Bucknell University

Graduate Studies Catalog

2010-2012

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Bucknell University Graduate Studies

Bucknell University is committed to supporting a focused and robust Graduate Studies Program within a diverse range of areas of study, in order to

1. offer prospective students a select array of distinctive, high quality graduate credentials
2. directly support faculty scholarship and teaching, and
3. enrich and broaden the overall undergraduate experience.

In all of Bucknell's graduate programs, students work closely with faculty toward common academic and research goals substantially beyond those available to undergraduates. The individual departmental missions share an overarching goal: a deepening of the student's knowledge and experience base in the discipline by building on the increased commitment that graduate students bring to their work. Each departmental program provides students with the education necessary for them to advance to the next level of their academic or professional career path.

About the program:

- Fully supported graduate assistantships offered to select applicants in Animal Behavior, Biology, Chemistry, English, Mathematics and Psychology as well as ,Chemical, Civil, Environmental, Electrical and Mechanical Engineering
- Require maintenance of 3.0 GPA
- Most programs completed in two years
- Education degree programs in School Psychology and College Student Personnel. Tuition scholarships and assistantships available to highly qualified applicants. Programs are 2-3 years in length.

Applicant requirements:

- Minimum undergraduate GPA: 3.0
- GRE's required with minimum score of 1000 combined
- Applicants whose native language is not English must provide TOFEL scores
- Fall semester applications due by FEBRUARY 1
- For department requirements, please see individual department web pages

About Bucknell:

- Highly selective private university situation on 450 acres in central Pennsylvania
- 3,500 undergraduate students, 150 graduate students
- About three hours from New York City, Philadelphia and Washington, D.C.
- All classes are taught by faculty

Requirements for Admission

1. **UNDERGRADUATE DEGREE** - Applicants must hold from an accredited American college or university a bachelor's degree comparable to one offered by Bucknell, or certification of corresponding achievement from a foreign institution. A final official transcript, verifying final grades and conferral of the baccalaureate degree, must be filed with the registrar before acceptance to graduate standing can be confirmed and finalized.
2. **GPA** - Applicants must have a minimum undergraduate grade point average of 3.0 (on a scale of A=4.0) in coursework comparable to that offered at Bucknell and a grade point average of 3.0 (a) in the undergraduate major, and (b) in courses of the proposed graduate major.

3. **GRE** - All applicants for admission must submit their scores on the Graduate Record Examination general test and a subject test (if required by department). The minimum score on the general test is 1000.
4. **UG MAJOR/MINOR** - The student must have completed an undergraduate major or a minor of at least four courses or the equivalent in the department of the proposed graduate major. **The following exceptions should be noted:**

   a. In education, a candidate's undergraduate work will be appraised in relation to graduate objectives in professional education. Requirements for graduate work and, possibly, for additional undergraduate work will be designed to meet requirements for certification and for a graduate degree from Bucknell.

   b. In psychology, undergraduate majors in other subjects may be acceptable, provided the applicant has a background in experimental science. Additional undergraduate prerequisites may be specified.

   c. In engineering, an undergraduate major in one of the physical sciences from an accredited institution may be acceptable. However, each engineering department lists areas of emphasis, normally covered in its undergraduate degree program, which must be satisfied in addition to the standard graduate course requirements for the master of science degree. Therefore the number of actual courses required will vary, depending upon a candidate's previous academic experience.
5. GRADUATE ADVISER - In some programs, admission will be contingent on the availability of an adviser for the area or project of interest.

Send your application materials to:
Office of Graduate Studies
Bucknell University
Lewisburg, Pennsylvania 17837.

Procedures for Admission

Applicants will find the application forms for admission to graduate studies and for financial aid can be found at www.bucknell.edu/Graduate Studies.xml. Students may print these forms from the web and send them to Bucknell by mail when completed. Applications may also be obtained from the office of graduate studies. Applications submitted by email are not accepted.

Applicants for admission are required to furnish the following information:

1. Completed application form and the application fee of $25. This fee is not returnable and will not be applied toward tuition; fee is waived for applicants whose baccalaureate degree is from Bucknell.
2. Personal statement of area of interest. Please refer to specific department web pages for program information.
3. Recommendation letters from two persons familiar with the applicant's academic work or performance related activities.
4. Official transcripts of all college and previous graduate work sent *directly* from the registrar of the credit-granting institution to the Graduate Studies Office. International students should also supply certified documentation of all secondary school exit examinations passed and diplomas issued.
5. Official report of scores on the Graduate Record Examinations. Please have test scores sent directly from the Educational Testing Service. Subject GRE's required in some departments.
6. Official report of the TOFEL score (required of all applicants whose first language is not English). Please have all scores sent directly from the Educational Testing Service.
7. Completed financial aid form (if applicable) , requesting merit-based financial aid through the University.

Application materials should be sent to Bucknell University, Office of Graduate Studies, Lewisburg, Pennsylvania 17837.

Be sure to include:

- application form
- $25 application fee
- personal statement
- two letters of reference
- financial aid form (if applicable)
- official transcript from student undergraduate institution or institutions
- official GRE and GRE subject scores (when required by the department)

An official transcript from student undergraduate institution or institutions as well as official GRE and GRE subject scores (when required by the department) should be sent directly to Bucknell University, Office of Graduate Studies by the application deadline.

Application Deadlines

- **February 1 - fall semester**
- **April 15 - summer session**
- **November 15 - spring semester (not all programs admit in spring).**

Transfer Credit
No more than eight semester hours, the equivalent of two Bucknell graduate level course credits, from other institutions may be credited toward a degree. Graduate students at Bucknell who wish to take special courses at other institutions and to apply these credits toward a Bucknell degree must have permission from their advisers and the dean of graduate studies. Only those courses with the grade of B or above are acceptable for transfer credit.

Non-degree applications
Non-degree students wishing to enroll in graduate courses may request an application from the Office of Graduate Studies. Individuals who are admitted as non-degree students and who later are approved to become candidates for a degree may receive credit for not more than two course credits of graduate work taken previously. The change in status to that of degree candidate may be authorized only by the dean of graduate studies and is not valid until confirmed in writing

Any applicant for admission to graduate study or for an award of financial aid, any candidate for a degree in progress or any student pursuing graduate coursework, who knowingly submits false or fraudulent information, conceals material information, or intentionally misleads or misinforms the University, may be denied admission; be subject to revocation of an award of financial aid; if already admitted, be subject to discipline under the University's student conduct regulations, including dismissal from the University; or if a degree has already been awarded, have the degree rescinded if based on material fraud. Each applicant is required to certify that the information furnished to the University is accurate and complete

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Graduate International Students

Application Process

Applications from students living outside the United States of America should be received by **January 1** preceding the desired fall semester of enrollment.

The application must include:

- Certification of the students undergraduate degree (in original language and English) including date of conferral, degree title and major.
- Official transcript from undergraduate institution with explanation of credit and grading system with appropriate translations of coursework or grading as necessary.
- Official TOFEL scores for applicants whose native language is not English
- Official GRE scores (subject GRE scores may also be required by some departments)

- Completed application including 2 letters of reference, personal statement, and application fee
- Completed graduate studies financial aid form
- Completed Confidential Statement of Finances form

Application Requirements

- Minimum undergraduate GPA: 3.0
- Minimum TOFEL score of 100 points on internet-based test
- Minimum GRE total score of 1000
- For department requirements, please see individual department web pages

Admission to graduate studies does not imply financial assistance will be given. Admission means only that the student may take graduate courses.

Admission Information

Admitted international students must be able to finance at least one year of school (12 months in 2011-12 cost $ 33,425) which also includes the purchase of mandatory Bucknell student health insurance.

Prior to attendance at the university the student must:

- Complete and submit to graduate studies the **confidential statement of finances for international students** including an original bank statement indicating U.S. dollar amount of personal/parent savings or notarized affidavit indicating guaranteed support from a relative, government or other sponsoring agency.
- Obtain a student visa (F-1 status) from the U.S. consulate in their home country. Graduate students are not required to submit the $500 deposit. This visa requires a Form I-20 document issued by the Director of Immigration Services. An I-20 will only be issued to international students who have completed the confidential statement of finances form.
- International students must show sources of support in the amount of $2000 in addition to the financial aid award before an I-20 can be issued.

The Graduate Student Financial Guarantee sheet provides information concerning the cost of attending Bucknell University. Further information concerning the Guarantee can be found on the International Student Services webpage. Please note that Graduate students must use financial estimates for Graduate students.

International Student Orientation is required of all new international students. This program is scheduled 10 days before the start of fall classes

Notice of Nondiscriminatory Policy

Bucknell University admits students of any race, national or ethnic origin, religion, or gender to all the rights, privileges, programs and activities generally accorded or made available to students at Bucknell, and does not discriminate on the basis of race, color, gender, sexual orientation, age, religion, national or ethnic origin, marital status, veteran status, or disability in the administration of its educational policies, admissions policies, scholarship and loan programs, and athletic and other University-administered programs. It complies fully with the prohibitions against discrimination on the basis of sex contained in Title IX of the Educational Amendments of 1972.

Expenses and Financial Aid

During the University's academic year, tuition is charged at the rate of $4,624 per course (2010-11 academic year). One course credit equals four credit hours. The maximum number of course credits for which a student may register in a semester is four. During the summer session students may enroll for a total of two full course credits or the equivalent.

Financial assistance is available to well-qualified degree candidates who assist departmental faculty, or who qualify for tuition scholarships granted by the university. **The deadline for financial aid applications is February 1.** Financial aid is awarded on a yearly basis and is normally limited to two years. Preference is given to full-time students.

There are three types of merit based financial aid available through the University. To apply for this financial aid, the Graduate Studies Financial Aid form must be returned with your application.

- **Graduate Assistantship** - includes a stipend and tuition remission and is available in the Animal Behavior, Biology, Chemistry, English and Psychology departments .The College of Engineering has assistantships available in Chemical, Civil, Electrical, Environmental, and Mechanical Engineering.
- **Graduate Internship** - includes a stipend and tuition remission, and is available through a small number of individual offices.
- **Tuition Scholarship** - includes tuition remission only and is offered by the Education Department.

Educator's tuition discount- may be available to graduate students in the education program. Applicants must be teachers or other professionals (counselors, psychologists, supervisors, administrators, etc.) employed in public, private not for-profit, or parochial elementary or secondary schools or programs and must be enrolled at Bucknell University in an approved program of courses leading to a master's degree or state certification in an area of specialization. Other educational objectives may be considered but at the discretion of the university. Forms are available at the Office of Graduate Studies and the Finance Office.

Information concerning loans and other federal support can be obtained from the Financial Aid Office.

Continuation of financial aid in the form of tuition scholarships is contingent upon the maintenance of an acceptable GPA (3.0). Continuation of financial aid in the form of a graduate assistantship into the second year of enrollment is contingent upon satisfactory performance of duties expected of a graduate assistant, including the maintenance of an acceptable GPA (3.0), progress on the thesis project, and satisfactory performance as a teaching assistant.

The purpose of financial aid is:

1. to assist graduate students by providing financial support and work experience which is meaningful for their course of study
2. to assist departments in carrying out their mission by providing talented students who can help in the instructional program or in faculty research.

Financial aid is allocated in order to recruit students with exceptional qualifications and talents, to enhance diversity in the student body, and to recruit students whose curricular interests and abilities are particularly compatible with the curriculum and faculty research in a department. Only the dean of graduate studies has the authority to award financial aid through the Office of Graduate Studies.
Graduate students are responsible for arranging their own housing.

Degree Programs

Ordinarily a student selects a program leading to a degree that corresponds to the undergraduate degree: students holding the bachelor of arts degree will be admitted to the master of arts degree program; those holding the bachelor of science degree will be admitted to the master of science degree program. Exceptions may be made at the discretion of the department concerned and with the approval of the dean of graduate studies, provided that the candidate's undergraduate program includes sufficient work in the subjects appropriate to the degree desired. Normally, this will mean that the candidate has included in the undergraduate program work equivalent to that required by Bucknell for corresponding undergraduate degrees.

College of Arts and Sciences

Master of Arts (MART)
A candidate normally seeks this degree in the field of his/her undergraduate major. The degree may be terminal or preliminary to further study leading to a doctorate at another institution. Degree programs are available in chemistry, English, and mathematics.

Master of Science (MSCI)
Similarly, the master of science degree is usually pursued in the field of the undergraduate major; it may be terminal or preparatory to a doctorate to be taken elsewhere. The MSCI degree is available in animal behavior, biology, chemistry, mathematics, and psychology.

Master of Science in Education (MSED)
This is a professional degree, the curriculum for which permits concentration in any one of the following areas:

1. College student personnel
2. School psychologist program
3. Administration (superintendency)

College of Arts and Sciences graduate study programs:

- **Animal Behavior**
  The program is intended primarily for those who hope to later earn a Ph.D. or wish to amplify their expertise in an animal-related career, such as laboratory research, field research, or conservation biology. The program is administered by the departments of biology and psychology.
- **Biology**
  The degree of master of science in biology is designed to provide students with a solid foundation in their subfield of biology and to prepare them to either purse an advanced degree at another institution or obtain employment in industry, government or education. Graduate-level courses are offered in cell and molecular biology, organismal biology, and ecology and evolution.
- **Chemistry**
  The degree of master of science in chemistry is designed to ensure students a thorough foundation in their field and to prepare them to continue their graduate education elsewhere or to obtain attractive employment in industry, government, or education. The M.A. degree program in chemistry is for high school teachers of chemistry. It is designed to allow high school teachers to experience chemistry as it is actually practiced.
- **Education**
  The education department seeks to cultivate citizens who are broadly educated, thoughtful, and committed to lifelong learning as a means to better themselves and society. Our blend of social sciences and professional preparation coursework is theoretically grounded and presents issues within social contexts that are diverse and evolving. The Master of Science degree in education (MSED) is offered in school psychology and college student personnel.
- **English**
  The M.A. in English is designed for A) those who plan to pursue a Ph.D. or M.F.A. and B) those who plan to teach in high school or community colleges and C) those who desire to advance in related careers or programs of study.
- **Mathematics**
  Bucknell offers a master's degree in mathematics. We offer a variety of courses in pure and applied mathematics and statistics. This program is tailored for students with specific goals.
- **Psychology**
  The department offers programs leading to the M.S. degree in general experimental psychology, intended primarily for students planning to enter a Ph.D. program and pursue a career in research or teaching. The program involves both research and course work but is unusual in the extent to which it provides students with extensive research experience and skills under the close supervision of faculty members.

- **Other Courses**
  A number of departments offer courses which may be taken for graduate credit although the departments do not have graduate programs. These courses may be taken with permission of the student's adviser to supplement the graduate programs of other departments.

Animal Behavior (ANBE)

570-577-1200
www.bucknell.edu/AnimalBehavior

***Coordinating Committee**:* Warren G. Abrahamson II, Ph.D. Harvard. Owen R. Floody, Ph.D. Rockefeller. Peter G. Judge (Director), Ph.D. Georgia. Kevin P. Myers, Ph.D. Duke.Elizabeth C. Evans, Ph.D Michigan State. DeeAnn Reeder, Ph.D. University of California Davis. Jennie Stevenson, Ph.D. University of North Carolina.

