

Frank Batten College of Engineering and Technology

Web Site: <http://www.odu.edu/eng>

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Mission Statement

In accordance with the mission of Old Dominion University, the Frank Batten College of Engineering and Technology promotes the advancement of engineering knowledge, both by its creation and dissemination, and by providing successful graduates and a continuously improving learning environment to its constituents, while maintaining ethical, multicultural and global standards.

Overview

The Frank Batten College of Engineering and Technology at Old Dominion University offers degrees in engineering and in engineering technology. The course of study that leads to engineering degrees is characterized by a solid foundation in the theoretical underpinnings of engineering based in science and mathematics. Graduates are well equipped to pursue graduate education, pursue professional registration, or enter the engineering profession. The course of study that leads to engineering technology degrees is characterized by strong laboratory experiences that will prepare the graduate to hit the ground running as a technical partner of the engineer who can implement advanced design analysis and development concepts. The engineering technology degree is considered to be a terminal degree and graduates are prepared for manufacturing, testing, production and operations.

The Batten College of Engineering and Technology established the first academic department in Modeling, Simulation and Visualization Engineering in 2010. This department offers well established graduate degrees and the first Bachelor of Science degree in Modeling and Simulation Engineering.

The engineering and engineering technology programs at Old Dominion University are specifically designed to take advantage of the unique assets in the Hampton Roads area. These assets include:

1. a strong technology center to promote and use modeling and simulation
2. the NASA Langley Research Center with its focus on aerospace and virtual environments
3. the Jefferson Laboratories, a major center of nuclear physics
4. one of the major international deepwater ports on the east coast of the United States;
5. a major ship building and ship repair industry,
6. a major high technology industry base
7. very large military presence and installations

These assets have enabled the development of distinctive engineering and technology curricula. Points of distinction (from other programs in and out of the state) include the following:

Career Development Services

Engineering and technology graduates get a head start on the engineering job market by preparing academically and experientially for their engineering and technology careers. Students receive direct assistance in locating full- and part-time employment including co-op and internship opportunities through the college's Career Development Services office.

Engineering Up-Front

Freshmen immediately become engaged in practical engineering and technology activities through a required course, Explore Engineering/Technology. Team projects in different engineering disciplines allow students to experience the professional spectrum from idea generation through its translation into the design, manufacture and commercialization cycle. Students are encouraged to complete this course before declaring a specific engineering discipline as a major.

Multi-Disciplinary Industry Senior Project

Seniors may choose to join a multi-disciplinary team of students led by faculty and industry representatives to work on an industry project subject to specific deliverables and time and budget constraints.

Linked Bachelor's/Master's Degree Programs

Students in the Batten College of Engineering and Technology may be accepted into both a bachelor's and master's program at the freshman year through the junior year. The degrees need not be in the same field of engineering.

Professional Engineer (P.E.) Certification

The College encourages all of its graduates to eventually be certified as Professional Engineers (P.E.). The certification requires taking the Fundamentals of Engineering (FE) Examination and the Professional Engineering (P.E.) Examination. All students are encouraged to take the FE Examination in their senior year. For details, contact the Dean's Office and the following web site: www.dpor.virginia.gov (<http://www.dpor.virginia.gov>).

For further information, please visit the college's web site: <http://www.odu.edu/eng>.

Programs of Study

Bachelor's

Engineering Programs:

- Civil
- Computer
- Electrical
- Mechanical
- Modeling & Simulation

Engineering Technology:

- Civil (CET)
- Electrical (EET)
- Mechanical (MET)

Master's

Engineering Programs:

- Aerospace
- Biomedical
- Civil
- Electrical & Computer
- Engineering Management
- Environmental
- Mechanical
- Modeling & Simulation
- Systems Engineering

Doctoral

Engineering Programs:

- Aerospace
- Biomedical
- Civil & Environmental

- Electrical and Computer
- Engineering Management
- Engineering Management & Systems Engineering
- Mechanical
- Modeling & Simulation

Accreditation

The following are engineering programs accredited by the Engineering Accreditation Commission of ABET www.abet.org (<http://www.abet.org>):

Bachelor of Science in Civil Engineering
 Bachelor of Science in Computer Engineering
 Bachelor of Science in Electrical Engineering
 Bachelor of Science in Mechanical Engineering
 Bachelor of Science in Modeling and Simulation Engineering

