

**Bucknell University**  
**Graduate Studies Catalog**  
**2015-17**

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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 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
- 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 situated on 450 acres in central Pennsylvania
- 3,500 undergraduate students, 100 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).
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.

Apply online or send your application materials to:  
**Office of Graduate Studies**  
**Bucknell University**  
**Lewisburg, Pennsylvania 17837.**

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## Procedures for Admission

Applicants will find the application form for admission to graduate studies on the Graduate Studies web page under "How to Apply". Students may complete the online application or request a printed application by contacting the Graduate Studies Office at 570-577-3655.

### Applicants for admission are required to furnish the following information:

1. Completed application form and the application fee of \$50. 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. Applicant must request letters from the recommenders. Letters should be sent directly from the recommenders to the Graduate Studies Office.
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.

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

**Be sure to include:**

- application form – can also be submitted online
- \$50 application fee – can also be submitted online
- personal statement – can also be submitted online
- two letters of reference
- official transcript from student undergraduate institution or institutions
- official GRE (required) 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.*

## **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

**Application Requirements**

- Minimum undergraduate GPA: 3.0
- Minimum TOFEL score of 100 points on internet-based test
- GRE scores
- 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 show financial proof to cover the cost of one year of attendance. Most graduate students cover the cost of attendance through the acceptance of a Graduate Assistantship which pays for tuition and fees plus a living stipend. Students with assistantships need to provide a bank statement showing proof of \$2,000 is required in order to confirm ability to pay for the mandatory student health insurance. Submit this bank statement to International Student Services at [iss@bucknell.edu](mailto:iss@bucknell.edu)

If the student does not have an assistantship, the student would need to provide a bank statement showing approximately \$34,950 which includes mandatory health insurance. (estimate reflects 2015-16 costs).

Prior to attendance at the university the student must contact International Student Services at [iss@bucknell.edu](mailto:iss@bucknell.edu) to request a Form I-20. If abroad, ISS will mail the form I-20 to the student. It is the student's responsibility to obtain a student visa (F-1 status) from a U.S. consulate in their home country or country of residence (outside of the U.S).

Active F-1 students within the U.S. may transfer their SEVIS record to Bucknell University while in active F-1 status, including OPT. Consult [www.bucknell.edu/iss](http://www.bucknell.edu/iss) for the SEVIS Transfer-In Form. Graduate students are not required to submit the \$500 deposit for Bucknell enrollment.

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 ([www.bucknell.edu/iss](http://www.bucknell.edu/iss)). Please note that Graduate students must use financial estimates designated for Graduate students.

International Student Orientation is required of all new international students. This program is scheduled approximately 10 days before the start of fall classes. Check the ISS website for the schedule:

[www.bucknell.edu/iss](http://www.bucknell.edu/iss).

**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 \$5,475 per course (2015-16 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. **Students will automatically be considered for financial assistance and do not need to submit a university financial aid form.**

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.

- **Graduate Assistantship** - includes a stipend and tuition remission and is available in the Animal Behavior, Biology, Chemistry, English, Mathematics 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 to those enrolled on the College Student Personnel program.
- **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 which permits concentration in College Student Personnel.

## 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 pursue 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 College Student Personnel concentration.

- **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](http://www.bucknell.edu/AnimalBehavior)

**Coordinating Committee:** Morgan Benowitz- Fredericks, Elizabeth Capaldi, Regina Paxton Gazes, Peter G. Judge (Director), Kevin P. Myers, DeeAnn M. Reeder, Jennifer R. Stevenson, Mizuki Takahashi.

The program is intended primarily for those who wish to later pursue 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.

### Admission Requirements

No specific undergraduate major is required, but successful candidates will demonstrate work in biology and/or psychology. GRE scores are required and subject GRE scores in biology and/or psychology are encouraged. 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.

### 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

*Elizabeth Capaldi* - Behavioral Biology, Insect behavior and Brain Structure

*Regina Gazes* – Evolutionary pressures and the development of cognitive abilities in primates

*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

*Morgan Benowitz-Fredericks* - Endocrinology & Avian life-history

*Mizuki Takahashi* - Evolutionary ecology, behavioral ecology, and conservation biology of amphibians

### 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
- Altered behavior in bats affected by 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

(Other 600-level courses from the Departments of Biology and/or Psychology can be included in the program of study after consultation with the advisor.)

### **609. Appetite and Eating Behavior. 1 Credit.; Lecture hours:3,Other:0**

Advanced seminar considering psychological factors involved in appetite food preferences, and food intake. Prerequisite: permission of the instructor.

### **614. Amphibian Biology and Conservation. 1 Credit. Fall Semester Only; Lecture hours:3, Other:3**

The biology of amphibians, including classification, physiology, reproduction, ecology, evolution, and conservation. Laboratory section will include identification of amphibians and field work to identify conservation issues surrounding local amphibian populations. Prerequisite: permission of the instructor.

### **619. Topics in Animal Behavior .5-1 Credits.Offered Both Fall and Spring; Lecture hours:3; Repeatable**

Occasional seminars on selected topics of current interest in animal behavior. Prerequisite: permission of the instructor.

### **620. Advanced Topics in Animal Behavior. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Culminating Experience seminar for senior animal behavior majors covering selected topics of current interest in animal behavior. Prerequisite: permission of the instructor.

### **621. Behavioral Ecology 1 Credit. Offered Fall Semester Only; Lecture hours:3**

The consideration of behavioral adaptations to various ecological situations. Topics include habitat choice, foraging behavior, defenses against predation, mate choice, and brood care. Prerequisites: permission of the instructor. Crosslisted as BIOL 621.

### **641. Evolution. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Survey of evolutionary processes, phenomena, and mechanisms. Topics covered may include natural selection, sexual selection, adaptation, evolutionary constraints, speciation, evolution and development, coevolution, behavioral evolution, and macroevolution.. Prerequisite: permission of the instructor. Crosslisted as BIOL 641.

### **642. Neuroethology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

A course that integrates neurobiology and behavior in natural contexts. Emphasis on signal detection, recognition, discrimination, localization, orientation, and the control of complex acts. Neuronal and hormonal mechanisms, ontogeny and evolution of behavior will be considered. Prerequisite: permission of the instructor. Crosslisted as BIOL 642.

### **654. Tropical Ecology. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

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 BIOL 654.

### **655. Social Insects. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Recitation:2; May require dissection or live animal experimentation**

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. Crosslisted as BIOL 655.

### **657. Ornithology 1 Credit. Offered Occasionally; Lecture hours:3,Other:3**

The biology of birds, including evolution, behavior, anatomy, physiology, ecology, and conservation; lab trips focus on identification of birds in the field. Prerequisite: permission of the instructor. Crosslisted as BIOL 657

**660. Graduate Research Offered Fall, Spring, Summer .5 to 1 credit**

Graduate research in animal behavior. Prerequisite: permission of the instructor. Crosslisted with BIOL 660.

**670. Primate Behavior and Ecology. 1 Credit. Offered Fall Semester Only; Lecture hours:3; May require dissection or live animal experimentation**

Introduction to research on prosimians, monkeys, and apes with emphasis on the evolutionary origin of diversity, habitat use, social structure, social behavior, and cognitive abilities Prerequisite: permission of the instructor. Crosslisted as BIOL/PSYC 670.

**671. Primate Cognition. 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3; May require dissection or live animal experimentation**

An investigation into the cognitive abilities and capacities of nonhuman primates emphasizing a comparative perspective. Prerequisite: permission of the instructor. Crosslisted as BIOL/PSYC 671.

**672. Evolution of Acquired Behavior. 1 Credit. Offered Both Fall and Spring; Lecture hours:3**

Advanced seminar exploring cognition and behavior from evolutionary and comparative perspectives. Topics will include social behavior, memory, communication, spatial cognition, learning, and meta-cognition. Prerequisite: permission of the instructor. Crosslisted as BIOL/PSYC 672.

**680. Thesis. Offered Fall, Spring, Summer.1 Credit**

Preparation of a thesis leading to the M.S. degree.

**686. Graduate Research. Offered Fall, Spring, Summer. .5-1 Credits.**

Graduate research in animal behavior. Prerequisite: permission of the instructor. Crosslisted with PSYC 686.

**691. Graduate Research Offered Fall, Spring, Summer. .5-1 Credits.**

Graduate research in animal behavior. Prerequisite: permission of the instructor.

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## Biology (BIOL)

570-577-1124

[www.bucknell.edu/Biology](http://www.bucknell.edu/Biology)

**Professors:** Mitchell I. Chernin (Chair), Kathleen C. Page, DeeAnn M. Reeder,

**Associate Professors:** Elizabeth Capaldi, Kenneth A. Field, Julie Gates, Mark F. Hausmann, Matthew B. Heintzelman (Associate Chair), Stephen D. Jordan, Christopher T. Martine, Matthew E. McTammany, Leocadia V. Paliulis, Marie C. Pizzorno, Mark D. Spiro, C. Tristan Stayton, Emily L. Stowe

**Assistant Professors:** Z. Morgan Benowitz-Fredericks, Joseph Johnson (visiting), Elizabeth C. Marin, Mizuki Takahashi

### 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 pursue 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.

### 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. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Lab:4**

Ultra-structure, behavior, metabolism, molecular biology, and development of micro-organisms. Roles in disease and food production. Laboratory will emphasize cultivation and identification. Prerequisite: permission of the instructor.

**604. Biology of Cancer. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

The study of the molecular and cellular mechanisms that create cancer. Prerequisite: permission of the instructor.

**609. Wildlife and Emerging Diseases. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3**

The study of the molecular and cellular mechanisms that create cancer. Prerequisite: permission of the instructor.

**612. Comparative Vertebrate Anatomy. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:3;  
May require dissection or live animal experimentation**

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. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3,Other:3;  
May require dissection or live animal experimentation**

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.

**614. Amphibian Biology and Conservation. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:3**

The biology of amphibians, including classification, physiology, reproduction, ecology, evolution, and conservation. Laboratory section will include identification of amphibians and field work to identify conservation issues surrounding local amphibian populations. Prerequisite: permission of the instructor. Crosslisted as ANBE 614.

**616. Plant Growth and Development. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3,Other:3**

The physiological and molecular bases of growth and development at the organ, tissue, and cellular levels. Effects of environmental stimuli and hormones on gene expression and the resultant changes at higher levels of organization. Prerequisite: permission of the instructor.

**618. Principles of Physiology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Lab: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. Prerequisite: permission of the instructor.