The program is intended primarily for those who hope to later earn a Ph.D. or wish to amplify their expertise in animal-related career, such as laboratory research, field research, or conservation biology. The program is administered by the departments of biology and psychology.

Admission Requirements

No specific undergraduate major is required, but successful candidate will demonstrate work in biology and/or psychology .Required UG courses include core Biology courses and statistics. Recommended courses include Animal Behavior-related biology and/or Psychology courses and research methods. Minimum GPA in major is 3.0.GRE scores required and subject GRE scores in biology and /or psychology encouraged

Program Description

The program requires two years of full-time work (including one summer) and consists of in residence course work in biology and psychology while conducting continuing research. A minimum of eight courses approved by the adviser is required, two of which can be research hours, and the satisfactory completion of a research thesis.
Research programs for this degree do not involve human-animal interactions or animal training (i.e.,applied animal behavior).

Faculty Research Interests

Warren Abrahamson - Evolutionary Ecology and Conservation Biology, Plant-insect interactions
Elizabeth Evans - Behavioral Biology, Insect behavior and Brain Structure
Peter Judge - Biopsychology, Primate social behavior and social cognition
Kevin Myers - Psychology, Learning and Motivation, Appetite in Rodents
DeeAnn Reeder - Comparative Behavior and Physiology, Stress Responsiveness of Bats
Jennie Stevenson - Hormone and Stress Physiology, Reward in Prairie Voles

Facilities and Resources

The facilities include well-equipped laboratory space for research entailing work with insects, laboratory rodents, bats, indoor and outdoor enclosures for four species of primates, and surgical and histological equipment. The program is also equipped to incorporate the use of physiological and genetic tools for the study of behavior.

Recent Graduate Projects

- Absolute numerous judgments in capuchin monkeys (*Cebus apella*)
- Affiliative post-conflict interactions among hamadryas baboons (*Papio hamadryas hamadryas*): Testing the "relationship" hypothesis
- Behavior of bats with white-nose syndrome
- Behavioral correlates of salivary cortisol in hamadryas baboons (*Papio hamadryas hamadryas*)
- The influence of reconciliation on the quadratic post-conflict interactions of baboons (*Papio hamadryas*)

- Picture recognition of food in brown capuchin monkeys (*Cebus apella*)
- Transport of appropriate tools from distant locations by capuchin monkeys (*Cebus apella*): Implications for working memory

Courses Offered

603. Behavioral Neuroendocrinology (I or II; 3, 0)
Relationship between the neuroendocrine system and animal behavior, including human behavior; incorporating and integrating evolutionary, developmental, and clinical perspectives. Crosslisted as BIOL 603.

613. Mammalogy (I; 3, 3*)
Biology of mammals, including evolution, classification, biodiversity, behavior, anatomy, physiology, ecology, and conservation. Lab will include specimen identification, preparation, and field study. Crosslisted as BIOL 613.

617. Learning and Adaptive Behavior (I or II; 3, 0)
Advanced seminar in issues of nature/nurture, learning, development, and adaptation, in behaviors such as foraging, mating, and communication in several species. Crosslisted as PSYC 617.

618. Comparative Physiology (I; 3, 0)
Compares the physiological mechanisms of animals, both invertebrate and vertebrate, from the standpoint of their evolutionary history and ecology. Crosslisted as BIOL 618.

621. Behavioral Ecology (II; 3, 0) The consideration of behavioral adaptations to various ecological situations. Topics include habitat choice, foraging behavior, defenses against predation, mate choice, and brood care. Crosslisted as BIOL 621.

624. Analysis of Psychological Data (I or II; 3, 0)
Statistical analysis of experimental and correlational data. Prerequisite: permission of the instructor. Crosslisted as PSYC 624.

641. Organic Evolution (AI; 4, 0) The principles and mechanisms of evolution in plants and animals, covering population phenomena, speciation, life history strategies, adaptation, systematics, and biogeography. Prerequisite: permission of the instructor. Crosslisted as BIOL 641.

642. Neuroethology (II; 3, 0)
A course that integrates neurobiology and behavior in natural contexts. Emphasis in signal detection, recognition, discrimination, localization, orientation, and the control of complex acts. Neuronal and hormonal mechanisms, ontogeny and evolution of behavior will be considered. Crosslisted as BIOL 642.

653. Ecosystem Ecology (II; 3, 0) The physical and biological mechanisms that structure natural populations, including nutrient cycling, energy flow, succession, species interactions, food webs and broader ecosystem and biogeographic processes. Prerequisite: permission of the instructor. Crosslisted as BIOL 653.

654. Tropical Ecology (II; 3, 0)
Introduction to tropical ecology, including life history strategies of vertebrates and invertebrates, biodiversity management and conservation. Prerequisite: permission of the instructor. Crosslisted as BIOL 654.

655. Social Insects (I; 3, 3) Evolution and genetics of social behavior, caste, communication in foraging and colony defense, queen and worker control over reproduction, social homeostasis, and population dynamics. Prerequisite: permission of the instructor. Crosslisted as BIOL 655.

656. Plant-Animal Interactions (I; 3, 3) The coevolution and ecology of plants and animals covering pollination ecology, seed dispersal, plant-herbivore interactions, and habitat constraints on the behavioral ecology of animals. Prerequisite: permission of the instructor. Crosslisted as BIOL 656.

660. Graduate Research (I or II; R) Half to full course
Graduate research in animal behavior. Prerequisite: permission of the instructor. Crosslisted with BIOL 660.

670. Primate Behavior and Ecology (I; 3, 3) Introduction to research on prosimians, monkeys, and apes, including diversity,reproduction, social behavior, cognitive abilities. Crosslisted as BIOL/PSYC 670

680. Thesis (I, II; or S) Preparation of a thesis leading to the M.S. degree.

686. Graduate Research (I or II) Half to full course
Graduate research in animal behavior. Prerequisite: permission of the instructor. Crosslisted with PSYC 686.

691. Graduate Research (I or II) Half ot full course Graduate research in animal behavior. Prerequisite: permission of the instructor.

Biology (BIOL)

570-577-1124
www.bucknell.edu/Biology

Professors: Warren G. Abrahamson II, Ph.D. Harvard University, Mitchell Chernin, Ph.D. Clemson University. Kathleen C. Page, Ph.D. Pennsylvania State University

Associate Professors*:* Donald C. Dearborn, Ph.D. University of Missouri. . Elizabeth C. Evans, Ph.D. Michigan State University, Kenneth A. Field, Ph.D. Cornell University. Matthew B. Heintzleman, Ph.D. Yale University. Steve Jordan, Ph.D. University of Connecticut. Matthew E. McTammany, Ph.D. Virginia Polytechnic Institute and State University. Marie C. Pizzorno (chair), Ph.D. Johns Hopkins University. DeeAnn M. Reeder, Ph.D. University of California at Davis. Mark D. Spiro (associate chair), Ph.D. University of Georgia.

Assistant Professors: Morgan Benowitz-Fredericks, Ph.D. University of Washington,Seattle. Julie Gates, Ph.D. University of Utah. Mark F. Haussmann, Ph.D. Iowa State University. Elizabeth C. Marin, Ph.D. Stanford University. Leocadia Paliulis, Ph.D. Duke University. C. Tristan Stayton, Ph.D. University of Chicago. Emily L. Stowe-Evans, Ph.D. University of Missouri.

Master of Science in Biology

The degree of master of science in biology is designed to provide students with a solid foundation in their subfield of biology and to prepare them to either purse an advanced degree at another institution or obtain employment in industry, government or education. Graduate-level courses are offered in cell and molecular biology, organismal biology, and ecology and evolution.

Admission Requirements

Applicants must have completed at least eight undergraduate courses in biology or supporting disciplines (chemistry, physics, mathematics, etc.) with a grade point average of at least 3.0 in these courses. Exceptions may be made for applicants showing marked improvement during their undergraduate program or demonstrating exceptional aptitude or achievement in other ways. **Applicants must submit both general and subject test GRE scores.**

Program Description

The program requires two years of full-time work including course work in biology and research. Eight courses (2 per semester) are required for the master of science degree.At least five of the eight courses must be in biology, and all must be at the 600 level. BIOL 660 (Graduate research) and BIOL 680 (Thesis) cannot account for more than three of the required eight courses. Applicants whose undergraduate program is too narrow or limited may be required to take additional courses. In such cases, the student must achieve the equivalent of a B.S. or B.A. degree in biology from Bucknell University.Candidates for the master of science degree are required to pass a course in statistics or biostatistics unless they have already passed such a course as an undergraduate.

By the end of the first semester, candidates must identify a research adviser. By the end of the second semester, they must form a graduate committee consisting of their research adviser and two other professors (one can be from outside of the department), develop a detailed program of study (approved by the graduate committee), and pass an oral defense of a written thesis research proposal.By the end of their second year, each candidate must present a formal departmental seminar and have a written research thesis completed and approved by the candidate's graduate

committee. Specific deadlines are published by the Bucknell University graduate school and the Department of Biology.

Facilities and Resources

The biology department is housed in a modern building with spacious labs and state-of-the-art facilities for graduate research in several areas of biology. Research is being carried out in the following disciplines: cell biology, molecular biology, ecology, evolution, biochemistry, physiology, genetics, animal behavior, plant-animal interactions, conservation biology, regulation of gene expression, ecological genetics, plant physiology, plant development and invertebrate zoology. Students specifically interested in studying animal behavior should apply to the Animal Behavior Graduate Program.

Courses Offered

602. Microbiology (II; 3, 3)
Ultra-structure, metabolism, systematics, evolution, and ecology of prokaryotes. Roles in disease and food production. Laboratory will emphasize bacterial cultivation and identification. Prerequisite: permission of the instructor.

603. Behavioral Neuroendocrinology (AI; 3, 3)
Relationship between the neuroendocrine system and animal behavior, including human behavior; incorporating and integrating evolutionary, developmental, and clinical perspectives. Prerequisite: permission of the instructor.

604. Biology of Cancer (I or II; 3,0)
The study of the molecular and cellular mechanisms that create cancer. Prerequisite: permission of the instructor.

612. Comparative Vertebrate Anatomy (I; 3, 3)
Organogenesis and gross morphology with emphasis on functional and evolutionary modifications of animal structure. Gross dissection and techniques used in morphology. Prerequisite: permission of the instructor.

613. Mammalogy (AI; 3, 3)
Biology of mammals, including evolution, classification, biodiversity, behavior, anatomy, physiology, ecology, and conservation. Lab will include specimen identification, preparation, and field study. Prerequisite: permission of the instructor.

616. Plant Growth and Development (AI; 3, 3)
The physiological and molecular bases of growth and development at the organ, tissue, and cellular levels. Effects of light and hormones on gene expression and the resultant changes at higher levels of organization. Prerequisite: permission of the instructor.

618. Principles of Physiology (I or II; 3, 3)
Emphasizes the breadth of physiology and explores physiological principles of animals from a cellular, organismal, medical, and ecological framework. Laboratory focuses on experimental design and independent research.

619 and 620. Seminar (I or II; R; 3,0)

621. Behavioral Ecology (I or II; 3, 0)
A consideration of behavioral adaptations to various ecological situations. Topics include habitat choice, foraging behavior, defenses against predation, mate choice, and brood care. Prerequisite: permission of the instructor.

622. Physiological Mechanisms (II; 3, 3)
Integration of cell and organ physiology. Emphasis on protein, ion transport, nerve and muscle physiology, cardiovascular, renal, and respiratory systems. Laboratory included. Prerequisite:permission of the instructor.

623. Mammalian Histology (II; 3, 3)
A detailed study of the microscopic architecture and associated physiology of mammalian cells, tissues and organ systems. Prerequisite: permission of the instructor.

624. Neurophysiology (I; 3, 0)
A study of neural signaling via stimulus-response with an emphasis on cellular integration. Sensory-motor as well as more complex brain systems will be explored. Prerequisite: permission of the instructor.

626. Cytogenetics (II; 3, 3)
Study of chromosome structure, organizations, aberrations, and behavior. Multiple eukaryotic systems will be considered, with links to human disease. Prerequisite: permission of the instructor.

627. Molecular Biology (I and/or II; 3, 3)
Synthesis of DNA, RNA, and protein, genetic phenomena in both prokaryotic and eukaryotic cells; laboratory experience in the regulation and manipulation of genes. Prerequisite: permission of the instructor.

628. Endocrinology (II; 3, 3)
Regulation and function of hormones and their receptors from molecular to organismal levels. Role of hormones in development, physiology, and behavior; endocrine disease. Prerequisite: permission of the instructor.

631. Functional Genomics (II; 3, 0)
The study of the structure, content, expression and evolution of genomes, emphasizing the impact of genomic information on our ability to answer biological questions. Prerequisite: permission of the instructor.

634. Limnology (I; 3, 3)
The physical, chemical, and biological characteristics of freshwater communities are studied. Prerequisite: permission of the instructor.

637. Biology of Aging (I; 3, 0)
This course will explore questions in the biology of aging from a physiological, genetic, and evolutionary framework with an emphasis on critical reading of primary literature. Prerequisite: permission of the instructor.

639. Developmental Biology (I; 3, 3)
This course provides an introduction to early animal development with emphasis on the molecular, cellular, and genetic mechanisms that drive the formation of the embryo. Prerequisite: permission of the instructor.

640. Biochemical Methods (II; 2, 6) A course in laboratory techniques including cell fractionation and analysis of proteins and nucleic acids. Spectrophotometry, chromatography, centrifugation, electrophoresis and methods of molecular cloning are emphasized. Prerequisite: permission of the instructor.

641. Organic Evolution (AI; 4, 0)
The principles and mechanisms of evolution in plants and animals, covering population phenomena, speciation, life history strategies, adaptation, systematics, and biogeography. Prerequisite: permission of the instructor.

642. Neuroethology (I or II; 3, 0)
A course that integrates neurobiology and behavior in natural contexts. Emphasis in signal detection, recognition, discrimination, localization, orientation, and the control of complex acts. Neuronal and hormonal mechanisms, ontogeny and evolution of behavior will be considered. Crosslisted as ANBE 642.

643. Neural Plasticity (I; 3, 0) Brain structure and function emphasizing cellular and molecular approaches to neural development, plasticity and degeneration. Prerequisite: permission of the instructor.

647. Virology (I; 5, 0)
The study of virus structure, genome organization, replication and host-interactions. Emphasis will be on animal and bacterial viruses. Prerequisite: permission of the instructor.

648. Immunology (II; 3, 3)
Development and function of the immune system in animals. The immune response in health and disease. Techniques in immunology. Prerequisite: permission of the instructor.