The following are engineering technology programs accredited by the Engineering Technology Accreditation Commission ABET www.abet.org (<http://www.abet.org>):

Bachelor of Science in Engineering Technology - Civil Engineering Technology
 Bachelor of Science in Engineering Technology - Electrical Engineering Technology
 Bachelor of Science in Engineering Technology - Mechanical Engineering Technology

The following program is certified by the American Society for Engineering Management www.asem.org (<http://www.asem.org>):

Master of Engineering Management

Collaborative Programs

Commonwealth Graduate Engineering Program (CGEP)

Linda Vahala, Director

The Commonwealth Graduate Engineering Program (CGEP) is a unique cooperative agreement. This agreement is among the five largest engineering schools in the Commonwealth of Virginia: Old Dominion University, George Mason University, the University of Virginia, Virginia Commonwealth University and Virginia Polytechnic Institute and State University. The program was developed in response to the diverse continuing education needs of engineering graduates working in industry and government.

Graduate engineering courses leading to a Master of Science or Master of Engineering degree or nanotechnology certificate are offered through these universities via a statewide interactive distance-learning network.

Students seeking admission to the various degree programs should request and process their applications through the Commonwealth Graduate Engineering Program Office in the Batten College of Engineering and Technology at Old Dominion University: www.eng.odu.edu/cgep

Enterprise Centers

The Batten College of Engineering and Technology is a catalyst for the economic development of Hampton Roads. To this end, the college has established a number of centers to serve as engines for enterprise development. These centers utilize all University resources, including students and faculty. The former engineering centers now elevated as University Centers are: VMASC (the Virginia Modeling, Analysis and Simulation Center) and Bioelectrics. One that has been transferred to the Commonwealth is MARS (the Mid-Atlantic Regional Spaceport).

Applied Research Center (ARC)

Hani Elsayed-Ali, Director

ARC is an advanced materials engineering and laser technology research center. Staffed with industry/university teams utilizing the Jefferson Lab technologies, ARC provides commercial product-related research in the

areas of thin film technology, laser and plasma processing of materials, materials analysis, and devices and sensor fabrication. For more information: www.eng.odu.edu/arc.

National Center for System of Systems Engineering (NCSOSE)

Charles Keating, Director

NCSOSE is a collection of independent, nonprofit, engineering research and application organizations, government entities, and universities that have joined together with a common goal to solve problems, develop technologies, and direct research focused on critical issues related to the integration of complex systems of systems.

Affiliated Centers

Frank Reidy Research Center for Bioelectrics

To be named, Director

The mission of the Center is to increase scientific knowledge and understanding of the interaction of electromagnetic fields and ionized gases with biological cells and to apply this knowledge to the development of medical diagnostics, therapeutics, and environmental contamination. The objectives of the Center are to perform leading edge interdisciplinary and multi-institutional research, recruit top faculty and exceptional graduate students, support regional, national, and international programs, and increase external funding and institutional visibility. For more information: www.odu.edu/engr/bioelectrics/.

Virginia Modeling, Analysis, and Simulation Center (VMASC)

Eric Weisel, Interim Director

VMASC is a multi-disciplinary research center of Old Dominion University. Working with more than one hundred industry, government, and academic members, VMASC furthers the development and applications of modeling simulation, and visualization as enterprise decision-making tools to promote economic, business, and academic development. For more information: www.vmasc.odu.edu.

Departmental Institutes

Coastal Engineering is part of the college's Department of Civil and Environmental Engineering. Its mission is to foster interdisciplinary educational and research opportunities for faculty and students interested in applied coastal science and engineering. Director: Gangfeng Ma.

Naval Systems and Marine Engineering Institute (NEMSI) was founded in 2014 with the vision to build a robust, sustainable center of excellence that supports the Naval Enterprise and Marine Industry in research and professional workforce development. NEMSI's mission is to: (1) expand Old Dominion University's research capabilities to assist the Navy and industry in addressing complex challenges in design, construction, operations and modernization of marine vessels for military, commercial and recreational use and (2) promote curriculum and lab advancements, faculty-student research at the undergraduate and graduate level, and student engagement and retention initiatives to produce an engineering workforce that meets the national competitive needs of the navy and marine industry constituencies. Director: Jennifer Michaeli.

