## REQUEST FOR CHANGE IN MASTERS DEGREE PROGRAM

### 1. GENERAL INFORMATION

| | | | |
|---|---|---|---|
| College: | Education | Department: | Curriculum & Instruction |
| Current Major Name: | Secondary Education - Science and/or Math | *Proposed Major Name:* | *STEM Education* |
| Current Degree Title: | Master of Science in Education | *Proposed Degree Title:* | *Master of Science in Education* |
| Formal Option(s): | | *Proposed Formal Option(s):* | |
| Specialty Fields w/in Formal Option: | | *Proposed Specialty Fields w/in Formal Options:* | |
| Date of Contact with Associate Provost for Academic Administration[1]: | | | |
| Bulletin (yr & pgs): | | CIP Code[1]: 13.1399 | Today's Date: 11.06.09 |
| Accrediting Agency (if applicable): | National Council for Accreditation of Teacher Education and Kentucky Education Professional Standards Board | | |
| Requested Effective Date: | ☒ Semester following approval. | OR | ☐ Specific Date[2]: |
| Dept. Contact Person: | Margaret Schroeder | Phone: 257.3073 | Email: m.mohr@uky.edu |

### 2. CHANGE(S) IN PROGRAM REQUIREMENTS

| | | Current | *Proposed* |
|---|---|---|---|
| 1. | Number of transfer credits allowed<br>(Maximum is Graduate School limit of 9 hours or 25% of course work) | 9 | *9* |
| 2. | Residence requirement (if applicable) | | |
| 3. | Language(s) and/or skill(s) required | N/A | *N/A* |
| 4. | Termination criteria | | |
| 5. | Plan A Degree Plan requirements[3] (thesis) | | |
| 6. | Plan B Degree Plan requirements[3] (non-thesis) | Kentucky Teacher Standards Portfolio | *Kentucky Teacher Standards Portfolio* |
| 7. | Distribution of course levels required<br>(At least one-half must be at 600+ level & two-thirds must be in organized courses.) | one-half 600+ level and two-thirds in organized courses | *one-half 600+ level and two-thirds in organized courses* |
| 8. | Required courses (if applicable) | EDC 714; EDC 607 or 732; EDC 730 or 777; EDC XXX | *6 hours of EDC 732, 733, or* EDP 522, 9 hours of EDC 603, 604 (or EPE 651), *607, 613, 701, 704, 706, 708, or 770; 12* |

[1] Prior to filling out this form, you MUST contact the Associate Provost for Academic Administration (APAA). If you do not know the CIP code, the APAA can provide you with that during the contact.

[2] Program changes are typically made effective for the semester following approval. No changes will be made effective until all approvals are received.

[3] If there is only one plan for the degree, plans involving a thesis (or the equivalent in studio work, etc.) should be discussed under Plan A and those not involving a thesis should be discussed under Plan B.

| | | | |
|---|---|---|---|
| | | | *hours of STEM content courses; 3 hours of ELS courses (Please see attached curriculum contract)* |
| 9. | Required distribution of courses within program (if applicable) | 12 hours in EDC; 6 hours in College of Education; 12 hours in content specialization area | *6 hours in EDC Departmental Core; 9 hours in EDC Stem Education; 12 hours in STEM content area; 3 hours in ELS* |
| 10. | Final examination requirements | Department Master's Examination | *STEM Education Master's Examination* |

| | |
|---|---|
| 11. | Explain whether the proposed changes to the program (as described in sections 1 to 10) involve courses offered by another department/program. Routing Signature Log must include approval by faculty of additional department(s). |
| | The proposed changes to this Master's degree program does not change the requirements for content courses outside of the College of Education. Students are still required to take 12 hours of content courses outside of the College of Education (Please see attached list for suggestions). The proposed changes to this Master's degree program does require courses to be taken from the Department of Educational Leadership. Permission has been obtained to require a selection of their course offerings. |
| 12. | List any other requirements not covered above? |
| | N/A |
| 13. | Please explain the rationale for changes. If the rationale involves accreditation requirements, please include specific references to those requirements. |
| | 16 KAR 5:010 Section 12 specifies that all Advanced Master's Degree Programs must be redesigned and approved prior to December 31, 2010 using the Proposed Kentucky Teacher Leader Standards. The current Master of Science in Education - Secondary Education (Science and/or Math) program currently does not meet the needs of its students nor does it prepare our teachers to be teacher leaders and be prepared for the 21st century. The program changes proposed will allow for students of this program to practice 21st century skills and concepts that can then be integrated into their classrooms. It will also give them the background skills and knowledge needed to become a STEM Education teacher leader in their schools, districts, and the Commonwealth.<br><br>The current title and course requirements for the degree separate out science and mathematics. The proposed degree title and course requirements reflect a move towards preparing our teachers to integrate STEM (Science, Technology, Engineering, and Mathematics) effectively into their classrooms. The goal is to increase STEM learning in the teachers and subsequently the students. Please see the attached Executive Summary of the Program. |

**REQUEST FOR CHANGE IN MASTERS DEGREE PROGRAM**

Signature Routing Log

**General Information:**

Proposal Name: Master of Science in STEM Eduction

Proposal Contact Person Name: Margaret Schroeder Phone: 257.3073 Email: m.mohr@uky.edu

INSTRUCTIONS:

Identify the groups or individuals reviewing the proposal; note the date of approval; offer a contact person for each entry; and obtain signature of person authorized to report approval.

**Internal College Approvals and Course Cross-listing Approvals:**

| Reviewing Group | Date Approved | Contact Person (name/phone/email) | Signature |
|---|---|---|---|
| Curriculum & Instruction | 1/20/10 | Mary Shake / 257.5676 / mcshak1@email.uky.edu | Mary C. Shake |
| Educational Leadership | 1/21/10 | Lars Bjork / 257.2450 / lbjor1@uky.edu | |
| Courses & Curricula | 1/26/10 | Jeff Reese 257-4909 jeff.reese@uky.edu | |
| College of Education | 2/9/10 | Robert Shapiro 257-9795 rshap01@uky.edu | |
| | | / / | |

**External-to-College Approvals:**

| Council | Date Approved | Signature | Approval of Revision[4] |
|---|---|---|---|
| Undergraduate Council | | | |
| Graduate Council | | Jeannine Blackwell 2010.04.05 08:56:43 -04'00' | |
| Health Care Colleges Council | | | |
| Senate Council Approval | | University Senate Approval | |

Comments:

[4] Councils use this space to indicate approval of revisions made subsequent to that council's approval, if deemed necessary by the revising council.

UNIVERSITY OF KENTUCKY® see blue.

# Department of Curriculum and Instruction
# Curriculum Contract – Master's Verification
# Master's Degree with Rank II Certification – STEM Education

*STEM PLUS+ – Producing +eacher Leaders for rUral Schools*

Please TYPE

| | | | | | |
|---|---|---|---|---|---|
| **Name** | | | | | |
| **Email** | | | | | |
| **Address** | | | | | |
| | **Street** | | **City** | **State** | **Zip** |
| **Phone** | | | | | |
| | **Home** | **Work** | **Cell/Other** | **Semester of Admission to Master's Program** | |

**Professional Goals:** Briefly describe the professional growth goals you hope to meet in pursuing the Rank II Certification and STEM Education Master's Degree. Please attach a copy of your Professional Growth Plan.

**Program Goals:** In helping you develop your own professional goals, the STEM PLUS+ Master's degree program will also focus on helping you:

1. Connect theory and practice through reflection, teaching, scholarship, and STEM educational research.
2. Design authentic, project-based learning experiences that consider students of diverse backgrounds and perspectives.
3. Explore uses of appropriate assessments and technological tools to enhance STEM teaching and learning.
4. Develop communication skills through multiple forms of discourse and written, oral, and on-line narratives.