649. Special Topics in Biology (I or II; 3, 0)
Topics vary. Prerequisite: permission of the instructor.

652. Cell Biology (I and/or II; 3, 3)
Covers biomembranes, cell growth patterns, cell signalling, the cytoskeleton, cell organelles, and microscopic technique. Laboratory includes experience with cell culture. Prerequisite: permission of the instructor.

653. Ecosystem Ecology (I, 3, 0)
Interactions between organisms and physical and chemical environment including nutrient cycling and energy flow, global biogeochemistry, temporal and spatial dynamics of ecosystems. Prerequisite: permission of the instructor.

654. Tropical Ecology (I or II; 3, 0)
Introduction to tropical ecology, including life history strategies of vertebrates and invertebrates, biodiversity management and conservation. Emphasis on class and individual projects, data collection, and journal keeping. Prerequisite: permission of the instructor. Crosslisted as ANBE 654.

655. Social Insects (I; 3, 3)
Evolution and genetics of social behavior, caste, communication in foraging and colony defense, queen and worker control over reproduction, social homeostasis and population dynamics. Occasionally may be taught as a laboratory science. Prerequisite: permission of the instructor.

656. Plant-Animal Interactions (I; 3, 3)
The coevolution and ecology of plants and animals covering pollination ecology, seed dispersal, plant-herbivore interactions, and habitat constraints on the behavioral ecology of animals. Prerequisite: permission of the instructor.

658. Invertebrate Zoology (AI; 3, 3)
A survey course on the invertebrate phyla covering phylogenetic relationships, functional morphology, ecology, life histories, symbiosis, ontogeny, and behavior. Includes hands-on study of organisms in lab and field. Prerequisite: permission of the instructor.

659. General Entomology (AI; 3, 3)
The biology of insects and their kin: anatomy, physiology, ecology, behavior, development, evolution, systematics, and diversity. Prerequisite: permission of the instructor.

660. Graduate Research (I or II; R; 0, 12 or 24) One half, one, or two full courses

661. Systematic Biology (AI; 3, 0)
Seminar in systematics, the study of the classification, diversity, and evolutionary relationships of all life. Emphasis placed on molecular data and the importance of systematics to all fields of biology. Prerequisite: permission of the instructor.

665. Introduction to Microscopy (II; 3, 3)
This course is designed as an overview of light and electron microscopy, with emphasis placed on the use of instrumentation. Prerequisite: permission of the instructor.

670. Primate Behavior and Ecology (AI; 3, 3)
Introduction to research on prosimians, monkeys, and apes, Diversity, habitat, diet, growth, reproduction, social behavior, cognitive abilities. Prerequisite: permission of the instructor.

680. Thesis (I or II; 0, 6 or 12) Half or full course

Chemistry (CHEM)

570-577-3258
www.bucknell.edu/Chemistry

Professors: Charles H. Clapp (chair), Ph.D. Harvard. Margaret E. Kastner, Ph.D. Notre Dame. George C. Shields, Ph.D. Georgia Institute of Technology. Timothy G. Strein, Ph.D. Pennsylvania State University.

Associate Professors: Dee A. Casteel, Ph.D. Illinois. Karen J. Castle, Ph.D. Oregon State University. Molly McGuire, Ph.D. Wisconsin-Madison. David Rovnyak, Ph.D. M.I.T. Thomas T. Shawe, Ph.D. Emory. Robert A. Stockland, Ph.D. Missouri-St. Louis. James S. Swan, Ph.D. Pennsylvania State University. Eric S. Tillman, Ph.D. University of Southern California, Brian W. Williams, Ph.D. Cornell.

Assistant Professors: Thomas L. Selby, Ph.D. Emory University. William D. Kerber, Ph.D. University of North Carolina.

Bucknell offers a Master of Science as well as a Master of Arts in chemistry.

Master of Science in Chemistry

The degree of master of science in chemistry is designed to ensure students a thorough foundation in their field and to prepare them to continue their graduate education elsewhere or to obtain attractive employment in industry, government, or education. Graduate-level courses are offered in analytical, biochemical, environmental, inorganicc, organic, and physical chemistry.

Courses and Requirements

The program normally requires two full years.Graduate students must complete at least seven courses for graduate credit, including research and thesis and a graduate seminar, in which they are expected to participate each semester.There is no uniform set of course requirements; the courses recommended to students depend on their backgrounds and interests.

Candidates for the master of science degree must satisfactorily pass a written examination in their area of specialization and must either pass a comprehensive examination or obtain a satisfactory passing grade in an approved graduate credit course in each of three additional areas. In all, the candidate must in some way show competence in at least three of the four traditional areas of analytical, inorganic, organic, or physical chemistry. Students must present and orally defend a master's thesis summarizing the results of their research.

Financial Aid

Graduate teaching assistantships are awarded to nearly all chemistry M.S. candidates to support graduate study. In addition, summer research stipends are normally available for focused laboratory research during the summer months.

Research

Research in the well-equipped laboratories of the Rooke Chemistry Building is conducted in analytical, inorganic, organic, environmental, physical, and biochemistry.

Faculty Research Interests

Dee Ann Casteel, Ph.D., University of Illinois-Urbana. As*sociate Professor, Organic Chemistry*. Organic synthesis, synthesis of peroxides, anti-malarial, anti-viral, anti-tumor agents, medicinal chemistry.

Karen J. Castle, Ph.D., Oregon State University. *Associate Professor, Physical Chemistry*. Laser spectroscopic studies of atmospheric cooling and heating processes.

Charles H. Clapp, Ph.D., Harvard University. *Professor, Biochemistry. Enzyme mechanisms* and enzyme inhibitors.

Margaret E. Kastner, Ph.D., University of Notre Dame. *Professor, Inorganic Chemistry.* X-ray crystallography; chemical education.

William D. Kerber, Ph.D., University of North Carolina. *Assistant Professor, Inorganic Chemistry*. Redox chemistry of iron in natural waters; speciation of Fe(III) complexes; photochemical oxidation of carboxylates and phenols by iron(III).

Molly M. McGuire, Ph.D., Wisconsin-Madison, *Associate Professor. Environmental Chemistry.* Environmentally important redox reactions at clay mineral surfaces.

David Rovnyak, Ph.D., M.I.T., *Associate Professor. Biophysical Chemistry.* Application of magnetic resonance techniques to the study of biological macromolecules.

Thomas L. Selby, Ph.D., The Ohio State University, *Assistant Professor, Biochemistry.* Structure-Function Studies of Signaling Proteins; X-ray crystallography, biophysical characterization, enzymology, computational methods, and combinatorial protein libraries.

Thomas T. Shawe, Ph.D., Emory University. *Associate Professor, Organic Chemistry.* Organic synthetic methodology: stereoselective reactions and alkaloid synthesis.

George C. Shields, Ph.D., Georgia Institute of Technology. *Professor, Computational Chemistry*. Computational chemistry and structural biochemistry.

Robert A. Stockland, Jr., Ph.D., University of Missouri. *Associate Professor, Inorganic and Polymer Chemistry*. Design and synthesis of transition metal complexes with useful catalytic properties. Use of transition metal complexes to control polymerization and to modify polymers.

Timothy G. Strein, Ph.D., Pennsylvania State University, *Professor, Analytical Chemistry.* Capillary electrophoresis of biological fluids, charge transfer reactions at ultrasmall electrodes, GC/MS of environmental samples.

James S. Swan, Ph.D., Pennsylvania State University. *Associate Professor, Analytical Biochemistry.* Affinity chromatography; conformational changes in proteins.

Eric S. Tillman, Ph.D., University of Southern California, *Associate Professor, Organic Chemistry.* Synthesis of functionalized polymers, development of new initiating systems, synthesis of polymers for electronic and photochemical applications.

Brian W. Williams, Ph.D., Cornell University. *Associate Professor, Physical Chemistry.* Synthesis and spectroscopic characterization of solvatochromic molecules; fluores

Master of Arts in Chemistry

The M.A. degree program in chemistry is for high school teachers of chemistry. It is designed to allow high school teachers to experience chemistry as it is actually practiced. A goal of the department is to help the teachers see themselves as chemists as well as teachers.

Courses and Requirements

The program normally consists of three summers of work; a fourth summer might be needed depending on the background of the individual teacher. Candidates must complete seven graduate credits, including research and thesis. A graduate class open only to M.A. candidates is offered each summer. Course work for graduate credit at Bucknell during the regular academic year can be counted toward the seven credits needed. Transfer of credit from other institutions may be accepted at the discretion of the department.

In addition to course work, each student will choose a research adviser before starting the first summer of work. The student will normally conduct research with that adviser for the duration of the program; the research will culminate in a written thesis. Students will present and orally defend a master's thesis summarizing the results of their research.

Admission Requirements

Students must be full-time high school teachers. A letter of recommendation and support from the principal of the school is required. An undergraduate degree in chemistry is not required; if the degree is not in chemistry, a significant number of chemistry courses must have been completed.

Financial Aid

Bucknell will provide free housing during the summer for all M.A. candidates. In addition, by applying to the Office of Finance, M.A. students who are teachers in service may obtain a substantial discount in tuition. Forms are available at the Graduate Studies Office. Research assistantships are awarded to M.A. students on the basis of availability of funds and on seniority in the program.

Courses Offered

613. Synthetic Organic Chemistry (I or II; 4, 0)
Modern synthetic organic chemistry, with examples involving natural products and compounds of theoretical interest, and also demonstrating the applicability of organic chemical theory.

614. Mechanistic Organic Chemistry (I; 4, 0)
Discussions of the reaction mechanisms of substitution, elimination, cycloaddition, and acylation reactions are presented. Class topics include the influence of solvent on mechanism, and steric, stereochemical, and kinetic aspects of reactions. Weekly problem sessions are held. Prerequisite: permission of the instructor.

617. Special Topics in Organic Chemistry (I or II; 4, 0)

622. Inorganic Chemistry II (II; 3, 0)
Descriptive chemistry of inorganic compounds and topics in coordination chemistry. Laboratory: synthetic techniques and physical measurements.

627. Special Topics in Inorganic Chemistry (I or II; 4, 0)
Applications of group theory to spectroscopic properties of compounds. Theory and interpretation of electronic, vibrational, and magnetic resonance spectra.

632. Analytical Chemistry II (I; 3, 0)
Theory and practice of techniques of instrumental analysis including spectrophotometry, fluorescence, mass spectrometry, atomic absorption and emission, chromatography, capillary electrophoresis, cyclic voltammetry, and specific ion electrodes.

637. Special Topics in Analytical Chemistry (I or II; R; 3, 0)
Prerequisite: permission of the instructor.

640. Biological Physical Chemistry (II; 4, 3)
Introduction to physical chemistry structured for life science and premedical students. Not open to chemistry majors.

641. Physical Chemistry (I; 3, 0)
Introductory physical chemistry with emphasis on thermodynamics and kinetics.

642. Physical Chemistry (II; 3, 0)
Introductory physical chemistry with emphasis on quantum and statistical mechanics, molecular structure and spectroscopy.

643. Advanced Physical Chemistry (I or II; 4, 0)
Selected topics in quantum mechanics, statistical mechanics, thermodynamics, kinetics, photochemistry, and structure. Prerequisite: permission of the instructor.

647. Special Topics in Physical Chemistry (I or II; 4, 0)

651. Biochemistry I (I; 4, 0)
Introduction to modern biological chemistry, including synthesis, degradation and characterization of proteins, lipids, nucleic acids, and the mechanism of enzyme action. Prerequisite: permission of the instructor.

652. Biochemistry II (II; 4, 0)
A continuation of Biochemistry I (CH 330) with the emphasis on metabolism, nucleic acids, genetic engineering, lipids, carbohydrates and selected aspects of biotechnology. Prerequisite: permission of the instructor.

657. Special Topics in Biochemistry
Prerequisite: permission of the instructor.

658. Biochemical Methods (II; 2, 6)
A course in laboratory techniques including cell fractionation, protein, and nucleic acid analysis. Spectrophotometry, chromatography, centrifugation, and electrophoresis are emphasized. Prerequisite: permission of the instructor. Crosslisted as BIOL 640.

660. Advanced Environmental Chemistry (II; 4, 0)
Chemistry in the environment, including water chemistry, soil, and atmospherics. Elementary toxicology, hazardous waste production, control and disposal will be addressed.

675 and 676. Research (I and II; R; 0; 6-12) One-half to two course credits

685 and 686. Seminar (I and II; 3, 0) Half course

699. Thesis (I or II or S; 6) Half or full course
Courses for the M.A. Summer Chemistry Program for High School Teachers

610. Advanced Organic Chemistry for High School Teachers

620. Advanced Inorganic Chemistry for High School Teachers

630. Advanced Analytical Chemistry for High School Teachers

645. Advanced Physical Chemistry for High School Teachers

650. Advanced Biochemistry for High School Teachers

665. Advanced Environmental Chemistry for High School Teachers

677. Research Methods for High School Teachers

Education (EDUC)

570-577-1324
www.bucknell.edu/Education

Associate Professors: Abra N. Feuerstein, Ph.D. Virginia. Amy G. Golightly, Ph.D. Iowa. Sue Ellen Henry, Ph.D. Virginia. Lynn Hoffman (chair), Ed.D. Maryland. Robert M. Midkiff Jr., Ph.D. Arizona State. Joseph L. Murray, Ph.D. Michigan State. Katharyn E. Nottis, Ph.D. SUNY-Buffalo. Candice R. Stefanou, Ph.D. Pennsylvania State.

Assistant Professors: Richard Henne-Ochoa, Ph.D. Illinois. Sarah MacKenzie, Ph.D. Pennsylvania State. Lakeisha Meyer, Ph.D. Indiana. Lori Smolleck, Ph.D. Pennsylvania State.

The education department seeks to cultivate citizens who are broadly educated, thoughtful, and committed to lifelong learning as a means to better themselves and society. Our blend of social sciences and professional preparation coursework is theoretically grounded and presents issues within social contexts that are diverse and evolving. The Master of Science degree in education (MSED) is offered in school psychology and college student personnel. The MSED will be offered in administration, with certification as a K-12 principal, only for students enrolled prior to fall 2009. Detailed information about each of these programs can be obtained by contacting the education department, or accessing the department webpage.

Admission Requirements

In addition to meeting the University's general admission requirements and regulations for graduate study at the University, the student desiring to pursue graduate work in education may be expected to complete specific courses in education prior to enrollment or as a condition of enrollment. A candidate's undergraduate and/or graduate work, application essay, GRE scores, and letters of recommendation will be appraised in relation to graduate objectives in professional education. Students seeking entry into a certification program who do not already possess a Pennsylvania educator's certification must have an undergraduate cumulative GPA of 3.0. All new certificate holders must show

evidence of two undergraduate mathematics courses, one undergraduate course in English literature, and one in English composition.

Graduate Requirements

Candidates for the Master of Science in education (MSED) must complete a master's thesis, master's treatise, or case study, depending upon the area of specialization. Candidates seeking state certification must take and pass all required Praxis exams to be recommended for certification. Students in school psychology must successfully complete an oral examination; students in the college student personnel program who elect to write a master's treatise must also complete a written comprehensive exam. For those who elect a thesis option, an oral defense will substitute for the comprehensive written examination.