**619. 620. Seminar. Offered Either Fall or Spring; Lecture hours:Varies,Other:3; Repeatable**

**621. Behavioral Ecology 1 Credit. Offered Spring Semester Only; Lecture hours:3**

The 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. Crosslisted as ANBE 621.

**622. Physiological Mechanisms 1 Credit. Offered Alternating Spring Semester; Lecture hours:3**

Integration of cell and organ physiology; emphasis on protein, ion transport, nerve and muscle physiology, cardiovascular, renal, and respiratory systems. Prerequisite: permission of the instructor.

**623. Mammalian Histology 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other: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 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

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. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other: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. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:3**

Synthesis of DNA, RNA, and protein, and the regulation of these processes both prokaryotic and eukaryotic cells; laboratory experience in the manipulation and analysis of genes. Prerequisite: permission of the instructor.

**628. Endocrinology. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Problem Session:2**

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.

**630. Plant Systematics. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

Exploration of the diversity of plant life on Earth through lectures, labs, and field trips; includes biogeography, natural history, evolutionary relationships, ethnobotanical uses, and identification. Prerequisite: permission of the instructor. Crosslisted as BIOL 630.

**631. Genomics. 1 Credit. Offered Occasionally; Lecture hours:3,Other:2**

A computer research-based course in which students study the structure, content, expression and evolution of genomes. Prerequisites: permission of the instructor. Crosslisted as BIOL 631.

**632. Developmental Neurobiology. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Recitation:1**

Primary literature-based senior seminar on topics in developmental neurobiology. Prerequisites: permission of the instructor. Crosslisted as BIOL 632.

**634. Limnology. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:3**

The physical, chemical, and biological characteristics of freshwater communities are studied. Prerequisite: permission of the instructor.

**637. Biology of Aging. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

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. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:3;  
May require dissection or live animal experimentation**

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. 1 Credit. Offered Spring Semester Only; Lecture hours:2,Other: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. Crosslisted as CHEM 658.

**641. Evolution. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Survey of evolutionary processes, phenomena, and mechanisms. Topics covered may include natural selection, sexual selection, adaptation, evolutionary constraints, speciation, evolution and development, coevolution, behavioral evolution, and macroevolution. Prerequisites: permission of the instructor. Crosslisted as ANBE 641.

**642. Neuroethology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

A course that integrates neurobiology and behavior in natural contexts. Emphasis on signal detection, recognition, discrimination, localization, orientation, and the control of complex acts. Neuronal and hormonal mechanisms, ontogeny and evolution of behavior will be considered. Prerequisite: permission of the instructor. Crosslisted as ANBE 642.

**647. Virology. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**

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. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:3;  
May require dissection or live animal experimentation**

Development and function of the immune system in animals. The immune response in health and disease. Techniques in immunology. Prerequisite: permission of the instructor.

**651. Field Botany. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:1**

Outdoor field experience in plant diversity and ecology. Excursions to natural areas focused on identification, community dynamics, and ecological interactions/adaptations. Prerequisites: permission of the instructor. Crosslisted as BIOL 651.

**652. Cell Biology. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Lab:3**

Covers biomembranes, cell growth patterns, cell signaling, the cytoskeleton, cell organelles, and microscopic technique. Laboratory includes experience with cell culture. Prerequisite: permission of the instructor.

**653. Ecosystem Ecology. 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3,Recitation:1**

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. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

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. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Recitation:2**

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. Crosslisted as ANBE 655.

**657. Ornithology. 1 Credit. Offered Occasionally; Lecture hours:3,Other:3**

The biology of birds, including evolution, behavior, anatomy, physiology, ecology, and conservation; lab trips focus on identification of birds in the field. Prerequisite: permission of the instructor. Crosslisted as ANBE 657.

**658. Invertebrate Zoology. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3,Other:3**

A survey of 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. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3,Other: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. .5 to 2 Credits. Offered Either Spring or Fall****661. Systematic Biology. 1 Credit. Offered Occasionally; Lecture hours:3**

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. Prerequisites: permission of the instructor.

**665. Introduction to Microscopy. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other: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. 1 Credit. Offered Fall Semester Only; Lecture hours:3;****May require dissection or live animal experimentation**

Introduction to research on prosimians, monkeys, and apes with emphasis on the evolutionary origin of diversity, habitat use, social structure, social behavior, and cognitive abilities. Crosslisted as ANBE/PSYC 670.

**671. Field Entomology. 1 Credit. Offered Fall Semester Only; Lecture hours:2,Other:2**

Introduction to insects in their natural habitats, with emphasis on insect collecting, taxonomy, identification, ecology, and natural history. Students will make a professional-quality insect collection and acquire skills appropriate for biodiversity surveys. Prerequisites: permission of the instructor.

**680. Thesis. .5 to 1 Credits. Offered Either Spring or Fall**

## Chemistry(CHEM)

570-577-3258

www.bucknell.edu/Chemistry

**Professors:** Charles H. Clapp, George S. Shields (Dean of the College of Arts and Sciences), Robert A. Stockland, Timothy G. Strein, Eric S. Tillman, Brian W. Williams

**Associate Professors:** Dee Ann Casteel (Chair), Karen J. Castle, Molly M. McGuire, David S. Rovnyak, James S. Swan

**Assistant Professors:** Dabrina Dutcher (visiting), Rebecca L. Fagan, William D. Kerber, Michael R. Krout, Paul Kennedy (visiting)

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, inorganic, 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. **Associate 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.

*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.

*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; fluorenes

### **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 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Modern synthetic organic chemistry, with examples involving complex natural products. Application of organic mechanism, synthetic strategy, and advanced transformations to total synthesis.

**614. Mechanistic Organic Chemistry. 1 Credit. Offered Either Fall or Spring; Lecture hours:4,Recitation:2**

Thermal and kinetic aspects of organic reactions are discussed along with the effect of substituents, solvents, and stereochemistry on reaction pathways. Qualitative molecular orbit theory of organic compounds is covered in depth. Weekly problem sessions are held.

**617. Special Topics in Organic Chemistry. 1 Credit. Offered Either Fall or Spring**

Available by independent study. Prerequisite: permission of the instructor.

**622. Inorganic Chemistry II. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Lab:4**

Survey course in modern inorganic chemistry covering transition metal, coordination, organometallic, and bioinorganic chemistry. Laboratory will consist of synthetic and physical measurements as well as the manipulation of air-sensitive materials.

**627. Special Topics in Inorganic Chemistry. 1 Credit. Offered Either Fall or Spring; Lecture hours:4; Repeatable**

Topics vary. Available by independent study.

**632. Analytical Chemistry II. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Lab:4**

Theory and practice of techniques of instrumental analysis including spectrophotometry, fluorescence, mass spectrometry, atomic absorption, chromatography, capillary electrophoresis, and dynamic electrochemistry.

**637. Special Topics in Analytical Chemistry. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Available by independent study. Prerequisite: permission of the instructor.

**640. Biological Physical Chemistry. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:6**

Introduction to physical chemistry for life science students, with emphasis on thermodynamics, hydrodynamics and spectroscopy.

**641. Physical Chemistry I. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:5**

Introductory physical chemistry with emphasis on thermodynamics, kinetics, and electrochemistry.

**642. Physical Chemistry II. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:5**

Introductory physical chemistry with emphasis on quantum mechanics, structure and bonding, molecular spectroscopy and statistical mechanics. The customized laboratory experience will emphasize applications of spectroscopy and computational methods. Prerequisite: CHEM 641.

**643. Physical Chemistry for Engineers. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Recitation:1**

Introductory physical chemistry for engineers with emphasis on thermodynamics and electrochemistry.

**647. Special Topics in Physical Chemistry. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Available by independent study. Prerequisite permission of the instructor.

**651. Biochemistry I. 1 Credit. Offered Fall Semester Only; Lecture hours:4,Recitation:1**

Introduction to biological chemistry with emphasis on the structure and function of proteins, lipids, carbohydrates and nucleic acids, kinetics and mechanisms of enzymes, bioenergetics, and metabolism.

**652. Biochemistry II. 1 Credit. Offered Spring Semester Only; Lecture hours:4,Recitation:1**

Advanced topics in protein structure and function, protein folding, enzyme mechanisms, electron transport and free-energy coupling mechanisms, biosynthesis, metabolic regulation, and supramolecular assemblies.  
Prerequisite: CHEM 651 or permission of the instructor.

**657. Special Topics in Biochemistry. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:1**

Structure/function relationships and dynamics of biomolecules. Prerequisite: permission of the instructor.

**658. Biochemical Methods. 1 Credit. Offered Spring Semester Only; Lecture hours:2,Other:6**

A course in laboratory techniques including cell fractionation, protein, and nucleic acid analysis. Spectrophotometry, chromatography, centrifugation, electrophoresis, and mass spectrometry are emphasized.  
Prerequisite: permission of the instructor.

**660. Advanced Environmental Chemistry. 1 Credit. Offered Fall Semester Only; Lecture hours:4**

Chemistry of the atmosphere, hydrosphere and lithosphere. Natural processes and anthropogenic effects will be discussed. Prerequisite: permission of the instructor.

**675 and 676. Research .5-2 Credits. Offered Both Fall and Spring; Lecture hours:Varies,Other:Varies; Repeatable**

Original investigations in analytical, biological, organic, physical, environmental or inorganic chemistry.

**685 and 686. Seminar. .5 Credits. Offered Both Fall and Spring; Lecture hours:2; Repeatable**

Topics vary.

**699. Thesis. .5 – 1 Credit. Offered Either Fall or Spring****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](http://www.bucknell.edu/Education)

**Professor:** Katharyn E.K. Nottis

**Associate Professors:** Abra N. Feuerstein, Amy Golightly, Sue Ellen Henry, Lynn M. Hoffman, Robert M. Midkiff Jr. (Associate Provost), Sarah MacKenzie, Joseph L. Murray, Lori A. Smolleck (Chair).

**Assistant Professors:** Ramona Fruja, Richard B. Henne-Ochoa, Lakeisha D. Meyer

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 in Education (MSED) is offered in college student personnel. Detailed information about each of these programs can be obtained by contacting the education department or accessing the department webpage.

### Post Baccalaureate Teaching Certification

Post baccalaureate students may obtain teaching certification in Early Childhood Education (Pre-K -4); in Grades K-12 areas of art, French, German, Latin, Spanish, or music; and in Grades 7-12 in biology, chemistry, English, mathematics, physics, or social studies. Certification in general science and earth and space science may be obtained with majors in geology and biology, chemistry, or physics, respectively. Candidates may be recommended for a teaching certificate, but they will not earn a master's degree. However, selected courses may be taken for graduate credit.