**Required Departmental Core:** Choose 2 of the following (6 hours)

| Course | Title | Term | Grade | Credits |
|---|---|---|---|---|
| EDC 732 | Curriculum Design for Learning and Leading | | | 3 |
| EDC 733 | Leadership in Curriculum & Instruction: Strategies for Analytic Practice | | | 3 |
| EDP 522 | Educational Tests and Measurements | | | 3 |

**Required STEM Education Core:** Choose 3 of the following (9 hours)

| Course | Title | Term | Grade | Credits |
|---|---|---|---|---|
| EDC 603 | Curriculum and Instruction in STEM Education | | | 3 |
| EDC 604<br>EPE 651 | History of STEM Education *or*<br>History of Education in the United States (special section) | | | 3 |
| EDC 607 | Instructional Design I | | | 3 |
| EDC 613 | Effective Use of Technology for Modeling-Based Inquiry in STEM Education | | | 3 |
| EDC 670 | Advanced Elementary Mathematics Methods | | | 3 |
| EDC 701 | History of Mathematics Education | | | 3 |
| EDC 704 | Designing Project-Enhanced Environments in STEM Education | | | 3 |
| EDC 706 | Research in STEM Education | | | 3 |
| EDC 708 | Engineering in STEM Education | | | 3 |
| EDC 770 | Special Topics in STEM Education: | | | 3 |

**Specialization STEM Coursework:** Choose 12 hours in STEM content area(s) outside the College of Education. See attached list for course suggestions. *(Recommended: 6 hours in your area of expertise and 6 hours outside of your area of expertise).* (12 hours)

| Course | Title | Term | Grade | Credits |
|---|---|---|---|---|
| | | | | 3 |
| | | | | 3 |
| | | | | 3 |
| | | | | 3 |
| | | | | 3 |
| | | | | 3 |

**Elective Leadership Coursework:** Choose 1 - 3 of the following (3 hours)

| Course | Title | Term | Grade | Credits |
|---|---|---|---|---|
| EDC 548 | Instructional Technology Leadership | | | 3 |
| ELS 600 | Leadership for Learning-Centered Schools | Fall | | 3 |
| ELS 601 | Building a Professional Learning Community | Fall | | 1 |
| ELS 602 | Leadership Roles in Professional Learning Communities | Fall | | 1 |
| ELS 603 | Leadership for Student Learning | Fall | | 1 |
| ELS 604 | Leadership in Professional Learning Communities | Fall | | 3 |
| ELS 605 | Legal Rights and Responsibilities of Students | Spring | | 1 |
| ELS 606 | Legal Rights and Responsibilities for Teachers | Spring | | 1 |
| ELS 607 | Teacher Responsibilities in School-Based Decision Making | Spring | | 1 |
| ELS 608 | School Law and Governance for Teachers | Spring | | 3 |
| ELS 609 | Technology Leadership | Summer | | 1 |
| ELS 610 | Distributed Leadership in Schools | Summer | | 1 |
| ELS 611 | Current Issues for Education Leaders | Summer | | 1 |
| ELS 612 | Leadership for Technology and Innovation | Summer | | 3 |
| ELS 613 | Leadership in the Public Context of Education | Spring | | 1 |
| ELS 614 | Partnerships for Closing Achievement Gaps | Spring | | 1 |
| ELS 615 | Leadership for Response to Intervention in Inclusive Classrooms | Spring | | 1 |
| ELS 616 | Leadership for School as Inclusive Community | Spring | | 3 |
| ELS 617 | Teacher Leadership for Instructional Teams | Fall | | 1 |
| ELS 618 | Introduction to Leading Action Research for School Renewal | Fall | | 1 |
| ELS 619 | Evidence-Based Decision Making | Fall | | 1 |
| | **Total Credit Hours** | | | |

*Minimum 30 credit hours required for graduation and Rank II certification*

**Continuous Assessment**

| Checkpoint | Date |
|---|---|
| **Satisfactory Entry Review** | |
| **Satisfactory Mid-point Review** | |
| **Satisfactory Exit Portfolio/Review** | |

**Master's Committee:**

| Member | Department |
|---|---|
| **, Chair** | |
| | |
| | |

Student Signature Date

Advisory Signature Date

# General Program Information

## Grade Point Equivalent Requirements

You must maintain a minimum GPA of 3.0 in all graduate coursework to be retained in the program.

## Assessment Requirements

### Program Admission

Admission criteria for entry into a master's degree program leading to Rank II certification include presentation of the following:

*Required*

- Evidence of initial certification (Rank III)
- A Professional Growth Plan
- Satisfactory GRE Scores (minimum 800 combined; 4.0 analytical)
- 2.75 or above in undergraduate GPA
- Three letters of recommendation

*Recommended*

- Undergraduate portfolio (if available)

### Program Retention

Assessment for program retention occurs at several points in a student's program:

- **Individual courses** Instructors of graduate courses are responsible for assessing student progress toward meeting standards specific to that course.
- **Mid-program review** Upon completion of between 15 and 20 credit hours of course work, apply to your advisor for a mid-program portfolio review. You and your advisor will review your graduate GPA, Professional Growth Plan (PGP), curriculum contract, and Teacher Portfolio for evidence of content knowledge, reflection, and self-assessment. You will receive specific feedback along with advice on changes to the PGP and Portfolio. You may be advised
    - You are making good progress towards program and individual goals
    - You need to make specific changes in your program in order to better meet program and individual goals, or
    - You are making too little progress to continue in the program

  Either advisor or student *may* ask for further feedback from other graduate faculty if this midpoint review indicates the need for substantial change in a student's program. However, an advisor *must* call for a full committee (3 members of graduate faculty) review before a student can be counseled out of the program.

### Program Exit

Consult your advisor to select a suitable *committee, date, time* and *room* for your final review. Apply to the Director of Graduate Studies for a **final portfolio review** (examination) at the beginning of your last semester in the program. You will submit the following:

1. Graduate School Application for Degree (done via myUK)
2. Master's Verification Form (this form filled out and turned in with a copy of your unofficial transcript)

These forms will prompt the Office of Graduate Studies to submit the final examination form to the UK Graduate School:

3. Final Examination Recommendation

   The Graduate School requires that the examination be scheduled **no later than two weeks** prior to the portfolio presentation. It will be helpful to the Director of Graduate Studies in Curriculum and Instruction if you will submit your paperwork even earlier.

   The portfolio review (examination) cannot be scheduled if a student has any of the following stops:

   *Missing or incomplete grades from a previous semester*

   *Transfer of graduate credit from another institution or from post-baccalaureate work at UK has not been applied to the student's degree program.*

After a review committee reads your portfolio, you will have an opportunity to discuss your work with the committee. This presentation should emphasize the ways in which the portfolio demonstrates the application of knowledge, skills, and dispositions consistent with program and individual goals.

## Applying for Rank II Certification

Upon successful completion of your portfolio defense, take a copy of your Master's Verification From along with $50 processing fee (money order or certified check) to the Office of Teacher Certification in room 166 Taylor Education Building.