Certification

Recommendations for Pennsylvania certification in school psychology, and the superintendent's letter of eligibility can be made when all designated coursework and requirements are complete. Completion of a master's degree does not assure certification or recommendation for certification to the Commonwealth of Pennsylvania.

Courses Offered

601. Applied Behavioral Psychology (AII; 3, 1)
An exploration of human behavior in educational institutions, mental health facilities, and industry with an emphasis on understanding the determinants of behavior and designing interventions that result from data-driven decision making. Problems considered will focus on motivation, design of instructional systems, and human communications.

605. Cognitive Learning in Multiple Contexts (AI; 3, 0)
Both the theories and practical applications of psychology applied to cognitive, social, and emotional learning are emphasized. Additionally, the research process used to study learning is a major focus of attention.

608. Advanced Social Foundations; Democracy and Education (II; 3, 0)
This course employs a multidisciplinary approach to explore the relationship between education and democracy in "free" societies such as the United States. Students will critically examine the American educational system and its contemporary problems through the lenses of history, philosophy, sociology, and anthropology.

612. Counseling Techniques (I; 3, 1)
This course provides an introduction to counseling theory and training in the micro-skills of counseling and interviewing. Students have an opportunity to practice a wide range of counseling techniques with videotaping. Required field placement or service learning experience.

614. Introduction to School Psychological Services (I; 3, 1) An overview of psychological services as provided by school psychologists and counselors. This course specifically addresses theory and practice of collaborative consultation and problem-solving in the school environment on individual and systems levels. Field experience required.

617. Problems in Education (I or II or S; R; 2-4, 0) Half or full course
Research on a problem not involved in a student's thesis. Prerequisite: permission of the instructor.

618. Multiculturalism and Education (II; 3, 0)
This course combines social science and educational research with narrative accounts to explore the historical, philosophical, sociological, and political foundations of the multicultural movement in American education. The course will examine and critique contemporary issues, such as the educational experiences of minority groups, inclusive pedagogy, and bilingual education.

622. Psychology of the Exceptional Child (AI; 3, 1)
An examination of the neuropsychological theories and applications of brain behavior research related to the identification of and the provisions of services for learning disabled, emotionally and behaviorally disordered, and mentally retarded children. Prerequisite: permission of the instructor.

623. Education of Young Children (I; 3, 1)
A conceptual-developmental overview of the social, emotional, cognitive, and physical characteristics of the early childhood years (to age 7) stressing extrapolation from developmental theory to educational practice for teachers and parents who function as the earliest educators. Field experience required.

625. Career Development (S; 3, 0)
An examination of career decision-making and career choices within the context of cognitive, social, emotional, and physical development, with emphasis on both theory and practice. Prerequisite: permission of the instructor.

628. Advanced Tests and Measurements (AII; 3, 1)
Introduction to the fundamental concepts of measurement and testing theory with emphasis on the application of those concepts in a variety of educational and clinical settings. Field experience may be required.

629. Cognitive Assessment (II; 3, 16)
Development of the ability to administer and interpret individualized tests, including Binet, Woodcock-Johnson, and Wechsler. Limitations with respect to generating hypotheses related to the modification of learner behavior are discussed. Field experience required. Prerequisite: permission of the instructor.

634. Later Childhood and Adolescence: (I or II or S; 3, 1)
Later childhood and adolescence is viewed as a period of change. These changes are investigated by studying multiple contexts. Knowledge application is fostered in a tutoring experience. Field experience required.

635. Child and Adolescent Development (I or II; 3, 1)
Theoretical and research frameworks, as well as case studies, for exploring physical, cognitive, psychosocial, and literacy development, ages 5-22, and contexts for development, such as families, peer relationships, schools, cultures. Implications for teaching, counseling, coaching, parenting, and policy-making. Field experience required.

640. Literacy and Learning (II; 3, 0)
This course focuses on the development of secondary school teacher's knowledge and skills related to the development of literacy skills in various content areas.

641. The Teaching of Reading (I; 3, 1)
A study of the learning problems involved in acquiring skills in reading and writing. Contemporary theories of reading behavior. Field experience required. Prerequisite: Permission of the instructor.

642. Inclusive Practices (I; 3, 1)
This course is focused on planning, instruction, and assessment strategies to enable educators to differentiate instruction in a variety of subject areas. Educational needs of elementary level students with disabilities, varied cultural and language backgrounds, as well as the gifted are addressed. Knowledge application is fostered in a tutoring experience. Field experience required.

643. Supervision and Teaching of Social Studies (I or II; 3, 0)
Consideration of special problems arising in teaching social studies in elementary and secondary schools. Also examines influences determining course content, objectives, means of realizing objectives, and materials and methods.

644. Teaching Science in Elementary Schools (I; 3, 1)
Science content, process skills, and attitudes are addressed in order to help elementary educators develop knowledge frameworks necessary for effective science teaching. Frequent connections to national and state standards for science and environmental education are made. A lab component allows for exploration of hands-on learning activities.

646. Developmentally Appropriate Practice in Elementary Education (II; 3, 1)
Overview of children's development and implications for classroom instruction. Examination of ways to create a developmentally appropriate elementary learning environment. Other topics include classroom management, conflict resolution, and motivation. Field experience required.

648. Professional Seminar - Elementary
This is a co-requisite with 649. Students will have the opportunity to reflect and analyze their student teaching experience. Prerequisite: GPA restrictions; see department chair.

649. Student Teaching - Elementary
Prerequisites will vary as a function of certification area. Students must consult with the education department to determine eligibility for student teaching. Prerequisites: GPA restrictions; see department chair.

650. Higher Education in the U.S. (I; 3, 0)
Overview of historical and contemporary trends in post-secondary education: systematic examination of selected social, political, economic, and educational forces and problems affecting contemporary higher education.

651. Learning and Development in Post Secondary Education (I; 3, 0)
Investigation of contemporary theories pertaining to the processes of learning and development that occur from later adolescence through old age.

654. Teaching of Art (I or II; 3, 4)
Principles and practices of teaching art in grades K-12. Prerequisite: permission of the instructor.

655. Teaching of Science: Secondary (S; 3, 0)
Considerations of issues in the teaching of science. Focuses on instructional methods, resources, and safe laboratory management.

658. Professional Seminar - Secondary
This is a co-requisite with 659. Students will have the opportunity to reflect and analyze their student teaching experience. Prerequisite: GPA restrictions; see department chair.

659. Student Teaching - Secondary
Prerequisites will vary as a function of the student's background. Students must consult with the education department to determine eligibility for student teaching. Prerequisites: GPA restrictions; see department chair.

662. Research Methods I (II or S; 3, 0)
This course is designed to develop the skills needed to understand, evaluate, and do educational and psychological research. Both quantitative and qualitative methodologies are presented. Data analysis involves the use of the statistical package SPSS, which is broadly applicable to the social and psychological sciences.

665. Psychodiagnostics (AI; 3, 1)
An overview of developmental psychopathology, educational exceptionality and the issues affecting the child's adjustment to learning.

669. Local Educational Politics (AI; 3, 0)
This course focuses on the political nature of decisions in education and the influence of national or state politics on local policy actors, such as superintendents and school board members.

676. Graduate Research (I or II or S; R; 0, 6-24) One-half to two course credit.
May be taken for credit more than once.

698. Student Affairs Programs in Higher Education (II; 3, 0)
The study of historical and philosophical foundations of the student affairs profession, and the roles and functions of student affairs professionals in contemporary collegiate institutions. Prerequisite: EDUC 651 or permission of the instructor. Other Courses Open to Graduate Students

631. K-12 Administrative Internship (I, II, S) One course credit

633. Superintendents Internship (I, II, S) One course credit

677. School Psychology Practicum (I) One course credit

678. School Psychology Internship (I, II) 1.5 course credit

680. Thesis (I or II or S)

681. Master's Treatise (I or II or S) One course credit

691. Case Study (I or II or S) One course credit

697. College Student Personnel Internship (I, II) One course credit Supervised practice in student affairs, together with structured reflection. Prerequisites: EDUC 698 and EDUC 651.

English (ENGL)

570-577-1553
www.bucknell.edu/English

***Professors**:* Greg Clingham, Ph.D. Cambridge. Carmen Gillespie, Ph.D. Emory. Saundra Morris, Ph.D. Cornell. Harriet Pollack, Ph.D.,Virginia, John Rickard (Chair), Ph.D. North Carolina at Chapel Hill. Harold Schweizer, Ph.D. Zurich.

Associate Professors: Paula C. Buck, Ph.D. Ohio. Christopher Camuto, Ph.D. Virginia. Glynis Carr, Ph.D. Ohio State. Michael Drexler, Ph.D. Brown. Eric S. Faden, Ph.D. Florida, Shara McCallum, Ph.D. SUNY Binghamton, Ghislaine McDayter, Ph.D. Duke. Jean Peterson, Ph.D. University of Pennsylvania, Meenakshi Ponnuswami, Ph.D. Illinois. Alfred Siewers, Ph.D. Illinois. Virginia Zimmerman, Ph.D. Virginia.

***Assistant Professors**:* Alexandra M. Block, Ph.D. Wisconsin. Mara de Gennaro, Ph.D. Columbia. James Peterson, Ph.D. University of Pennsylvania. Robert Rosenberg, M.F.A Iowa. G.C. Waldrep, Ph.D. Duke, M.F.A. Iowa.

The Program

The graduate program in English offers the student a structure consisting of eight courses in English or six courses in English and two in other disciplines with adviser's approval, and a thesis.The M.A. in English is designed for A) those who plan to pursue a Ph.D. or M.F.A. and B) those who plan to teach in high school or community colleges and C) those who desire to advance in related careers or programs of study.

Admission Requirements

An undergraduate English major is strongly recommended. Writing sample and general GRE test results are required. We encourage personal interviews.

Degree Requirements

1. eight courses, including Seminar in Literary/Critical Theory (ENGL 600) and the thesis workshop or a seminar in creative writing. Two of the eight courses may be taken outside the department with permission of the adviser;
2. a master's thesis proposal;
3. a master's thesis and an oral examination;
4. intermediate reading proficiency in a foreign language to be determined by testing or by four courses in a foreign language, two of which must be university courses at the intermediate level.

Graduate students in English may not enroll in more than two independent study (ENGL 619) courses without special written permission from the Graduate Committee and should propose independent study only if the material they wish to cover is not available in regularly offered seminars.

Courses

Students are required to have the permission of the instructor to enroll in all English 600-level courses. The sequence of courses normally taken by master's degree candidates consists of:

First Year: Seminar in Literary/Critical Theory (ENGL 600; Fall) Three electives from among 600-level English courses or 400-level Capstones. Students might also consider, with adviser's approval, courses, for example, in language in translation, the social sciences, or the humanities.
Second Year: Fall: ENGL 678 — Thesis Workshop OR seminar in creative writing for those writing creative theses.

A thesis proposal, developed with the approval of the adviser, and submitted by to the departmental Graduate Committee by October 15. One elective (see First Year) Spring: One elective Thesis (ENGL 680)

Thesis/Exam

A thesis (typically 60-80 pages, including notes and bibliography; critical, creative, or theoretical) is required. The oral examination will be conducted by the thesis adviser, and at least two other members of the faculty (in English or another appropriate department).

Setting

The English department encourages collegial relationships between professors and graduate students, as well as among graduate students themselves. Bucknell is home to the Stadler Center for Poetry, Bucknell University Press, and the journals *West Branch* and *Aperçus.* Coursework is further enhanced by an excellent library, computer facilities, a writing center, and a rich offering of literary and critical publications. Seminars require active participation; student reports, oral and written; and a substantial paper.

Courses Offered

600. Seminar in Literary Theory and Criticism (I; 3,0)
Introduction to graduate study, including literary and critical theory, research, and other elements of literary scholarship.

601. Seminar in American Literature Topics (I or II; R; 3, 0) Advanced topics, such as Cross-Cultural Encounters, The American Novel, Gender and American Poetics, and Beat Generations.

602. Seminar in Selected American Writers (I or II; R; 3, 0)
Study of the works of one or more major American writers.

605. Seminar in Early American Literature (I or II; R; 3, 0) Special topics or selected authors.

607. Seminar in 19th-century American Literature (I or II; R; 3, 0) Special topics or selected authors.

610. Seminar in Modern American Literature (I or II; R; 3, 0) Special topics or selected authors.

611. Seminar in Contemporary American Literature (I or II; R; 3, 0) Special topics or selected authors.

619. Individual Projects (I and II; R) Individual, special projects supervised by instructor.

621. Seminar in African American Literature (I or II; R; 3, 0)
Study of selected thematic, aesthetic, and ideological issues in Black American writing.

623. Seminar in Women's Literature (I or II; R; 3, 0)
Advanced topics investigating relationships among gender, writing, and reading.

626. Seminar in Irish Literature (I or II; R; 3, 0) Advanced topics in Irish literature, including Irish Women Writers, Nationalism and Literature, and Contemporary Irish Writing.

627. Seminar in Caribbean Studies (I or II; R; 3, 0)
Study of selected thematic, aesthetic, and ideological issues in Caribbean writing.

640. Seminar in Early English Literature to 1485 (I or II; R; 3, 0)
The language and literature of Anglo-Saxon or medieval England.

650. Seminar in Renaissance Literature (I or II; R; 3, 0) Special topics. Student reports, oral and written.

658. Seminar in Shakespeare (I or II; R; 3, 0) Special topics. Student reports, oral and written.

660. Seminar in Restoration and 18th-century Literature (I or II; R; 3, 0)
Studies in canonical and marginalized texts, cultural and philosophical formations, and the continuing historical and theoretical relevance of the period.

670. Seminar in 19th-century English Literature (I or II; R; 3, 0)
Examination of a wide range of poetry and prose by selected authors with emphasis given to the literature's historical and cultural groundings.

678. Thesis Workshop (I; 3, 0) A colloquium on the writing of a scholarly thesis.

680. Thesis (I or II)

681. Seminar in 20th-century British Literature (I or II; R; 3, 0) In-depth study of selected modern authors (such as Yeats, Joyce, H.D., Lawrence, Woolf) and of the literary tendencies of the period.

682. Seminar in Contemporary British Literature (I or II; R; 3, 0)A selective study of the most recent developments in prose or poetry.

691. Seminar in Poetry (I or II; R; 3, 0)
A study of poetry as a genre and an analysis of the work of selected poets.

692. Seminar in the Novel (I or II; R; 3, 0) Special topics. Student reports, oral and written.

693. Seminar in Contemporary Drama (I or II; R; 3, 0)
Special topics. Studies in dramatic literature, theater, and performance.

697. Seminar in Special Topics (I or II; R; 3, 0)
Topics such as comparative literature, literature and the arts, queer theory, or satire.

698. Seminar in Literary/Critical Theory (I or II; 3, 0)
The study of Continental and American critical positions or schools from Modernism through Post-Structuralism.