A candidate must present an undergraduate transcript showing at least a 3.0 to be considered for admission to a teacher certification program. An individualized program of studies is created based upon a transcript review of prior relevant coursework and requirements for the desired certification. Generally, K-12 and secondary candidates should have an undergraduate major in the subject they want to teach. For the social studies certificate, an undergraduate major in anthropology, economics, geography, history, political science, psychology, or sociology is expected.

Candidates must present evident of clearances including Act 151 PA Child Abuse History; Act 34 PA Criminal History Record; and the FBI Criminal History (fingerprint check). In addition to relevant coursework and accompanying field experiences, all post baccalaureate candidates for teaching certification will be required to complete a semester of full time student teaching. Early childhood candidates should plan to student teach in the fall semester; all others student teach in the spring. All candidates must pass the tests mandated by PDE to be recommended for certification.

### Admission Requirements

Students desiring to pursue graduate work in education are required to meet the University's general admission requirements and regulations for graduate study at the University. 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.

### Graduate Requirements

Candidates for the Master of Science in Education (MSED) must complete a master's thesis or treatise. 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 the thesis option, an oral defense will substitute for the comprehensive written examination.

## Courses Offered

**601. Behavioral Assessment and Intervention. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:1**

Provides an understanding of applied behavior analysis (ABA) and its use in preventing and managing challenging behaviors that arise in classrooms and other settings.

**605. Cognitive Learning in Multiple Contexts. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3**

Both the theories and practical applications of cognitive psychology and development are emphasized. How theories connect to the field of cognitive neuroscience is also addressed. Prerequisite: permission of the instructor.

**608. Advanced Educational Foundations: Democracy and Education. 1 Credit.**

**Offered Spring Semester Only; Lecture hours:3**

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. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:4**

This course provides an introduction to counseling theory and basic micro-skills of counseling. Students will practice basic techniques of therapeutic interviewing.

**617. Problems in Education. .25-1 Credits. Offered Either Fall or Spring; Lecture hours:Varies; Repeatable**

Research on a problem not involved in a student thesis. Prerequisite: permission of the instructor.

**618. Multiculturalism and Education. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

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.

**619. Group Processes. 1 Credit. Lecture hours:3**

This course presents basic dynamics, theoretical components, and developmental aspects of group processes with clients. Students will participate in a group exercises as members and leaders.

**620. Academic Interventions. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Students apply knowledge of learning and cognitive strategies to design and assess interventions that promote learning in students with diverse strengths, needs, backgrounds and experiences.

**622. Psychology of the Exceptional Child. 1 Credit. Offered Alternating Fall Semester; Lecture hours:3**

Understanding the psychology of the exceptional child from childhood through adolescence. Focused involvement in building an understanding of the diverse ways cognitive disabilities are manifested in children and adolescents with an emphasis on prevention, intervention and remediation. Optional fieldwork.

**623. Education of Young Children. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

A conceptual-developmental overview of the social, emotional, cognitive, and physical characteristics of the early childhood years (to age 9) stressing extrapolation from developmental theory to educational practice for teachers and parents who function as the earliest educators.

**625. Career Development. 1 Credit. Offered Summer Session Only; Lecture hours:6**

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.

**627. Immigrant Youth in U.S. Society. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

This course examines the varied trajectories in contemporary immigrant youth adaptations across social contexts, including schools, families, peer groups and work.

**628. Tests and Measurement. 1 Credit. Offered Alternating Spring Semester; Lecture hours:3**

Introduction to the fundamental concepts of measurement and testing theory with emphasis on the application of those concepts in a variety of educational, psychological, and employment settings.

**634. Later Childhood and Adolescence. 1 Credit. Offered Both Fall and Spring; Lecture hours:3**

Uses theory, case studies, and field experience to illustrate early and later adolescent development. Required fieldwork. Not open to students who have taken EDUC 635.

**635. Child and Adolescent Development. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Social, emotional, cognitive, and physical development from age 5 to 18 in relation to the educational environment, including the interaction of the child with family, adults, and peers. Required fieldwork. Not open to students who have taken EDUC 634.

**639. Inclusive Practices. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:4**

Students will explore the unique instructional needs of L2 learners and students with disabilities and learn how to modify and adjust content, process, and product to enhance their development in inclusive classrooms. Required fieldwork.

**641. Early Literacy. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

A study of the strategies and techniques involved in teaching children to read and to write (Pre-K-4 level). Contemporary theories of reading behavior. Required fieldwork.

**642. Differentiation and Diversity in Education. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

Differential instruction and cultural awareness to foster the learning of all students in inclusive classrooms. Adaptations for reading, writing, spelling, and mathematics included. Required field work. Prerequisite: permission of the instructor.

**643. Culture and Community. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

Consideration of special problems arising in teaching social studies in elementary and secondary schools. Influences determining course content, including state and national standards.

**644. Science as Inquiry. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:4**

This course reflects best practices for the teaching of science as outlined in the National Science Education Standards and the Pennsylvania State Standards. This course provides students with instructional methods and curricular materials appropriate for teaching science concepts, processes, and skills to young children. Teaching science as inquiry will serve as the foundation for the course.

**646. Literacy Across Contexts. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

This course will explore principles of creating a developmentally appropriate elementary learning environment. Emphasis is placed on writing as process, designing literacy instruction and using approaches to management appropriate to learners of various levels of cognitive, emotional, and social development. Prerequisite: permission of instructor.

**648. Professional Seminar – Elementary. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Systematic approach to the observation, interpretation, verification, and remediation of problems affecting student learning. Psychological and sociological theory informing teaching practice. Implications of student diversity for adaptation of instruction.

**649. Student Teaching Elementary. 3 Credits. Offered Fall Semester Only; Lecture hours:Varies,Other:35**

Supervised practice in the design and implementation of instruction in elementary school classrooms. Emphasis on professional conduct and use of theory to inform practice. Prerequisite: permission of the instructor. Corequisite: EDUC 648.

**650. Higher Education in the United States. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

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 Postsecondary Education 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Investigation of contemporary theories pertaining to the processes of learning and development that occur from later adolescence through old age.

**654. Teaching of Art. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:4**

Principles and practices of teaching art in grades K-12. Prerequisite: permission of the instructor.

**655. Teaching of Science in Secondary School. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:4**

Principles and practices of teaching biology, chemistry, physics, earth and space science, and environmental science in grades 7-12.

**658. Professional Seminar – Secondary.1 Credit. Offered Either Fall and Spring; Lecture hours:3**

Systematic approach to the observation, interpretation, verification, and remediation of problems affecting student learning. Psychological and sociological theory informing teaching practice. Implications of student diversity for adaptation of instruction.

**659. Student Teaching: Secondary. 3 Credits. Offered Fall Semester Only; Lecture hours:Varies,Other:35**

Supervised practice in design and implementation of instruction in secondary school classrooms. Emphasis on professional conduct and use of theory to inform practice. Prerequisite: senior status and permission of the instructor. Corequisite: EDUC 658.

**662. Quantitative Research Methods. 1 Credit. Offered Spring or Summer; Lecture hours:3**

This course emphasizes the design of quantitative research and the development of skills in analyzing and interpreting data. Quantitative research in education and psychology is critiqued in terms of theory, past research, hypothesis generation, and research design.. Data analysis involves the use of the statistical software package SPSS.

**664. Qualitative Methods in Education. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

This is an introduction to the foundations of qualitative design in education, including: history, philosophy, nature, types, examples, and the challenges associated with data collection and its interpretation.

**669. Local Educational Politics 1 Credit. Offered Spring Semester Only; Lecture hours:3**

This course introduces students to a variety of philosophical, political, and sociological theories that explain the nature of conflict in the educational arena.

**675. Methods of Teaching English as a Second Language. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

This course focuses on preparing to teach students for whom English is their second language (ESL). It focuses on three primary areas: instructional materials development for ESL; assessment and support of ESL students; and cultural awareness and sensitivity.

**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.

**680. Thesis. 1 Credit. Offered Fall, Spring or Summer**

**681. Master's Treatise. 1 Credit. Offered Fall, Spring or Summer**

**697. College Student Personnel Internship. 1 Credit. Offered Either Fall or Spring**

One course credit supervised practice in student affairs, together with structured reflection. Prerequisite: EDUC 698 and EDUC 651.

**698. Student Affairs Programs in Higher Education. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

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: permission of the instructor.

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## English (ENGL)

570-577-1553

[www.bucknell.edu/English](http://www.bucknell.edu/English)

**Professors:** Paula Closson Buck, Greg J.H. Clingham, Carmen Gillespie, Shara M. McCallum, Ghislaine G. McDayter, Sandra K. Morris, Harriet Pollack, John S. Rickard, Harold Schweizer, Anthony F. Stewart, Virginia Zimmerman

**Associate Professors:** Christopher Camuto, Glynis Carr, Michael J. Drexler, Eric S. Faden, Jean Peterson, Meenakshi Ponnuswami, Robert Rosenberg, Alfred K. Siewers(Chair), G. C. Waldrep III

**Assistant Professors:** Derek Palacio, Claire Watkins

### 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.; B) those who plan to teach in high school or community colleges; C) those who desire to advance in related careers or programs of study (including, but not limited, to publishing, library work, etc.).

### 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 Theory and Criticism(ENGL 600) and the thesis workshop (or appropriate substitute 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 studies 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 Theory and Criticism (ENGL 600; Fall) and three electives from among 600-level English courses. Students might also consider, with their 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 (critical, creative, or theoretical; typically 60-80 pages, including notes and bibliography) 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. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Introduction to graduate study, including literary and critical theory, research, and other elements of literary scholarship. Open to advanced undergraduates. Prerequisite: permission of the instructor.

### **601. Seminar in American Literature Topics 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced topics, such as Cross-Cultural Encounters, The American Novel, Gender and American Poetics, and Beat Generation. Prerequisite: permission of the instructor.

### **602. Seminar in Selected American Writers. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Study of the works of one or more major American writers. Prerequisite: permission of the instructor.

### **603. Seminar in Writing Creative Nonfiction. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced workshop in the writing of creative nonfiction. Prerequisite: permission of the instructor.

### **605. Seminar in Early American Literature. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Seminar in a special topic or genre of Early American and/or 18th-century American culture. Prerequisite: permission of the instructor.