Plasma Engineering and Medicine Institute is focused on conducting fundamental and applied investigations using Laser and Plasma Technologies. It offers state-of-the-art equipment and a vibrant academic environment where faculty, graduate and undergraduate students engage together in advanced research encompassing fundamental and applied research aspects in the field of cold plasmas, and its applications in engineering and medicine. Director: Mounir Laroussi.

Sustainable Development Institute promotes and provides engineering, ecological, environmental, and economic assistance to local, regional, and national governmental agencies, as well as international organizations and businesses. The institute actively participates in community service by

conducting waste minimization and pollution prevention assistance to local businesses. Director: Mujde Erten-Unal.

Transportation Research Institute collaborates with centers and departments across the ODU campus to conduct innovation-based research in the core areas of transportation operations, transportation safety, transportation planning, freight transportation, and environment, energy, and sustainable transport. Director: Mecit Cetin.

Virginia Institute for Photovoltaics research spans from the Nanoscale (Fundamental Sciences and Engineering) through the Devices and balance of systems, to the deployment of Gigascale commercial power generation. The current focus is to research and develop the Science and Engineering of Photovoltaic Devices (or Solar cells) and bring them from the laboratory to the industry. Director: Sylvain Marsillac.

Virginia Institute for Vision Analysis aims to leverage complimentary expertise of faculty in computer vision, signal/image processing and machine learning to become one of the leading institutes in the field. Research focuses on novel theory, state-of-the-art algorithms, architectures, real-time implementations for biomedical engineering, human- and machine-centric recognition, environmental and geoscience applications and computer-aided medical diagnosis systems. Director: Khan Iftakharuddin.

Special Programs

Cooperative Education/Internships Program

The cooperative education programs in the Frank Batten College of Engineering and Technology at Old Dominion University are of the highest academic quality. These programs allow students to combine academic study with professional-level training. Cooperative education positions may be based on the alternating program style in which periods of full-time study are alternated with periods of full-time employment. Full-time employment periods must accumulate to the equivalent of one calendar year. Participation in the cooperative education program can be a source of financial support to help meet a substantial portion of college expenses. All departments in the Frank Batten College of Engineering and Technology strongly endorse the concept of cooperative education and internships.

Linked Bachelor's/Master's Degree Programs

These are designed to allow qualified students to secure a space in a master's program available in the Frank Batten College of Engineering and Technology while they are still pursuing their undergraduate degrees. An eligible student can choose a master's program in the same discipline as his/her bachelor's program or in a complementary discipline. Subject to the approval of the undergraduate and graduate program directors, a student enrolled in a linked program can count up to six credit hours of course work towards both the undergraduate and the graduate degrees. Full-time students may be able to complete the requirements for the bachelor's degree in four years and the master's degree in one additional year. Students in linked programs must earn a minimum of 150 credit hours (120 for the undergraduate degree and 30 for the graduate degree).

Students who are matriculated in an undergraduate major in the Frank Batten College of Engineering and Technology with a GPA of at least 3.00 overall and 3.00 in the major are eligible to apply for admission to a linked bachelor's/master's program. Transfer students who desire to be admitted to a linked program at the time they join an undergraduate major at Old Dominion University are eligible to apply if their overall GPA at their previous institution is 3.25 or higher. Prerequisite courses may be required for engineering technology majors to pursue a master's degree in engineering.

Continuance in a linked bachelor's/master's program requires maintenance of a GPA of 3.00 or higher overall and in the major.

Old Dominion University/Eastern Virginia Medical School Joint Program in Medicine

The joint program in medicine is designed to encourage highly qualified students to receive a B.S. from Old Dominion University and an M.D. from Eastern Virginia Medical School. Students apply after completion of their freshman year at Old Dominion University. Upon successful completion

of requirements and graduation from Old Dominion University, a student accepted in the ODU/EVMS Joint Program in Medicine will be guaranteed admission to Eastern Virginia Medical School. Engineering and engineering technology students are encouraged to apply for this program. Complete information can be found in the College of Sciences section of this catalog.

