Chancellor’s Message

Welcome to the Air Force Institute of Technology - - AFIT. Whether you are a U.S. or international military member, a government employee or a non-federal civilian, AFIT’s Graduate School of Engineering and Management offers you a wide range of exciting education and cutting-edge research opportunities.

AFIT develops the world-class technologists, game-changing technologies, and defense leaders who are capable of using these technologies in support of national security, now and in the future. We are able to accomplish this because of our strong partnerships with other DoD agencies, federal departments, Defense Industry companies and many other research universities.

Regardless of the academic program you choose, your AFIT graduate-school experience will prepare you to think more critically, logically, systematically and objectively, as you tackle some of our most demanding and important national-security challenges and opportunities. You will have the opportunity to learn – by doing – the value of inspiration, innovation, teamwork, effective communication and, yes, hard work!

For more than 90 years - since 1919, AFIT has educated the air, space, and cyberspace leaders who have made history. Former Secretary of the Air Force Mike Wynne; the 10th Chief of Staff of the Air Force, General Lew Allen; Air Force Materiel Command’s newest Commander, General Janet Wolfenbarger; General William Shelton, Commander Air Force Space Command; and Major General Tim Byers, The Air Force Civil Engineer; are just a few of AFIT’s distinguished alumni. It is very likely that some student starting this fall could be among these AFIT distinguished alumni.

Students enrolled in the Graduate School of Engineering and Management soon realize AFIT provides rigorous, respected, and relevant graduate-education, research, and consultation opportunities, to push the frontiers of air, space, and cyberspace power. However, this is just part of AFIT’s mission. Through our School of Systems and Logistics and the Civil Engineer School, AFIT also provides world-class professional continuing education for the civil engineer, acquisition, logistics, and cyber communities. In fact, most of our graduate-school alumni have also taken courses from these schools, to continue their professional development; many more will take additional courses in the future. My goal is to develop in all of our graduates a passion for lifelong learning and for AFIT to be an important partner in that continuing, professional-development journey.

Again, welcome to the AFIT team. We look forward to working with you, as you prepare to help create the Air Force of the future.

TODD I. STEWART, PhD, Major General (Ret.), USAF
Director and Chancellor
Graduate School of Engineering and Management

The Graduate Catalog represents the offerings, programs, and requirements in effect at the time of publication, but there is no guarantee that they will not be changed or revoked. The course offerings and requirements of the institution are continually under examination and revision. However, adequate and reasonable notice will be given to students affected by any change. This catalog is not intended to state contractual terms and should not be regarded as a contract between the student and the institution. The institution reserves the right to change any provision, offering, or requirement to be effective when determined by the institution. These changes will govern current and readmitted students. Enrollment of all students is subject to these conditions.

Graduate students must assume full responsibility for knowledge of rules and regulations of the Graduate School of Engineering and Management and the departmental requirements for their chosen degree program. Any exceptions to Graduate School policy stated in this catalog must be approved by the Dean of the Graduate School of Engineering and Management. Individual departments may have requirements beyond the minimum established by the Graduate School. Students are referred to the academic departments for the most current requirements of a program.

This catalog is nondirective and should not be used for quoting AFIT, Air Force, or Department of Defense policy. It is intended as a compilation of AFIT academic information. Cleared for public release, distribution unlimited.

AFIT Leadership

Dr. Todd I. Stewart, Maj Gen (Ret.)
Chancellor and Director

Colonel Timothy J. Lawrence, PhD
Commandant and Vice Chancellor

Dr. Marlin U. Thomas
Dean

Colonel Kevin E. Burns
Associate Dean

Lt Colonel Michael L. Hastriter
Associate Dean of Students

Dr. Heidi R. Ries
Dean for Research

Dr. Paul J. Wolf
Associate Dean for Academic Affairs
TABLE OF CONTENTS

The Air Force Institute of Technology

Chancellor’s Message........................................................................................................1
Graduate School of Engineering and Management..........................................................2
Table of Contents .............................................................................................................3
AFIT Mission and Organization.......................................................................................4
History-Dayton and AFIT...............................................................................................5
Accreditation and Board of Visitors ..............................................................................13
Academic Programs and Degrees Offered.....................................................................15
Graduate Certificate Programs.......................................................................................17
Distance Learning..........................................................................................................17
Intermediate Development Education.............................................................................18
Academic Policies.........................................................................................................19
Academic Performance and Standard...........................................................................23
Master’s Degree Programs.............................................................................................24
Doctor of Philosophy Programs.....................................................................................26
Scholarships/Academic Consortia..................................................................................30
Academic Calendar, 2012–2013....................................................................................32

Admissions/Registrar

Admissions.......................................................................................................................35
Registrar............................................................................................................................43
Research............................................................................................................................45
Library Services................................................................................................................48
Financial Assistance........................................................................................................50
Computer Support..........................................................................................................52
Student Services............................................................................................................54
Student Association........................................................................................................55

Academic Departments

Astronautics and Aeronautics.........................................................................................56
Electrical and Computer Engineering............................................................................74
Engineering Physics.........................................................................................................92
Mathematics and Statistics..........................................................................................115
Operational Sciences.....................................................................................................119
Systems and Engineering Management......................................................................142
Course Descriptions......................................................................................................171
Faculty .............................................................................................................................303
Mission

Education and Research

The mission of the Graduate School of Engineering and Management is to provide high-quality graduate education programs and engage in research activities that enable the Air Force to maintain its scientific and technological dominance. The Graduate School's vision is to become the top-ranked graduate school of choice in engineering and applied science for defense-focused research-based education.

The Graduate School of Engineering and Management provides scientific, technological, and management education applicable to Air Force, Department of Defense, and civilian research and development environments. The Graduate School not only enhances the intellectual growth of its students by offering a broad range of high-quality graduate programs, but also prepares them for successful careers in engineering, applied science, and management. In the preparation of its curricula and in its operation, the Graduate School is continually cognizant of its unique responsibility—the technical and management education of Air Force officers so they can fulfill their roles in serving their country to the greatest degree possible.

Organization

The Graduate School of Engineering and Management offers graduate programs leading to Master of Science and Doctor of Philosophy degrees in engineering, applied science, and management disciplines.

1. All academic and admission policies as developed and approved by the faculty council
2. The development of new programs
3. Maintaining the appropriate standards for graduate-level programs

Administration

The Dean of the Graduate School is the chief academic and executive officer. The administrative leadership team includes the Associate Dean, the Dean for Research, the Associate Dean for Academic Affairs, and the Associate Dean for Students.

Academic Departments

Six academic departments deliver the academic programs. These departments are Aeronautics and Astronautics, Electrical and Computer Engineering, Engineering Physics, Mathematics and Statistics, Operational Sciences, and Systems and Engineering Management. Each department is responsible for the development and operation of its laboratories at all levels of activity, for the content and teaching of its academic courses, and the conduct of research programs. The chief administrative officer of each department is the Department Head, who reports directly to the Dean of the Graduate School of Engineering and Management.
History

Dayton & AFIT

The Air Force Institute of Technology was established in Dayton in 1919. In 1954, the Graduate School of Engineering and Management was authorized to grant degrees, and it graduated its first class two years later. Since 1956, AFIT has granted more than 17,000 master's degrees and 550 doctorates. The Graduate School not only enhances the intellectual growth of its students by offering a broad range of high-quality graduate programs but also prepares them for successful careers in those areas. To that end, research at AFIT is an essential ingredient of academic life because it creates the inquisitive and creative background characteristic of graduate-level teaching and learning.

AFIT has long been an active participant in the larger educational community, and its many partnerships contribute to its strong research environment.

- Strategic alliance with the Air Force Research Laboratory clears the path for streamlined access and resource sharing between AFIT and the lab sites across the United States.
- The Southwestern Ohio Council for Higher Education, an association of colleges, universities, and industrial organizations in the Dayton area, are united to promote educational advancement.
- The Dayton Area Graduate Studies Institute—which includes AFIT, Wright State University, the University of Dayton, the University of Cincinnati, and the Ohio State University—coordinates, integrates, and leverages the resources of the schools to improve and expand graduate-level educational opportunities in the engineering disciplines.

What's more, the Ohio Board of Regents, the educational governing board for the State of Ohio, funds DAGSI to provide scholarships for graduate engineering students at the local institutions. In addition, the Board of Regents provides more than $1 million in state funds each year to encourage collaborative research in support of the Air Force Research Laboratory at Wright-Patterson Air Force Base.

Not only is AFIT recognized as a world class graduate school and research institution, but the Dayton area is a great place to live! Dayton has long been known to the world for the history-impacting innovations born here, such as Wilbur and Orville Wright's flying machines. Today, Dayton's cooperative spirit is still alive in the nearly one million Greater Dayton residents who live, work, and play in the city and the surrounding area.