### **606. US: Fever/Fantasy/Desire. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Seminar on American literature between 1770-1861 with an emphasis on psychoanalytic approaches to literary and cultural study. Authors may include Brown, Sansay, Poe, and Melville. Prerequisite: permission of the instructor.

**607. Seminar in 19th-century American Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Seminar in a special topic, author, or genre of 19th-century American literature and culture. Prerequisite: permission of the instructor.

**608. Seminar in Writing Poetry. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced workshop in the writing of poetry. Prerequisites: permission of the instructor

**609. Seminar in Writing Fiction. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced workshop in the writing of fiction. Prerequisites: permission of the instructor.

**610. Seminar in Modern American Literature. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Seminar in a special topic, author or genre of modern American literature and culture. Prerequisite: permission of the instructor.

**611. Seminar in Contemporary American Literature. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Seminar in a special topic, author, or genre of contemporary American literature and culture. Prerequisite: permission of the instructor.

**615. Unsettling Memories. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Cultural analysis of unsettling, historically powerful racial ideas about purity and pollution written on the "lady's" and "black" bodies in 20th-century Southern fiction and photography.

**619. Individual Projects .5-1 Credits. Offered Either Fall or Spring; Lecture hours:Varies,Other:Varies; Repeatable**

Individual special projects supervised by instructor; honors thesis. Prerequisite: permission of the instructor.

**621. Seminar in African-American Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Study of selected thematic, aesthetic, and ideological issues in Black American writing. Prerequisite: permission of the instructor.

**626. Seminar in Irish Literature. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced topics in Irish literature, including Irish Women Writers, Nationalism and Literature, and Contemporary Irish Writing. Prerequisite: permission of the instructor.

**627. Seminar in Caribbean Studies 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Study of selected thematic, aesthetic, and ideological issues in Caribbean writing.

**632. Seminar in Film and Technology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Traces technology's impact on film form and content. Topics include early cinema, sound technology, widescreen, and computer-generated images. Weekly screenings. Prerequisite: permission of the instructor.

**636. Seminar in Film Genres and Auteurs. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Examination of a particular genre (film noir, Hong Kong action movies, Westerns, etc.), director, cinematographer, screenwriter, or producer. Weekly screenings. Prerequisite: permission of the instructor.

**637. Seminar in Film Theory. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Survey of approaches to film analysis and critique, ranging from realist/formalist debates to psychoanalytic, feminist, and semiotics approaches. Weekly screenings. Prerequisite: permission of the instructor.

**639. Film/Video Production. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

This course applies film theory concepts to advanced video/audio production through a range of hands-on production assignments. Prerequisite: permission of the instructor.

**640. Seminar in Early English Literature to 1485 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

The language and literature of Anglo-Saxon or medieval England. Prerequisite: permission of the instructor.

**641. Seminar on Ecocriticism and Ecossemiotics. 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

This seminar will focus on research and discussion of ecocritical and ecossemiotic approaches to literature.

Prerequisite: permission of the instructor.

**650. Seminar in Renaissance Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Special topics. Student reports, oral and written. Prerequisite: permission of the instructor.

**658. Seminar in Shakespeare 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Special topics. Student reports, oral and written. Prerequisite: permission of the instructor.

**660. Seminar in Restoration and 18th-century Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Studies in canonical and marginalized texts, cultural and philosophical formations, and the continuing historical and theoretical relevance of the period. Prerequisite: permission of the instructor.

**661. Law and Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Studies in the relationship between law, narrative and social and fictional forms in the 18th century and modern Britain and America as these raise questions about identity, justice, historical powers, God, and the nature of civil obligations.

**662. Seminar in Translation Studies. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Advanced seminar in the history, theory, and practice of translation, including investigation of the role of translation in intercultural communication and comparative studies. Facility in a language other than English is strongly recommended.

**670. Seminar in 19th-century English Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Examination of a wide range of poetry and prose by selected authors with emphasis given to the literature's historical and cultural groundings. Prerequisite: permission of the instructor.

**678. Thesis Workshop 1 Credit. Offered Fall Semester Only; Lecture hours:3**

A colloquium on problems arising from the writing of a scholarly thesis. Prerequisite: permission of the instructor.

**680. Thesis. 1 Credit. Offered Either Fall or Spring;****682. Seminar in Contemporary Literature 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

A selective study of the most recent developments in English and American prose or poetry. Prerequisite: permission of the instructor.

**691. Seminar in Poetry 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

A study of poetry as a genre and an analysis of the work of selected poets. Prerequisite: permission of the instructor.

**692. Seminar in the Novel 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Special topics. Student reports, oral and written. Prerequisite: permission of the instructor.

**693. Seminar in Contemporary Drama 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Special topics. Student reports, oral and written. Prerequisite: permission of the instructor.

**694. History of Sexuality 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

A cross-cultural and interdisciplinary examination of the signification of sexuality in literature, philosophy, scientific discourse, and the visual arts. Prerequisite: permission of the instructor.

**697. Seminar in Special Topics 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Topics such as comparative literature, literature and the arts, queer theory, or satire. Prerequisite: permission of the instructor.

**698. Issues in Literary/Critical Theory 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Advanced topics in the study of literary and critical theory. Prerequisite: permission of the instructor.

**699. Seminar in Cultural Studies 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Introduction to significant issues and debates characterizing the field known as Cultural Studies. Prerequisite: permission of the instructor.

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## Mathematics(MATH)

570-577-1343

[www.bucknell.edu/Math](http://www.bucknell.edu/Math)

**Professors:** Gregory T. Adams, M. Lynn Breyfogle, Thomas Cassidy (Chair), Ulrich Daepf, George R. Exner, Michael R. Frey, Pamela B. Gorkin, Paul J. McGuire

**Associate Professors:** KB Boomer, Peter A. Brooksbank, Emily Dryden, Sharon A. Garthwaite, James E. Hutton, Peter McNamara, Adam Piggott, Nathan C. Ryan, Linda B. Smolka, Karl A. Voss

**Assistant Professors:** Kelly A. Bickel, Jodi Black, Van T. Cyr, Laura Dick, Gabrielle Flynt, Jeffrey Langford, Mark J. Meyer Bonnie B. Smith (visiting)

**Instructor:** Amy M. Donner

### 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 1 Credit. Offered Both Fall and Spring; Lecture hours:3**

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 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Point and interval estimation, hypothesis testing, Fisher's likelihood theory, frequentist versus Bayesian approach, computational statistics. Prerequisite: permission of the instructor.

**605. Statistical Modeling 1 Credit. Offered Spring Semester Only; Lecture hours:3**

Regression and analysis of (co)variance. Model diagnosis and remediation. Model selection, multicollinearity, logistic regression. R or SAS will be used. Prerequisite: permission of the instructor.

**607. Statistical Design of Scientific Studies 1 Credit. Offered Spring Semester Only; Lecture hours:3**

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.

**609. Real Analysis II 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Continuation of MATH 308. Integration theory and advanced topics in analysis. Prerequisite: MATH 308.

**611. Theory of Numbers 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

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: permission of the instructor.

**619. Topics in Advanced Mathematics 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3; Repeatable**

Special topics, to be selected from algebra, analysis, geometry, statistics, applied mathematics, etc.

**633. Topology 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Topological spaces, connectedness, compactness, continuity, separation, and countability axioms. Metric, product, function, and uniform spaces. Prerequisite: permission of the instructor.

**635. Geometry 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Historical and axiomatic foundations of geometry. Euclidean and non-Euclidean geometries. Prerequisite: permission of the instructor.

**643. Numerical Analysis 1 Credit. Offered Fall Semester Only; Lecture hours:3,Lab:2**

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; lab component. Prerequisite: or permission of the instructor.

**645. Advanced Linear Algebra 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

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: permission of the instructor.

**646. Abstract Algebra. II 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Advanced topics in group theory including solvable groups, field theory and Galois theory.

**650. Methods in Applied Mathematics 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Techniques drawn from partial differential equations, transform methods, Fourier and complex analysis, and variational calculus. Prerequisite: permission of the instructor.

**658. Topics in Operations Research 1 Credit. Offered Spring Semester Only; Lecture hours:3**

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: permission of the instructor.

**662. Complex Analysis 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3**

Limits, analytic functions, integrals including contour integrals. Cauchy's Integral Theorem, entire functions and singularities. Prerequisite: permission of the instructor.

**678. Seminar. .5 Credits. Offered Either Fall or Spring; Lecture hours:2; Repeatable**

Seminar based on topics from algebra, analysis, topology, differential equations, statistics, or applied mathematics; topics selected according to demand or interest. Prerequisite: permission of the instructor.

**691. 692. Reading and Research .5-2 Credits. Offered Either Fall or Spring; Lecture hours:Varies; Repeatable**

Reading and research in various topics for qualified graduate students. Prerequisite: permission of the instructor.

## Psychology (PSYC)

570-577-1200

[www.bucknell.edu/Psychology](http://www.bucknell.edu/Psychology)

**Professors:** Chris J. Boyatzis, David W. Evans, Judith Grisel, Andrea R. Halpern, Peter G. Judge, John T. Ptacek (Chair), Michael A. Smyer, T. Joel Wade

**Associate Professors:** Kimberly A. Daubman, William F. Flack Jr., , Kevin P. Myers

**Assistant Professors:** Regina Gazes, Aaron Mitchel, Jennifer R. Stevenson, Ruth Tincoff

### 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 social psychology and the psychology of women (Daubman) 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).

### Facilities and Resources

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 1 Credit. Offered Spring Semester Only; Lecture hours:3**

A history of scholarly ideas about thought, feelings, and behavior.

#### **603. Critical Psychologies. 1 Credit. Offered Alternating Spring Semester; Lecture hours:3**

Critical psychologies (e.g., critical liberation, radical) are progressive alternatives to mainstream psychology, emphasizing untoward consequences of the mainstream focus on the individual. Prerequisite: permission of the instructor. A service-learning practicum is part of the course.

#### **604. Advanced Developmental Psychology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Analysis of selected topics in human development, such as gender issues, or religious and spiritual development, or other topics.

#### **605. Developmental Psychopathology 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Addresses the behavioral phenotypes of a variety of neurodevelopmental and neuropsychiatric disorders in the context of theories and processes of normal development. Genetic and neurobiological underpinnings of disorders are discussed. Prerequisite: permission of the instructor.

#### **606. Trauma Psychology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Analysis of specific topics in the fields of psychopathology and/or clinical psychology. Prerequisite: permission of the instructor.