Bachelor-to-Ph.D. Programs

For a select number of exceptionally well-qualified students, the college has established a linked doctoral program that enables students to be admitted directly into the Ph.D. program upon completion of the baccalaureate degree. A select number of exceptionally well-qualified students can be admitted to the Bachelor/Ph.D. program in their junior year while they are pursuing one of the undergraduate programs at Old Dominion University. This program encourages admitted students to work closely with faculty members and pursue a research experience. Just as in the linked Bachelor/M.S. program, six credit hours of graduate course work may again be counted towards the undergraduate degree and doctoral course work mentioned above for the Bachelor/Ph.D. program. For linked bachelor's to doctoral programs, students must earn a minimum of 198 credit hours (120 for the undergraduate degree and 78 for the graduate degree). Students in these programs must maintain a GPA of 3.50 or better throughout their bachelor's and doctoral studies.

The student may opt to obtain the master's degree along the way to the doctorate. To obtain the master's degree, the student must utilize the six graduate credits obtained as part of their undergraduate program, use 18 credits of the graduate course work that is part of the Ph.D., and also write a master's thesis.

Undergraduate Programs

The Bachelor of Science in Civil Engineering, the Bachelor of Science in Computer Engineering, the Bachelor of Science in Electrical Engineering, the Bachelor of Science in Mechanical Engineering and the Bachelor of Science in Modeling and Simulation Engineering are accredited by the Engineering Accreditation Commission (EAC) of ABET, <http://www.abet.org>.

The Bachelor of Science in Engineering Technology has programs in civil engineering technology, electrical engineering technology, and mechanical engineering technology that are accredited by the Engineering Technology Accreditation Commission (ETAC) of ABET, <http://www.abet.org>.

Engineering Fundamentals Division

The Engineering Fundamentals Division (EFD) is designed to provide support to students as they make the transition into the Frank Batten College of Engineering and Technology. All students are admitted to this division until they are prepared to successfully take courses in their major. While in this division, students receive individualized counseling, mentoring, and advising support designed to prepare them for success in their chosen engineering or technology major. A key experience for students in this division is the year-long course in the Fundamentals of Engineering. This group-oriented course uses hands-on projects to expose students to the spectrum of engineering practices from innovation through design, manufacture and commercialization of a product or process. It also provides students with an opportunity to experience various aspects of engineering and have a basis for selecting their major.

Admission

Students who qualify for regular admission to the University will be accepted into EFD. Students in EFD may identify a desired degree program or may declare that they are undecided among engineering and engineering technology programs. They will be assigned an intended major code classification, which indicates that they are enrolled and, if appropriate, which is their preferred program.

Matriculation into a Degree Program

Students should apply to the desired program during the semester in which they complete the requirements in the Engineering Fundamentals Division.

Students will be notified of the admission decision upon satisfying these requirements:

1. complete the course Explore Engineering and Technology
2. complete at least 30 credit hours applicable toward a degree
3. have an overall GPA of 2.00 or higher
4. meet any other additional degree program admission requirements.

Normally, students are not eligible to enroll in major courses until they are accepted into the degree program. Students may petition to waive this rule when extenuating circumstances warrant.

Continuance

Students are eligible to continue in the EFD as long as they:

1. meet the continuance regulations of the University and
2. make reasonable progress toward matriculation into an engineering or engineering technology program.

A student who has ceased reasonable progress toward matriculation into a college degree program will be notified in writing. One semester following this notification, if reasonable progress has not resumed, the student will be referred to the Center for Major Exploration. A student who successfully completes the requirements must apply to and be accepted by a college degree program. Students not accepted into a degree program during a period of one semester beyond completion of the requirements will be referred to the Center for Major Exploration.

Computer Requirement

The Frank Batten College of Engineering and Technology requires that all incoming freshmen to the college have a notebook or laptop computer that meets or exceeds the Mobile Monarch Student Notebook Program's recommended models for engineering majors. Students are strongly encouraged to consider purchasing one of the Mobile Monarch Student Notebook Program's notebooks; however, students may bring their own notebook if it meets the specifications. More information, including the notebook loaner program, can be found at: <https://www.odu.edu/efd>.

Engineering Fundamentals—Engineering Programs

The following courses are to be taken Freshman year.