Creative Writing ENGL 608 may be repeated for credit. Individual projects in writing (e.g., a novel or a collection of verse) may be taken under the rubric of ENGL 619.

603. Seminar in Writing Creative Nonfiction (I or II; R; 3, 0)
Advanced workshop in the writing of creative nonfiction.

608. Seminar in Writing Poetry (I or II; R; 3, 0) Advanced workshop in writing poetry.

609. Seminar in Writing Fiction (I or II; R; 3, 0) Advanced workshop in writing fiction.

Courses in Film Studies

632. Film and Technology (I or II; 3, 0)
Traces technology's impact on film form and content. Topics include early cinema, sound technology, widescreen, and computer-generated images. Weekly screenings.

636. Film Genres and Auteurs (I or II; 3, 0)
Examination of a particular genre (film noir, Hong Kong action movies, Westerns, etc.), director, cinematographer, screenwriter, or producer. Weekly screenings.

637. Film Theory (I or II; 3, 0)
Survey of approaches to film analysis and critique, ranging from realist/formalist debates to psychoanalytic, feminist, and semiotics approaches. Weekly screenings.

639. Special Topics in Film Studies (I or II; 3, 0)

Examination of specialized topic in film studies. Weekly screenings.

Mathematics (MATH)

570-577-1343
www.bucknell.edu/Math

Professors: George R. Exner, Ph.D. Michigan. Michael R. Frey, Ph.D. North Carolina. Pamela B. Gorkin, Ph.D. Michigan State. Paul J. McGuire, Ph.D. Indiana. Howard Smith, Ph.D. Cardiff, Wales.

Associate Professors: Carmen O. Acuña, Ph.D. Massachusetts. Gregory T. Adams, Ph.D. Indiana. Lynn Breyfogle, Ph.D. Western Michigan. Peter A. Brooksbank, Ph.D. Oregon. Thomas Cassidy, Ph.D. Oregon. Ulrich Daepp, Ph.D. Michigan State. James E. Hutton, Ph.D. Cornell. Karl A. Voss (Chair), Ph.D. Yale.

Assistant Professors: K. B. Boomer, Ph.D. Pennsylvania State University. Emily Dryden, Ph.D. Dartmouth. Sharon Garthwaite, Ph.D. Wisconsin. Peter McNamara, Ph.D. MIT. Adam Piggott, D.Phil. Oxford. Nathan Ryan, Ph.D. Dartmouth. Linda B. Smolka, Ph.D. Pennsylvania State University. Stephen Wang, Ph.D. Chicago.

Admission Requirements

The student is expected to have completed courses in modern abstract algebra, real analysis (advanced calculus) beyond calculus of several variables, linear algebra, and probability. Those courses are prerequisite to advanced courses required for the M.A. and M.S. degrees.Students must demonstrate proficiency in real analysis and either abstract algebra or probability. Proficiency is demonstrated by means of a preliminary exam or by auditing the relevant course with a grade of B or better on the final exam.

It is not possible to obtain the M.A. or M.S. degree in summers alone because the required courses of the M.A. or M.S. degree are offered only during the fall and spring semesters.

Program Description

After having been admitted, candidates will confer with their academic adviser in the department of mathematics no later than the day of graduate enrollment. A tentative program of courses will be prepared; candidates may select programs with concentrations in pure mathematics, applied mathematics, or statistics.Final approval of a candidate's program rests with the department's Graduate Committee. Granting of the master's degree is dependent on the student's having:

1. passed the preliminary examination or audited the corresponding courses with a grade of B or better on the final examination;
2. completed MATH 609 or MATH 646, MATH 645, MATH 662 , and either five approved electives or four approved electives and a master's thesis under the direction of a faculty member in the mathematics department;
3. passed a comprehensive oral examination;
4. presented a mathematical talk in the Student Colloquium lecture series. The final decision as to whether or not the student is to be recommended for a degree rests with the department's Graduate Committee. Every graduate student is expected to attend regularly the functions of Pi Mu Epsilon, the Bucknell chapter of the Mathematical Association of America, and the lectures given by local or visiting mathematicians and, upon occasion, to contribute to these programs.

Courses Offered

603. Probability (I and II; 3, 0)
Elementary probability, random variables, moments, central limit theorem, conditional expectation, statistical distributions derived from the normal distribution. Probability simulations and applications from various fields.

604. Mathematical Statistics (AI or II; 3, 0) Point and interval estimation, hypothesis testing, Fisher's likelihood theory, frequentist versus Bayesian approach, computational statistics. Prerequisite: a course in probability.

605. Linear Statistical Models I (AI or II; 3, 0) Regression and analysis of (co)variance. Model diagnosis and remediation. Model selection, multicollinearity, logistic regression. R or SAS will be used.

607. Statistical Design of Scientific Studies (II; 3, 0)
Experiments, observational studies. Completely randomized, block, mixed models, crossed, nested design. Simple random, stratified, cluster sampling. Estimation procedures, sample size calculations. Uses R or SAS. Prerequisite: a course in statistics.

609. Introduction to Real Analysis II (AI or II; 3, 0)
Integration theory and advanced topics in analysis.

611. Theory of Numbers (AI or II; 3, 0)
Classical number theory in an algebraic setting. Topics include unique factorization, diophantine equations and linear and quadratic congruences. Advanced topics from algebraic or analytic number theory. Prerequisite: a course in abstract algebra.

617. Statistics for the Biological Sciences (I; 3, 0)
Exploratory data analysis, design of experiments and inference emphasizing applications in biology and environmental science. Includes multiple linear regression, analysis of variance, categorical data analysis, nonparametric statistics. Not available to graduate students in the mathematics department.

619. Topics in Advanced Mathematics (I or II; R; 3, 0)
Special topics, to be selected from algebra, analysis, geometry, statistics, etc.

633. Topology (AI or II; 3, 0)
Topological spaces, connectedness, compactness, continuity, separation and countability axioms. Metric, product, function, and uniform spaces.

635. Geometry (I; 3, 0)
Historical axiomatic foundations of geometry. Euclidian and non-Euclidean geometries.

643. Numerical Analysis (I; 3, 0)
Floating-point arithmetic, development of computational algorithms and error estimates for root approximation, interpolation and approximation by polynomials, numerical differentiation and integration, cubic splines, least squares, linear systems. Prerequisites: a course in multivariable calculus and a course in programming.

645. Linear Algebra (AI or II; 3, 0)
Systems of linear equations, determinants, vector spaces, canonical forms for linear transformations and matrices, bilinear forms, inner-product spaces, applications to such other areas as geometry, differential equations, linear programming. Prerequisite: an introductory course in linear algebra.

646. Modern Algebra (AI or II; 3, 0)
Advanced topics in group theory including solvable groups, field theory, Galois theory. Prerequisite: a course in abstract algebra.

650. Methods in Applied Mathematics (AI or II; 3, 0)
Techniques drawn from partial differential equations, transform methods, Fourier and complex analysis, and variational calculus. Prerequisite: a course in differential equations.

658. Topics in Operations Research (AI orII; 3, 0)
Mathematical and statistical techniques in operations research. Queueing theory. Additional topics may include simulation, forecasting, non-linear programming, inventory models. Methods and applications drawn from various fields. Prerequisite: a course in probability or permission of the instructor.

662. Introduction to Complex Analysis (AI or II; 3, 0)
Limits, analytic functions, integrals including contour integrals. Cauchy's Integral Theorem, entire functions and singularities. Prerequisite: a course in multivariable calculus.

678. Seminar (AI or II; R; 2, 0) One-half course credit
Informal seminar in various topics as the need arises. Topics may deal with algebra, analysis, topology, differential

equations, statistics, or applied mathematics. Prerequisite: permission of the instructor.

691 and 692. Reading and Research (I or II or S; 2-8, 0) One-half to two courses
Reading and research in various topics for qualified graduate students.

Psychology (PSYC)

570-577-1200
www.bucknell.edu/Psychology

Professors: Chris J. Boyatzis, Ph.D. Brandeis, David W. Evans, Ph.D. Boston University, Owen R. Floody, Ph.D. Rockefeller. Eugenia P. Gerdes, Ph.D. Duke. Andrea R. Halpern, Ph.D. Stanford. J. T. Ptacek, Ph.D. Washington, Michael A. Smyer, Ph.D.,T. Joel Wade (chair), Ph.D. University of North Carolina.

Associate Professors: Kimberly A. Daubman, Ph.D. Maryland. William F. Flack, Ph.D. Clark. Peter Judge, Ph.D. Georgia. Kevin Myers, Ph.D. Duke. Arthur G. Shapiro, Ph.D. Columbia.

Programs and Degrees

The department offers programs leading to the M.S. degree in general experimental psychology. All programs culminate in a thesis and require two full academic years, including one or two summers. Students take eight courses for the degree, one of which is a thesis credit.

The general experimental program is intended primarily for students planning to enter a Ph.D. program and pursue a career in research or teaching. The program involves both research and course work but is unusual in the extent to which it provides students with extensive research experience and skills under the close supervision of faculty members. The graduate student-to-faculty ratio is excellent.

Faculty

The faculty is highly research-oriented, with special interests in the behavior and social cognition of nonhuman primates (Judge), the neural and neurochemical control of reproductive behavior (Floody), social psychology and the psychology of women (Daubman, Gerdes) and evolutionary theory and beauty (Wade), stress, coping, and health (Ptacek), children's religious/spiritual, social and cognitive development (Boyatzis), cognitive processes, including those used in the perception and production of music (Halpern), emotion, trauma, and social conflict (Flack), developmental psychopathology (Evans), learning and motivation (Myers), and visual perception (Shapiro).

Facilities and Resource

The department has research laboratories in perception, animal behavior, physiological psychology, cognitive psychology, social psychology, personality psychology, developmental psychology, and human and animal conditioning. The animal laboratories are exceptionally broad and include four species of semi-naturally housed Old and New World primates as well as hamsters and rats. Faculty and students conduct observational research at a local child-care center. There are excellent computer facilities.

Admission Requirements

- An undergraduate psychology major is not essential; however, it is critical that candidates have adequate training in experimental psychology and statistics.
- Verbal, quantitative, written and **subject psychology GRE scores are required**.
- Important admissions criteria include previous research experience and letters of recommendation. In addition, the department's emphasis on individualized instruction requires indication of research experience and interests in each candidate's statement.
- Personal admission statements should mention one or two potential mentors from among the faculty.

Courses Offered

601. History of Psychology (I or II; 3, 0)
A history of scholarly ideas about thoughts, feelings, and behavior.

604. Advanced Developmental Psychology (I or II; 3, 0)
Analysis of selected topics in development, including cognitive, social, and religious/spiritual development.

605. Developmental Psychopathology (I or II; 3, 0)
Discusses the origin, nature, and processes underlying atypical development and psychological disorders from a developmental perspective. Emphasis is placed on the interplay between normative and pathological development.

606. Advanced Abnormal Psychology (I or II; 3, 0) Analysis of specific topics in the fields of psychopathology and/or clinical psychology. Prerequisite: permission of the instructor.

607. Culture and Child Development (I or II; 3, 0)
Study of culture-specific and universal processes of child development in societies all over the world. Cultural issues in family, education, government, religion, labor, war, and hunger.

609. Appetite and Eating Behavior (I or II; 3, 0)
Advanced seminar considering psychological factors involved in appetite, food preferences, and food intake.

616. Advanced Social Psychology (AI or II; 3, 2)
Consideration of experimental and theoretical issues in social psychology.

617. Learning and Adaptive Behavior (I or II; 3, 0)
Advanced seminar in issues of nature/nurture, learning, development, and adaptation, in behaviors such as foraging, mating, and communication in several species.

618. Cognitive Aging (I or II; 3, 0)
Seminar discussing the development and changes in cognition in senior citizens. Topics include memory, language, attention, and decision making.

619. Topics in Psychology (I and II; R; 0, 3)
Occasional seminars on selected topics of current interest in psychology. Prerequisite: permission of the instructor.

624. Analysis of Psychological Data (I or II; 3, 0) A survey of advanced statistical techniques with emphasis on analysis and interpretation of experimental and correlational data.

625. Advanced Personality Theory (II; 3, 0)
Consideration of current issues in personality psychology. Possible topics include: persons and situations, personality and health, and personality and relationships.

639. Psychology of Music (I or II; 3, 0)
Seminar examining how musicians and non-musicians comprehend, remember, perform, and respond to music, including developmental aspects. Some background in music is required.

643. Neural Plasticity (I or II; 3)
Brain structure and function, emphasizing cellular and molecular approaches to neural development, plasticity, and degeneration.

649. Human Neuropsychology (I or II; 3, 0) Brain mechanisms of language, memory, and other processes as revealed by studies of human brain activity or pathology.

652. Advanced Perception (I or II; 3, 0) Theories of and research on sensory and perceptual processes.

669. Psychology of Beauty and Attraction (I or II; 3, 0)
Examination of research on beauty and attraction from an evolutionary perspective.

670. Primate Behavior and Ecology (I; 3, 3*)
Introduction to research on prosimians, monkeys and apes with emphasis on the evoluntionary origin of diversity, habitat use, social structure, social behavior, and cognitive abilities.

673. Psychology of Race and Gender (II; 3, 0)
Critical analysis of major theories. Emphasis on experimental research findings in the areas of racism, discrimination, gender difference, sexual violence, etc.

College of Engineering

Welcome

This is your gateway to graduate studies in engineering at Bucknell University. Here you will find our mission and objectives, as well as links to the individual academic programs and departments graduate degrees, current research projects, and University facilities. If you are interested in applying to a particular degree program, please follow the admissions guidelines and procedures links.

Mission

The College of Engineering Graduate Program is dedicated to providing student-centered graduate educational opportunities with a focus on high-quality scientific/engineering research. Because Bucknell University is a predominantly undergraduate institution, the integration and synergy of the graduate program with the undergraduate educational mission is a central priority. Curricula emphasize intensive coursework, hands-on research experience, and professional and personal development in a diverse variety of engineering disciplines. The independent research work, closely supervised by faculty mentors, culminates in a Master of Science thesis. Our faculty are internationally-recognized scholars, with a number of externally-supported cutting edge research programs. Our graduates are self-motivated, critical thinkers who are well prepared to apply their knowledge and skills to create new products and services, and become global leaders throughout their future careers in both academia and industry.

Master of Science degrees in:

- Chemical Engineering (MCHE)
- Civil Engineering (MSCE)
- Electrical Engineering (MSEE)
- Environmental Engineering (MSEV)
- Mechanical Engineering (MSME)

- **Chemical Engineering**
  The core courses are offered in engineering mathematics, thermodynamics, reaction engineering, and transport theory. Topics offered as chemical engineering electives include polymer science, bioprocess engineering, advanced materials science and engineering, particle technology, fuel cell technology and independent study projects. In addition, graduate-level courses offered by other departments may be taken as electives with the approval of the chemical engineering department.
- **Civil Engineering**
  Faculty research interests emphasize the following areas: environmental engineering, soil mechanics and foundation engineering, structures, transportation, water resources, computer graphics, computer-aided design, railroad engineering, engineering mechanics, timber structures, pavement design, and materials performance and characterization, construction safety and innovation.
- **Electrical Engineering**
  The faculty research interests emphasize the following areas: antenna design, control systems, computer architecture and performance, computer networks, electromagnetics, digital system design, digital signal and image processing, simulation, communication systems, power electronics, VLSI, optoelectronic materials and devices, optical signal processing and devices.