#### **607. Culture and Child Development. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Study of culture-specific and universal processes in child development in diverse societies. Focus on cultural influences on social, emotional, and cognitive development, and on parenting, family, and education contexts and practices. Prerequisite: permission of the instructor.

#### **609. Appetite and Eating Behavior. 1 Credit. Offered Occasionally; Lecture hours:3**

Advanced seminar considering psychological factors involved in appetite, food preferences, and food intake. Prerequisite: permission of the instructor. Crosslisted as ANBE 609

**611. Advanced Health Psychology 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Advanced seminar considering current topics in health psychology, potentially including health behavior change, adolescent risk behavior, and/or social determinants of health. Prerequisite: permission of the instructor.

**613. Researching Behavioral Neuroscience. 1 Credit. Offered Both Fall and Spring; Lecture hours:3**

Following a general orientation to behavioral genetics and pharmacology using mice, we will conduct group experiments. Each student will then develop and conduct an independent research project. Prerequisites: an applied research methods course and permission of instructor. Crosslisted as NEUR 613.

**615. Language Development. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Advanced seminar examining how children learn sounds, words, and grammar. Focus on reading primary research sources. Special topics based on students' interests. Prerequisites: a PSYC methods course and permission of the instructor.

**616. Advanced Social Psychology 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Consideration of experimental and theoretical issues in social psychology. Prerequisite: permission of the instructor.

**617. Comparative Animal Cognition. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

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 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Seminar discussing the development and changes in cognition in senior citizens. Topics include memory, language, attention, and decision-making. Prerequisite: permission of the instructor.

**619. Topics in Psychology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3; Repeatable**

Occasional seminars on selected topics of current interest in psychology. Prerequisite: permission of the instructor.

**620. Children's Studies 1 Credit. Offered Fall Semester Only; Lecture hours:3, Other:Varies**

Critical examination of childhood from multiple disciplinary lenses. Topics include children's advertising and consumerism, child labor, child soldiers, children's spirituality, children in diverse cultures, children and the arts. In this service-learning course students work with children/youth in field placements (e.g., Geisinger Children's Hospital, residential treatment centers). Prerequisite: permission of the instructor.

**624. Advanced Psychological Statistics 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

A survey of advanced statistical techniques with emphasis on analysis and interpretation of experimental and correlational data. Prerequisite: permission of the instructor.

**625. Personality, Psychopaths, and Serial Killers. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Considers personality disorders with a focus on psychopathy and serial murders. Biological and environmental causes of psychopathy are considered as well as the developmental course of the condition and ethics of treatment. Prerequisite: permission of the instructor.

**626. Language and Cognition 1 Credit. Offered Spring Semester Only; Lecture hours:3**

Advanced study of language perception, production, acquisition, evolution, computational models and neural mechanisms. Focus on recent developments in the field.

**639. Psychology of Music 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Seminar examining how musicians and non-musicians comprehend, remember, perform, and respond to music, including developmental aspects. Some background in music is required. Prerequisite: permission of the instructor.

**644. Developmental Brain Research. 1 Credit. Offered Spring Semester Only; Lecture hours:3; Repeatable**

Students learn a variety of assessment techniques in developmental neuropsychology and neuroscience (including EEG) and conduct quantitative research culminating in written and oral reports. Crosslisted as NEUR 644.

Prerequisite: permission of the instructor.

**648. Behavioral Pharmacology 1 Credit. Offered Spring Semester Only; Lecture hours:3**

Focus on drugs that affect the nervous system, drugs of abuse, therapeutic drugs, drug action, behavioral changes as a result of long-term drug use, animal models and human studies. Prerequisite: permission of the instructor.

Crosslisted as NEUR 648.

**649. Cognitive Neuroscience. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Brain mechanisms of language, memory, and other processes as revealed by studies of human brain activity or pathology. Prerequisite: permission of the instructor.

**652. Face Perception. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Advanced seminar in face perception, including issues of holism, uniqueness, language, emotion, and race.

Prerequisite: permission of the instructor.

**669. Psychology of Beauty and Attraction 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Examination of research on beauty and attraction from an evolutionary perspective. Prerequisite: permission of the instructor.

**670. Primate Behavior and Ecology 1 Credit. Offered Fall Semester Only; Lecture hours:3;****May require dissection or live animal experimentation**

Introduction to research on prosimians, monkeys, and apes with emphasis on the evolutionary origin of diversity, habitat use, social structure, social behavior, and cognitive abilities. Prerequisite: permission of the instructor.

Crosslisted as ANBE/BIOL 670.

**671. Primate Cognition. 1 Credit. Offered Alternate Fall or Spring; Lecture hours:3; May require dissection or live animal experimentation**

An investigation into the cognitive abilities and capacities of nonhuman primates emphasizing a comparative perspective. Prerequisite: permission of the instructor. Crosslisted as ANBE 671 and PSYC 671.

**672. Evolution of Acquired Behavior. 1 Credit. Offered Both Fall and Spring; Lecture hours:3, Other:3**

Advanced seminar exploring cognition and behavior from evolutionary and comparative perspectives. Topics will include social behavior, memory, communication, spatial cognition, learning, and meta-cognition. Prerequisite: permission of the instructor. Crosslisted as ANBE 672.

**673. Psychology of Race and Gender. 1 Credit. Offered Occasionally; Lecture hours:3**

Critical analysis of major theories. Emphasis on experimental research findings in the areas of racism, discrimination, gender difference, sexual violence, etc. Prerequisite: permission of the instructor.

**680. Thesis. .5- 1 Credit. Offered Both Fall and Spring****685. 686. Graduate Research. .5- 2 Credit. Offered Both Fall and Spring**

Graduate Research. Prerequisite: permission of the instructor.

## College of Engineering

### 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.

## Chemical Engineering (CHEG)

570-577-1114

[www.bucknell.edu/ChemicalEngineering](http://www.bucknell.edu/ChemicalEngineering)

**Professors:** Jeffrey Csernica, William E. King, James E. Maneval, Michael J. Prince, William J. Snyder, Margot A.S. Vigeant (Associate Dean of Engineering)

**Associate Professors:** Daniel P. Cavanagh, Michael Gross, Erin L. Jablonski, Timothy R. Raymond (Chair), Brandon M. Vogel, Kat Wakabayashi, Wendelin J. Wright

**Assistant Professors:** Ryan C. Snyder

### 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:

- Assessing the Validity of Brain Glucose Concentration Measurement Using Microdialysis
- The Investigation of Uniform, Monodisperse Crystalline Particles via the Evaporation of Small Droplets
- Development of Solid Oxide Fuel Cell Electrodes with High Conductivity and Enhanced Redox Stability
- Characterization of Biodegradable Polymer Nanocomposites Fabricated via Solid-State Processing
- Morphology and Cloud Condensation Nuclei Activity of Single-Component and Multi-Component Organic Aerosols

- Calcium Alginate Encapsulation and Continuous Separation of the Capsules Through Co-Laminar Flow of Immiscible Fluids
- Investigation of Drag Reducing Polymers by Dielectric Spectroscopy
- eLEAPS - an Investigation of Web Application to Support Learning Engineering and Problem Solving

### 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](mailto:cheg@eg.bucknell.edu). Departmental website is [www.bucknell.edu/chemicalengineering](http://www.bucknell.edu/chemicalengineering)

### Courses Offered

#### **600. Process Engineering. 1 Credit. Offered Fall Semester Only; Lecture hours:3**

Applications of engineering, economic, environmental, and ethical principles in preliminary process design using computer aids such as process simulators. Problem definition, literature survey, flowsheet development, material and energy balances, equipment design, profitability analysis, oral and written communication. With design laboratory. Open only to students without previous design course work.

#### **610. Project Engineering. 1 Credit. Offered Spring Semester Only; Lecture hours:3**

Second of two Capstone experiences for chemical engineering majors. Students refine a general problem statement in order to plan, execute, and assess a project that achieves specified goals. Design, construction, and testing of an apparatus, system, or simulation. Problem-solving, teamwork, communication, professional development, and laboratory work are emphasized. With design laboratory. Prerequisite: permission of instructor.

#### **630. 631. Chemical Engineering Project .5 Credits. Offered Either Fall or Spring; Lecture hours:1,Other:5; Repeatable**

Individual work with a faculty adviser on a development or design project beginning with a written plan and culminating with a deliverable product and a written report. Problem analysis involving information synthesis, experimentation, mathematical modeling, or software development. Prerequisite: permission of the instructor.

#### **640. 641. Chemical Engineering Research. 1 Credit. Offered Both Fall and Spring; Lecture hours:1,Other:9; Repeatable**

Independent study with a faculty adviser on a research project. Submit a project proposal for group review, conduct the work, and culminate with a written and an oral presentation before a faculty group. Prerequisite: permission of the instructor.

#### **648. Electrochemical Energy Conversion. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Principles of electrochemistry including electrochemical thermodynamics, kinetics, and catalysis. Related emerging energy applications such as fuel cells and advanced batteries. Prerequisite: permission of the instructor.

#### **650. Polymer Science. 1 Credit. Offered Spring Semester Only; Lecture hours:4,Recitation:1**

Structure, characterization and properties of polymeric materials. Chemistry and kinetics of polymerization. Processing and application of polymers. Prerequisite: permission of the instructor.

#### **652. Bioprocess Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. 1 Credit. Offered Spring Semester Only; Lecture hours:4**

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. Product and process history, design and improvement will be covered through discussions, simulations and case studies. Prerequisite: permission of the instructor.

**655. Atmospheric Chemistry and Physics. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. 1 Credit. Offered Fall Semester Only; Lecture hours:4**

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. 1 Credit. Offered Either Fall or Spring; Lecture hours:4,Recitation:1**

Classes of biomaterials, their applications, and current trends in biomaterials research and technology. Medical/ethical implications of biomaterials development and research. Prerequisite: permission of the instructor.

**665. Advanced Materials Science and Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:4, Recitation:1** Advanced, in-depth exploration of processing - structure - property - performance relationships of materials through real-world examples and case studies. Prerequisite: permission of the instructor.

**670. 672. Special Topics in Chemical Engineering. 1 Credit. Offered Both Fall and Spring; Lecture hours:4; Repeatable** Advanced, in-depth courses developed from areas of chemical engineering science or technology. Prerequisite: permission of the instructor.

**680. Graduate Research and Thesis. 1 Credit. Offered Both Fall and Spring; Lecture hours:1,Other: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. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Advanced study of thermodynamics applied to fluid flow, heat transfer, gas compression, air conditioning, refrigeration, and chemical equilibria. Prerequisite: permission of the instructor.

