td>
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<td>106</td>
<td>Quantitative Methods in Agricultural Economics</td>
</tr>
<tr>
<td>240A</td>
<td>Econometric Methods</td>
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<tr>
<td>240B</td>
<td>Advanced Econometrics: Theory</td>
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<tr>
<td>[ \text{ANIMAL GENETICS} ]</td>
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<tr>
<td>208</td>
<td>Estimation of Genetic Parameters</td>
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<tr>
<td>[ \text{ATMOSPHERIC SCIENCE} ]</td>
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<tr>
<td>230</td>
<td>Atmospheric Turbulence</td>
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<td>[ \text{CHEMISTRY} ]</td>
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<tr>
<td>110A</td>
<td>Physical Chemistry: Thermodynamics</td>
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<td>110B</td>
<td>Physical Chemistry: Quantum Mechanics</td>
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<td>110C</td>
<td>Physical Chemistry: Kinetics</td>
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<tr>
<td>210A</td>
<td>Advanced Physical Chemistry: Thermodynamics</td>
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<td>[ \text{ELECTRICAL AND COMPUTER ENGINEERING} ]</td>
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<td>160</td>
<td>Fourier Analysis and Modulation</td>
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<td>165</td>
<td>Data Communication</td>
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<td>207</td>
<td>Pattern Recognition and Classification</td>
</tr>
<tr>
<td>262</td>
<td>Spectrum Analysis</td>
</tr>
<tr>
<td>263</td>
<td>Random Signals and Noise</td>
</tr>
<tr>
<td>264</td>
<td>Estimation of Detection of Signals in Noise</td>
</tr>
<tr>
<td>266</td>
<td>Information Theory and Coding</td>
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<tr>
<td>[ \text{MATHEMATICS} ]</td>
<td></td>
</tr>
<tr>
<td>131</td>
<td>Methods Of Mathematical Probability</td>
</tr>
<tr>
<td>132A,E</td>
<td>Introduction to Stochastic Processes</td>
</tr>
<tr>
<td>213A,B,C</td>
<td>Stochastic Differential Equations and Applications</td>
</tr>
<tr>
<td>235A,B,C</td>
<td>Probability Theory</td>
</tr>
</tbody>
</table>
MECHANICAL ENGINEERING

151 Statistical Methods in Design
176 Measurement Systems
213 Advanced Turbulence Modelling
276A,B Digital Data Acquisition and Analysis

PHYSICS

112A,B Thermodynamics and Statistical Physics
219A,B Statistical Mechanics

PSYCHOLOGY

205 Advanced Statistical Inference from Psychological Experiments
206 Statistical Analysis of Psychological Experiments
207 Multivariate Analysis of Psychological Data

STATISTICS

Almost all undergraduate level courses are appropriate.
Selections should be discussed with the Graduate Adviser.
All graduate level courses are appropriate.
NUMERICAL ANALYSIS & COMPUTATION

ADMINISTRATION

281 Systems Analysis and Design
282 Discrete System Simulation

AGRICULTURAL ECONOMICS

255 Systems Analysis and Simulation

APPLIED SCIENCE

115 Introduction to Numerical Methods for Engineers and Scientists
209 Numerical Solution of Partial Differential Equations
210A,B Advanced Methods of Computational Physics
215A,B Computational Mathematics

CIVIL ENGINEERING

131B Matrix Structural Analysis and Introduction to Finite Elements
212A Finite Element Procedures in Applied Mechanics

ELECTRICAL AND COMPUTER ENGINEERING

151 Discrete Time Systems
206 Digital Image Processing
220 Theory of Computation
222A Design and Analysis of Algorithms
222B Advanced Design and Analysis of Algorithms

MATHEMATICS

128A Numerical Analysis
128B Numerical Analysis in Solution of Equations
128C Numerical Analysis in Differential Equations
140 Simulation and Modelling
228A,B,C Numerical Solution of Differential Equations
229A,B Numerical Methods in Linear Algebra
230 Numerical Methods for Nonlinear Equations and Optimization
272 Numerical Optimization
### MECHANICAL ENGINEERING

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>214</td>
<td>Advanced Numerical Fluid Mechanics</td>
</tr>
<tr>
<td>273</td>
<td>Computer Aided Design of Estimation and Control System</td>
</tr>
<tr>
<td>274</td>
<td>Analysis and Design of Digital Control Systems</td>
</tr>
<tr>
<td>277</td>
<td>Computer-Aided Design of Nonlinear Dynamic Systems</td>
</tr>
</tbody>
</table>

### RANGE SCIENCE

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>208</td>
<td>Computer Modeling in Range and Crop Management</td>
</tr>
</tbody>
</table>

### STATISTICS

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>141</td>
<td>Statistical Computing</td>
</tr>
</tbody>
</table>
Various application courses for purpose of cultural enrichment (may be used in one of the five categories with approval of the Graduate Adviser).