Award-winning, internationally recognized arts programs:

- The Dayton Opera
- The Dayton Philharmonic Orchestra
- The Victoria Theatre
- The Schuster Performing Arts Center
- The Dayton Ballet
- The Dayton Contemporary Dance Theatre
Museums and Recreation:

- The Dayton Art Institute
- The National Museum of the United States Air Force
- The High Street Gallery
- The Dayton Visual Arts Center
- The Boonshoft Museum of Discovery
- The Dayton Dragons Minor League baseball team
- RiverScape Park along the Great Miami River

Community activities:

- Neighborhood festivals
- Clean-up projects
- Picnics
- Special events

From vibrant downtown Dayton to its charming, unique neighborhoods, citizens are working together to make the city a friendly, safe, progressive, and very affordable place to live. And, of course, more fun is always close by!

- Cincinnati—home of the Reds, the Bengals, and Paramount's Kings Island—is less than an hour's drive (50 miles)
- Columbus—the state's bustling capital, home to the acclaimed Columbus Zoo, and host to Big Ten athletics—is only one hour and 15 minutes away (75 miles)
- Indianapolis, Indiana—home of the Indianapolis Colts, the Indy 500, and the Brickyard 500—is just two hours away (120 miles)

AFIT History

AFIT was established to follow Orville and Wilbur Wright's quest to further research in the development of air power and science, and to educate many of the nation's future leaders of aviation. AFIT's flexibility is such that it adjusts quickly to changing Air Force requirements. The faculty, comprised of highly qualified military and civilian personnel, stay abreast of projected Air Force operations, and the programs are continually updated to offer its students the latest available material.

AFIT...Where it all began

The history of the Air Force Institute of Technology dates back to the fledgling days of powered flight, for it early became apparent that the progress of military aviation was closely dependent upon the availability of military specialists in aeronautical science and allied technical fields.
1914

Formal education in aviation required.

Education in scientific aspects of aviation began when the Army detailed Captain Virginius E. Clark to the Massachusetts Institute of Technology (MIT) to study aeronautical engineering. During World War I, an Army and Navy School of Aeronautical Engineering was opened at MIT, and two classes were graduated.

1919

Need for an aeronautical school proposed.

The original idea of an aeronautical school was proposed by Colonel Thurman H. Bane, Commanding Officer of McCook Field, Dayton, Ohio. The suggestion was approved by the War Department.

November 1919

First school established at McCook Field in Dayton, OH, the home of Orville and Wilbur Wright.

The Air School of Application was established within the Engineering Division at McCook Field with seven officers enrolled and Colonel Bane as the Commandant.

1920

School renamed.

Following the creation of the Air Service, the school was redesignated the Air Service Engineering School.

1926

Second stage in development of the Institute of Technology.

Following Congress' authorization of the Air Corps in 1926, the school was redesignated the Air Corps Engineering School and moved to Wright Field in 1927.

1927

School relocated.

Air Corp Engineering School was moved to a 4500 acre tract of land donated to the government by the citizens of Dayton. The new installation was named Wilbur Wright Field in honor of one of Dayton's celebrated native sons, the late Orville and Wilbur Wright.

1927

School curriculum evolved to research and design.

Fundamental changes in philosophy and policy stimulated the increasing importance of science and the need for specialization in the development of air power. Originally designed to provide technical education for senior officers holding command positions, the school was now given the additional mission of preparing
younger officers to fill positions in research and design within the Engineering Division. It graduated more than 200 officers, including many of the nation's foremost wartime and post-wartime leaders of aviation.

December 1941

Attack on Pearl Harbor.

The attack on Pearl Harbor caused the Air Corps Engineering School to suspend classes.

April 1944

School renamed and reopened.

The school reopened as the Army Air Forces Engineering School to conduct a series of accelerated courses to meet emergency requirements.

September 1946

Army Air Forces Institute of Technology officially established.

On 3 September 1946, the Army Air Forces Institute of Technology was officially opened as part of the Air Materiel Command. The Institute was composed of two colleges: Engineering and Maintenance, and Logistics and Procurement. These colleges were later redesignated the College of Engineering Sciences and the College of Industrial Administration.

1947

Institute adopts present name: Air Force Institute of Technology (AFIT).

When the Air Force became an autonomous unit in the military establishment during 1947, the Institute was renamed the Air Force Institute of Technology. Wright Field, with its extensive research and development facilities, was combined with neighboring Patterson Field, center of Air Force supply and procurement activities, to form the present single installation, Wright-Patterson Air Force Base.

1950

AFIT put under jurisdiction of Air University.

In 1950, command jurisdiction of AFIT shifted from Air Materiel Command to Air University (AU), with headquarters at Maxwell AFB, Alabama. The Institute, however, remained at Wright-Patterson AFB.

1951

Two AFIT colleges combined into Resident College.

Progress towards a graduate school at AFIT was marked by the enrollment of eight officers in the first Advanced Engineering Management Class in January 1951.

1954

AFIT authorized to confer degrees with ECPD accreditation.
The 83rd Congress authorized the Commander, Air University, to confer degrees upon accreditation by a nationally recognized association or authority, to persons who met all requirements for those degrees in the Air Force Institute of Technology Resident College. In October 1954, the Engineering Council Professional Development (ECPD) accredited the undergraduate Aeronautical and Electrical Engineering program.

**April 1955**

Logistics program established.

AFIT designed a logistics education program in 1955, and The Ohio State University (OSU) conducted the first courses on a contract basis.

**1956**

First bachelor's degrees conferred.

The first undergraduate engineering degrees were granted in 1956.

**1958**

First graduate degree conferred.

In 1958, the first graduate degrees in business were awarded and a School of Logistics was added to AFIT. The curriculum included the Advanced Logistics Course as well as twenty-two other courses offered in conjunction with the Air Force Logistics Command's Logistics Education Program.

Established leadership in Logistics Management program.

Its capability placed the school in position of real leadership, Air Force-wide, in logistics management education for military and civilian personnel alike. AFIT was admitted to membership of the American Association of Collegiate Schools of Business (AACSB).

**1960**

Business programs transferred.

The School of Business programs were transferred to civilian universities in 1960.

**1960**

Graduate programs accredited

AFIT obtains its initial accreditation from the North Central Association of Colleges and Schools (NCA) to award graduate degrees.

**1961**

International Students enrolled.

AFIT began accepting international students in 1961, and since then more than 50 countries have been represented, including up to eight countries at once.
1963

School of Logistics and Civil Engineering School redesignated.

The School of Logistics and the Civil Engineering Center were renamed the School of Systems and Logistics and the Civil Engineering School, respectively.

1970s

Technology growth.

The seventies saw a scientific expansion as technology accelerated further. AFIT graduates were closely involved in the Apollo space program.

1972

Ohio State contract expired.

As a result of this action in fiscal year 1972, the Air Force hired the OSU teaching faculty as civil servants, retained its own Deans and Department Heads, and thereby assumed full management of the School.

1977-1978

AFIT facilities expanded.

New construction at the Institute was marked by the erection of a new School of Systems and Logistics facility in 1977. Air University and AFIT became part of the Air Training Command (ATC), the largest USAF major command.

1980s

AFIT programs embody high technology education. By the 1980s, AFIT was comprised of the School of Engineering, the School of Systems and Logistics, and the School of Civil Engineering and Services, as well as a Civilian Institution Programs Directorate. Programs developed included information processing, electro-optics, radiation hardening, advanced composites, space structures, software engineering and software systems management.

1990s

Graduate environmental and meteorology programs designed. When environmental concerns culminated in the Pollution Prevention Act of 1990, AFIT designed and implemented both graduate and professional continuing education programs in environmental engineering management. Similarly, when Air Force Weather Command requested a meteorology program designed specifically for the warfighter, AFIT delivered a graduate program in military meteorology with fourteen officers enrolled.

1995

New consortium formed.

The Dayton Area Graduate Studies Institute (DAGSI) consortium was formed with AFIT, Wright State University, and the University of Dayton as the original members. The Ohio Board of Regents provides state
funds to encourage collaborative research in support of the Air Force Research Laboratory at Wright-Patterson AFB.

1997-1998

Air Force supported AFIT's continued existence.

The Acting Secretary of the Air Force, F. Whitten Peters announced a reversal of the Air Force decision to terminate the Institute's resident graduate programs. In December 1998, AFIT broke ground for an $8.9 million engineering laboratory to be used for experimental research in aeronautical engineering, electrical engineering, applied physics, and environmental science.

1999

AFIT restructured.

As part of the restructuring, the two resident graduate schools were merged into the Graduate School of Engineering and Management.

2002

Enrollment increased.

The first group of enlisted students was enrolled in the AFIT Graduate School.

Also in 2002, AFIT and the Naval Postgraduate School formed an educational alliance to eliminate duplicate degree programs and consolidate educational resources.

2003

AFIT continued tradition of meeting Air Force needs.

At the direction of the Secretary of the Air Force, AFIT opened the USAF Center for Systems Engineering. In addition, AFIT is home to six other research centers: the Center for Directed Energy, the Center for Information Security Education and Research, the Center for Measurement and Signature Intelligence Studies and Research, the Center for Operational Analysis, the Advanced Navigation Technology Center, and the Center for Space Studies and Research.

Also in 2003, the Intermediate Developmental Education (IDE) 12 month program of study was offered at AFIT for the first time and the Commandant's position was restored to that of a brigadier general.