**685. Topics in Transport Theory. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Mass, energy, and momentum transfer in continuous media. General equations of transfer developed and used to analyze real systems. Development and application of mathematical techniques appropriate to the topic. Prerequisite: permission of the instructor.

**687 and 688. Advanced Study in Chemical Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**  
Courses in chemical engineering theory designed to meet the needs of graduate students in residence.

**CHEG 695. Advanced Topics in Engineering Mathematics. 1 Credit. Offered Fall Semester Only; Lecture hours:4**  
Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor.

## Civil Engineering (CEEG)

570-577-1112

[www.bucknell.edu/CivilEngineering](http://www.bucknell.edu/CivilEngineering)

**Professors:** Richard D. Crago, Thomas D. DiStefano, Jeffrey C. Evans, Matthew J. Higgins, James G. Orbison (Dean, College of Engineering, emeritus), T. Michael Toole (Associate Dean of Engineering), Ronald D. Ziemian

**Associate Professors:** Stephen G. Buonopane, Douglas J. Gabauer, Michael A. Malusis (Acting Chair), Kelly A. Salyards

**Assistant Professors:** Jean Batista Abreu (visiting), Michelle R. Beiler, Kevin Gilmore, Jessica T. Newlin, Deborah L. Sills, Corrie Walton-Macaulay.

### 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 compound 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 eight course credits, including the thesis, is required for the MSCE degree.

### Courses Offered

#### **601. Structural Analysis. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Analysis of structures including: review of essential mechanics; sketching deflection, moment, and force diagrams for indeterminate systems; influence lines; application of virtual force and displacement principles; and a comprehensive study of the direct stiffness method with a focus on matrix analysis. Prerequisite: permission of the instructor.

#### **603. Wood Engineering Design Principles. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Wood properties as construction material; design of beams, columns, fasteners, and connections. Glued-laminated timber and many other uses for structures in accordance with the National Design Specifications. Form work for concrete structures, plywood and plywood diaphragms. Prerequisite: permission of the instructor.

#### **606. Design of Concrete Structures. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Lab:2**

Introduction to behavior and design of concrete elements and structures: beams, columns, slabs, footings, bridges. Reinforced and prestressed concrete. Material properties and behavior, flexural and shear strength, serviceability and deflections. Use of relevant codes and specifications including ACI and ASSHTO. Design loads according to contemporary standards and international building codes. Prerequisite: permission of the instructor.

#### **607. Prestressed Concrete. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Analysis and design of prestressed concrete members and structures: flexural stresses, flexural strength, shear strength, loss of prestress, deflections.

#### **608. Finite Element Methods. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other: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 programs. Prerequisite: permission of the instructor. Crosslisted as MECH 667.

#### **609. Earthquake Engineering. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**

Analysis and design of structures subjected to earthquakes. Single and multi degree-of-freedom systems, response spectra, seismology, soil dynamics. Seismic design methods in building codes. Isolation and energy dissipation systems. Laboratory to include experiments with shake tables. Prerequisite: permission of the instructor.

**619. Advanced Topics in Structural Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**  
Topics will vary. Prerequisite: permission of the instructor.

**621. Hydrology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**  
The interrelation of meteorological conditions, precipitation, surface runoff, and groundwater storage. Prerequisite: permission of the instructor.

**622. River Mechanics. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**  
Mechanics of free-surface flows in rivers; introduction to sediment transport mechanisms; application to river engineering design (bridge crossing, culverts, flood control, river stabilization). Prerequisite: permission of the instructor.

**629. Advanced Topics in Water Resources Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2,** Topics will vary. Prerequisite: permission of the instructor.

**630. Introduction to Roadside Safety. 1 Credit. Offered Fall Semester Only; Lecture hours:4**  
Fundamentals of roadside safety design and analysis: topics include traffic barrier warranting and selection, crash data analysis, hardware performance evaluation, and benefit/cost analysis. Prerequisite: CENG 330 or permission of the instructor.

**631. Introduction to Urban and Regional Planning. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**  
Problems of urban and regional planning and the treatment of various factors of a comprehensive plan. Emphasis on the sustainability and interrelationships between engineering, sociology, geography, and economics. Prerequisite: permission of the instructor.

**632. Sustainable Transportation Planning. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**  
This course will explore the balance of enhancing mobility while simultaneously reducing impacts on the environment, society, and the economy. Prerequisite: permission of the instructor.

**639. Advanced Topics in Transportation. .5-1 Credits. Offered Either Fall or Spring; Lecture hours:4**  
Topics will vary. Prerequisite: permission of the instructor.

**640. Physical/Chemical Treatment Processes. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**  
Fundamentals of physical and chemical treatment processes used to remove pollutants from water, air, and soil such as ion-exchange, coagulation, sedimentation, filtration, air stripping, disinfection, adsorption, and membrane processes. Laboratory experiments reinforce theory and are help develop design criteria for full-scale treatment processes. Prerequisite: instructor permission.

**641. Environmental Engineering Biotechnology. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:2**  
Theory and design of biological waste treatment systems for industrial, municipal and hazardous pollutants and natural biotransformation of pollutants in the environment. Laboratory experience on startup, operation, and analysis of systems that biodegrade pollutants and produce useful forms of energy. Prerequisite: permission of the instructor.

**642. Sustainability Principles for Engineers (II; 3, 2)**  
An introduction to concepts for the application of sustainable engineering principles. Topics include life-cycle assessment, biogeochemical cycles, climate changes, fossil fuels and renewable energy, embedded water, global and cultural context, market externalities, sustainability metrics, and carbon footprint. Prerequisite: CENG 340 or third- and fourth-year engineers with permission of the instructor.

**644. Hazardous Waste Management (I or II; 3, 2)**

Identification of common hazardous chemicals and related industrial activities, determination of risk-based clean-up levels for hazardous waste sites, toxicology, pump-and-treat ground water remediation, in situ bioremediation, legal and liability issues, and remedial action. Prerequisite: permission of the instructor.

**645. Environmental Engineering Chemistry (I or II; 3, 2)**

Principles of aquatic chemistry and applications with emphasis on acid-base reactions, metal speciation and solubility, and oxidation-reduction reactions in water. Prerequisite: permission of the instructor.

**646. Design of Water and Wastewater Treatment Systems (I or II; 3, 2)**

Design of municipal water and wastewater treatment facilities. Emphasis on water and wastewater characterization, followed by physical, chemical, and biological processes for treatment and reuse.

**647. Sustainable Cities (I; 3, 2)**

This team-taught course introduces students to the core concepts of sustainability and how they have been applied to promote sustainability in London, the UK, and Europe. This course is part of Bucknell in London core course.

**649. Advanced Topics in Environmental Engineering (I; R; 4, 0)**

Prerequisite: permission of the instructor.

**650. Geotechnical Engineering II (I; 3, 2)**

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, 2)**

Interaction between hazardous and toxic wastes and geotechnical properties of soils. Remediation of the subsurface environment. Prerequisite: permission of the instructor.

**652. Ground Improvement Engineering (II; 3, 2)**

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.

**659. Advanced Topics in Geotechnical Engineering (I or II; 4, 0)**

Topics will vary. Prerequisite: permission of the instructor.

**672. Construction Engineering (I; 3, 2)**

Project documents, processes, and organizational structures. Construction estimating, equipment, labor, and procurement. Building methods and materials. Prerequisite: junior status or permission of the instructor.

**675. Forensic Engineering (I or II; 4, 0)**

Introduction to identification, evaluation, and analysis of a wide variety of engineering failures; failure investigation and the legal process; serviceability failure, material or system failure, design errors; expert witness testimony.

**679. Advanced Topics in Construction Engineering and Management (I or II; R; 3, 2)**

Topics will vary. Prerequisite: permission of the instructor.

**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. Prerequisite: permission of the instructor.

**681. Graduate Research (I and II; R) Half to full course.**

Original investigations in structural engineering, transportation engineering, environmental engineering, geotechnical engineering, or water resources engineering.

**ENGR 695. Advanced Topics in Engineering Mathematics (I; 4, 0)**

Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor.

**699. Thesis (I and/or II)**

Research on the graduate level under the direction of a faculty member.

**Courses offered occasionally**

**625** Groundwater Hydrology, **653** Advanced Soil Mechanics

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**Electrical & Computer Engineering (ECEG)**

570-577-1234

[www.bucknell.edu/ElectricalAndComputerEngineering](http://www.bucknell.edu/ElectricalAndComputerEngineering)

**Professors:** Maurice F. Aburdene, John C. Bravman (University President), R, Alan Cheville (Chair), Richard J. Kozick

**Associate Professors:** Peter Mark Jansson, David F. Kelley, Robert M. Nickel, Michael S. Thompson, Joseph V. Tranquillo

**Assistant Professors:** Philip Asare, Amal Kabalan

**Areas of Concentration**

Faculty research interests include the following areas: control systems, communication systems, computer networking, electromagnetics, digital system design, digital signal processing, embedded computing, high performance computer architecture, information theory, mobile computing, nonlinear photonics, optoelectronic materials and devices, speech and audio signal processing, smart grid, electrical power systems, renewable energy systems, and VLSI.

**Facilities**

A wide range of microprocessors, digital logic analyzers, high-speed digital signal processors, optoelectronics equipment, high-frequency oscilloscopes, RF test and measurement equipment, and computer-aided analysis and design software is available for graduate work. Graduate students have full access to all of the department's laboratory facilities, including those for specialized applications.

## Master of Science in Electrical Engineering Degree Requirements

At least eight course credits are required beyond those applied toward the BS/BA degree and must be distributed as follows:

- One credit must be ENGR 695 (Advanced Topics in Engineering Mathematics).
- One credit must be ECEG 699 (Thesis).
- At least four additional credits must be 600-level or higher elective courses in electrical engineering. Any number of credits may be in the form of independent study (ECEG 628 or 629) courses, but they must be approved by the student's advisor.
- The remaining credits, if any, may be in any approved technical area.

In addition to the course requirements listed above, the student must present and successfully defend a master's thesis. Students coming from non-electrical engineering programs might have to take additional junior or senior-level courses to satisfy prerequisites for advanced courses.

### Thesis

The primary purpose of the thesis is to contribute to the education of the candidate. The thesis might or might not also contribute to the state of the art in the chosen field. The thesis requirement in electrical engineering may be satisfied by one of the following:

1. an exercise in solving a practical engineering problem involving novel features, which might or might not comprise design;
2. an exercise designed to develop research skills and ability;
3. an experiment or theoretical research project.