# STEM Content Courses – Possible Electives

*Required: 12 hours of content hours outside of the College of Education. Suggested: 6 hours inside content area and 6 hours outside of content area; total 12 hours.*

*For those interested in teaching at the community college level, you need no less than 18 hours in your content area in order to be eligible to teach.*

*To be certified to teach a Project Lead the Way course, you need to take ****

*This list is not exhaustive. Please refer to the current bulletin and course catalog for specific course information and offerings.*

### BCH 401G Fundamentals of Biochemistry – 3 hours

Descriptive chemistry of amino acids and proteins, carbohydrates, lipids, and nucleic acids. Discussion of structure and function; metabolism and bioenergetics; and biological information flow. At the undergraduate level, understanding is demonstrated through hour examinations; at the graduate level, understanding is demonstrated through hour examinations and a brief paper. Lecture, three hours; one optional conference. Prereq: CHE 107, CHE 236 and BIO 152 or equivalent.

### BCH 601 Special Topics in Molecular and Cellular Genetics – 1 hour

Each semester five distinguished scientists visit the UK campus to deliver a series of three formal lectures each and participate in numerous informal contacts with graduate students. The emphasis is on the presentation of the most current advances (often unpublished) in selected topics in molecular and cellular genetics. May be repeated to a maximum of six credits. (Same as BIO/MI/PLS/PPA 601).

### BCH 607 Biomolecules and Metabolism – 3 hours

An introductory graduate-level biochemistry course designed to provide a basic knowledge of molecular and biochemical principles necessary for advanced graduate study. Protein structure and function, enzyme catalysis, the generation and storage of metabolic energy, amino acid, nucleotide, and lipid metabolism and biological membranes and transport will be covered. Prereq: CHE 105, 107, 230 and 232; BIO 150 and 152; or equivalents.

### BCH 608 Biomolecules and Molecular Biology – 3 hours

An introductory graduate-level biochemistry course focused on the cellular mechanisms that underlie the regulated expression of genes, including transcription and translation, as well as basic mechanism of DNA replication/repair and recombination. Genetic engineering and other experimental approaches critical to molecular biology research will be reviewed. Prereq: CHE 105, 107, 230 and 232; BIO 150 and 152; or equivalents.

### AEN 461G Biometeorology – 3 hours

An introduction to the impact and relationship of the atmosphere on living organisms. Emphasis on the practical application of meteorology to everyday problems within the biosphere. Weather analysis, interpretation, psychometrics of the atmosphere, and the impact of weather and climate on animals, plants and man are discussed. Lecture, two hours; laboratory, two hours per week. Prereq: BIO 150 and STA 291 or consent of instructor.

### AST/PHY 591 Astrophysics I – Stars – 3 hours

The physics of stars from star formation to stellar death. Topics include stellar structure and evolution, energy generation and transport, the later stages of stellar evolution and stellar remnants. Prereq: PHY 361, PHY 416G, PHY 417G or consent of instructor.

### AST/PHY 592 Astrophysics II – Galaxies and Interstellar Material – 3 hours

The physics of galaxies and of the interstellar medium. Topics include galaxy formation, evolution and interaction, phases of the interstellar medium, and physical processes in the interstellar medium. Prereq: PHY 361, PHY 416G, PHY 417G or consent of instructor.

### BAE 435G Waste Management for Biosystems – 3 hours

A study of the characteristics; treatment and utilization principles; and analysis and design of systems for managing waste from the production and processing of food and fiber. Lecture, two hours; laboratory, three hours per week. Prereq: MA 214 and BIO 108

### BAE 437 Land and Water Resources Engineering – 3 hours

The hydrologic cycle is studied and design procedures are developed for flood control structures, water table management, wetlands, irrigation, and erosion control systems. Prereq: CE 3541 or ME 330

### BAE 517 Off-Road Vehicle Design – 3 hours

Morphology, operational characteristics, and design considerations of off-road vehicles used in agriculture, forestry and construction. This course provides an introduction to conceptualization, analysis and design and these vehicles. Topics to be addressed include: engine performance and design, vehicle testing, turbo chargers and intercoolers, drivetrains, chassis mechanics, electronic systems, hydraulic systems, and human factors.

### BIO 401G Special Topics in Biology for Elementary, Middle and High School Teachers – 1 – 4 hours

Selected topics in biology of special interest to teachers such as biological research experiences related to pharmacological assays, collecting behavioral data, compilation and statistical analysis of data. When the course is offered, a specific title with specific credits, the number of hours in lecture-discussion and laboratory, will be given. Lecture/discussion, two-four hours; laboratory, zero-four hours. May be repeated to a maximum of 12 credits. Prereq: By consent of instructor only.

### BIO 420G Taxonomy of Vascular Plants – 4 hours

A survey of the evolutionary relationships among the major of vascular plant groups, concentrating heavily on important families flowering plants. Issues in contemporary systematic, including cladistic methods, will be covered. Students will gain practical experience learning the language of descriptive botany and using botanical keys in technical manuals for species identification. Field trips highlight the local spring flora. Lecture, three hours; laboratory, three hours; plus two Saturday field trips. Prereq: Junior standing; BIO 150, 152 or one course in introductory botany, or consent of instructor.

### BIO 430G Plant Physiology – 3 hours

Basic principles of plant physiology; the physiological processes of green plants and the effect of the environment on these processes. Prereq: BIO 150, 151, 152, 153 (or equivalent); CHE 230/231 (or equivalent); BIO 315 (or equivalent) or consent of instructor.

### BIO 507 Biology of Sleep and Circadian Rhythms – 3 hours

This course provides an introduction to the fields of sleep and circadian rhythms including the underlying neuroanatomy, neurophysiology, and the molecular and genetic underpinnings of sleep and circadian behaviors. The medical and societal relevance of these areas will also be emphasized. Considerable time will be spent reading and analyzing the primary literature in these fields, including student presentations of selected articles. Prereq: BIO 304; BIO 315; BIO 350 (or equivalent).

### BIO 515 General Cell Biology – 3 hours

An integrative, analytical study of the cell as the basic unit of biological structure and function, with emphasis on eukaryotes. Lecture, discussions with readings in some original literature. Prereq: BIO 315 or BCH 401G and consent of instructor.

### BIO 520 Bioinformatics – 3 hours

An introduction to computer analysis of macromolecular structure information. This course describes how to access, process, and interpret structural information regarding biological macromolecules as a guide to experiments in biology. Prereq: BIO 315 or BIO 304 or BCH 401 or BCH 501 or BCH 502 or BIO 105 or consent of instructor.

### BIO 529 Development Biology – 3 hours

An introduction to the principles of developmental biology, particularly of animals, including genetic and environmental control of development at the molecular, cellular, and physiological levels. Prereq: BIO 304 and BIO 315, or graduate standing in life sciences, or consent of instructor.

### BIO 530 Biogeography and Conservation – 3 hours

An introduction to the geographic patterning of biological diversity, exploring its origins, dynamics, and present trends. Examines the interplay among physical conditions, ecological interactions, evolutionary processes, and the historical movements of organisms and land masses as they have combined to affect the distribution of species, with particular attention to the application of biogeographic knowledge to current problems of species loss and conversation. Prereq: Two semesters of introductory biology or physical geography, or consent of the instructor.

### BIO 535 Comparative Neurobiology and Behavior – 3 hours

The course consists of an introduction to neurophysiology and study of the neural basis of sensory processing and motor patterns. A comparative analysis of the neurobiological basis of behavioral responses will be made, utilizing a broad range of vertebrates and invertebrates. Prereq: BIO 350 or consent of instructor.

### BIO 542 Histology – 5 hours

An in-depth study of vertebrate cell and tissue structure and function. Human tissue is emphasized. Some knowledge of biochemistry, physiology, and anatomy is desirable. The laboratory involves study of prepared microscope slides. Lecture, three hours; laboratory, four hours per week. Prereq: BIO 315 or consent of instructor.

### BIO 550 Comparative Physiology – 3 hours

Physiological mechanisms by which animals cope with different environmental stresses. Osmoregulation, respiration, temperature regulation and tolerance, sensory reception, circulation, etc. Prereq: One year of college chemistry, BIO 350 or equivalent, one year college physics or consent of instructor.