**ADMINISTRATION**

243 Risk Management  
252 Production and Operations Management

**AGRICULTURAL ECONOMICS**

147 Natural Resource Economics  
157 Analysis for Production Management  
240C Advanced Econometrics: Applications  
283 Analysis of Research in Natural Resource Economics

**AGRICULTURAL ECONOMICS/ECONOMICS**

200A,B,C Microeconomic Theory

**AGRONOMY**

230 Advanced Population Biology

**ANIMAL GENETICS**

204 Theory of Quantitative Genetics  
207 Quantitative Genetics and Animal Breeding Theory

**APPLIED BEHAVIORAL SCIENCES**

202 Systems Approach for Organizational Change  
203 Evaluation and Decision Making

**APPLIED SCIENCE**

165A,B Quantum Optics  
230A,B,C Structure of Matter  
233A,B,C Theory and Applications of Solid State Physics  
234A,B,C Electromagnetic Theory  
265A,B,C Laser Physics
### Atmospheric Sciences

- 120   Atmospheric Thermodynamics
- 150   Numerical Weather Prediction
- 241   Climate Dynamics

### Biochemistry/Biophysics

- 133   Behavior and Analysis of Enzyme Systems
- 215   Kinetics of Biological Systems

### Chemistry

- 108   Physical Chemistry of Macromolecules
- 121   Introduction to Molecular Structure and Spectra

### Civil Engineering

- 131A  Structural Analysis
- 141   Engineering Hydraulics
- 143   Water Resources Engineering and Management
- 144   Groundwater Systems Design
- 145   Hydraulic Systems Design
- 161   Transportation Systems Engineering
- 171   Soil Mechanics
- 202   Buckling of Columns and Plates
- 211   Advanced Matrix Structural Analysis
- 212B  Finite Elements: Application to Linear and Nonlinear Structural Mechanics Problems
- 212C  Finite Elements: Application to Fluid Problems
- 213   Analysis of Structures Subjected to Dynamic Loads
- 221   Theory of Plates
- 222   Theory and Analysis of Shells
- 251   Transportation Systems Planning
- 273   Water Resources Systems Engineering
- 275   Stochastic Hydrology
- 276   Hydrologic Systems Analysis
- 284   Theoretical Soil Mechanics

### Economics

- 102H  Intermediate Micro Theory
- 101   Intermediate Macro Theory
- 160A  International Microeconomics
- 160B  International Macroeconomics
- 200A, B, C  Microeconomic Theory
- 200D, E  Macroeconomic Theory
- 222A, B  Advanced Economic Theory
ELECTRICAL AND COMPUTER ENGINEERING

112  Linear Systems and Circuits
132A,B  High Frequency Systems, Circuits and Devices
134  Radar Systems and Signals
140  Fundamental Principles of Device Physics
145A,B,C  Solid State Electronics
148  Superconductivity
171  Introduction to Computer Architecture
176  Digital Systems, I
177  Digital System, II
182A,B  Operating System Design
204  Digital Processing of Signals
221  Passive Filter Design
222  Active Filter Design
226A,B  Quantum Electronics
245A,B,C  Applied Solid State Physics
266  Information Theory and Coding

GENETICS

205  Theoretical Population Genetics

HORTICULTURE

251  Modeling Horticultural Systems

MECHANICAL ENGINEERING

129  Aircraft Stability and Control
134  Vehicle Stability
165  Fundamentals of Heat Transfer
216  Advanced Thermodynamics
217A,B  Principles of Combustion
220A,B  Mechanical Vibrations
270  Modelling and Simulation of Engineering Systems
275  Advanced Topics in Aircraft Stability

MATERIALS SCIENCE

240  Transport Phenomena in Materials Processes
247  Advanced Thermodynamics of Solids
PHYSICS

108 Optics
121 Foundations of Atomic and Molecular Physics
127 Introduction to Astrophysics
129A Introduction to Nuclear and Particle Physics
129B Nuclear Physics
129C Elementary Particle Physics
153 Introduction to Heat Transfer
230A,B Quantum Theory of Fields
239A,B Quantum Mechanics of Many Body Systems

REACTOR DESIGN AND CONTROL (Electrical and Computer Engineering)

Che 156A,B Chemical Engineering Kinetics
Che 157 Process Dynamics and Control
Che 256 Applied Kinetics and Reactor Design
EE 157A,B Control Systems
EE 251 Nonlinear Control Systems
EE 254 Digital and Sampled-Data Control Systems

SOIL SCIENCE

107 Soil Physics
207 Transport Processes in Soils

TRANSPORT PHENOMENA (Mechanical and Chemical Engineering)

Che 150A Chemical Engineering Fluid Mechanics
Che 153 Chemical Engineering Heat Transfer
Che 154A Mass Transfer
Che 159 Chemical Engineering Analysis
Che 253A Advanced Fluid Mechanics
Che 253B Advanced Heat Transport
Che 253C Advanced Mass Transport
Che 259 Advanced Chemical Engineering Analysis
Che 262 Transport Phenomena in Multiphase Systems
Che 264 Introduction to Hydrodynamic Stability
Me 210A Fundamentals of Fluid Mechanics and Heat Transfer
Me 210B Advanced Fluid Mechanics and Heat Transfer
Me 214 Advanced Numerical Fluid Mechanics

WATER SCIENCE

149 Groundwater Hydrology
217 Hydrochemical Models
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<td>Evolution of Ecological Systems</td>
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<tr>
<td>155</td>
<td>Behavior of Animals</td>
</tr>
<tr>
<td>202</td>
<td>Biomathematics</td>
</tr>
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