The thesis must be defended in a final oral or written examination in accordance with the deadlines imposed by the College of Engineering Graduate Committee.

## Courses Offered

### **602. Special Topics in Electrical or Computer Engineering. 1 Credit.**

**Offered Either Fall or Spring; Lecture hours:3,Lab:2**

Current topics of interest in electrical or computer engineering. The course includes a laboratory section.

Prerequisite: permission of the instructor.

### **603. Special Topics in Electrical and Computer Engineering. 1 Credit.**

**Offered Either Fall or Spring; Lecture hours:4**

Current topics of interest in electrical and computer engineering. This course does not include a lab section.

Prerequisite: permission of the instructor.

### **609. Advanced Electrical and Computer Engineering Laboratory. 1 Credit.**

**Offered Either Fall or Spring; Lecture hours:Varies**

Special laboratory work, by permission.

### **611. Neural Signals and Systems. 1 Credit. Offered Occasionally; Lecture hours:3,Recitation:1**

Introduction to neural systems and signaling. Topics include neural physiology, models of action potential generation and synapse dynamics, neural networks and techniques of neural waveform analysis. Prerequisite: permission of the instructor.

**630. Mobile Computing. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Mobile computing ecosystem including apps, devices, wireless networks, and back-end systems. Includes at least one major project; the specific course content will vary based on projects, student interest, and current technology trends. This course typically includes a considerable amount of software development. Prerequisite: permission of instructor.

**642. Digital VLSI Circuit Design. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Topics include "good" computer architecture, RISC/CISC, pipelining, super-scalar, super-pipelining, out-of-order execution, speculative execution, virtual memory, caches, and cache coherence. Prerequisite: permission of the instructor.

**644. Advanced Digital Design. 1 Credit. Offered Either Fall or Spring; Lecture hours:2,Other:2**

Design of multi-part digital systems using contemporary digital components centered around a system-on-chip with a microprocessor and FPGA. Hardware description languages, specialized FPGA elements, peripheral interfacing and protocols, high-level synthesis. Prerequisite: permission of the instructor.

**663. Introduction to Mechatronics. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

This multidisciplinary course is the synergistic integration of mechanical engineering with electronic and computer engineering. This course will study actuators, drive systems, sensors, controllers, micro-controllers programming and interfacing, and automation systems integration. Prerequisite: permission of the instructor. Crosslisted as MECH 663.

**670. Communication and Information Systems. 1 Credit. Lecture hours:3**

Digital and analog communication systems, modulation techniques, noise considerations, optimum receivers. Prerequisite: permission of the instructor.

**671. Applications of Probability in Electrical and Computer Engineering. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Lab:2**

Probability theory, random variables, probability mass/density functions, expected value, Gaussian distribution, detection, estimation, applications in electrical and computer engineering. Prerequisite: ECEG 320 or permission of the instructor.

**672. Digital Signal Processing. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Lab: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.

**673. Digital Speech and Audio Processing. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Theory and application of digital speech and audio processing. Topics include speech and audio (MP3) coding, artificial speech synthesis, automatic speech recognition, and audio effects. Prerequisite: permission of the instructor.

**675. Computer Communication Networks. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

An introduction to computer networking using the seven-layer Open Systems Interconnection model. Hands-on exploration of the data link, network, transport, and application layers.

**677. Wireless System Design. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Introduction to hardware aspects of wireless communication systems, including RF circuit design, transmitter and receiver architecture, antennas, and radio wave propagation. Prerequisite: permission of the instructor.

**691. Electrical Energy Conversion. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Lab:3**

Three phase power circuits, transformer circuits, rotating machines and equivalent circuits, power electronic switches, machine dynamics, motor generator control. Prerequisite: permission of the instructor.

**694. Renewable Energy Systems. 1 Credit. Offered Either Fall or Spring; Lecture hours:3**

Engineering analysis of photovoltaic, wind, and other renewable energy systems. Modeling of systems, resources, and performance with an emphasis on grid-tied photovoltaic system optimization.

**ENGR 695. Advanced Topics in Engineering Mathematics. 1 Credit. Offered Fall Semester Only; Lecture hours:4**

Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor.

**699. Thesis. Offered Either Fall or Spring**

A professional-level investigation under the direction of a faculty member; required for a Master of Science in electrical engineering degree.

## Environmental Engineering (EVEG)

570-577-1112

[www.bucknell.edu/CivilandEnvironmentalEngineering](http://www.bucknell.edu/CivilandEnvironmentalEngineering)

**Professor:** Richard D. Crago, Thomas D. DiStefano, Jeffrey C. Evans, Matthew Higgins

**Associate Professors:** Michael A. Malusis (Acting Chair)

**Assistant Professor:** Kevin Gilmore, Jessica Newlin, Deborah L. Sills, Corrie Walton-Macaulay

### 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 eight course credits, including the thesis, is required for the MSEV degree.

### Courses Offered

**621. Hydrology. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

The interrelation of meteorological conditions, precipitation, surface runoff, and groundwater storage. Prerequisites: permission of the instructor.

**622. River Mechanics. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**

Mechanics of free-surface flows in rivers; introduction to sediment transport mechanisms; application to river engineering design (bridge crossing, culverts, flood control, river stabilization).

**625. Groundwater. 1 Credit. Offered Occasionally; Lecture hours:3,Other:2**

The study of the occurrence of groundwater, the laws and equations governing storage and movement of groundwater, and the interaction between surface and ground waters. Prerequisite: permission of the instructor.

**629. Advanced Topics in Water Resources Engineering. 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Topics will vary. Prerequisite: permission of the instructor.

**640. Physical/Chemical Treatment Processes. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**

Fundamentals of physical and chemical treatment processes used to remove pollutants from water, air, and soil such as ion-exchange, coagulation, sedimentation, filtration, air stripping, disinfection, adsorption, and membrane processes. Laboratory experiments reinforce theory and help develop design criteria for full-scale treatment processes. Prerequisite: instructor permission.

**641. Environmental Engineering Biotechnology. 1 Credit. Offered Fall Semester Only; Lecture hours:3,Other:2**

Theory and design of biological waste treatment systems for industrial, municipal and hazardous pollutants and natural biotransformation of pollutants in the environment. Laboratory experience on startup, operation, and analysis of systems that biodegrade pollutants and produce useful forms of energy. Prerequisite: permission of the instructor.

**642. Sustainability Principles for Engineers. 1 Credit. Offered Spring Semester Only; Lecture hours:4**

An introduction to concepts for the application of sustainable engineering principles. Topics include life-cycle assessment, biogeochemical cycles, climate changes, fossil fuels and renewable energy, embedded water, global and cultural context, market externalities, sustainability metrics, and carbon footprint.

**644. Hazardous Waste Management. 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**

Identification of common hazardous chemicals and related industrial activities, determination of risk-based clean-up levels for hazardous waste sites, toxicology, pump-and-treat ground water remediation, in situ bioremediation, legal and liability issues, and remedial action. Prerequisite: permission of the instructor.

**645. Environmental Engineering Chemistry 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**  
Principles of aquatic chemistry and applications with emphasis on acid-base reactions, metal speciation and solubility, and oxidation-reduction reactions in water. Prerequisite: permission of the instructor.

**649. Advanced Topics in Environmental Engineering 1 Credit. Offered Fall Semester Only; Lecture hours:4**  
Prerequisite: permission of the instructor.

**651. Environmental Geotechnology 1 Credit. Offered Spring Semester Only; Lecture hours:3,Other:2**  
Interaction between hazardous and toxic wastes and geotechnical properties of soils. Remediation of the subsurface environment. Prerequisite: permission of the instructor.

**ENGR 695. Advanced Topics in Engineering Mathematics 1 Credit. Offered Fall Semester Only; Lecture hours:4**  
Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor.

**699. Thesis. Offered Either Fall or Spring**  
Research on the graduate level under the direction of a faculty member.

## Mechanical Engineering (MECH)

570-577-3193

[www.bucknell.edu/MechanicalEngineering](http://www.bucknell.edu/MechanicalEngineering)

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**Associate Professors:** M. Laura Beninati, Charles J. Kim, Mala M. Sharma, Peter C. Stryker, Wendelin J. Wright,

**Assistant Professors:** Craig E. Beal, , Indranil Brahma, Christine M. Buffinton, Stephen J. Covey (visiting), Emily Geist, Sarah J. Manoogian, Christopher J. Mordaunt, Nathan P. Siegel, Andrew R. Sloboda, Durul Ulutan

### Requirements

The mechanical engineering department requires a total of eight course credits: seven graduate level courses and a written thesis for the master's degree. Of these seven courses, one must be a graduate-level advanced mathematics course; 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 perform applied, computational, experimental, and theoretical research in the following broad areas: acoustics, bioengineering, combustion, composite materials, energy systems, finite element modeling, fracture mechanics, fluid dynamics, heat transfer, materials processing, robotics, and system dynamics. Specific research interests include: computer-aided design, computer-based mechanics, computer modeling of engineering systems, and design theory and methodology; computer-aided materials testing, nano-materials, and laser-induced and environmental degradation of materials; flow-induced noise and vibration, and bluff body aerodynamics; multi-phase and environmental fluid mechanics and sediment transport; automotive emission control, hybrid powertrains, internal combustion engines, alternative fuel combustion, and combustion emissions, instabilities, and processes; renewable energy systems, energy for transportation, and building energy conservation; mechanical vibrations and control systems, medical devices and medical robotics, and compliant systems.

### Thesis

The master's thesis is regarded as both education for the candidate and a contribution to public knowledge. This requirement of a 1.0 course credit for the written 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, computer-aided 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

#### **620. Solar Thermal Systems 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Fundamental aspects of the design and operation of solar energy conversion systems including photovoltaics, solar thermal power, solar heating and production. Prerequisite: permission of the instructor.

#### **622. Renewable Energy Conversion 1 Credit. Offered Alternate Fall or Spring; Lecture hours:4**

Current energy demands, environmental effects, renewable energy resources, includes photovoltaic, thermal solar, wind, tidal, ocean thermal, wave energies; clean coal, nuclear energy, smart grid technology. Prerequisites: permission of instructor

#### **624. Internal Combustion Engines 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Description of internal combustion engines, methods of evaluating performance, the thermodynamics of combustion, engine testing, and design. Prerequisites: permission of the instructor.

#### **627. Engine Generated Emissions Control 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Combustion thermochemistry, availability analysis, emission formation, emissions reduction technologies, greenhouse gas reduction, emission modeling and optimization, engineering system integration for emission control. Prerequisite: permission of the instructor.