### BIO 551 Life Cycle Ecology of Flowering Plants – 4 hours

The effect of physical and biotic factors on plants and environment. Physiological, morphological and anatomical adaptations of plants to the physical factors of the environment are emphasized. Some of the laboratory exercises are carried out in the field. Lecture, three hours; laboratory, two hours. Prereq: BIO 325 or consent of instructor.

### BIO 553 Fish Biology – 4 hours

This course explores the biology of fishes from an evolutionary perspective. Lecture covers physiology, functional morphology, ecology, population biology, behavior, evolutionary relationships, and fisheries biology. Laboratory exercises include development of a fish collection; experiments in fish physiology, behavior and ecology; computer modeling of problems in fisheries biology; and field trips. Lecture, three hours; laboratory, two hours per week. Prereq: BIO 150, 151, 152 and 153 or consent of instructor.

### BIO 555 Vertebrate Zoology – 5 hours

An intensive survey of the vertebrate classes with emphasis on trends and processes in evolution, classification, phylogeny, ecology, and adaptations in morphology and behavior. Lecture, three hours; laboratory, four hours per week. Prereq: BIO 150, 151, 152, 153 or consent of instructor.

### BIO 556 Communication Biology – 3 hours

Animals sense and respond to numerous signals from their environment by using sensory modalities attuned to visual, auditory, chemical, and electromagnetic cues. This course is an in-depth examination of the physiological bases of sensory input and the interactive, motor system-mediated, behavioral repertoires exhibited by different species in response to such inputs. Prereq: BIO 325 or BIO 350.

### BIO 559 Ornithology – 4 hours

A study of the life histories, habits, identification, structure, adaptations, and physiology of birds. Special emphasis upon migrations, songs, nests and economic importance of our native birds. Lecture, field excursions, laboratory studies. Prereq: BIO 104, 105 or BIO 150, 151, 152, 153 or consent of instructor.

### BIO 560 Environmental Physiology and Toxicology – 4 hours

Emphasis will be placed on the physiological and toxicological effects of chemicals on natural biota, including considerations at cellular, organismal, population, and community levels. This will include assimilation and metabolism of pollutants by animal species, with emphasis upon biochemical and physiological mechanisms involved in stress-induced responses and stress reduction. Additional areas of concern will include the transport, fate, and effects of chemical stressors on structure and function of biotic communities and will include introductions to ecotoxicology and environmental regulatory strategies. Lecture, three hours; recitation, two hours per week. Prereq: BIO 350 or PGY 502 or equivalent or consent of instructor.

### BIO/ENT 561 Insects Affecting Human and Animal Health – 3 hours

Discussion of arthropod parasites and disease vectors. Topics include an overview of disease transmission and public health, epidemiology, vector biology, important arthropod groups and their control. Prereq: One year of biology.

### BIO/ENT 563 Parasitology – 4 hours

Protozoan, helminth and arthropod parasites of man and domestic animals, emphasis on etiology, epidemiology, methods of diagnosis, control measures, and life histories. Techniques for host examination and preparation of material for study. Prereq: BIO 150, 151, 152, 153 or consent of instructor.

### BIO/ENT 564 Insect Taxonomy – 4 hours

A study of insect taxonomy including the collection, preparation and identification of adult insect specimens. Prereq: Consent of instructor.

### BIO 567 Applications of Genetics – 4 hours

Course covers genetic concepts with an emphasis on interpretation and analysis of molecular and population genetic data using examples from the entomological literature. Prereq: ABT 360 or BIO 304 or equivalent and an introductory statistics course.

### BIO/ENT 568 Insect Behavior – 3 hours

The principles of animal behavior will be stressed using insects as examples. Physiology, mechanisms, behavioral ecology and evolution of insect behavior will be covered. Prereq: One year of Biology.

### BIO 573 Mycology – 4 hours

A survey of the physiology, morphology, life histories, taxonomy and evolutionary relationships of the various groups comprising the fungi. Lecture, three hours; laboratory, two hours. Prereq: BIO 106, 107 or BIO 152, 153

### BIO 575 Plant Anatomy and Morphology – 4 hours

A survey of the diverse structural features of plants and their functional and phylogenetic significance. Emphasis will be on the adaptive design of modern vascular plants as a response to natural and artificial selection. Lecture, three hours; laboratory, two hours per week. Prereq: Introductory biology sequence (six hours) or consent of instructor.

### BIO 582 Virology – 3 hours

Physical, chemical and biological properties of viruses. Modes of replication and control of gene product formation displayed by representative plant, animal, and bacterial viruses. Prereq: BIO 304 and biochemistry or equivalent strongly recommended, or consent of instructor.

### BIO/ENT/FOR 605 Empirical Methods in Ecology and Evolution – 2 hours

This course provides students with hands-on experience in a diverse array of modern research methods used by ecologists and evolutionary biologists, including techniques used in: molecular genetics, chemical ecology, behavioral studies, motion analyses, using high-speed video, image analyses for morphometrics and color, and field techniques in both aquatic and terrestrial systems. Lecture, one hour; laboratory, three hours per week. Prereq: BIO 325 or FOR 340 or ENT 665 or consent of instructor.

### BIO/ENT/FOR 606 Conceptual Methods in Ecology and Evolution – 3 hours

This course provides students with hands-on experience in a diverse array of conceptual research techniques used by ecologists and evolutionary biologists. The focus will be on optimization methods used for predicting animal and plant behaviors and life histories, and on methods for assessing population trends and dynamics. Mathematical techniques used will include graphical analyses, matrix algebra, calculus, and computer simulations. The latter part of the course will consist of collaborative modeling projects, in which small groups of students will work with the instructor to address an important contemporary research problem and will report their results in a public talk and a project writeup. Prereq: one year of calculus and BIO 325 or FOR 340 or ENT 665, or consent of instructor.

### BIO/ENT/FOR 608 Behavioral Ecology and Life Histories – 2 hours

This course uses an evolutionary approach to examine behavior and life histories. Topics addressed include: the optimality approach, constraints on optimality, kin and group selection, predator and prey behaviors, social and mating behaviors, and life history evolution. Prereq: BIO 325 or FOR 340 or consent of instructor.

### BIO/ENT/FOR 609 Population and Community Ecology – 3 hours

This course discusses the processes that determine population distributions and dynamics and community structure for both plants and animals. Topics addressed include: population regulation and population stability, community diversity and stability, ecological succession, population interactions (competition, predation, mutualism), coevolution, and the effects of spatial and temporal heterogeneity on population and community patterns. Prereq: BIO 325 or FOR 340 or consent of instructor.

### BIO/PLS 620 Plant Molecular Biology – 3 hours

This course is intended to be a treatment of current concepts of plant molecular biology. It will be a literature-based course, supplemented by hands and reading lists. This course will deal as much as is possible with topics that are unique to plants. Current aspects of molecular biology that are relevant to course content will be covered in the first part of the course; however, these lectures will not be a review of topics that should have been retained from introductory genetics and biochemistry courses. Also, they will not be a substitute for a molecular biology course. Prereq: One semester of undergraduate genetics and biochemistry or consent of instructor.

### BIO/ENT 625 Insect-Plant Relationships – 3 hours

This course examines the natural history, ecology, and evolution of insect/plant relationships. Topics include mechanisms and theory of plant defense, behavioral and physiological adaptations of herbivorous insects, pollination

biology, multitrophic-level interactions, causes of insect outbreaks, and applications to managed ecosystems. Critical reading and discussion of current literature is emphasized. Prereq: Two years of college-level biology.