- **Environmental Engineering**
  Faculty research interests emphasize the following areas: biodegradation of municipal solid waste and aqueous organics; biological conversion of waste materials to useful forms of energy, such as methane and hydrogen; life-cycle analysis of engineered environmental systems; bioremediation of contaminated ground water; coagulation, flocculation, and sedimentation in aqueous systems; mitigation of odor potential at wastewater and solid waste treatment facilities; bioremediation of contaminated ground water; environmental geotechnics; vertical subsurface barriers for the remediation of hazardous waste sites; transformation of slurry trench cutoff wall materials from the passive hydraulic barrier materials into active treatment materials while maintaining their passive hydraulic barrier characteristics; watershed processes and land surface-atmosphere interactions; appropriateness of existing numerical models for nonlinear transport processes in environmental systems; adsorption of heavy metals by microorganisms; characterization of pollution from agricultural sources.
- **Mechanical Engineering**
  Faculty research interests are in the following areas: acoustics, bioengineering, bluff body aerodynamics, building energy conservation, combustion processes, composite materials, computational fluid dynamics (CFD), computer-aided design, computer-aided materials testing, computer-based mechanics, computer modeling of engineering systems, design theory and methodology, energy for transportation, flow-induced noise and vibration, fluid dynamics, fracture mechanics, heat transfer, hybrid powertrains, internal combustion engines, robotics, air-borne contaminant transport modeling, history of technology, nano materials, environmental degradation, materials processing.
- **Other Courses**
  A number of departments offer courses which may be taken for graduate credit although the departments do not have graduate programs. The courses listed below may be taken with permission of the student's adviser to supplement the graduate programs of other departments.

Chemical Engineering (CHEG)

570-577-1114
www.bucknell.edu/ChemicalEngineering

***Professors*:** Jeffery Csernica (chair), Ph.D. Massachusetts.Institute of Technology. William E. King Jr., Ph.D. University of Pennsylvania. Michael J. Prince, Ph.D. University of California, Berkeley. William J. Snyder,Ph.D. Pennsylvania State University.

***Associate Professors**:* Daniel P. Cavanagh, Ph.D. Northwestern University. James E.Maneval, Ph.D. University of California, Davis. Margot A.S. Vigeant, Ph.D. University of Virginia.

***Assistant Professors**:* Michael Gross, Ph.D. University of Pennsylvania. Erin Jablonski, Ph.D. Iowa State University. Timothy Raymond, Ph.D. Carnegie Mellon University. Ryan C. Snyder, Ph.D., University of California, Santa Barbara. Brandon Vogel, Ph.D. Iowa State University. Katsuyuki Wakabayashi, Ph.D. Princeton University.

Program of Study

Candidates for a master's degree in chemical engineering must complete three required core courses in chemical engineering, four elective courses, and a graduate thesis. The program requires an average of 24 months of full-time study.The core courses are offered in engineering mathematics, thermodynamics, reaction engineering, and transport theory. Topics offered as chemical engineering electives include polymer science, bioprocess engineering, advanced materials science and engineering, particle technology, fuel cell technology and independent study projects. In addition, graduate-level courses offered by other departments may be taken as electives with the approval of the chemical engineering department.

Master's Thesis

A written master's thesis is an integral part of Bucknell chemical engineering master's program and a primary contribution to the education of the candidate. The thesis must describe work on an experimental or educational research, mathematical and/or computational modeling, or design or other problem involving original scientific inquiry. Selection of a thesis advisor will be conducted prior to the start of the candidate's graduate program.

Thesis Projects and Facilities

The department maintains state-of-the-art laboratory and computing facilities, enabling master's degree candidates to pursue a variety of research/thesis activities. Graduate students are encouraged to present their work at professional meetings at both the regional and national levels, and serve as coauthors for journal and other peer-reviewed publications. Some recent thesis titles are:

- Development of Solid Oxide Fuel Cell Electrodes with High Conductivity and Enhanced Redox Stability
- Solid-State Fabrication and Characterization of Polymer-Graphite Nanocomposites
- vMorphology and Cloud Condensation Nuclei Activity of Single-Component and Multi-Component Organic Aerosols
- Investigation of Drag Reducing Polymers by Dielectric Spectroscopy
- eLEAPS - an Investigation of Web Application to Support Learning Engineering and Problem Solving
- Calcium Alginate Encapsulation and Continuous Separation of the Capsules Through Co-Laminar Flow of Immiscible Fluids
- Ultrasonic Studies of Polymer-Toluene Solutions in the Dilute Region
- Nuclear Magnetic Resonance Measurements of Fluid-Solid Interactions in Dialysis-Membrane Materials

Contact Information

For additional information, contact: Graduate Studies Adviser, Department of Chemical Engineering, Bucknell University, Lewisburg PA 17837, USA; 570-577-1114; cheg@eg.bucknell.edu. Departmental website is www.bucknell.edu/chemicalengineering

Courses Offered

600. Process Engineering (I; 4, 2)
Applications of engineering, economic, environmental, and ethical principles in preliminary process design. Problem definition, literature survey, flowsheet development, material and energy balances, equipment design and profitability analysis. Open only to students without previous process design course work.

610. Advanced Process Engineering (II; 4, 2)
Applying principles of process synthesis and analysis to evaluate the economic potential of alternate flowsheets using sophisticated computer-aided design tools, such as process simulators. Tasks include HAZOP analysis, separation sequence selection, energy integration, parametric and continuous-variable optimization, and technical report writing. Prerequisite: permission of the instructor.

640 and 642. Chemical Engineering Projects (I and II; R; 1, 8) Half to two courses
Individual research, development, or design projects. Problem analysis involving collection, correlation, and interpretation of experimental data, or a mathematical modeling study. Prerequisite: permission of the instructor.

644. Green Engineering (II; 4, 0)
Economic design of processes and products that reduce the generation of pollution as well as risk to human health and the environment. Risk assessment, evaluation and prediction of toxicity and fate of chemicals, and environmental performance analysis applied to chemical products and processes. Prerequisite: permission of the instructor.

650. Polymer Science (I or II; 3, 3)
The chemistry and kinetics of polymerization. Polymerization processes and polymer processing. Properties and application of polymers.

651. Applied Process Analysis (II; 3, 2)
Exploration of computer-assisted solutions of chemical processing problems in fluid flow, thermodynamics, heat and mass transfer, reaction kinetics, engineering design and economics. Application of software systems, such as spreadsheet, symbolic processor, numeric computation and visualization environment, optimizer, and process simulator.

652. Bioprocess Engineering (I or II; 4, 0)
Survey course in biochemical engineering. Introduction to microbiology, biochemistry, cell metabolism and genetic

control. Enzyme structure and function; enzyme kinetic mechanisms. Emphasis on the design of biochemical reactors and separation processes utilizing fundamental principles of kinetics, thermodynamics and heat, mass and momentum transfer. Prerequisite: permission of the instructor.

653. Product and Process Chemistry (II; 4, 0)
Examination of the internal structure of the chemical industry. The roles of key chemicals and intermediates in modern chemical synthesis will be emphasized to provide an overview of current industrial product methods. Process history, design and improvement will be covered through discussions, simulations and case studies. Prerequisite: permission of the instructor.

655. Atmospheric Chemistry and Physics (I; 4, 0)
Addresses the relationships of chemistry, physics, and engineering principles in understanding processes in the Earth's atmosphere. Topics include overview of the Earth's atmospheric history and problems of current environmental concerns including urban ozone, acid rain, particulate pollution, and global change. Prerequisite: permission of the instructor

657. Applied Colloid, Surface, and Nanoscience (I; 4, 0)
Exploration of the ways in which surfaces are different from bulk substances, and how this impacts processes such as illness, chemical processing, contaminant transport, and enzymatic activity. The topics discussed will be shaped by student interest. Prerequisite: permission of the instructor

660. Biomaterials: Materials in Medicine (I or II; 4, 0)
Classes of biomaterials, their applications, and current trends in biomaterials research and technology. Medical/ ethical implications of biomaterials development and research

670 and 672. Special Topics in Chemical Engineering (I and II; R; 4, 0)
Advanced in-depth courses developed from areas of chemical engineering science or technology. Prerequisite: permission of the instructor.

680. Graduate Research and Thesis (I or II; 1, 6-12)
Individual graduate-level investigations culminating in a thesis. Required for the master of science in chemical engineering degree.

681. Topics in Reaction Engineering (I or II; 4, 0)
Reactor design and analysis applied to specific systems. Complex chemical reaction networks with emphasis on nonideal flow and transport effects on heterogenous reactors. Prerequisite: permission of the instructor.

682. Topics in Chemical Engineering Applied Mathematics (I or II; 4, 0)
Analytical and numerical methods for ordinary and partial differential equations with problems drawn from chemical engineering. Topics include transform methods, matrix methods, weighted-residual methods, and finite differences. Prerequisite: permission of the instructor.

683. Topics in Chemical Engineering Thermodynamics (I or II; 4, 0)
Advanced study of thermodynamics applied to fluid flow, heat transfer, gas compression, air conditioning, refrigeration, and chemical equilibria.

685. Topics in Transport Theory (I or II; 4, 0)
Mass, energy, and momentum transfer in continuous media. General equations of transfer developed and used to analyze real systems.

686. Advanced Transport Theory (II; 4, 0)
Turbulent momentum, energy and mass transport. Interphase transport phenomena. Transport of heat, mass, and momentum in lumped systems. Radiant energy transport. Prerequisite: CHEG 685.

687 and 688. Advanced Study in Chemical Engineering (I and II; R; 4, 0)
Courses in chemical engineering theory designed to meet the needs of graduate students in residence.

695. Advanced Topics in Engineering Mathematics
Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications.

Civil Engineering (CENG)

570-577-1112
www.bucknell.edu/CivilEngineering

Professors: Jeffrey C. Evans (chair), Ph.D. Lehigh. Matthew Higgins, Ph.D. Virginia Polytechnic Instiitute and State University. Richard G. McGinnis, Ph.D. California-Berkeley. James G. Orbison, Ph.D. Cornell. Thomas D. DiStefano, Ph. D. Cornell. Ronald D. Ziemian, Ph.D. Cornell.

Associate Professors: Steven G. Buonopane, Ph.D. John Hopkins University. Richard D. Crago, Ph.D. Cornell. Michael A. Malusis, Ph.D Colorado State. Michael Toole, Ph.D. Massachusetts Institute of Technology.

Assistant Professors: Douglas Gabauer, Ph.D Virginia Polytechnic & State University. Kevin Gilmore, Ph.D Virginia Polytechnic & State University. Jessica Newlin, Ph.D Penn State University. Kelly A. Salyards, Ph.D. Pennsylvania State University.

Areas of Concentration

Faculty research interests emphasize the following areas: environmental engineering, soil mechanics and foundation engineering, structures, transportation, water resources, computer graphics, computer-aided design, railroad engineering, engineering mechanics, timber structures, pavement design, and materials performance and characterization, construction safety and innovation.

Current research topics are: vertical subsurface barriers for the remediation of hazardous waste sites; transformation of slurry trench cutoff wall materials from the passive hydraulic barrier materials into active treatment materials while maintaining their passive hydraulic barrier characteristics; flow in compounds section open channels with mixed flow at a free overfall; interaction of main channel and flood flows in unsteady flow; design of steel structures using advanced methods of analysis; appropriateness of existing numerical models for nonlinear transport processes in environmental systems; pedestrian safety; guardrails and median barrier crash worthiness; tests of open web steel joist; full-scale tests of metal-plated timber trusses; rotational stiffness of truss heel joints; stiffness coefficients of metal plated connected truss joints with varying direction of loading between grain angles and metal plate axis; in-situ nondestructive testing of timber structural members; vibration serviceability; the diffusion of having engineers and architects design for construction safety; biodegradation of municipal solid waste in engineered reactors; coagulation, flocculation and sedimentation in aqueous systems; mitigation of odor potential at wastewater and solid waste treatment facilities; bioremediation of contaminated ground water; adsorption of heavy metals by microorganisms; characterization of pollution from agricultural sources; biological conversion of waste materials to useful forms of energy, such as methane and hydrogen, lifecycle analysis of engineered environmental systems.

Thesis

The thesis is considered a contribution to the education of the candidate and normally results in an original contribution to the body of engineering knowledge. Thesis requirements in civil engineering may be satisfied by:

1. an experimental or theoretical research project;
2. an exercise in solving a practical engineering problem involving novel features, which may or may not comprise design, and with or without required experimental verification. The thesis is followed by a final oral or written examination that must be passed at least two weeks before the degree is to be received.

Facilities and Courses

Thesis work can be conducted in any of the current research areas in the department or in any area acceptable to the adviser and the department. Excellent computational and experimental facilities are available, including university computing resources and laboratory facilities for computer-aided engineering and design, materials testing, structural testing, dynamic materials characterization, geotechnical engineering, environmental engineering, and fluid mechanics and hydraulics. The following describes the courses offered by the department.

Note that not all courses are taught every year. A total of seven and one-half course credits, including the thesis, is required for the MSCE degree.

Courses Offered

600. Design in Structural Engineering (I; 3, 3)
First assumptions, selection of initial sections, connect design, beam-columns design, and procedure to follow after making a first choice so as to arrive at a final design; major national specifications affecting designs such as AISC, AASHTO 1996, ACI, ASCE 7-95 Standard, and various building codes. Prerequisite: permission of the instructor.

601. Advanced Reinforced Concrete Design (I; 4, 0)
Behavior and design of reinforced concrete beams, beam columns, slender columns, footings, retaining walls, and abutments; introduction to two-way slab behavior and design. Prerequisite: permission of the instructor.

602. Structural Theory II (II; 4, 0)
Analysis of statically indeterminate structures, comprehensive study of the flexibility and stiffness methods in conjunction with the digital computer; computer graphics. Prerequisite: permission of the instructor.

603. Wood Engineering Design Principles (II; 3, 3)
Wood properties as construction materials; beams, columns, connections, and fasteners. Glue-laminated timber and other uses for timber framed structures in accordance with the 1997 National Design. Prerequisite: permission of the instructor.

604. Structural Dynamics (I or II; 4, 0)
Analysis and design of structure subjected to dynamic loads, i.e. earthquake, wind gust, blast pressure, moving loads, machine foundations, etc. Prerequisite: permission of the instructor.

605. Advanced Structural Steel Design (I or II; 4, 0)
Connection design and performance, plastic analysis, load and resistance factor design, stability of compression members, composite construction. Prerequisite: permission of the instructor.