2004

AFIT awarded degrees to historically significant graduates.

In March 2004, more than 200 scientists and engineers received graduate and doctoral degrees from AFIT, bringing the total number of graduates to more than 15,000. Under the initiative of the Secretary of the Air Force, Dr. James G. Roche, the school's first enlisted students received master's degrees as part of that class, eight Air Force and six Marine Corps senior non-commissioned officers.
AFIT Graduate School of Engineering and Management Catalog 2012-2013

2005

AFIT graduate became SECAF.

On 10 November, Michael W. Wynne was sworn in as the 21st Secretary of the Air Force. Mr. Wynne, who graduated from the United States Military Academy, earned a master's degree in electrical engineering from the Air Force Institute of Technology and earned a master's degree in business from the University of Colorado.

2006

Significant events.

On 4 July, AFIT graduates, Commander Steve Lindsey and Astronaut Mike Fossum, were on the "Return to Flight" Discovery space shuttle.

On 31 July, AFIT welcomed its first female commandant, Brigadier General Paula G. Thornhill, who holds a PhD in history from Oxford University.

On 14 December, AFIT broke ground for a new building. This project will increase AFIT's overall footprint by 50,000 square feet and will support the growing AFIT curriculum by housing the faculty and staff of the Center for Systems Engineering. It will also house classrooms and laboratory facilities that will enable AFIT's graduates to conduct state-of-the-art, interdisciplinary, Air Force-sponsored research.

2007

CISER changes to CCR

The Center for Information Security and Education Research changes its name to the Center for Cyberspace Research to more closely align to the Air Force mission in cyberspace

2008

New Facility opens at AFIT

Building 646 officially opens after two years of construction, this 50,000 sf facility houses the new offices of the Commandant and support staff, as well as the Center for Systems Engineering, 14 new classrooms, labs, and collaborative design centers. The first silver LEED (Leadership in Energy and Environmental Design) certified facility at Wright Patterson AFB.

AFIT and the Center of Cyberspace Research are designated The Air Force Cyberspace Technical Center of Excellence by the Secretary of the Air Force

2009

AFIT continues its quest to develop education to meet Air Force goals.

AFIT celebrates its 90th Anniversary during the 2009 Heritage Symposium. Faculty and staff members reflect with pride on the contributions the Institute's graduates have made on engineering, science, technology, medicine, logistics, and management. During the past 90 years, more than 266,000 Department of Defense personnel, including 30 United States astronauts, have attended AFIT programs. The future
promises to be even more challenging than the past, and AFIT is prepared to continue providing the environment and the opportunity for Air Force personnel to develop the professional and technological skills needed to master this dynamic challenge.

2010

AFIT expands its leading role in the AF Cyber Education mission by developing and executing Cyber professional continuing education. AFIT will graduate 600 students per year ready to lead the AF in this technically demanding domain. AFIT was re-accredited by both the Higher Learning Commission and the Accreditation Board of Engineering and Technology for the maximum time period allowed.

2011

AFIT is given authority by Congress to enroll up to 125 defense industry civilians in degree granting programs within the Graduate School of Engineering and Management.

2012

The Air University Commander and President preside over the Change of Leadership ceremony for AFIT's first senior civilian leader, the Chancellor and Director.

Accreditation

The Air Force Institute of Technology is accredited by The Higher Learning Commission (HLC) and is a member of the North Central Association of Colleges and Schools (NCA).

The HLC can be contacted at:
The Higher Learning Commission, NCA
230 South LaSalle Street, Suite 7-500
Chicago, Illinois 60604-1413
Phone: (800) 621-7440
www.ncahlc.org

In addition to institutional accreditation, the Engineering Accreditation Commission of ABET accredits the following engineering programs in the Graduate School of Engineering and Management: Aeronautical Engineering, Astronautical Engineering, Computer Engineering, Electrical Engineering, Engineering Management, Environmental Engineering and Science, Nuclear Engineering, and Systems Engineering.

ABET can be contacted at:
ABET, Inc.
111 Market Pl, Suite 1050
Baltimore, MD 21202
Phone: (410) 347-7700
www.abet.org
Board of Visitors

The Air University Board of Visitors includes an Air Force Institute of Technology (AFIT) Subcommittee that is comprised of a select group of eminent educators from prominent US colleges and universities and senior executives from major industries. The Subcommittee serves in an advisory capacity and meets annually. Its purpose is to review and evaluate AFIT policies related to accreditation, admission requirements, curricula, instructional methodology, facilities, management, and other aspects of AFIT. The Subcommittee presents its findings and recommendations in a written report to the AFIT Commandant. The report is included in the annual report submitted by the Air University Board of Visitors to the Commander, Air University and is reviewed by Headquarters United States Air Force.

CURRENT MEMBERSHIP

Chairman

Major General Stephen Condon, USAF, Retired
Aerospace Consultant

Chairman Elect

Major General Richard Paul, USAF, Retired
Former Vice President
Strategic Development & Analysis, Boeing

Members

Dr. Kyle Terry Alfriend
Professor of Aerospace Engineering
Texas A&M University

Chief Master Sergeant Karl Meyers, USAF, Retired
Realtor, Realty Executives
Simmons Group

Vice Admiral Daniel Oliver, USN, Retired
President
Naval Postgraduate School

Major General (Dr.) Ronald Sega, USAF, Retired
Woodward Professor of Systems Engineering and
VP for Energy, Environment and Applied Research
Colorado State University Research Foundation

Dr. Eugene Spafford
Professor and Executive Director of CERIAS
Purdue University
Academic Programs and Degrees Offered

- Graduate Certificate Programs
- Distance Learning (DL) Offerings
- Intermediate Development Education

The degrees currently available through the faculty of the Graduate School of Engineering and Management are: the Master of Science (M.S.) degree, and Master of Science in (the appropriate discipline) degree programs, and the Doctor of Philosophy (Ph.D.) degree. With the exception of the M.S. and Ph.D. degree programs in Aeronautical and Astronautical Engineering within the Department of Aeronautics & Astronautics, students desiring to pursue ABET-accredited graduate degrees at AFIT must have earned an ABET-accredited undergraduate degree.

<table>
<thead>
<tr>
<th>Program</th>
<th>Degree</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautical Engineering*</td>
<td>M.S., Ph.D.</td>
<td>Aeronautical and Astronautical Engineering</td>
</tr>
<tr>
<td>Applied Mathematics</td>
<td>M.S., Ph.D.</td>
<td>Mathematics and Statistics</td>
</tr>
<tr>
<td>Applied Physics</td>
<td>M.S., Ph.D.</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td>Astronautical Engineering*</td>
<td>M.S., Ph.D.</td>
<td>Aeronautical and Astronautical Engineering</td>
</tr>
<tr>
<td>Combating Weapons of Mass Destruction</td>
<td>M.S.</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td>Computer Engineering*</td>
<td>M.S., Ph.D.</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td>Computer Science</td>
<td>M.S., Ph.D.</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td>Cost Analysis</td>
<td>M.S.</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Cyber Operations@</td>
<td>M.S.</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td>Cyber Warfare</td>
<td>MS</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td>Program</td>
<td>Level</td>
<td>Department</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Electrical Engineering*</td>
<td>M.S.,</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td></td>
</tr>
<tr>
<td>Engineering Management*</td>
<td>M.S.</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Environmental Engineering and Science*</td>
<td>M.S.</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Industrial Hygiene</td>
<td>M.S.</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Logistics</td>
<td>Ph.D.</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td>Logistics and Supply Chain Management</td>
<td>M.S.</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td>Materials Science</td>
<td>M.S.,</td>
<td>Aeronautical and Astronautical</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td>Engineering; Engineering Physics</td>
</tr>
<tr>
<td>Nuclear Engineering*</td>
<td>M.S.,</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td></td>
</tr>
<tr>
<td>Operations Research</td>
<td>M.S.,</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td></td>
</tr>
<tr>
<td>Optical Science and Engineering</td>
<td>M.S.,</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td></td>
</tr>
<tr>
<td>Space Systems#</td>
<td>M.S.,</td>
<td>Aeronautical and Astronautical</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td>Engineering Engineering</td>
</tr>
<tr>
<td>Systems Engineering*</td>
<td>M.S.,</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td></td>
</tr>
</tbody>
</table>

*The ABET-accredited master's degree programs are identified with an asterisk.

@ The Ph.D. in Computer Science or Computer Engineering allows students to specialize in Cyber Operations (or Information Assurance).

# A Ph.D. is available that allows students to take the core Space Systems coursework and then specialize in an approved Ph.D. program such as Aeronautical, Astronautical, Electrical, Materials Science, or Systems Engineering. Students will start their program in the Department of Aeronautical and Astronautical Engineering, complete the Space Systems coursework, and then finish their studies in the department of their specialization.
# Graduate Certificate Programs

Programs offered in 2012-2013 Academic Year

AFIT graduate certificate programs generally consist of four to six graduate courses focusing on a particular technical area. Students who complete these programs attain a demonstrated, well-defined proficiency in some body of knowledge related to military and/or aerospace technologies. Students can also apply the credits earned from these certificate programs toward advanced degrees in the future, either at AFIT, or at a participating civilian university, making the certificate programs even more valuable for military officers and DoD civilians. The academic requirements for each certificate are listed in each academic department's section.