### CHE 410G Inorganic Chemistry – 2 hours

An overview of inorganic chemistry, including fundamental aspects of structure, bonding, periodicity, spectroscopic properties, reaction mechanisms and applications. Prereq: CHE 231 and 232; prereq or concur: a physical chemistry course at or above the 400 level.

### CHE 421G Inorganic Chemistry Laboratory – 2 hours

A laboratory course that will acquaint the student with the synthesis, characterization and properties of inorganic and organometallic compounds of both main-group and transition elements. Laboratory, six hours per week. Prereq: CHE 410G; prereq or concur; a physical chemistry course at or above the 400 level.

### CHE 440G Introductory Physical Chemistry – 4 hours

An introduction to the laws of thermodynamics, the thermo-dynamic function and their application to phase equilibria, chemical equilibria, solutions and electrochemistry. Chemical kinetics, including rate laws, reaction mechanisms, Arrhenius, collision, and activated complex theories, and catalysis. Quantum theory including an elementary introduction to spectroscopy. The fourth hour to be devoted to problem solving and problem-solving techniques. Prereq: CHE 226; MA 114; PHY 213 or 232.

### CHE 441G Physical Chemistry Laboratory – 6 hours

Laboratory studies in physical chemistry, including quantum chemistry, spectroscopy, thermodynamics and chemical kinetics. Laboratory, six hours. Prereq: A physical chemistry course at above the 400 level.

### CHE 442G Thermodynamics and Kinetics – 3 hours

Principles of physical chemistry including thermodynamics, chemical kinetics, and statistical thermodynamics. Prereq: CHE 226; MA 213; PHY 213 or 232.

### CHE 446G Physical Chemistry for Engineers – 3 hours

An introductory course in physical chemistry for engineering students. Kinetic theory, thermodynamics, phase diagrams, colligative properties, electrochemistry, transport properties, kinetics, quantum theory, spectroscopy. Prereq: CHE 107, 113; PHY 232; MA 213; CME 200 or the equivalent.

### CHE 510 Advanced Inorganic Chemistry – 3 hours

A course dealing with the concepts of inorganic chemistry with emphasis on atomic structure, periodicity, nomenclature, bonding, reaction mechanisms and acid-based theories. Prereq: CHE 107 or 226.

### CHE 514 Descriptive Inorganic Chemistry – 3 hours

A course dealing in detail with descriptive chemistry of the elements and their compounds, excluding the hydrocarbons and their derivatives. Prereq: CHE 226 and 232; or CHE 450G, or permission of instructor.

### CHE 520 Radiochemistry – 3hours

Applications of radionuclides in chemistry with emphasis on principles of radioactive decay, interactions of radiation with matter, use of isotopic tracers, activation analysis, isotope dilution analysis, hot atom chemistry, and nuclear dating methods. Prereq: CHE 107 or 226.

### CHE 522 Instrumental Analysis – 4 hours

The theory and application of instrumental methods of analysis. Lecture, two hours; laboratory, six hours. Prereq or concur: a physical chemistry course at or above the 400 level.

### CHE 524 Chemical Instrumentation - 4 hours

Aspects of electronics, microcomputers, computer interfacing, and data analysis as they apply to chemical measurements and measurement systems. Lecture, two hours; laboratory, six hours per week. Prereq: a physical chemistry course at or above the 400 level or consent of instructor.

### CHE 525 Bioanalytical sensors - 3 hours

Theory, principles, and applications of bioanalytical sensors and sensing systems, including transducers, molecular recognition, and microfabrication. Prereq: a physical chemistry course at or above the 400 level or consent of instructor.

### CHE 526 Chemical Separations - 2 hours

An advanced study of the theory, instrumentation, and analytical applications of chemical separation methods. Prereq: a physical chemistry course at or above the 400 level or consent of instructor.

### CHE 532 Spectrometric Identification of Organic Compounds - 2 hours

Problems involving the use of nuclear magnetic resonance, ultraviolet and infrared spectroscopy, mass spectrometry and differential chemical reactivity in determining the structure of organic compounds. Discussion of chemical and physical methods for separation of mixtures of organic compounds. Prereq: CHE 231 and 232.

### CHE 535 Synthetic Organic Chemistry - 3 hours

A general survey of organic chemistry with emphasis on synthetic methods and the synthesis of natural products. Prereq: CHE 232

### CHE 538 Principles of Organic Chemistry - 3 hours

A general survey of the field of organic chemistry. Topics emphasized are: mechanistic principles are relating molecular structure to reaction outcome, stereoisomerism and its effect on chemical reactivity, and simple molecular orbital theory as required to understand aromaticity and to predict the occurrence and stereochemistry of pericyclic reactions. Prereq: CHE 232.

### CHE 547 Principles of Physical Chemistry I - 3 hours

An introduction to quantum chemistry and spectroscopy, emphasizing modern applications of quantum theory to the calculation of molecular properties. Practical experience with quantum chemistry software on various computer platforms is included. Prerq: MA 213; PHY 213 or 232; or consent of instructor.

### CHE 548 Principle of Physical Chemistry II - 3 hours

Fundamental principles of classical physical chemistry, including thermodynamics, statistical thermodynamics, and chemical kinetics. Prereq: A physical chemistry course at the 400 level or above, or consent of instructor.

### CHE 550 Biological Chemistry I - 3 hours

An introduction to biological chemistry. Topics include amino acids and proteins; nucleic acids and nucleotides; enzyme structure, function and energetics; metabolism including glycolysis; the tricarboxylic acid cycle; electorn transport and oxidative phosphorylation; glycogen metabolism; hormone action; and other aspects of modern biological chemistry. Prereq: CHE 232 and a physical chemistry course at or above the 400 level, or consent of instructor.

### CHE 552 Biological Chemistry II - 3 hours

A further introduction to biological chemistry. Topics include lipid metabolism, biosynthesis and metabolism of nitrogen-containing compounds, storage and utilization of genetic information, immunochemistry, and other contemporary topics in biological chemistry. Prereq: CHE 232 and a physical chemistry course at or above the 400 level or consent of the instructor.

### CHE 559 Molecular Biophysics – 3 hours

Overview of intermolecular forces responsible for formulation tertiary structure and macromolecular assemblies, as well as linked equilibria, allostery and propagatin of signals. Extension of these principels to explain macrmolecular machines, complex molecular behavior and, ultimately, processes of life. Prereq: A physical chemistry course at the 400 level or above, or consent of instruction.

### CHE 565 Environmental Chemistry – 3 hours

A study of the sources, reactions, transport, effects, and fates of chemical species in the atmosphere, hydrosphere, lithosphere, and biosphere. Prereq: Two semesters of general college chemistry are required. Courses in analytical and physical chemistry are recommended, but are not required.

### CHE 580 Topics in Chemistry – 1-3 hours

A detailed investigation of a topic of current significance in chemistry. May be repeated to a maximum of six credits. Lecture and/or laboratory: variable. Prereq: CHE 232 and a physical chemistry course at the 400 level or above, or consent of instructor.

### CHE 623 Chemical Equilibrium and Data Analysis – 3 hours

An advanced treatment of chemical equilibrium, sampling, and the evaluation of data obtained from chemically related measurements. Prereq: CHE 226 or 522 or a physical chemistry course at the 400 level or above.

### CHE 626 Advanced Analytical Chemistry – 3 hours

An advanced study of the theory and practice of quantitative analysis.

### CHE/CME/EE/MSE 664 Multidisciplinary Sensors Laboratory – 3 hours

A multidisciplinary laboratory course with laboratory experiences in areas related to sensors and sensing architectures, typically including chemistry, chemical and materials engineering, and electrical engineering. Lecture, 1 hour; laboratory, 2 hours. Prereq: One year of college chemistry, calculus, and physics. GS 660 or consent of instructor.