606. Advanced Structural Stability (II; 2, 2)
Provides a detailed treatment of the buckling characteristics of various structural elements and presents the different analytical methods used in the solution of stability problems.

607. Prestressed Concrete (I or II; 4, 0)
Analysis and design of various types of prestressed concrete units and structures with consideration of shear stresses and deflection, prestress losses, composite construction, and fabrication methods.

608. Finite Element Methods (AI; 3, 3)
Fundamental theory and applications for civil engineering, mechanical engineering, and engineering mechanics stress analysis problems. One-, two-, and three-dimensional elements, and axisymmetric elements, and their formulations; stress recovery techniques; modeling considerations; convergence criteria and error estimates; includes use of commercial and developmental finite element analysis programs.

609. Advanced Mechanics of Materials (I or II; 4, 0)
Unsymmetrical bending, torsion, plates, beams on elastic-foundations, plasticity, elastic stability.

619. Advanced Topics in Structural Engineering (I or II; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

621. Hydrology (I or II; 3, 3)
The interrelation of meteorological conditions, precipitation, surface runoff, and groundwater storage. Prerequisite: permission of the instructor.

622. Open Channel Flow (I or II; 4, 0)
Steady flow with the continuity, energy, momentum, and flow resistance equations; flow profiles; channel controls

and transitions; introduction to unsteady flow.

629. Advanced Topics in Water Resources (I or II; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

631. Urban and Regional Planning (I or II; 4, 0)
Problems of urban and regional planning and the treatment of various factors of a comprehensive plan. Emphasis on the interrelationships among engineering, sociology, geography, and economics.

632. Transportation Policy and Planning (I or II; 4, 0)
Analysis of policy in a social and environmental context. Transportation supply, demand, and pricing. Evaluation of alternative plans. Analysis of transportation benefits and costs.

633. Mass Transportation Seminar (II; 4, 0)
A pragmatic analysis of mass transportation, its history, present condition, and future; with emphasis on the social and economic aspects of transit. Prerequisite: permission of the instructor.

634. Innovative Transportation Engineering (II; 4, 0)
Innovative concepts in the field of transportation engineering, including planning techniques, such as context-sensitive design and GIS and engineering/design/operations techniques, including roundabouts, traffic calming, andITS. Prerequisite: CENG 330 or permission of the instructor.

639. Advanced Topics in Transportation (I or II; R; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

640. Physical/Chemical Treatment Processes (I or II; 3, 3)
Fundamental principles of physical and chemical treatment processes used to treat air and water pollution, such as ion-exchange, coagulation, sedimentation, filtration, air stripping, disinfection, adsorption, and membrane processes. Laboratory experiments are used to reinforce theory and to develop design criteria
for full-scale treatment processes. Prerequisite: permission of the instructor.

641. Environmental Engineering Biotechnology (I or II; 3, 3)
Theory and design of biological waste treatment facilities. Conversion of waste materials to useful forms of energy and life-cycle analysis of engineered environmental systems. Biological treatment of industrial wastes and bioremediation of hazardous wastes. Prerequisite: permission of the instructor.

642. Solid Waste Management (I or II; 4, 0)
This course covers the technology, policy, and management of municipal solid waste generation. Topics include recycling, material recovery, waste reduction, landfilling, and combustion.

644. Hazardous Waste Management (I or II; 3, 3)
Toxicology, industrial waste pretreatment, stabilization techniques, facilities siting, secure landfill design, incineration, legal and liability issues, public participation, remedial action, and emergency response. Prerequisite: permission of the instructor.

645. Environmental Engineering Chemistry (I or II; 3, 3)
Principles of aquatic chemistry and applications with emphasis on acid-base reactions, solubility, precipitation, and oxidation reduction reactions in water. Prerequisite: permission of the instructor.

646. Water Treatment Design (I or II; 4, 0)
Design of water supplies, water treatment plants, distribution systems, sewers and wastewater treatment plants. Environmental and economic impact. Prerequisite: permission of the instructor.

647. Air Pollution Control (I; 3, 1)
Historical perspective on air pollution in the United States, measurement of air quality, meteorology and climatology, modeling of atmospheric dispersion, sources of air pollution — stationary sources and mobile sources, health effects, control of gaseous and particulate emissions, global problems such as greenhouse
gases and ozone, regulatory and legal concerns. Prerequisite: permission of the instructor.

648. Environmental Engineering Unit Operations and Processes (I or II; 3, 3)
Fundamental principles of physical, chemical, and biological systems used in the treatment of air, soil and water in the field of environmental engineering. Prerequisite: permission of the instructor.

649. Advanced Topics in Environmental Engineering (I or II; R; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

650. Foundation Engineering (I or II; 3, 3)
Application of the theories and principles of soil mechanics to foundation design. Subsurface investigations; methods of analysis, design, and construction of foundations; bearing capacity and settlement of shallow and deep foundations; excavation and bracing; earth structures. Prerequisite: permission of the instructor.

651. Environmental Geotechnology (II; 3, 3)
Interaction between hazardous and toxic wastes and geotechnical properties of soils. Hazardous and toxic wastes in the subsurface environment. Prerequisite: permission of the instructor.

652. Ground Improvement Engineering (I or II; 3, 3)
Application of soil mechanics principles to improving the engineering characteristics of soils. Includes mechanisms of soil stabilization, grouting, deep dynamic compaction, reinforced earth, sand drains, and preconsolidation. Prerequisite: permission of the instructor.

653. Advanced Soil Mechanics (I or II; 3, 3)
Advanced study of the theories of strength, hydraulic conductivity and compressibility. Critical review of soil origin and composition effects upon the physical and engineering properties of soils. Introduction to soil dynamics. Planning, execution, and interpretation of soil testing programs. Prerequisite: permission of the instructor.

659. Advanced Topics in Geotechnical Engineering (I or II; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

671. Architectural Engineering (I or II or S; 4, 0)
Introduction to the engineering of buildings, methods and materials of construction; design of windows and wall systems; design and specifications of mechanical systems. Prerequisite: permission of the instructor.

672. Construction Engineering (II; 3, 4)
Construction materials and processes; contracting, planning and scheduling; estimating and project control.

680. Special Topics in Civil Engineering (I or II; R) Half to full course
Individual projects in laboratory work, design, or library studies, depending upon the nature of the problem selected.

699. Thesis (I and/or II)
Research on the graduate level under the direction of a faculty member.

Electrical Engineering (ELEC)

570-577-1234
www.bucknell.edu/ElectricalEngineering

***Professors**:* Maurice F. Aburdene (chair), Ph.D. Connecticut. Richard J. Kozick, Ph.D. University of Pennsylvania. Edward J. Mastascusa, Ph.D. Carnegie Mellon.

Assistant Professors: David Kelley, Ph.D. Pennsylvania State University. Jie Lin, Ph.D. University of Maryland. Kundan Nepal, Ph.D. Brown University. Robert Nickel, Ph.D. University of Michigan. Michael Thompson, Ph.D. Virginia Polytechnic Institute and State University.

Areas of Concentration

The faculty research interests emphasize the following areas: antenna design, control systems, computer architecture and performance, computer networks, electromagnetics, digital system design, digital signal and image processing,

simulation, communication systems, power electronics, VLSI, optoelectronic materials and devices, optical signal processing and devices.

Thesis

The thesis is considered primarily a contribution to the education of the candidate rather than a contribution of knowledge. Thesis requirements in electrical engineering may be satisfied by one of the following:

1. an exercise in solving a practical engineering problem involving novel features, which may or may not comprise design;
2. an exercise designed to develop research ability rather than to demonstrate research performance;
3. an experiment or theoretical research project. A final oral or written examination must be passed at least two weeks before the degree is to be received.

Facilities and Courses

A wide range of microprocessors, high-speed digital signal processors, optoelectronics equipment, and computer-aided design software is available for graduate work. A total of eight course credits, including the thesis, is required for the MSEE degree.

Courses Offered

608 and 609. Advanced Electrical Engineering Laboratory (I or II; R) Special laboratory work, by permission.

610. Biomedical Signal Processing and Instrumentation (I or II; 3)
Basics of biomedical signal processing and instrumentation, general design principles. Semester-long project to design a device for use in a biomedical application. Teams conceptualize, design, and implement class projects using appropriate analog and digital instruments.

611. Neural Signals and Systems (I or II; 3, 2)
Introduction to neural systems and signaling. Topics include neural physiology, factors affecting action potential generation, modeling of cellular membrane dynamics, and stimulation intensities and waveforms that produce neural and muscular responses.

628 and 629. Advanced Electrical Engineering Problems (I or II; R) One-half or one course credit Problems in electrical engineering theory adapted to the needs of the student.

642. Digital VLSI Circuit Design (I or II; 3, 3)
Introduction to digital integrated circuit design, from wafer fabrication through structured design techniques. Teams conceptualize, design, simulate, layout, extract, and verify small VLSI systems using appropriate CAD tools. Prerequisite: permission of the instructor.

643. High Performance Computer Architecture (I or II; 3, 0) Topics include "good" computer architecture, RISC/CISC, pipelining, superscalar, super-pipelining, out-of-order execution, speculative execution, virtual memory, caches, and cache coherence. Prerequisite: permission of the instructor.

644. Advanced Digital Design (I or II; 3, 3)
Hardware description languages. High-level synthesis. Logic synthesis. Field programmable gate-array architectures and applications.

645. Simulation (I or II; 3, 3) Digital simulation of continuous systems; digital integration algorithms; simulation languages; discrete modeling and simulation of dynamic systems; and simulation of stochastic systems. Prerequisite: permission of the instructor.

652. Power Electronics (AI; 3)
Design and analysis of solid-state power conversion systems. Circuit theory, computer-based modeling, and analytical

tools for efficient electronic conversion, control, and conditioning of electric power.

660. Optoelectronic Materials and Devices (I or II; 3, 3)
Introduction to the principles and applications of optoelectronic devices, including compound semiconductors, LEDs, lasers, photodetectors, waveguide couplers and modulators. Switching and logic devices. Prerequisite: permission of the instructor.

662. Fiber Optics Fundamentals (I or II; 3, 3)
Applications of Maxwell's equations, dielectric planner waveguides, optical modes in fibers. Fiber dispersion and loss mechanism. Optical fiber data transmission link and components. Fiber fabrication techniques. Prerequisite: permission of the instructor.

663. Introduction to Mechatronics (I; 2, 2)
Mechatronics is a multidiscipline technical area defined as the synergistic integration of mechanical engineering with electronic and intelligent computer control in the design and manufacture of industrial products and processes. This design-directed course covers topics such as actuators and drive systems, sensors, programmable controllers, microcontroller programming and interfacing, and automation systems integration.

670. Communication and Information Systems (I or II; 3, 0)
Digital and analog communication systems, modulation techniques, noise considerations, optimum receivers. Prerequisite: permission of the instructor.

671. Random Signals and Noise (II; 4, 0)
Mathematical method of describing and analyzing random signals and noise. Probability theory; random processes. Time and ensemble averages, correlation, and power spectra. Linear filtering. Detection and estimation of signals in noise. Prerequisite: permission of the instructor.

672. Digital Signal Processing (II; 3, 2)
Sampling A/D and D/A conversion; digital filters; recursive and nonrecursive designs, quantization effects; Fast Fourier Transform; spectral estimation; computer implementations; applications. Prerequisite: permission of the instructor.

674. Digital Image Processing (AI; 3, 0)
Introduction to the basic concepts and technique of digital image processing. Characterization and representation of images. Image enhancement. Image restoration. Image analysis. Image coding and reconstruction. Prerequisite: permission of the instructor.

675. Computer Communication Networks (II; 3, 0)
An introduction to packet-switched networks (land-based point-to-point networks, satellite networks, and ground radio networks). Experience with existing networks. Operational procedures. Design issues and modeling techniques.

677. Topics in Wireless System Design (I or II; 3, 3) Introduction to various aspects of wireless communication system design, including RF circuit design, antennas, radioware propagation and computer simulation.

681. Advanced Control Systems (II; 3, 3) Nonlinear control systems; signal-flow diagrams; statistical design; sampled data techniques. Prerequisite: permission of the instructor.

683. Fuzzy Systems and Neural Networks (I or II; 3, 3) Fuzzy logic and fuzzy control systems. Neural networks and adaptive fuzzy systems. Adaptive algorithms for neural networks.

692. Antennas and Microwave Techniques (I or II; 3, 3) Fundamentals of antenna analysis and design. Survey of antenna types, including dipole and monopole antennas, directive antennas, microstrip patch antennas, aperture antennas, and phased arrays. Microwave system design issues, including impedance matching, radiowave propagation, transmission lines, and radiation patterns. Prerequisite: permission of the instructor.

693. Electric Power Systems (I or II; 3, 0) Analysis of power distribution, load control, economics of operation, symmetrical and unsymmetrical faults, stability and issues in deregulation.

699. Thesis (I or II) A professional-level investigation under the direction of a staff member; required for master of science in electrical engineering degree.

Environmental Engineering (EVEG)

570-577-1112
www.bucknell.edu/CivilandEnvironmentalEngineering

Professor: Jeffrey C. Evans, Ph.D. Lehigh.

Associate Professors*:* Richard D. Crago, Ph.D. Cornell. Thomas D. DiStefano, Ph.D. Cornell. Matthew Higgins, Ph.D. Virginia Polytechnic Institute and State University.

Assistant Professor*:* Michael A. Malusis, Ph.D. Colorado State.

Areas of Concentration

Faculty research interests emphasize the following areas: biodegradation of municipal solid waste and aqueous organics; biological conversion of waste materials to useful forms of energy, such as methane and hydrogen; life-cycle analysis of engineered environmental systems; bioremediation of contaminated ground water; coagulation, flocculation, and sedimentation in aqueous systems; mitigation of odor potential at wastewater and solid waste treatment facilities; bioremediation of contaminated ground water; environmental geotechnics; vertical subsurface barriers for the remediation of hazardous waste sites; transformation of slurry trench cutoff wall materials from the passive hydraulic barrier materials into active treatment materials while maintaining their passive hydraulic barrier characteristics; watershed processes and land surface-atmosphere interactions; appropriateness of existing numerical models for nonlinear transport processes in environmental systems; adsorption of heavy metals by microorganisms; characterization of pollution from agricultural sources.

Potential Applicants

Applicants who have earned a Bachelor of Science degree in any engineering discipline, environmental science, biology, chemistry, or physics will be considered for admission. Some students may be required to successfully complete prerequisite courses in addition to graduate level courses and thesis.

Thesis

Refer to the Civil Engineering graduate program for details.

Facilities and Courses

Excellent computational and experimental facilities are available, including university computing resources and laboratory facilities for instrumental analysis, bench-scale reactor operation, maintenance of aerobic and anaerobic systems, environmental geotechnics, fluid mechanics and hydraulics. The following describes the courses offered by the Civil and Environmental Engineering Department. Courses offered by other departments include BIOL634 Limnology, BIOL602 Microbiology, GEOL624 Hydrogeology, GEOL601 Geophysics, and CHEM651/652 Biochemistry.
Note that not all courses are taught every year. A total of seven and one-half course credits, including the thesis, is required for the MSEV degree.