Freshman First Semester

| | | |
|-------------------------|---|-----------|
| ENGN 110 | Explore Engineering and Technology | 2 |
| MATH 211 | Calculus I | 4 |
| CHEM 121N | Foundations of Chemistry I Lecture | 3 |
| CHEM 122N | Foundations of Chemistry I Laboratory | 1 |
| ENGL 110C | English Composition (grade of C or better required) | 3 |
| GEN ED - Way of Knowing | | 3 |
| Total Hours | | 16 |

Freshman Second Semester

| | | |
|--------------------|---|-----------|
| CEE 111 | Information Literacy and Research * | 2 |
| or ECE 111 | Information Literacy and Research for Electrical and Computer Engineering | |
| or MAE 111 | Mechanical and Aerospace Engineering Information Literacy and Research | |
| or MSIM 111 | Information Literacy and Research for Modeling and Simulation Engineers | |
| or ENGT 111 | Engineering Technology Information Literacy/ Research | |
| MATH 212 | Calculus II | 4 |
| CHEM 123N | Foundations of Chemistry II Lecture | 3 |
| PHYS 231N | University Physics I | 4 |
| CS 150 | Problem Solving and Programming I | 4 |
| Total Hours | | 17 |

* Meets information literacy and research general education requirement in conjunction with courses in the major.

Engineering Fundamentals—Engineering Technology Programs

Refer to the program curriculum listing appearing in the Engineering Technology section.

Advanced Placement

The University provides for possible advanced placement for up to 60 semester hours of course work. The student should refer to the advanced placement policy of specific departments (Mathematics and Statistics, Physics, Chemistry and Biochemistry, etc.) and the Policy for Prior Learning Assessment Credit Options at the Undergraduate Level found in this Catalog.

Qualified students may take advanced placement examinations in certain courses in the various departments of the Batten College of Engineering and Technology. The student should contact the chair of the department offering the course for information on applicability and approval.

Prospective freshmen are encouraged to take as many advanced placement courses as possible in high school. Further, prospective freshmen are encouraged to take as many AP examinations of the Educational Testing Service and CLEP examinations as possible. Qualifying scores on these examinations may result in advanced placement credit. However, freshmen should still consult with their faculty advisor before "skipping" courses given at Old Dominion University.

Transfer Students

Transfer students seeking admission to an engineering or engineering technology program at Old Dominion University must complete the standard admission procedures as established by the Office of Admissions.

Transfer students are usually in one of the following categories:

(a) students who have completed some course work, but who have not completed associate degrees

(b) students who have completed associate degrees in appropriate fields before transferring.

Certain special policies have been developed for students in category (b). If the overall educational background of the transfer student who has completed an associate degree is felt to be sufficiently strong to permit him or her to pursue upper-division work satisfactorily, a composite or "package" evaluation of transfer credit may be made. This approach will permit some flexibility in accommodating students with slightly different but equally appropriate backgrounds, dependent on the engineering or engineering technology program involved. Certain deficiencies can be made up while the student is pursuing upper-division studies.

To be admitted as a transfer student with departmental junior standing, the student should have either completed an associate degree in an acceptable program or received full credit for two years of work indicated by the completion of the equivalent number of semester hours in the chosen engineering or engineering technology curriculum with a grade of C or better in each course.

Transfer students must earn a minimum of 25 percent of the total number of credits required for the degree from Old Dominion University and complete a minimum of 12 credit hours in upper-level courses in the major program from Old Dominion University.

ENGINEERING Courses

ENGN 100. Spatial Visualization. 0 Credits.

The course introduces students to spatial visualization/thinking. The objective of the course is to enhance students' ability of thinking in three dimensions. The course covers student experience with spatial visualization/thinking, design and representation, and strategic use. Educational interventions and testing to improve three-dimensional visualization skills are used. The course does not count towards College of Engineering & Technology graduation credit. Prerequisites: Permission of instructor required; enrollment limited to first-year engineering students participating in the Summer Preview/Orientation.

ENGN 108. Introduction to Engineering. 3 Credits.

A one-semester course covering topics in civil, environmental, mechanical, electrical and computer engineering. For non-engineering majors. Prerequisites: MATH 102M.

ENGN 110. Explore Engineering and Technology. 2 Credits.

This course involves a series of projects to introduce a variety of engineering and technology disciplines; hands-on experiences with selected engineering problems and issues; a team approach to managing engineering projects; discovering the unknown, formulating solutions, designing, manufacturing, and testing; and emphasis on learning modules, communication and presentation skills, creativity and innovation. Pre- or corequisite: eligible to enroll in MATH 162M or higher.

ENGN 150. Computer Programming for Engineering Problem Solving. 4 Credits.