### MFS/ME 503 Lean Manufacturing Principles and Practices – 3 hours

Introduction of the fundamental concepts for production improvement utilizing lean manufacturing principles and practices. This course will consist of lectures, manufacturing simulation laboratory, plant tours, design projects, and assigned problems drawn from industry. Prereq: Enrollment restricted to junior-level and above students.

### MSF 526 Operations Management in Lean Manufacturing – 3 hours

Principles and practices of lean manufacturing operations management. The focus in on manufacturing as a sociotechnical system and how to limit variability through various methods of control of basic processes. Emphasis is on managing an effective and efficient technical system. Prereq: Enrollment restricted to junior-level or above students.

### MFS 599 Topics in Manufacturing Systems Engineering (Subtitle Required) – 3 hours

A detailed investigation of a topic of current significance in manufacturing systems engineering such as: computer-aided manufacturing, special topics in robotics, and lean/agile manufacturing. May be repeated under different subtitles to a maximum of six credits. A particular topic may be offered at most twice under the MFS 599 number. Prereq: Variable: given when topic is identified.

### MFS 681 Sustainable Quality Systems Design – 3 hours

This course provides the theory and principles of sustainable quality production systems as originally developed by Shewhart and Deming. The course will focus on statistical methods from the viewpoint of quality control; at the product specification level; at the product production level; and at the judgment of quality at the inspection level. Prereq: Basic Statistics.

### MFS 699 Topics in Manufacturing Systems Engineering (Subtitle Required) – 1-3 hours

A detailed investigation of a topic of current significance in manufacturing systems engineering such as: computer-aided manufacturing, special topics in robotics, and lean/agile manufacturing. May be repeated under different subtitles to a maximum of six credits. A particular topic may be offered at most twice under the MFS 699 number. Prereq: Variable: given when topic is identified.

### ME 610 Engineering Acoustics – 3 hours

A comprehensive study of wave propagation in fluids; derivation of the scalar wave equation and a study of its elementary solutions for time harmonic and transient waves in one, two and three dimensions. Radiation and scattering of waves at fluid and solid boundaries. Integral equation solution of the scalar velocity wave potential; numerical methods. Prereq or concur: MA 432G.

### ME/BAE 647 System Optimization I – 3 hours

Introduction to linear and nonlinear optimization and their use in engineering design. Emphasis on numerical approaches and use of optimization methods for engineering systems (e.g., biological, mechanical, structural). Prereq: CS 221; one mathematics course beyond MA 214 or equivalent.

### ME 651 Mechanics of Elastic Solids I – 3 hours

Many engineering applications involve the use of materials that behave elastically when performing their designed function. This course concerns the general analysis of small deformations, stress, and stress-deformation relations for elastic bodies. The solution of typical problems frequently encountered in engineering applications, e.g., extension, bending, and torsion of elastic bars, stress concentrations and thermoelastic behavior, are studied. Some modern computational methods currently used in engineering practice are introduced. Prereq: MA 432G or consent of instructor.

### ME 653 Methods of Applied Differential Equations – 3 hours

Integrals of nonlinear partial differential equations; similarity variables and other transformations; perturbation methods; weighted residual methods; numerical methods; selected topics. Prereq: MA 432G or consent of instructor.

### ME 690 Advanced Algorithms for Computational Fluid Dynamics – 3 hours

Theory and implementation of main algorithms widely used for solving multi-dimensional partial differential equations arising in engineering applications such as fluid dynamics, heat and mass transfer, semiconductor simulation, etc. Numerical solution of stead and time-dependent linear partial differential equations on rectangular domains via finite difference techniques. Linearization methods for treatment of nonlinear problems. Numerical grid generation for transforming irregular domains into rectangular computational grids. Prereq: MA 537, or consent of instructor, and competence with a high-level programming language.

### ES 600 Environmental Systems Seminar – 1 hour

A series of presentations by experts in the field on environmental systems topics including topics from the fields of law, economics, social sciences, medicine, biology, engineering and physical sciences. May be repeated to a maximum of two credits.

### ES 610 Engineering and Physical Sciences in Environmental Systems – 3 hours

Earth systems: environmental impacts of natural and human processes; the role of water systems on the earth including surface water systems, groundwater systems, and water quality and contamination systems; the role of atmospheric systems on earth including the nature and source of air pollutants, meteorological principles, radiation balance, climatology and air pollution, and air pollution control methodology; and processes and principles involved in waste producing organizations. Prereq: Freshman chemistry.

### ES 620/CPH 601 Environmental Health – 3 hours

An introduction to the theory and practice of assessing, correcting, controlling, and preventing environmental health hazards that may adversely affect the health of current and future generations. Prereq: Undergraduate chemistry and biology, or permission of instructor.

### ES 630 Legal, Social and Economic Sciences in Environmental Systems – 3 hours

Jurisprudential history, ethics and rule of law, environmental economics, history of science, governmental structures, process for development and enforcement of standards, social/political implications of environmental systems, regulatory schemes for environmental control.

### MA/CS 415G Combinatorics and Graph Theory – 3 hours

A basic course in the theory of counting and graph theory. Topics in enumerative combinatorics may include: generating functions, compositions, partitions, Fibnacci numbers, permutations, cycle structure of permutations, permutations statistics, Stirling numbers of the first and second kind, Bell numbers, inclusion-exclusion. Topics in graph theory may include: Eulerian and Hamiltonian cycles, matrix free theorem, planar graphs and the 4-color theorem, chromatic polynomial, Hall's marriage theorem, stable marriage theorem, Ramsey theory, electrical networks. Prereq: MA 213 or MA 322.

### MA/CS 416G Principles of Operations Research I – 3 hours

The course is an introduction to modern operations research and includes discussion of modeling, linear programming, dynamic programming, integer programming, scheduling and inventory problems, and network algorithms. Prereq: MA 213 or equivalent.

### MA/STA 417G Principles of Operations Research II – 3 hours

A continuation of MA 416 with topics selected from stochastic models, decision making under uncertainty, inventory models with random demand, waiting time models and decision problems. Prereq: CS/MA 416G and MA/STA 320 or consent of instructor.

### MA 432G Methods of Applied Mathematics I – 3 hours

Partial differentiation, Jacobians, implicit function theorem, uniform convergence of series, line and surface integrals. Green's and Stokes' theorems. Prereq: MA 213 or equivalent.

### MA 433G Introduction to Complex Variables – 3 hours

Elementary complex variable theory with applications. Complex field, analytic functions, Cauchy theorem, power series, residue theory. Prereq: MA 214.

### MA 471G Advanced Calculus I – 3 hours

A careful and vigorous investigation of the calculus of functions of a single variable. Topics will include elementary topological properties of the real line, convergence limits, continuity, differentiation and integration. Prereq: MA 214 and MA 322.

### MA 472G Advanced Calculus II – 3 hours

A continuation of MA 471G to functions of several variables. A careful and rigorous investigation of the extensions of the concepts of the one variable calculus to n-dimensions. Prereq: MA 471G or consent of instructor.

### MA 485G/EM/ME 585 Fourier Series and Boundary Value Problems – 3 hours

An introductory treatment of Fourier series and its application to the solution of boundary value problems in the partial differential equations of physics and engineering. Orthogonal sets of functions, Fourier series and integrals, solution of boundary value problems, theory and application of Bessel functions and Legendre polynomials. Prereq: MA 432G or equivalent.