<table>
<thead>
<tr>
<th>Program</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Geospatial Intelligence, IR/SAR</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td>Combating Weapons of Mass Destruction</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td>Nuclear Weapons Effects, Policy, and Proliferation</td>
<td>Engineering Physics</td>
</tr>
<tr>
<td>Information Assurance</td>
<td>Electrical and Computer Engineering Systems and Engineering Management</td>
</tr>
<tr>
<td>Human Systems</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Space Systems</td>
<td>Aeronautics and Astronautics</td>
</tr>
<tr>
<td>Supply Chain Management</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td>Test and Evaluation</td>
<td>Operational Sciences</td>
</tr>
</tbody>
</table>

## Distance Learning (DL) Offerings

Director, Extension Services, Mr. John A. Reisner  
AFIT/ENWE  
2950 Hobson Way Building 641, Room 219  
Wright Patterson AFB OH 45433-7765  
Phone: (937) 255-3636 x7422 (DSN 785-3636 x7422)

AFIT’s School of Engineering and Management offers a growing number of graduate-level distance learning (DL) programs to U.S. Government customers who can benefit from the institution's educational opportunities and expert faculty without having to enroll in a resident campus program. Generally speaking, AFIT DL programs use streamable and downloadable course lectures, accessible via the Internet. Most courses also have weekly webinars or teleconferences to augment these lectures. Hence, save for a couple of hours per week, all the coursework can be completed as scheduled by the student; the only hardware requirements are a telephone, webcam, and internet-capable computer with a high-speed connection.

Distance Learning programs are administered by AFIT's Office of Extension Services. For more information about these educational opportunities, you may:
Currently, the graduate school offers two master's (MS) degree programs and six graduate certificate programs via DL. These programs are:

**DL Certificate Programs (6)**

- Advanced Geospatial Intelligence Certificate Program (ACP)
- Space Systems Certificate Program (SSC)
- Supply Chain Management Certificate Program (SCM)
- Systems Engineering Certificate Program (SEC)
- Test and Evaluation Certificate Program (TECP)
- Nuclear Weapons Effects, Policy, and Proliferation Certificate Program (NWEPP)

Note: Generally speaking, students must be unit-sponsored (i.e., unit-funded) to enroll in most AFIT DL Programs. See our website for more details.

**DL Degree Programs (2)**

- Systems Engineering MS Degree Program (GSE)
- Cost Estimating and Analysis MS Degree Program (GCA)

Note: More information about these programs, including application and enrollment information, can be found at AFIT's Extension Services website: www.afit.edu/en/dl

**Applying Certificate Credit to Advanced Degree**

In addition to earning certificates, students can also apply the credits earned from their AFIT certificate programs toward advanced degrees in the future either at AFIT or at a participating civilian university located near a military base, allowing the program to be even more valuable for military officers and DoD civilians. AFIT currently has signed agreements with the University of New Mexico and Loyola Marymount University to facilitate this possibility.

**Intermediate Development Education (IDE)**

Intermediate Development Education (IDE) for 2012-2013 Academic Year

The Air Force (AF) has expanded the number of opportunities available to its officers to obtain their in-residence IDE to include graduate school. The faculty of the Graduate School of Engineering and Management has subsequently approved a set of graduate programs that support AFIT's role in providing the Air Force with alternatives to traditionally available IDE choices. Master's degree programs are available to meet the needs of Air Force officers who have been selected by a board for an in-residence IDE opportunity.
The list is provided below. Please contact the individual departments for detailed information about admission criteria and degree requirements, both of which may be slightly different than the traditional masters degree programs described in this catalog. Refer to each academic department in the catalog for additional information and refer to the AFIT Website, http://www.afit.edu for proposed 2012-2013 IDE programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Degree</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Engineering</td>
<td>Master of Science</td>
<td>Systems and Engineering Management</td>
</tr>
<tr>
<td></td>
<td>Master of Science in Systems Engineering</td>
<td></td>
</tr>
<tr>
<td>Cyber Warfare* (See note)</td>
<td>Master of Science in Cyber Warfare</td>
<td>Electrical and Computer Engineering</td>
</tr>
<tr>
<td>Logistics</td>
<td>Master of Science in Logistics</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td>Air Mobility (ASAM)</td>
<td>Master of Science in Logistics</td>
<td>Operational Sciences</td>
</tr>
<tr>
<td>Operations Analysis</td>
<td>Master of Science in Operations Analysis</td>
<td>Operational Sciences</td>
</tr>
</tbody>
</table>

* The Cyber Warfare degree program is only available to military personnel and DoD civilians (U.S. citizens) selected by their service component for the in-residence Intermediate Developmental Education (IDE) degree program. Students must have Top Secret Security Clearance with Special Compartmental Information (TS/SCI).

Academic Policies

Associate Dean for Academic Affairs: Paul J. Wolf, PhD
2950 Hobson Way, Building 641, Room 213
Wright-Patterson AFB OH 45433-7765
Phone: (937) 255-3636 x7415
Fax: (937) 656-7050

Academic Advisor

Each student is assigned a faculty member as an academic advisor who assists the student with academic planning. While advisors are available for advice and consultation, students are responsible for understanding the Graduate School's academic policies and completing all graduation requirements.

Academic Year

The academic year is divided into four 10 week quarters (fall, winter, spring, and summer), with an additional week devoted for final exams. Following student orientation, a 4-week technical review session (May or August) is available to all students entering a degree program on a full-time basis.

Auditing

Students wishing to audit a course need only obtain permission from the instructor teaching that course and register according to prescribed procedures. Audited courses do appear on the student's transcript, but have no bearing on GPA. Audited courses can also be retaken for credit in the future.
Classification of Students

The Graduate School recognizes 12 quarter hours as a minimum course load to be considered as a full-time student. Students who hold either Research Assistantships (RA) or Teaching Assistantships (TA) are considered full-time as long as they enroll in a minimum of 9 quarter hours per term. A student registered in courses totaling fewer than 12-quarter hours is considered part-time, unless stated otherwise in a student's approved curriculum plan. Part-time students are limited to courses totaling no more than eight quarter hours in a single quarter. Once admitted, part-time students are subject to the academic rules and regulations that apply to full-time students.

Course Listings and Schedules

Projected course listings for an academic year are typically published on the Graduate School's web site. Final class schedules are available one quarter in advance of the quarter when the courses are actually offered. Students can register for their required courses electronically via Web Advisor beginning in the second week of the quarter prior to the start of classes. The Institution reserves the right to cancel courses for administrative purposes.

Education Plan

The student is responsible for developing, reviewing, and maintaining his/her specific plan of study called an Education plan. The Education Plan is developed and reviewed with the assistance of the student's academic advisor, and approved by the department prior to the end of the first quarter of study. Both the student and the faculty advisor should review the Education Plan quarterly prior to course registration. Once the Education Plan is approved, it becomes the curriculum for that individual student, and deviations are permitted only if the student obtains formal approval for the change from the faculty advisor and the Department Head. All such changes are incorporated into the student's education plan and placed on file in the appropriate department.

Registration

Students must be admitted into the Graduate School of Engineering and Management in order to register and earn credit for coursework. The responsibility for being properly registered for courses rests with the student. Registration is required for each term for all students who enter coursework for credit. Registration instructions and guidelines can be obtained from the Registrar's Office, and the registration dates are published on the AFIT web site at http://www.afit.edu/EN/ener/registrar.cfm?a=calendars.

Registration Changes

Students can make changes in their registration on line through the end of the first week of the quarter or by submitting a Drop/Add form to the Registrar's Office. These forms are available in the academic department, the Registrar's Office and on the web. Courses may be added through the end of week-one of the term. Courses may be dropped without recording the course on the student's permanent academic record during the first two weeks of the term, subject to approval of the student's faculty advisor. Students should refer to the academic calendar for specific deadlines for dropping/adding courses. The most current calendar is posted by the Registrar's Office on their web site. Students may withdraw from a course through the eighth week of the
quarter. Any student who drops a course during the third week to the end of the eighth week will receive the grade of "W". Normally, drops are not permitted after the eighth week.

Repeated Courses

With proper approval, a student may repeat once for credit any course for which a grade of "D", "F", or "U" was received. Only the repeat course grade will be used in computing the GPA. Once a course has been repeated, the resulting grade may not be replaced by course substitutions.

Transfer of Credits

Students in master degree programs may transfer up to 12 credit hours of graduate credit from other accredited institutions. The faculty advisor, the head of the appropriate department, and the Academic Standards Committee must approve transfer credits. Courses will not be submitted until one quarter in residence is successfully completed. All courses transferred for credit must carry a grade of "B" or better. Neither the grades nor the credit hours pertaining to the transferred courses will be used in grade point average calculations except to remedy academic deficiencies. The complete policy is published in ENOI 36-167.