#### **632. Compressible Fluid Dynamics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Compressible flow, shock wave phenomena, potential flow, two-dimensional flow, numerical methods, acoustic wave propagation. Selected laboratory exercises. Prerequisites: permission of the instructor.

#### **634. Environmental Fluid Dynamics 1 Credit. Offered Occasionally; Lecture hours:3**

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: permission of the instructor

#### **635. Aerodynamics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Two dimensional flow theory; vortex and momentum theories of finite wings; viscous flows, boundary layers and drag; high lift devices. Prerequisites: permission of the instructor.

**645. Engineering Acoustics and Noise Control 1 Credit. Offered Occasionally; Lecture hours:4**

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.

**647. Fundamentals of Combustion 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

The fundamentals of chemically reactive flow systems with application to jet, rocket, and other air-breathing engines and special interest paid to pollutant formation. Prerequisites: permission of the instructor.

**652. Advanced Dynamics 1 Credit. Offered Occasionally; Lecture hours:4**

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. Prerequisites: permission of the instructor.

**653. Robotics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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. Prerequisites: permission of the instructor.

**654. Vehicle Dynamics and Control (I or II; 4, 0) 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Introduction to modeling of vehicles for analysis and control. Topics include tire models, handling response, stability control, suspension design, race tuning. Prerequisite: permission of the instructor.

**655. Control Systems Design. 1 Credit. Offered Alternating Spring Semester; Lecture hours:4**

Design/implementation of control systems on hardware. Sensor and actuator selection. Development of linear/nonlinear control algorithms. Performance analysis and testing. Applications in automotive, HVAC, medical, aero/astro, robotics. Prerequisite: permission of the instructor.

**657. Accident Analysis. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Vehicle crash dynamics and crashworthiness. Non motor-vehicle accidents. Mechanics of injuries. Evaluation of designs intended to reduce risk of injury. Prerequisite: permission of the instructor.

**659. Optical Measurements Systems in Biomedical Engineering. 1 Credit.****Offered Either Fall or Spring; Lecture hours:4**

Course integrates basic and advanced principles of lasers, optics and optical systems and their applications in biomedical field. Analysis of laser-based characterization and processing techniques of tissues. Permission of the instructor.

**662. Computer Integrated Manufacturing 1 Credit. Offered Occasionally; Lecture hours:4**

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.

**663. Introduction to Mechatronics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

This multidisciplinary course is the synergistic integration of mechanical engineering with electronic and computer engineering. This course will study actuators, drive systems, sensors, controllers, micro-controllers programming and interfacing, and automation systems integration. Prerequisite: permission of the instructor.

**664. Mechanism Design 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Design of traditional and compliant mechanisms. Topics include kinematics, analytical and graphical synthesis methods, and topics in research. Prerequisites: permission of the instructor.

**666. Applied Fracture Mechanics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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 1 Credit. Offered Occasionally; Lecture hours:3,Other: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 programs. Prerequisite: permission of the instructor. Crosslisted as CEEG 608.

**668. Applied Finite Element for Mechanical Design 1 Credit. Offered Occasionally; Lecture hours:2,Other: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: permission of the instructor.

**669. Computer-Aided Design 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Fundamentals of geometric modeling and computational geometry. Topics include geometric representation of surfaces, mesh generation, and design optimization. Prerequisite: permission of the instructor.

**670. Engineering Composite Materials 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Fundamental composite mechanics, including micromechanics and laminated plate theory. Design and analysis of composite structures; composite manufacturing techniques; current research topics in composite area. Prerequisites: permission of the instructor.

**672. Atomic Arrangements and Defects 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

The structure of crystalline and non-crystalline materials and the relationship between structure, defects, and mechanical properties.

**674. Bulk Metallic Glasses 1 Credit. Offered Either Fall or Spring; Lecture hours:3,Other:2**

Thermodynamics and kinetics of metallic glasses; deformation, fatigue and fracture behavior; and metallic glass composites. Alloy design, casting, and mechanical testing.

**676. Biomechanics 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

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.

**684. Artificial Intelligence for Engineering Systems. 1 Credit. Offered Either Fall or Spring; Lecture hours:4**

Engineering system modeling and optimization using artificial intelligence methods such as neural networks and genetic algorithms. MATLAB based. Prerequisite: permission of the instructor.

**685. Advanced Engineering Problems .5-1 Credits. Offered Either Fall or Spring; Lecture hours:2,Other:3; Repeatable**

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.

**ENGR 695. Advanced Topics in Engineering Mathematics (I; 4, 0)**

Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Prerequisite: permission of the instructor.

**699. Thesis. 1 Credit. Offered Fall/Spring**

Research on the graduate level under the direction of a faculty member. Prerequisite: permission of the instructor.

**Courses offered occasionally**

697. Graduate Thesis Research (I and /or II) **621** Advanced Engineering Thermodynamics, **623** Thermal Environmental Engineering, **630** Advanced Heat Transfer, **631** Boundary Layers and Convection Heat Transfer, **633** Advanced Fluid Mechanics, **640** Turbomachinery, **641** Gas Turbines, **646** Flow-induced Noise and Vibration, **651** Vibration Analysis, **660** Engineering Optimization, **665** Advanced Mechanics of Solids, **684** Special Topics, **690** Form and Function

## 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 be 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.

# Academic Calendar

## Fall Semester 2015

Monday, August 24, 2015	<b>Classes Begin</b>
Monday, September 7, 2015	<b>Labor Day--Classes in Session</b>
Tuesday, September 8, 2015	<b>Application for January Master's Graduates Due</b>
Friday, October 9, 2015	<b>Fall Recess Begins – 5:00 p.m.</b>
Wednesday, October 14, 2015	<b>Fall Recess Ends – 8:00 a.m.</b>
Monday, November 2, 2015	<b>Registration for Spring Semester Begins</b>
Friday, November 23, 2015	<b>Thanksgiving Recess (begins – 10:00 p.m.)</b>
Monday, November 30, 2015	<b>Thanksgiving Recess (ends – 8:00 a.m.)</b>
Tuesday, December 8, 2015	<b>Last Day to Present Final Master's Thesis for Format</b>
Tuesday, December 8, 2015	<b>Classes End</b>
Thursday, December 10, 2015	<b>Final Examinations Begin</b>
Thursday, December 17, 2015	<b>Final Examinations/Reading Period Ends</b>
Thursday, December 17, 2015	<b>Completed Master's Thesis Submitted Online via myBucknell</b>
Monday, December 21, 2015	<b>GRADES DUE in Registrar's Office by 12:00 p.m.</b>
Thursday, January 7, 2016	<b>January Graduation (no ceremony)</b>

## Spring Semester 2016

Tuesday, January 19, 2016	<b>Classes Begin</b>
Monday, January 25, 2016	<b>Last Day to Enroll Without Dean's Permission</b>
Monday, February 1, 2016	<b>Application for May Master's Graduates Due</b>
Friday, March 11, 2016	<b>Spring Recess Begins – 5:00 p.m.</b>
Wednesday, March 16, 2016	<b>Mid-Semester GRADES DUE by 12:00 p.m.</b>
Monday, March 21, 2016	<b>Spring Recess Ends – 8:00 a.m.</b>
Monday, April 4, 2016	<b>Registration for Fall Semester Begins</b>
Monday, May 2, 2016	<b>Last Day to Present Final Master's Thesis for Format</b>
Monday, May 2, 2016	<b>Classes End</b>
Wednesday, May 4, 2016	<b>Final Examinations Begin</b>
Wednesday, May 11, 2016	<b>Final Examinations/Reading Period Ends</b>
Wednesday, May 11, 2016	<b>Completed Master's Thesis Submitted Online via myBucknell</b>
Sunday, May 22, 2016	<b>Commencement</b>

## Contact Information

Telephone numbers listed are in the 570 area code.

**Dean of Graduate Studies**, Robert M. Midkiff, Jr., 230 Marts Hall/577-3655  
**Coordinator of Graduate Studies**, Gretchen H. Fegley, 210 Marts Hall/577-3655  
**Admissions/Graduate**, 226 Marts Hall/577-1304, email/[gradstds@bucknell.edu](mailto:gradstds@bucknell.edu)  
**Barnes & Noble at Bucknell University Bookstore**, 400 Market Street/577-1128  
**Campus Security**, Public Safety Office/577-3333  
**Career Development Center**, 101 Botany Bldg./577-1238  
**Counseling Service**, Lowry House/577-1604  
**Dining Service**, Elaine Langone Center/577-1240  
**International Student Services**, 064 Elaine Langone Center/577-3794  
**Library Services**, Bertrand Library/577-1462  
**Lost and Found**, Secretary, Main Desk, Elaine Langone Center/577-3588  
**Technology Support**, Bertrand Library/577-7777  
**Multicultural Student Services**, 056 Elaine Langone Center /577-3216  
**Registrar**, 102 Marts Hall/577-1201  
**Student Accounts**, 108 Marts Hall/577-3733  
**Student Health Service**, Zeigler Health Center/577-1401  
**Transcripts, Registrar's Office**, 102 Marts Hall/577-1201  
**Writing Center**, 100A Roberts Hall/577-3141

## Abbreviations and Codes

Abbreviations for subjects, as used in the recording of data, in the various graduate programs described in this catalog, in schedules of classes, and on students' records, are coded as follows:

Subject	Code	Subject	Code
Animal Behavior	ANBE	Electrical Engineering	ELEC
Biology	BIOL	English	ENGL
Chemical Engineering	CHEG	Environmental Engineering	EVEG
Chemistry	CHEM	Mathematics	MATH
Civil Engineering	CENG	Mechanical Engineering	MECH
Education	EDUC	Psychology	PSYC

Within the parentheses following the title of each course, in the course descriptions sections of this catalog, the following abbreviations are used:

- "I" indicates the first (fall) semester; "II" the second (spring) semester.
- The word "and" between "I" and "II" designates a course which is offered in each semester.
- The word "or" between "I" and "II" designates a course which may be offered in either one of the semesters.
- The appearance of "A" preceding "I" or "II" means that a course is offered in alternate years.
- The letter "S" designates a course offered during the summer session.
- The letter "R" following the semester designation indicates that the course may be repeated for credit.
- The first number after the semicolon shows the number of hours of classroom work for each week in a semester.
- The second number after the semicolon shows the number of hours in each week devoted to work in the laboratory, shop, studio, drafting room, field, etc.

"TBA" in any position within the parentheses indicates that the information was not available for inclusion