### MA 501, 502 Seminar in Selected Topics – 3 hours each

Various topics from the basic graduate courses. Designed as a course for teachers of lower division mathematics and usually offered in connection with a summer institute. May be repeated to a maximum of six credits. Prereq: Teaching experience in the field of mathematics or consent of instructor.

### MA/PHY 506 Methods of Theoretical Physics – 3 hours

The course and its sequel (MA/PHY 507) are designed to develop, for first-year graduate students, familiarity with the mathematical tools useful in physics. Topics include curvilinear coordinates, infinite series, integrating and solving differential equations of physics, and methods of complex variables. Work with Green's functions, eigenvalues, matrices and the calculus of variations are included as part of MA/PHY 506 and 507. Prereq: PHY 404G or equivalent.

### MA/PHY 507 Methods of Theoretical Physics II – 3 hours

Continuation of MA/PHY 506. Fourier and Laplace Transforms, the special functions (Bessel, Elliptic, Gamma, etc.) are described. Work with Green's functions, eigenvalues, matrices and the calculus of variations are included as a part of MA/PHY 506 and 507. Prereq: MA/PHY 506.

### MA/STA 515 Linear and Combinatorial Optimization – 3 hours

Mathematical and computational aspects of linear programming and combinatorial optimization. Linear optimization is introduced by presenting solution techniques (primal and dual simplex) and studying geometric properties and duality for linear systems of inequalities. Asics of combinatorial optimization, including trees, paths, flows, matchings, and matroids, and the corresponding algorithms are presented. Prereq: A course in linear algebra or consent of instructor.

### MA/CS 522 Matrix Theory and Numerical Linear Algebra I – 3 hours

Review of basic linear algebra from a constructive and geometric point of view. Factorizations of Gauss, Cholesky and Gram-Schmidt. Determinants. Linear least squares problems. Rounding error analysis. Stable methods for updating matrix factorizations and for linear programming. Introduction to Hermitian eigenvalues problems and the singular value decomposition via the QR algorithm and the Lanczos process. Method of conjugate gradients. Prereq: MA 322.

### MA/EM/ME 527 Applied Mathematics in the Natural Sciences I – 3 hours

Construction, analysis and interpretation of mathematical models applied to problems in the natural sciences. Physical problems whose solutions involves special topics in applied mathematics are formulated, various solution techniques are introduced, and the mathematical results are interpreted. Fourier analysis, dimensional analysis and scaling rules, regular and singular perturbation theory, random processes and diffusion are samples of selected topics studied in the applications. Intended for students in applied mathematics, science and engineering. Prereq: MA 432G or three hours in an equivalent junior/senior level mathematics course or consent of the instructor.

### MA/CS/EGR 537 Numerical Analysis – 3 hours

Floating point arithmetic. Direct methods for the solution of systems of linear algebraic equations. Polynomial and piecewise polynomial approximation, orthogonal polynomials. Numerical integration: Newton Cotes formulas and Gaussian quadrature. Basic methods for initial value problems for ordinary differential equations. The emphasis throughout is on the understanding and use of software packages for the solution of commonly occurring problems in science and engineering. Prereq: CS/MA 321 or equivalent or graduate standing or consent of instructor. Knowledge of a procedural computer language is required.

### MA 551 Topology I – 3 hours

Topological spaces, products, quotients, subspaces, connectedness, local compactness separation axioms, convergence. Prereq: consent of instructor

### MA 561 Modern Algebra I - 3 hours

Algebraic structures, quotient structures, product structures, groups, permutation groups, groups with operators, and the Jordan-Holder theorem. Prereq: consent of instructor

### MA 565 Linear Algebra - 3 hours

Review of finite dimensional linear algebra, systems of linear equations, determinants, characteristic and minimal polynomials of a matrix, canonical forms for matrices, the simplicity of the ring of linear mappings of a finite dimensional vector space, the decomposition of a vector space relative to a group of linear mappings and selected topics of a more advanced nature. Prereq: MA 322 or consent of instructor.

### MA 570 Multivariate Calculus - 3 hours

A self-contained course in n-dimensional analysis, including the general form of Stokes' theorem. Prereq: MA 432G or equivalent.

### MA 575 Principles of Analysis - 3 hours

Real and complex numbers, sequences and series, continuity, differentiation, integration, and uniform convergence. Prereq: MA 471G or equivalent or consent of instructor.

### MA 613/EE/STA 619 Problems Seminar in Operations Research - 3 hours

In this course the student is exposed to the art of applying the tools of operations research to "real world" problems. The seminar is generally conducted by a group of faculty members from the various disciplines to which operations research is applicable. Prereq: MA 617 and STA 525 or consent of instructor.

### MA 614 Enumerative Combinatorics - 3 hours

An introduction to the basic notions and techniques in enumerative combinatorics. The material has applications to polytopal theory, hyperplane arrangements, computational commutative algebra, representation theory and symmetric functions. Topics include generating functions, the principle inclusion and exclusion, bijections, recurrence relations, partially ordered sets, the Mobius function and Mobius algebra, the Lagrange inversion formula, the exponential formula and tree enumeration. Prereq: A graduate course in linear algebra or consent of instructor.

### MA 641, 642 Differential Geometry - 3 hours each

Tensor products, exterior algebra, differentiable maps, manifolds, geodesics, metric properties of curves in Euclidean fundamental forms, surfaces. Prereq: Consent of instructor.

### MA 761 Homological Algebra - 3 hours

Homological algebra, modules, exact sequences, functors, homological dimension, extension problems. Prereq: consent of instructor.

### ENT 550 Spider Ecology and Behavior - 3 hours

Spiders are fascinating in their own right, and are also major predators in terrestrial food webs. This course examines the ecology and behavior of spiders as model predators in systems ranging from undisturbed forests and meadows to agroecosystems and the urban landscape. While focusing on spiders, the course also intertwines two general sub-themes: (1) the advantages of employing diverse approaches (e.g. field and laboratory experiments, non-manipulative observations, and meta-analyses) in ecological and behavioral research; and (2) the strengths, and limitations, of using model organisms to develop and test theory. Prereq: One year of undergraduate biology.

### ENT 574 Advanced Applied Entomology - 4 hours

The objective of this course is to present the student with advanced concepts of applied entomology in a system-specific context. Each week, the insect problems associated with a different commodity/production system will be presented so as to illustrate a different broadly-based theme. Prereq: An introductory entomology course and consent of instructor.

### ENT/BIO 635 Insect Physiology - 4 hours

Study of insect physiological processes including development, digestion, reproduction, respiration, excretion, hormones and immunity. Opportunity to learn techniques used in insect physiology and molecular biology. Prereq: Consent of instructor.

### ENT/BIO 665 Insect Ecology - 3 hours

The biotic and physical factors influencing the distribution and abundance of insects and insect populations. Prereq: Consent of instructor.

### ENT/BIO/FOR 667 Invasive Species Biology - 3 hours

This course will examine circumstances that allow introduced species to become invasive, how invasive species threaten our resources, and approaches to minimizing the incidence and impact of invasions. Prereq: Graduate standing or consent of instructor.

### ENT/BIO 684 Phylogenetic Systematics - 3 hours

Theory and methods of phylogenetic analysis and cladistics will be explained. Applications of phylogenetic analysis, such as historical biogeography, biology classification, and testing of ecological hypotheses will be explored.

### EE/CS 635 Image Processing - 3 hours

The course outlines applications of image processing and addresses basic operations involved. Topics covered include image perception, transforms, compression, enhancement, restoration, segmentation, and matching. Prereq: Graduate standing and consent of instructor.