Appeal of Grades

A student who feels that an assigned grade is other than the grade earned must first discuss the matter with the course instructor to determine if the discrepancy is caused by error or misunderstanding. If the complaint is not satisfactorily answered by the instructor, and the student feels that an error has not been corrected or that the assigned grade was unfairly determined, the student may appeal the decision to the head of the department in which the course is offered. After discussing the matter with the student, the head will consult with the course instructor and report a decision to the student. The final authority in the determination of the grade, however, rests with the course instructor.

Confidentiality of Academic Records

The Family Education and Privacy Act of 1974, as amended, is a federal law that grants to students the right to inspect, obtain copies, challenge, and to a degree control the release of information contained in his/her records. Guidelines and a full text of the law can be obtained from the Registrar's Office.

Change of Address

Students, who have a change in their permanent or local address while attending AFIT, should make changes through Web Advisor or submit the change in writing to the Registrar Office or Student Services Office. Billing address changes should be reported to the Bursar.

Incomplete

Incomplete grades are given for failure to complete the required work on a course or thesis. A grade of "I" is subject to approval by the Dean. A student cannot graduate with a grade of "I". The student must resolve the "I" with a letter grade within a reasonable time period as determined by the instructor or the thesis advisor.
Transcripts

Upon receipt of a written, signed request, the Registrar's Office will issue a transcript of work completed at the Institution, provided all obligations to the school have been met, including all financial accounts with AFIT where applicable. A transcript is official only when it bears the signature of the Registrar and the seal of the Institution. Transcripts mailed directly to the student will be stamped "Issued to Student" and normally are not accepted as official copies. Transcripts are free of charge. Allow five business days for verification and processing. Transcripts, or copies of transcripts, from other colleges or institutions used for admissions will not be released by this Institution and must be obtained by the student from the institution holding the original record.

Grading System

Academic achievement is indicated by the following letter grades and grade points used in calculating the grade point averages:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Ranking</th>
<th>Grade Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Excellent</td>
<td>4.0</td>
</tr>
<tr>
<td>A-</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>B+</td>
<td>Good</td>
<td>3.3</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td>B-</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>C+</td>
<td></td>
<td>2.3</td>
</tr>
<tr>
<td>C</td>
<td>Fair</td>
<td>2.0</td>
</tr>
<tr>
<td>C-</td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>D</td>
<td>Poor</td>
<td>1.0</td>
</tr>
<tr>
<td>F</td>
<td>Failure</td>
<td>0</td>
</tr>
<tr>
<td>IP</td>
<td>In Progress (MS)</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>Incomplete</td>
<td>1,2</td>
</tr>
<tr>
<td>P</td>
<td>Progress (PhD)</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>Satisfactory</td>
<td>1,4</td>
</tr>
<tr>
<td>U</td>
<td>Unsatisfactory</td>
<td>1,4</td>
</tr>
<tr>
<td>W</td>
<td>Withdrawn</td>
<td>1</td>
</tr>
<tr>
<td>NG</td>
<td>No Grade Posted</td>
<td>3</td>
</tr>
<tr>
<td>AU</td>
<td>Audit</td>
<td>1</td>
</tr>
</tbody>
</table>

Further Clarification

1. Does not count toward earned credit hours nor does it affect GPA. The grades "IP" and "P" are given for satisfactory progress in thesis and dissertation research courses.
2. The instructor or the academic advisor, in coordination with the Dean, will determine the resolution deadline.
3. Please see your instructor as soon as possible.
4. Grades apply only to pass/fail courses.
Academic Performance

Academic Good Standing

To remain in good academic standing, all students must maintain a cumulative GPA of 3.0.

Academic Honors (Awards)

Several awards are presented to students by the various departments, professional associations, and the Institute. AFIT's academic honors include the Commandant's Award, the Mervin E. Gross Award, and the designation of students as "Distinguished Graduates".

The Commandant's Award is presented to the student with the most outstanding thesis in the graduating class, which is selected from single entries from each department. The department nominees also receive the Dean's Award to recognize the most exceptional thesis in each department.

The Mervin E. Gross Award is given to the graduating student who has demonstrated the most exceptional academic achievement and high qualities of character, initiative, and leadership while pursuing a master's degree in the Graduate School of Engineering and Management.

The Air Force Institute of Technology Rewards excellent academic performance during graduation by designating certain students as "Distinguished Graduates." The number of distinguished graduates is limited to no more than 10% of the graduating class.

Academic Standards

Academic Integrity

Students are expected to adhere to the highest standards of academic integrity, in accordance with Air University Instruction 36-2309, Academic Integrity. Individuals who violate this instruction are subject to adverse administrative actions including enrollment termination. Military students may be discharged from the service or face disciplinary action including punishment under Articles of the Uniform Code of Military Justice or comparable discipline for non-military students.

Attendance Policy

Prompt and regular attendance is considered necessary for satisfactory work. Therefore, students are expected to attend classes and absences should be explained to the instructor. The student should provide advance notice, if possible. This is especially important in the case of full-time military assigned to AFIT, since they attend AFIT as an official duty assignment. Therefore, class attendance is mandatory unless the student is formally on leave or in another non-duty status. A satisfactory explanation of absence may secure students from disciplinary action, but does not in any case relieve them from responsibility for the work during their absence. A student who misses an announced test, examination, or laboratory period in a regular course of study, and has the permission of the instructor, may be given the opportunity to make up the work at the instructor's convenience. The instructor determines in all instances the extent to which absences and tardiness affect each student's grade. Students may be dropped at any time by a course instructor or the dean for non-attendance or tardiness with a grade of "W".
Probation and Dismissal

Failure to meet established minimum acceptable standards of academic or disciplinary performance could result in probation or dismissal. The academic advisor will counsel students failing to maintain the minimum GPA of 3.0, and the advisor will develop a plan to help the student remedy the deficiency. At this point, the student is considered on academic probation. A student on probation is considered in "good standing" for certification purposes and is eligible to register for courses. No entry is made on the student's permanent record. Failure to meet the minimum academic standard after the probationary period could result in the student meeting an academic review board.

The purpose of the academic review board is to recommend to the Dean whether the student should be eliminated from or be allowed to continue with his/her academic program. A faculty board should be convened for any student who receives a letter grade of "F" or "U" in any course, any student at the request of his faculty advisor, any student by his own request, and any doctoral student at the request of the academic department. A faculty board will also be conducted for any graduate student with a cumulative GPA less than 2.6 by the end of the second quarter, less than 2.8 by the end of the third quarter, less than 3.0 by the end of the fourth or subsequent quarters, and any graduate student with a cumulative or quarterly GPA less than 2.50.

Dismissal is a permanent and involuntary separation of the student from AFIT. The student is not eligible for readmission and is not in good standing in the Graduate School of Engineering and Management. "Academic dismissal" is permanently recorded on the student's permanent record.

Student Advising

The dean, faculty and staff are available for consultation with individual students as well as with sections of students. Each student has a faculty advisor, a professor appointed by the department head on the basis of familiarity with Institute programs, the student's programs, and the student's individual background.

Master's Degree Programs

All master's degree programs typically consist of five elements

1. Core courses that provide the breadth of content in a particular field. These courses are identified by the department as those in which each student must demonstrate competence in order to meet the academic requirements of the particular field.

2. A specialization area* which provides in-depth knowledge in a chosen field.

3. Electives* that are used to round the student's experience or provide additional background material.

4. A mathematics requirement.

5. An independent research project, which carries a 12-credit-hour load. (The non-thesis programs, available only to those selected for Intermediate Development Education, may carry a group project requirement in lieu of a thesis. Consult with the academic department for specific guidance and information.)
*Students choose their electives and specialization courses based on their academic interest and the requirements of the Air Force for those military officers enrolled in AF sponsored programs.

**General Degree Requirements**

The Master's degree is awarded for the successful completion of a curriculum that has the approval of the faculty as meriting the award of that degree. To satisfy the specific requirements for the master's degree the student must:

1. Complete at least 48 quarter hours of required graduate courses and approved graduate electives.

2. Apply for candidacy at least one year prior to graduation. Candidacy is automatically granted for both Air Force students who are assigned to the Graduate School and students who are assigned to AFIT by other services and foreign countries. All other students are admitted into candidacy after petitioning the Dean through the department. Candidacy for these students requires the satisfactory completion of 12 quarter-hours of coursework with a minimum of a 3.0 grade-point average, and the student must file an Education Plan through a faculty advisor within the appropriate department. All students must be fully admitted into the institution prior to filing for candidacy.

3. Fulfill the appropriate residency requirement.

4. Complete an independent investigation of a problem approved by the major department, the results of which have been presented as a formal thesis (or research paper for non-thesis programs, if required). This thesis must be acceptable as partial fulfillment of the required quarter hours of credit. In certain programs, approved in advance by the Faculty Council, group design studies may replace the independent study.

5. Attain a grade point average of at least "B" (3.00) for all graded courses included in the student's approved program. Courses for which the student received the grade "D" or lower will not be accepted as a part of the 48 quarter hours required for the degree.