Introduction to computer programming using engineering problem-solving. Software design topics include program design, algorithm development, and testing. Programming language concepts include data types (primitive, composite, abstract, pointers) and program structure (assignment and control flow statements, functions). Laboratory exercises involve utilizing C++ and Matlab to solve engineering problems (control, information processing, simulation, data analysis). Pre- or corequisite: MATH 163.

ENGN 301. e-Engineering. 3 Credits.

A study of the theory and best practices involved in conducting physically-dispersed engineering team collaboration. Student teams will apply e-Engineering concepts using a distributed product engineering scenario. Course module topics include project management, virtual teaming, distributed collaborative tools, and scenario-specific engineering skills. Prerequisites: junior standing.

ENGN 401. Fundamentals of Engineering Review. 1 Credit.

This course prepares the engineering and engineering technology students for the Fundamentals of Engineering Examination. Prerequisites: Senior standing.

ENGN 402. Introduction to Engineering Design for Teachers. 3 Credits.

This course is for K-12 teachers seeking endorsement. No credit will be given to students pursuing majors in the College of Engineering and Technology. The major focus of this course is to expose students to the design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards, and technical documentation. Topics include engineering design process, modeling, sketching, measurement, statistics and applied geometry, engineering drawing standards, CAD solid modeling, reverse engineering, consumer product design innovation, graphic design and virtual design teams. Prerequisites: MATH 211 and PHYS 111N.

ENGN 403. Statics for Teachers. 3 Credits.

This course is for K-12 teachers seeking endorsement. No credit will be given to students pursuing majors in the College of Engineering and Technology. Scalar methods and free body diagrams are employed in the analysis of discrete and distributed force systems and their application to bodies in external equilibrium. Friction, moment of inertia, and center of gravity are also included. Prerequisites: MATH 211.

ENGN 404. Introduction to Fluids for Teachers. 3 Credits.

This course is for K-12 teachers seeking endorsement. No credit will be given to students pursuing majors in the College of Engineering and Technology. The study of fluid statics and dynamics, including momentum, energy, Bernoulli's Equation, laminar and turbulent fluid flow and friction in pipes, fluid machinery, and open-channel flow. Prerequisites: CET 200.

ENGN 405. Introduction to Thermodynamics for Teachers. 3 Credits.

This course is for K-12 teachers seeking endorsement. No credit will be given to students pursuing majors in the College of Engineering and Technology. The basic laws of thermodynamics, properties of fluids, heat and work and their applications in processes and cycles, and an introduction to conduction heat transfer will be covered. Prerequisites: CHEM 121N, MATH 211, and PHYS 111N.

ENGN 411. Energy Management and Policy. 3 Credits.

An introduction to energy management and contemporary policy issues. Topics include energy history, energy management principals, energy auditing, rates for commercial and industrial consumers, energy security and reliability, utility deregulation and energy system outsourcing, financing energy management projects, codes and standards, energy and climate change, and use of alternative energy. Prerequisites: Junior standing, PHYS 111N and MATH 162M.

ENGN 412. Fundamentals of Energy Conversion and Transmission. 3 Credits.

A general overview of energy conversion and transmission systems. The topics will include energy resources and units, fossil fuels, natural gas, nuclear fuel, energy from renewables, energy efficiency, energy management control systems, energy systems integration, energy systems and cyber security. Prerequisites: Junior standing, PHYS 111N and MATH 162M.

ENGN 444. Veterans in Engineering and Engineering Technology Seminar. 1 Credit.

This course aims to augment the transition from service to student to engineer through helping the veteran achieve a sense of belonging to the engineering profession through class discussions, seminars, and workshops designed to develop their identities as engineers and increase their feeling of belonging in engineering fields through self-efficacy and help with their persistence to degree completion. Class activities are designed to build a sense of community and increase students' relevance by helping students develop a career identity in engineering. Prerequisite: Junior standing or instructor permission.

ENGN 454/554. Introduction to Bioelectrics. 3 Credits.

Covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing, defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition, ultrashort electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered. (Cross-listed with ECE 454/554) Prerequisites: PHYS 111N or higher; MATH 200 or higher.

ENGN 495. Multidisciplinary Topics in Engineering and Technology. 1-3 Credits.

Special interdisciplinary or multidisciplinary topics of interest with emphasis on emerging areas in engineering. Prerequisites: instructor permission.