### CS 405G Introduction to Database Systems - 3 hours

Study of fundamental concepts behind the design, implementation and application of database systems. Brief review of entity-relationship, hierarchical and network database models and an in-depth coverage of the relational model including relational algebra and calculi, relational database theory, concepts in schema design and commercial database languages. Prereq: CS 315 and graduate or engineering standing.

### CE 555 Microbial Aspects of Environmental Engineering - 3 hours

Environmental microbiology for engineering students with emphasis on microbially mediated chemical cyclesmicrobial ecology, and industrial microbiology. Prereq: CHE 105 and 107, engineering standing or consent of instructor.

### BME 481G Topics in Biomedical Engineering - 3 hours

Detailed investigation of a topic of current significance in biomedical engineering such as: biomaterials, hard or soft tissue biomechanics, rehabilitation engineering, cardiopulmonary systems analysis, biomedical imaging. Prereq: Consent of instructor.

### BME 501 Foundations of Biomedical Engineering - 3 hours

This course demonstrates the application of diverse engineering principles to analysis and understanding of the structure, function, and control of biological systems. Quantitative measurements and analysis of homeostatic, regulatory, transport, biochemical, and biomechanical processes of the human body. Prereq: Engineering standing or consent of instructor.

### BME 599 Topics in Biomedical Engineering (Subtitle Required) - 3 hours

An interdisciplinary course devoted to detailed study of a topic of current significance in biomedical engineering, such as cellular mechanotransduction, systems biology, and tissue engineering. May be repeated to a maximum of six credits. Prereq: Consent of instructor.

### BME 642 Navigational Guides for Biomedical Product Development – 3 hours

This course teachers engineers how biomedical product designs are influences by government regulations, economic issues, and ethical concerns.

### BME 766 Management of Technology – 3 hours

Successfulness in developing new technologies relies upon knowing which technology advance, the ultimate scientific limits of that technology, and the forecasted rate of technological change. This course presents curricula that explore the direction of technological change and how this affects the rate and extent of innovation.

### STA 422G Basic Statistical Theory II – 4 hours

Theory of least squares; regression; analysis of variance and covariance; experimental design models; factorial experiments; variance component models. Lecture, three hours; laboratory, two hours per week. Prereq: STA 291, 295 or STA 321

### STA/OR 524 Probability – 3 hours

Sample space, random variables, distribution functions, conditional probability and independence, expectation, combinatorial analysis, generating functions, convergence of random variables, characteristic functions, laws of large numbers, central limit theorem and its applications. Prereq: MA 213, 322.

### STA/OR 525 Introductory Statistical Inference – 3 hours

Simple random sampling, statistics and their sampling distributions, sampling distributions for normal populations; concepts of loss and risk functions; Bayes and minimax inference procedures; point and interval estimation; hypothesis testing; introduction to nonparametric tests; regression and correlation. Prereq: STA 320 or 524 or consent of instructor.

### STA 570 Basic Statistical Analysis – 4 hours

Primarily in biological, behavioral and social sciences. Introduction to methods of analyzing data from experiments and surveys; the role of statistics in research, statistical concepts and models; probability and distribution functions; estimation; hypothesis testing; regression and correlation; analysis of single and multiple classification models; analysis of categorical data. Lecture, three hours; laboratory, two hours. Prereq: MA 109 or equivalent. For graduate students; undergraduates must have consent of instructor.

### STA 580 Biostatistics I – 3 hours

Descriptive statistics, hypothesis testing, paired and unpaired tests. ANOVA, contingency tables, log rank tests, and regression with biostatistics applications. Prereq: MA 109 or equivalent.

### STA 616 Design and Analysis of Sample Surveys – 3 hours

Sampling from finite populations; estimation of sample size; stratification; ratio and regression estimators; systematic sampling; cluster sampling; multistage sampling (selection of sampling units with probability proportional to size); double sampling; response errors. Prereq: STA 531 or consent of instructor.

### STA/ECO 626 Time Series Analysis – 3 hours

Time series and stochastic processes, auto-correlation functions and spectral properties of stationary processes; linear models for stationary processes, moving average, auto-regressive and mixed autoregressive-moving processes; linear nonstationary models, minimum mean square error forecasts and their properties; model identification, estimation and diagnostic checking. Prereq: STA 422G or equivalent.

### PHY 401G Special Topics in Physics and Astronomy for Elementary, Middle School and High School Teachers – 1-4 hours

Selected topics in physics and astronomy of special interest to teachers will be discussed. When the course is offered, a specific title with specific credits, the number of hours in lecture-discussion and laboratory will be announced.

Lecture/discussion, two-four hours; laboratory, zero-four hours. May be repeated to a maximum of eight credits. Prereq: Only open to elementary, middle school and high school teachers.

### PHY/EE 402G Electronic Instrumentation and Measurements – 3 hours

Elementary treatment of electronic circuits emphasizing laboratory work. Topics include AC circuits, filters, theory and operation of transistors and other semiconductor devices and a simple treatment of operational amplifiers. Lecture, two hours per week; laboratory, three hours per week. Prereq: PHY 242 or EE 305 or consent of instructor.

### PHY 404G Mechanics – 3 hours

A lecture and problem course covering the fundamental laws of mechanics. Topics include Newton's Laws, Kepler's Laws, oscillatory motion and an introduction to Lagrangian methods. Prereq: PHY 232 or with permission of DUS, PHY 213; concur: MA 214.

### PHY 416G Electricity and Magnetism – 3 hours

First of two lecture and problem courses covering: the theory of electrostatic fields in the presence of conductors and dielectric materials, magnetic fields due to steady currents in the presence of magnetic materials, electromagnetic induction, and electromagnetic fields due to time-varying currents. Prereq: PHY 308, MA 214, MA 432G recommended.

### PHY/RM 472G Interaction of Radiation with Matter – 3 hours

Basic aspects of the interaction of ionizing radiation with matter, Bohr atom, atomic spectra, radioactivity, energetics of decay. Sources of radiation, penetration of charged particles, electromagnetic radiation, and neutrons through matter; excitation and ionization processes; selected nuclear reactions; basic radiation detection and dosimetry. Prereq: PHY 213 or 232; MA 114 or equivalent.

### PHY 520 Introduction to Quantum Mechanics – 3 hours

A lecture and problem solving course providing and introduction to the concepts and formalism of quantum mechanics. Primary emphasis is on the Schrodinger equation and its applications including the simple harmonic oscillator, the square well, the hydrogen atom, orbital and spin angular momenta, matrix representation of two level systems. Prereq: PHY 361, MA 214; recommended: MA 322.

### PHY 522 Thermodynamics and Statistical Physics – 3 hours

Temperature, heat, and entropy, and the Laws of Thermodynamics, as applied to simple systems. Introduction to statistical mechanics and the description of thermodynamics quantities in terms of ensemble averages. Prereq: PHY 361 and MA 214.

### PHY 611 Electromagnetic Theory I – 3 hours

A lecture and problem solving course treating electrostatics, boundary conditions, potential problems, energy in electric and magnetic fields, magnetic materials and Maxwell's equations. Prereq: PHY 416G; MA 214.

### MSE 531 Powder Metallurgy – 3 hours

Study of the principles of powder metallurgy relating to alloys of unusual compositions, metal and nonmetal combinations, porous and laminated products, composite metals, and high-melting alloys. Prereq: consent of instructor.

### MSE/CME 622 Physics of Polymers – 3 hours

An in-depth look at the physical and mathematical descriptions of polymer behavior. Comparison of diverse approaches to modeling the same behavior. Study of isolated polymer chain and how it relates to polymers in rigid, rubbery, melt, and solution states. Prereq: Graduate standing and undergraduate degree in the physical sciences or engineering that includes advanced calculus, differential equations, and matrix algebra.