6. Complete all degree requirements within six calendar years after applying for admission as a candidate for the degree.

7. Be recommended for the degree by the Faculty Council of the Graduate School of Engineering and Management.

The degree title is "Master of Science," "Master of Science in (designated area) Engineering," or "Master's in (subject area)." Although the graduate programs for engineering students pursuing either degree are normally the same, the designated degree in criteria of the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) is awarded only to students whose total preparation, undergraduate and graduate, satisfies the appropriate accreditation.
Academic Standards

The Graduate School expects its students to meet fully the rigorous demands of its programs. For many students, this means a weekly investment averaging at least three hours per quarter hour of graduate registration.

Students are expected to maintain a 3.00 grade point average for all of their courses. In case of serious academic deficiencies, students must consult their faculty academic advisors regarding an appropriate study load to remedy their deficiencies.

Thesis Requirement

A student seeking certain master's degrees, except for those enrolled in a program for Intermediate Development Education, is required to pursue an independent study and submit a thesis in partial fulfillment of their degree requirements. The student is required to present the thesis at a formal defense to a faculty committee chaired by the research advisor. Upon successful completion of the defense, the student will submit a final document that contains a thesis approval page signed by the thesis examination committee. The administrative requirements for the thesis document are fully described in Style Guide for AFIT Theses and Dissertations.

Admission to Candidacy

Students who have not undergone a process which establishes candidacy upon matriculation (e.g., students who are not on full-time military or DoD sponsorship or full-time Dayton Area Graduate Studies Institute scholarships) must petition the Dean in writing for degree candidacy at least one year prior to the anticipated award of the degree. The application package includes an approved education plan, endorsement from the appropriate department, current grades, and an estimated time to completion. The student must successfully complete at least 12 quarter hours of coursework with a minimum GPA of 3.0 to apply for candidacy.

Doctor of Philosophy Programs

Purpose

The AFIT doctoral program is based on the following statement by the Council of Graduate Schools in the United States (from The Doctor of Philosophy Degree: A Policy Statement, Oct 1977):

The Doctor of Philosophy degree is awarded by universities in many parts of the world as the mark of highest achievement in preparation for active scholarship and research. The doctoral program is designed to prepare a student for a lifetime of intellectual inquiry that manifests itself in creative scholarship and research. The program emphasizes freedom of inquiry and expression and development of the student's capacity to make significant contributions to knowledge. An essential element is the development of the ability to understand and evaluate critically the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge. All of this is most effectively accomplished in close association with those experienced in research and teaching.
A central purpose of doctoral programs is the extension of knowledge, but this cannot be accomplished on all fronts simultaneously. Students must choose an area in which to specialize or a professor with whom to work. Individualized programs of study are then developed and committee members are selected cooperatively as course work is completed and research undertaken. When all courses have been taken, the research finished, the dissertation written, and all examinations passed, the student will have acquired the knowledge and skills expected of a scholar and will have extended knowledge in the field. Details of requirements and policies are documented in AFIT instructions, Graduate School of Engineering and Management instructions, and Doctoral Council policy letters. These are available at AFIT.

General Degree Requirements

The Doctor of Philosophy degree is awarded for the successful completion of a curriculum that has the approval of the faculty as meriting the degree. The PhD degree includes the following general requirements:

1. Complete an approved program of study,
2. Meet the residency requirement,
3. Pass specialty examination,
4. Be admitted into candidacy,
5. Submit a dissertation, and

These requirements and the policies and procedures that implement the program are specified in the Doctoral Council Policy Letters, and are summarized in the following sections.

Advising

Upon admission of each student into the program, a pro-tem faculty advisor is appointed by the Department Head to guide the student through the initial phases of the coursework, and suggest potential specialization areas. The pro-tem advisor is responsible for providing the student with advice on an appropriate plan of study and helping the student identify a research area and research advisor. A pro-tem advisor serves until the research advisor is selected and approved.

Upon selecting a field of specialization (research area), the student chooses a regularly appointed faculty member in that area to act as his/her research advisor and research committee chairperson. In many cases, the pro-tem advisor becomes the research advisor. The research advisor supervises the specialty examination and advises the student throughout the remainder of the program concerning the prospectus, the research project, writing of the dissertation, and any other matters pertaining to the program. The research advisor also chairs the research committee, which shall consist of no fewer than three faculty members, representing at least two academic departments from within the Graduate School of Engineering and Management. (A department of the engineering school of DAGSI partner schools may be represented in lieu of one of the AFIT departments.) The membership of the research committee, and any subsequent changes, must be approved by the department head of the admitting department.

Course Requirements

The student must complete at least 36 quarter hours of course work, of which at least 24 quarter hours must be successfully completed in the specialty area and at least 8 quarter hours must be successfully completed in the mathematics area.
Any additional hours are used for required courses and electives. The minimum 24 hours of specialty area courses may consist of courses from more than one department as long as these courses form an integrated program designed to make the student an expert in the chosen area of research. Individual departments approve the specific courses that will constitute the specialty area of study.

The residency requirement is met when the student completes three quarters of full-time study in residence during a single contiguous four-quarter period. The student must also attain an average grade of at least B (3.00) for all courses attempted after admission to the program. For the PhD program, qualifying examinations and the dissertation are paramount, and course requirements are identified to facilitate the student's education towards the qualifying examination.

Waivers may be granted to the 36 quarter-hour requirement. Such a waiver requires documentation that the student has previously successfully completed courses normally included in the AFIT PhD program of his or her chosen discipline, and that the program, including the waived courses, contains a well-integrated specialty sequence of at least 24 quarter-hours. No more than 12 credit hours may be waived under this provision, and none of the waived hours can be used in meeting the mathematics requirement.

**Academic Load**

Students assigned to AFIT for full-time Ph.D. study are expected to carry a full academic load of 12 credit hours per quarter. Other Ph.D. students generally have monetary or other support that entails its own requirements for full-time study, such as 8 quarter hours of courses plus 20 hours per week as a research assistant. Except in unusual circumstances, no student should carry more than 12 credit hours per quarter. The head of the admitting department may grant an exception to this guideline. This 12 credit hour limitation is based upon the following considerations:

1. The PhD courses are of such advanced nature that a student needs time to understand and assimilate the material contained therein.
2. The limitation allows time to interact with other PhD students and with the faculty.
3. It allows time to explore areas that may intrigue him or her in the pursuit of the course work.

Generally, a full-time PhD student will complete the course requirements during the first four or five quarters. During the succeeding quarters, the student's full load involves completing the examination requirements and working on his or her dissertation research.

**Standards of Work**

Each student is expected to perform at a high academic level and maintain a grade point average of at least "B" (3.00) on the course work. In addition, he/she must pass the examinations and be admitted to candidacy on a timely basis. A course grade less than "B" constitutes a deficiency. Failure of the specialty exam constitutes a deficiency. An academic board is usually convened if a student has two deficiencies. The board reviews the situation and may dictate corrective action or may take action to remove the student from the program.
Qualifying Examination

The PhD qualifying examination is the "specialty exam". This written and oral examination in the specialty area is required for each PhD student. The oral part may be included in the prospectus examination or it may be part of the specialty examination or both. The specialty examination has two objectives: to measure the student's mastery of the specialty area and to measure his or her readiness to define a dissertation research area.

Prospectus Examination

The Research Committee will examine the student on the prospectus that the student has submitted. Normally this examination will be an oral examination conducted after the committee has had an opportunity to study the prospectus. The prospectus examination will be graded as "pass" or as "not yet ready". Therefore, it can be viewed as an ongoing process, in which the "defense" can be adjourned and reconvened (as necessary) until the committee accepts the prospectus.

Admission to Candidacy

The graduate student does not formally become a candidate for the PhD degree until the application for candidacy is approved. Admission to candidacy requires the approval of the student's supervisory committee, the Department Head, the Academic Standards Committee of the Faculty Council, and the Dean of the Graduate School. The approval is based upon:

1. Passing the qualifying examination,
2. An academic record of the student that meets the program and grade point average requirements,
3. Approval of the student's prospectus for the dissertation project, and
4. Completion of the residency requirement or approval of a specific plan for meeting it.

The formal application for candidacy should be submitted as soon as these requirements are met and at least one year prior to receipt of the degree.

Dissertation Requirement

The most clearly distinguishing characteristic of a program leading to the PhD degree is the requirement that the candidate write a dissertation embodying the results of a significant and original investigation. The dissertation must make a real contribution to the engineering or applied science discipline chosen by the student, and it is expected to be a mature and competent piece of writing. With the exception of such progress reports as may be required by the sponsoring agency, no publication of the results of dissertation research will be made prior to acceptance of the dissertation without the approval of the student's Research Committee.