Courses Offered

621. Hydrology (I or II; 3, 3)
The interrelation of meteorological conditions, precipitation, surface runoff, and groundwater storage. Prerequisite: permission of the instructor.

622. Open Channel Flow (I or II; 4, 0) Steady flow with the continuity, energy, momentum, and flow resistance equations; flow profiles; channel controls and transitions; introduction to unsteady flow.

629. Advanced Topics in Water Resources (I or II; 4, 0) Topics will vary. Prerequisite: permission of the instructor.

640. Physical/Chemical Treatment Processes (I or II; 3, 3)
Fundamental principles of physical and chemical treatment processes used to treat air and water pollution, such as ion-exchange, coagulation, sedimentation, filtration, air stripping, disinfection, adsorption, and membrane processes. Laboratory experiments are used to reinforce theory and to develop design criteria for full-scale treatment processes. Prerequisite: permission of the instructor.

641. Environmental Engineering Biotechnology (I or II; 3, 3)
Theory and design of biological waste treatment facilities. Conversion of waste materials to useful forms of energy and life-cycle analysis of engineered environmental systems. Biological treatment of industrial wastes and bioremediation of hazardous wastes. Prerequisite: permission of the instructor.

642. Solid Waste Management (I or II; 4, 0)
This course covers the technology, policy, and management of municipal solid waste generation. Topics include recycling, material recovery, waste reduction, landfilling, and combustion.

644. Hazardous Waste Management (I or II; 3, 3)
Toxicology, industrial waste pretreatment, stabilization techniques, facilities siting, secure landfill design, incineration, legal and liability issues, public participation, remedial action, and emergency response. Prerequisite: permission of the instructor.

645. Environmental Engineering Chemistry (I or II ; 3, 3)
Principles of aquatic chemistry and applications with emphasis on acid-base reactions, solubility, precipitation, and oxidation reduction reactions in water. Prerequisite: permission of the instructor.

646. Water Treatment Design (I or II; 4, 0)
Design of water supplies, water treatment plants, distribution systems, sewers and wastewater treatment plants. Environmental and economic impact. Prerequisite: permission of the instructor.

647. Air Pollution Control (I; 3, 1)
Historical perspective on air pollution in the United States, measurement of air quality, meteorology and climatology, modeling of atmospheric dispersion, sources of air pollution — stationary sources and mobile sources, health effects, control of gaseous and particulate emissions, global problems such as greenhouse
gases and ozone, regulatory and legal concerns. Prerequisite: permission of the instructor.

648. Environmental Engineering Unit Operations and Processes (I or II; 3, 3)
Fundamental principles of physical, chemical, and biological systems used in the treatment of air, soil, and water in the field of environmental engineering. Prerequisite: permission of the instructor.

649. Advanced Topics in Environmental Engineering (I or II; R; 4, 0)
Topics will vary. Prerequisite: permission of the instructor.

651. Environmental Geotechnology (II; 3, 3)
Interaction between hazardous and toxic wastes and geotechnical properties of soils. Hazardous and toxic wastes in the subsurface environment. Prerequisite: permission of the instructor.

699. Thesis (I and/or II)
Research on the graduate-level under the direction of a faculty member.

Mechanical Engineering (MECH)

570-577-3193
www.bucknell.edu/MechanicalEngineering

Professors: James W. Baish (co-chair), Ph.D. University of Pennsylvania. Keith W. Buffinton (co-chair), Ph.D. Stanford University. Thomas P. Rich, Ph.D. Lehigh University. Steven B. Shooter, Ph.D. Virginia Polytechnic Institute and State University.

Associate Professors: Charles W. Knisely, Ph.D. Lehigh University. Peter C. Stryker, Ph.D. University of Minnesota. Constance W. Ziemian, Ph.D. Pennsylvania State University.

Assistant Professors: M. Laura Beninati, Ph.D. University of Iowa. Charles J. Kim, Ph.D. University of Michigan. Christopher L. Mordaunt, Ph.D. Pennsylvania State University. Mala M. Sharma, Ph.D. Pennsylvania State University.

Requirements

The mechanical engineering department requires six graduate level courses and a thesis for the master's degree. Of these six courses, five must be in the department of mechanical engineering; one may be a graduate level course in physics or in the College of Engineering.

Research Areas

Faculty research interests are in the following areas: acoustics, bioengineering, bluff body aerodynamics, building energy conservation, combustion processes, composite materials, computational fluid dynamics (CFD), computer-aided design, computer-aided materials testing, computer-based mechanics, computer modeling of engineering systems, design theory and methodology, energy for transportation, flow-induced noise and vibration, fluid dynamics, fracture mechanics, heat transfer, hybrid powertrains, internal combustion engines, robotics, air-borne contaminant transport modeling, history of technology, nano materials, environmental degradation, materials processing.

Thesis

The master's thesis is regarded as both education for the candidate and a contribution to public knowledge. This requirement of a 1.5 course credit thesis in the mechanical engineering department may be satisfied by:

1. an exercise utilizing novel approaches to solve a practical engineering problem;
2. an exercise designed to develop research ability and to demonstrate research performance;
3. an experimental or theoretical research project. A final oral examination must be passed at least two weeks before the degree is to be received. The students must defend a thesis proposal prior to registration for thesis credit.

Facilities and Courses

Thesis work may be conducted in the following laboratories: hybrid powertrain laboratory, bioengineering, composite materials, compressible flow, computeraided engineering and design, computational mechanics and fracture mechanics, materials characterization and nondestructive evaluation laboratory, heat transfer, product development, thermal-fluids-energy, robotics, and wind tunnel facilities.

Courses Offered

622. Advanced Energy Conversion (I or II; 4, 0)
Application of thermodynamic principles to alternate energy sources and advanced energy systems. Investigation of solar, geothermal, wind, tidal, and hydroelectric power and the operation of fuel cells, magnetohydrodynamic generators, and photovoltaic, thermoelectric and thermionic devices. Open to
seniors and graduate students only. Prerequisite: MECH 216 or permission of the instructor.

624. Internal Combustion Engines (I; 4, 0)
Description of internal combustion engines, methods of evaluating performance, the thermodynamics of combustion, engine testing and design. Prerequisites: MECH 216 and MECH 312 or permission of the instructor.

632.Compressible Fluid Dynamics (I or II; 4, 0)
Compressible flow, shock wave phenomena, potential flow, two-dimensional flow, numerical methods, acoustic wave propagation. Selected laboratory exercises. Prerequisites: MECH 213, MECH 313, and ENGR 214 or permission of the instructor.

635. Aerodynamics (I or II; 4, 0) Two-dimensional flow theory; vortex and momentum theories of finite wings; viscous flows, boundary layers and drag; high lift devices; lectures augmented by wind tunnel studies. Prerequisite: MECH 313 or permission of the instructor.

645. Engineering Acoustics and Noise Control (I or II; 4, 0)
Fundamentals of sound; instrumentation for noise measurement and analysis; sound sources, sound power; sound in enclosed areas; acoustic enclosures; muffling devices; vibration control; noise control of typical devices. Prerequisite: permission of the instructor.

646. Flow-induced Noise and Vibration (I or II; 4, 0)
Classification of flow-induced vibration; turbulence excitation; gust excitation; vortex shedding; galloping and stall flutter; flutter; impinging shear layers; cylinders and tube bundle vibrations; resonators and noise generation. Prerequisite: ENGR 222 or MECH 313 or permission of the instructor.

652. Advanced Dynamics (I or II; 4, 0) Kinematics and dynamics of particles and rigid bodies. Degrees of freedom. Partial velocities. Generalized active and inertia forces. Kane's equation. Lagrange's equation. Numerical simulation of motion. Prerequisite: MECH 252 or permission of the instructor.

653. Robotics (I or II; 4, 0)
History, evolution, capabilities, and applications of robotic devices. Introduction to robot kinematics, dynamics, and control. Research into current topics in robotics. Development and implementation of robotic operations using model and industrial robots. Prerequisite: MECH 252 or permission of the instructor.

660. Engineering Optimization (I or II; 4, 0)
Applied methods of linear, nonlinear, discrete, and global optimization. Numerical techniques for constrained and unconstrained problems. Emphasis on engineering applications and solution methods using Matlab. Prerequisite: permission of the instructor.

662. Computer Integrated Manufacturing (I or II; 4, 0)
Issues of integrated information in manufacturing systems. In-depth study of solid modeling. Computer control of manufacturing processes, computer-aided quality control, and computer-aided process planning. Prerequisite: MECH 355 or permission of the instructor.

663. Introduction to Mechatronics (I or II; 4, 0)
Mechatronics is a multidiscipline technical area defined as the synergistic integration of mechanical engineering with electronic and intelligent computer control in the design and manufacture of industrial products and processes. This design-directed course covers topics such as actuators and drive systems, sensors, programmable controllers, microcontroller programming and interfacing, and automation systems integration. Prerequisite: permission of the instructor. Crosslisted as ELEC 663.

664. Mechanism Design (I or II; 3,0)
Design of traditional and compliant mechanisms. Topics include kinematics, analytical and graphical synthesis methods, and topics in research. Prerequisite: MECH 353, MECH 392, or permission of the instructor.

666. Applied Fracture Mechanics (I or II; 4, 0)
Fundamentals of fracture mechanics and its applications to the design of damage tolerant structures. Case studies in the fields of aerospace, pressure, vessels, rotating machinery, railroads, etc. Illustrating fracture mechanics principles in design. Prerequisite: permission of the instructor.

667. Finite Element Methods (I or II; 3, 2)
Fundamental theory and applications for civil engineering, mechanical engineering, and engineering mechanics stress analysis problems. One-, two-, and three-dimensional elements, and axisymmetric elements, and their formulations; stress recovery techniques; modeling considerations; convergence criteria and error estimates, includes use of commercial and developmental finite element analysis problems. Prerequisite: CENG 402 or permission of the instructor. Crosslisted as CENG 408.

668. Applied Finite Element for Mechanical Design (I; 2, 3)
Practical uses of finite element software for problems common in research and mechanical design. Applications include sub-structure modeling, contact problems, stress concentrations and crack defects, elastic-plastic problems, and problems with dynamic loading. Prerequisite: MECH 302 or permission of the instructor.

670. Engineering Composite Materials (I or II; 4, 0)
Fundamental composite mechanics, including micromechanics and laminated plate theory. Design and analysis of composite structures; composite manufacturing techniques; current research topics in composite area. Prerequisite: MECH 353 or permission of the instructor.

676. Biomechanics (II; 4, 0)
Principles of mechanics applied to biological systems. Background in anatomy, physiology, and cell biology will be presented. Mechanical behavior of hard and soft biological materials. Topics in cellular, cardiovascular, musculoskeletal, implant, and sport/motion biomechanics. Prerequisite: permission of the instructor.

681. Engineering Analysis (I or II; 4, 0)
Advanced topics in mathematics and its applications in engineering. Both analytical and computational techniques may be included. Topics will be helpful to students considering graduate school. Prerequisite: permission of the instructor.

685. Advanced Engineering Problems (I or II; R; 2, 3) Half to full course An investigation under the direction of a staff member. Topics not covered in other courses may be studied in this course. Prerequisite: permission of the instructor.

686. Environmental Fluid Dynamics (I or II; 3, 0)
Environmental fluid flow in lakes, rivers, oceans, and the atmosphere; contaminant transport; mixing; reaction and particle dispersion processes; applications to natural and engineering systems. Prerequisite: MECH 313 or ENGR 222 or ENGR 233.

Courses offered occasionally: MECH 621 Advanced Engineering Thermodynamics; MECH 623 Thermal Environmental Engineering; MECH 630 Advanced Heat Transfer; MECH 631 Boundary Layers and Convection Heat Transfer; MECH 633 Advanced Fluid Mechanics; MECH 640 Turbomachinery; MECH 641 Gas Turbines; MECH 651 Vibration Analysis; MECH 665 Advanced Mechanics of Solids; MECH 671 Advanced Material Characterization; MECH 684 Special Topics

Graduate Studies Academic Requirements and Information

1. **CREDIT INFORMATION** - The unit of credit at Bucknell University is the course credit, which for transfer purposes is equivalent to four semester hours. Unless otherwise specified, a course listed in the project, except that a department may require seven course credits plus a master's essay or treatise or project report (which may equal one-half course credit) instead of a thesis.
2. **COURSE INFORMATION** - Courses with numbers at the 600-level are open to graduate students for graduate credit. Undergraduate students may register for the same course under the corresponding 300/400 number. In such courses graduate students are expected to perform at a significantly higher level and/or to submit additional assignments.
3. **MASTER OF ARTS REQUIREMENTS** - Candidates for the master of arts degree may be required by their department to demonstrate a reading knowledge of an approved foreign language. This requirement may be met by passing a reading test given by the appropriate department at Bucknell or by presenting evidence of having completed two years of college-level language study.
4. **GPA REQUIREMENT-** minimum cumulative grade point average of 3.0 is required of graduate students for all work attempted and must be attained upon completion of courses on the student's approved Program of Courses. No more than two courses of C or C+ work and no course with a grade of C- or below will be accepted toward the required number of courses for the master's degree. In computing the cumulative grade point average and determining good academic standing, all coursework is considered. Any student who does not maintain the minimum grade point average of 3.0 is liable to be dismissed.
5. **THESIS INFORMATION** - A thesis, treatise, or research/project report is required for all degrees and must be presented to the department at least three weeks before the last day of classes of the student's final semester. A final approved copy of the thesis must be delivered to the Office of Graduate Studies for approval of format on the last day of classes of the student's final semester. A final, approved, copy of the thesis must be submitted online to the University library, by the last day of the final exam period. Normally the master's essay, treatise, or project report is filed only in the department, unless otherwise required by the academic department, and a notice is sent to the Registrar's Office. The dean of graduate studies must approve essays and treatises for formatting only if they are to placed in the University library.
6. **GRADES** - All departmental requirements for the master's degree must be successfully completed and the results sent by the department chair to the registrar by the last day of classes of the student's final semester. This includes final reports for all courses taken prior to the current semester for which grades I or IP were reported.
7. **SEVEN YEAR LIMIT** - No course completed more than seven years before the degree is to be granted will be credited toward the master's degree. All graduate courses carrying the grade of I or IP which have not been completed within a seven-year period will revert to the grade of W (withdraw).
8. **INCOMPLETE GRADES** - All incomplete grades must be removed during the first three weeks after the close of the academic semester unless an extension is approved by the dean of graduate studies on the basis of special circumstances; all incomplete grades depending on laboratory work must be removed during the next semester in which the course is offered.

Disclaimer:

Nothing in this catalog may be considered as setting forth the terms of a contract between a student or prospective student and Bucknell University.

The matters covered in this catalog, including courses, curricula, and procedures described and the teaching personnel listed herein, are subject to change without prior notice at any time by action of Bucknell University.