While research in a classified area is acceptable, the dissertation document must be unclassified, stand alone, and be releasable for unlimited distribution. In compelling circumstances (quite rare), a classified dissertation may be accepted. Details regarding administrative requirements and style suggestions are provided by the Style Guide for AFIT Theses and Dissertations.
Defense of the Dissertation

The oral defense of the dissertation constitutes the final examination of the student's work. This examination must enable the research committee to satisfy itself that the dissertation is an original piece of work that has been carried out in keeping with the highest standards of investigation and reporting, and that it makes a contribution to knowledge that is of value to the engineering profession or scientific community. The written dissertation and the results of this defense will be judged satisfactory if they have the approval of a three-fourths majority (including the Advisor) of the evaluation committee. The committee may approve the defense subject to still further revisions in the written dissertation. This has been the rule rather than the exception. Therefore, the candidate should retain all materials, files, etc. that would be needed to make those revisions until the Dean has approved the dissertation and all necessary copies have been produced and accepted.

Time Limit

All requirements for the PhD degree must be satisfied not later than eight years from the beginning of the first course in the approved program and not later than four years from admission to candidacy. The time limit may be waived by the faculty council when appropriate, such as when the research has been vigorously pursued but is delayed by circumstances beyond the control of the student.

Scholarships / Consortia

The Dayton Area Graduate Studies Institute (DAGSI)

Students whose academic expenses are not funded by their military service or employer may apply for scholarships through the Dayton Area Graduate studies Institute (DAGSI) pending availability of funds. Tuition-only scholarships may be available for master's and Ph.D. programs and scholarships with a stipend for Ph.D. programs. Details are provided on DAGSI's website at www.DAGSI.org.

Graduate students who have candidacy in a master's degree program and Ph.D. students may apply for a non-competitive, Student Scholarship Enrichment Scholarship. This scholarship is designed to encourage students to take graduate courses at consortium engineering schools (Wright State University, University of Dayton) when courses are not available at AFIT and/or when such courses strengthen their programs of study. These courses must be part of the student's approved program. The scholarship only covers the tuition for the course. The student is responsible for other fees and charges imposed by the institution. These scholarships are awarded on a first come/first served basis until the DAGSI funds allocated to AFIT are exhausted. The student must submit a formal request to the Dean for this scholarship specifying the course(s) of interest. A copy of the student's approved education plan and advisor's endorsement must accompany the letter requesting the scholarship. Please see the DAGSI Operating Instructions for detailed information, a copy of which should reside in each department. DAGSI's web site also provides useful information (http://www.dagsi.org).
Cyber Security

The Air Force Institute of Technology (AFIT) at Wright-Patterson AFB Dayton, Ohio, provides scholarship opportunities targeted to U.S. citizens who are seeking a Master's Degree in Cyber Operations. This scholarship is made possible through a grant from the National Science Foundation (NSF) Scholarship for Service program (CyberCorp). The program allows students to obtain advanced graduate education in return for federal service upon degree completion. Federal government service time is equal to the amount of time of scholarship supports. A typical academic program length is 24 months. Fellowship benefits include full tuition, stipend, computer and book allowance, housing/health care allowances and conference travel opportunities.

Visit: https://www.afit.edu/CCR/CyberCorp/ or email/call Dr. Richard Raines, richard.raines@afit.edu, (937) 255-6565 x4278, Dr. Rusty Baldwin, rusty.baldwin@afit.edu, (937) 255-6565 x4445, or Mrs. Carrie Solberg, carrie.solberg.ctr@afit.edu, (937) 255-6565 x4534

Southwestern Ohio Council for Higher Education (SOCHE)

SOCHE is a consortium of twenty colleges and universities, one foundation, and two corporations (see http://www.soche.org). One of its goals is to promote inter-institutional cooperation and one of its programs, the Cross-Registration Program, can be used as a vehicle for our students to obtain additional courses not otherwise available at AFIT. The specifics of the program can be found at http://www.soche.org/student.htm.

Students can generally attend courses at consortium institutions with no charge of tuition. Enrollment is based upon the availability of space in the class and the courses must be part of their approved program. This program is particularly worthwhile for students who lack particular undergraduate courses as prerequisites for graduate courses and international officers who need to improve their English communication skills. Students should send their requests to the Associate Dean for Academic Affairs, AFIT/ENW with a copy of their education plan stating the reason for attending the requested course with the academic advisor's endorsement. Upon approval, the student will be directed to the Registrar's Office to complete the cross-registration process.

Please note: this program is intended for the few students who need additional courses and not for any significant numbers of students who have the need or desire to take courses elsewhere.
## Academic Calendar 2012 - 2013

### FALL ORIENTATION/REVIEW SESSION 2012

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 20</td>
<td>Monday</td>
<td>Military Students Arrive</td>
</tr>
<tr>
<td>August 20 - August 31</td>
<td>Monday - Friday</td>
<td>Student Orientation / In-Processing</td>
</tr>
<tr>
<td>September 03</td>
<td>Monday</td>
<td>Labor Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>September 04 - September 28</td>
<td>Tuesday - Friday</td>
<td>Technical Refresher Course</td>
</tr>
</tbody>
</table>

### FALL TERM 2012

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 01</td>
<td>Monday</td>
<td>Fall Quarter Classes Begin</td>
</tr>
<tr>
<td>October 05</td>
<td>Friday</td>
<td>Last day to add a class</td>
</tr>
<tr>
<td>October 08</td>
<td>Monday</td>
<td>Columbus Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>October 12</td>
<td>Friday</td>
<td>Last day to drop a class without receiving a &quot;W&quot; grade</td>
</tr>
<tr>
<td>October 29</td>
<td>Monday</td>
<td>Open Registration for Winter begins today</td>
</tr>
<tr>
<td>October 29</td>
<td>Monday</td>
<td>Winter class schedule available</td>
</tr>
<tr>
<td>November 12</td>
<td>Monday</td>
<td>Veteran's Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>November 22</td>
<td>Thursday</td>
<td>Thanksgiving Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>November 23</td>
<td>Friday</td>
<td>AETC Family Day - No Classes</td>
</tr>
<tr>
<td>November 23</td>
<td>Friday</td>
<td>Last Day to drop a class</td>
</tr>
<tr>
<td>December 12</td>
<td>Wednesday</td>
<td>Classes End</td>
</tr>
<tr>
<td>December 14 - December 18</td>
<td>Friday - Tuesday</td>
<td>Final Exams</td>
</tr>
</tbody>
</table>
# WINTER TERM 2013

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 02</td>
<td>Wednesday</td>
<td>Winter Quarter Classes Begin</td>
</tr>
<tr>
<td>January 11</td>
<td>Friday</td>
<td>Last day to add a class</td>
</tr>
<tr>
<td>January 18</td>
<td>Friday</td>
<td>Last Day to drop a class without receiving a &quot;W&quot; grade</td>
</tr>
<tr>
<td>January 21</td>
<td>Monday</td>
<td>Martin Luther King Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>February 04</td>
<td>Monday</td>
<td>Open Registration for Spring begins today</td>
</tr>
<tr>
<td>February 04</td>
<td>Monday</td>
<td>Spring class schedule available</td>
</tr>
<tr>
<td>February 18</td>
<td>Monday</td>
<td>President's Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>February 22</td>
<td>Friday</td>
<td>Last Day to drop a class</td>
</tr>
<tr>
<td>March 08</td>
<td>Friday</td>
<td>Classes End</td>
</tr>
<tr>
<td>March 11 - March 14</td>
<td>Monday - Thursday</td>
<td>Final Exams</td>
</tr>
<tr>
<td>March 21</td>
<td>Thursday</td>
<td>Commencement</td>
</tr>
</tbody>
</table>

# SPRING TERM 2013

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 25</td>
<td>Monday</td>
<td>Spring Quarter Classes Begin</td>
</tr>
<tr>
<td>April 01</td>
<td>Monday</td>
<td>Last day to add a class</td>
</tr>
<tr>
<td>April 05</td>
<td>Friday</td>
<td>Last day to drop a class without receiving a &quot;W&quot; grade</td>
</tr>
<tr>
<td>April 22</td>
<td>Monday</td>
<td>Open Registration for Summer begins today</td>
</tr>
<tr>
<td>April 22</td>
<td>Monday</td>
<td>Summer Class Schedule available</td>
</tr>
<tr>
<td>May 17</td>
<td>Friday</td>
<td>Last day to drop a class</td>
</tr>
<tr>
<td>May 24</td>
<td>Friday</td>
<td>AETC Family Day - No Classes</td>
</tr>
<tr>
<td>May 27</td>
<td>Monday</td>
<td>Memorial Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>May 31</td>
<td>Friday</td>
<td>Classes End</td>
</tr>
<tr>
<td>June 03 - June 06</td>
<td>Monday - Thursday</td>
<td>Final Exams</td>
</tr>
<tr>
<td>June 13</td>
<td>Thursday</td>
<td>Commencement</td>
</tr>
<tr>
<td>June 14</td>
<td>Friday</td>
<td>Air Mobility Graduation</td>
</tr>
</tbody>
</table>
### SUMMER ORIENTATION/REVIEW SESSION 2013

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 17</td>
<td>Friday</td>
<td>Military Students Arrive</td>
</tr>
<tr>
<td>May 21 - May 23</td>
<td>Tuesday - Thursday</td>
<td>Student Orientation / In Processing</td>
</tr>
<tr>
<td>May 24</td>
<td>Friday</td>
<td>AETC Family Day - No Classes</td>
</tr>
<tr>
<td>May 27</td>
<td>Monday</td>
<td>Memorial Day - No Classes / Offices Closed</td>
</tr>
<tr>
<td>May 28 - June 21</td>
<td>Tuesday - Friday</td>
<td>Technical Refresher Course</td>
</tr>
</tbody>
</table>

### SUMMER TERM 2013

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 24</td>
<td>Monday</td>
<td>Summer Quarter classes begin</td>
</tr>
<tr>
<td>July 01</td>
<td>Monday</td>
<td>Last day to add a class</td>
</tr>
<tr>
<td>July 04</td>
<td>Thursday</td>
<td>Independence Day Observed - No Classes / Offices Closed</td>
</tr>
<tr>
<td>July 05</td>
<td>Friday</td>
<td>AETC Family Day - No Classes</td>
</tr>
<tr>
<td>July 05</td>
<td>Friday</td>
<td>Last day to drop a class</td>
</tr>
<tr>
<td>July 05</td>
<td>Friday</td>
<td>Last day to drop a class without receiving a &quot;W&quot; grade</td>
</tr>
<tr>
<td>July 22</td>
<td>Monday</td>
<td>Open registration begins for Fall today</td>
</tr>
<tr>
<td>July 22</td>
<td>Monday</td>
<td>Fall class schedule available</td>
</tr>
<tr>
<td>August 30</td>
<td>Friday</td>
<td>Classes End</td>
</tr>
<tr>
<td>September 02</td>
<td>Monday</td>
<td>Labor Day - No Classes / Offices closed</td>
</tr>
<tr>
<td>September 03 - September 06</td>
<td>Tuesday - Friday</td>
<td>Final Exams</td>
</tr>
</tbody>
</table>
Admissions / Registrar Directorate

Robert J. LaVerriere, M.Ed.

Director of Admissions & Registrar
AFIT/ENER
2950 Hobson Way, Building 641
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-6234 x3125 (DSN 785-6234 x3125)
FAX: (937) 255-2791 (DSN 785-2791)

Admissions Division

Admissions Division Chief, Craig G. Hoon

AFIT/ENER
2950 Hobson Way, Building 641
Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-6234 x3134 (DSN 785-6234 x3134) or Toll Free 800-211-5097 x3134
Fax: (937) 255-2791 (DSN 255-2791)
Email address: ENERAdmissions@afit.edu

Web link:  http://www.afit.edu/en/Admissions/Default.cfm

ADMISSION TO THE AFIT GRADUATE SCHOOL

Who May Apply

Programs offered by the Graduate School of Engineering and Management are available to officers and enlisted members of all branches of the United States Armed Services, civilians employed by the U. S. Government, civilians employed by certain Department of Defense contractors (please contact the Office of Admissions for details), and military officers from select foreign countries. On-line applications for admission are available at:  http://www.afit.edu/en/admissions/Default.cfm?1=apps.

Admissions Standards

The faculty determines the admissions standards for the Graduate School of Engineering and Management. The standards maintained by the Graduate School and individual departments and programs are applied to ensure that applicants admitted to the Graduate School have adequate undergraduate and graduate preparation in their proposed field of study and possess a reasonable expectation of successfully completing a graduate program.
Prospective students may apply for admission to the Graduate School of Engineering and Management during or after their final year of undergraduate study, but must furnish proof of graduation before the end of their first quarter of enrollment. Prospective students applying for admission to a graduate degree program in a field of specialization in which they already hold that same degree or its equivalent may do so only if the previous degree program was of substantially different character or was not regionally accredited. Applicants who apply for admission to the Graduate School are evaluated on the individual merits of their academic achievements and scholarly potential to complete graduate-level coursework and curriculum requirements. Admission is granted only upon the recommendation of the department and approval of the Dean. The decision to admit an applicant to a program is based primarily on a combination of the following criteria and according to the academic requirements of the specific graduate program.

Eligibility Criteria – Masters Degree

Applicants, applying for master's programs, who meet the criteria below are generally considered fully-qualified and can immediately enter a master's degree program, and have a greater potential to successfully complete a master's degree program in the nominal time of 18 months.

1. Hold an appropriate bachelor's degree in an area relevant to the master's program of interest from a regionally accredited college or university in the United States, or the equivalent of this degree in another country.
2. Meet or exceed grade point average of 3.00 based on a 4.00 scale, and
3. Submit satisfactory scores on standardized examinations like the Graduate Record Examination (GRE) or, depending on the program, the Graduate Management Admissions Test (GMAT). The recommended GRE scores are 153 verbal and 148 quantitative (or 500 verbal and 600 quantitative for GREs taken prior to 1 Aug 2011). The recommended GMAT score is 550.

Eligibility Criteria – Doctoral Degree

Admission to Ph.D. programs is open to qualified individuals who:

1. Hold a bachelor's degree from a regionally accredited college or university in the United States, or the equivalent of this degree in another country, with grades averaging at least a 3.00 on a 4.00 scale.
2. Hold a master's degree with grades averaging at least a 3.50 in an area relevant to the doctoral program of interest, and
3. Depending on the program, GRE scores of at least 156 verbal and 151 quantitative (or 550 verbal and 650 quantitative for GREs taken prior to 1 August 2011) or a GMAT score of 650 or higher.
4. The faculty may also request endorsements by the student's graduate faculty and/or thesis advisor. The Educational Testing Service will be updating the GRE percentile ranks, and possibly the test scores, after 1 July 2012, thus our GRE scores may change.
A baccalaureate-to-doctoral admission may also be granted in some circumstances to applicants who are entering directly from an undergraduate program without a master's degree. The requirement to hold a master's degree will be met during the student's PhD program. Endorsements by the student's undergraduate faculty may be required. Note: This admission option is not available to active duty Air Force members selected for an advanced academic degree (AAD) assignment.

Eligibility Criteria for Certificate Programs And Non-Degree Seeking Applicants

The entry requirements for certificate programs and non-degree seeking status are the same as those stated above for master's degree programs, with the exception that standardized tests (GRE, GMAT) are not required. Waivers to the entry requirements may be granted on an individual basis. Students enrolled in a certificate program are limited to the classes required for the certificate program, therefore, taking additional classes requires department approval, or a change of enrollment to another certificate program or to a degree program. A maximum of 12 quarter hours of graduate credit, earned in a non-degree status and/or transferred from another regionally-accredited institution may be permitted for application toward an advanced degree, once the student obtains acceptance into a degree program. See the Change of Enrollment sub-section under the Changes After Admission section of this catalog.

Non-degree seeking students may enroll in graduate level courses as their qualifications and performance permit they must contact the department(s) offering the courses to ensure that courses are available to non-degree students. Admission in a non-degree-seeking status is reserved for those interested in course enrollment for professional development, intellectual enrichment, or exploring the possibility of applying later for a graduate degree program or certificate program. Non-degree students may earn a maximum of 12 quarter hours, either in non-degree status and/or transferred from another regionally-accredited institution. In addition, non-degree students may only register for up to 12 quarter hours of coursework. If the non-degree seeking student desires to take more classes, they must complete a Change of Enrollment form and choose non-degree-seeking status under a different academic focus, or move to a certificate or degree program. See the Change of Enrollment sub-section under the “Changes After Admission” section of this catalog.

General Application Process

Each applicant must submit an application to be considered for admission to the Graduate School of Engineering and Management. The application is completed online and submitted to the Office of Admissions. The application form and instructions are found online at http://www.afit.edu/en/Admissions, look for "Apply Online" or "Online Admission Form."

Applicants must submit their application packages so they are received, processed and the applicant admitted to the Graduate School no later than the last day of the first week of the first term the applicant plans to attend.

General inquiries for admission should be addressed to:

Office of Admissions
Graduate School of Engineering and Management
AFIT/ENER, Bldg 641, Room 102
2950 Hobson Way
Wright-Patterson Air Force Base OH, 45433-7765
1-800-211-5097 x3184;
Note: Officers, enlisted personnel, and federal civil servants applying for full-time graduate study who are interested in attending the Graduate School of Engineering and Management under the sponsorship of their respective military service or government agency must seek selection through a process defined by their respective service. All sponsored selection processes include establishing academic acceptance by the Graduate School's Admissions Office. More information is available on the Admissions Office home webpage, http://www.afit.edu/en/admissions/usmilitaryapply.cfm or http://www.afit.edu/en/admissions/usgovernmentapply.cfm.

Required Documentation for Master's and Doctoral Degree Programs

Each applicant must submit the following items, constituting a complete application package, to the Admissions Office:

1. A completed online application form.

2. One complete set of official transcripts from each school attended reflecting all undergraduate and graduate work completed or in progress. Each transcript must bear the signature of the registrar, the institution's official seal, years of attendance, courses taken, grades received, and if applicable, the degree, certificate or diploma received.

3. For doctoral programs only, if you did not receive a master's degree from the AFIT Graduate School of Engineering and Management, please submit two letters of academic recommendation, preferably from faculty involved in or aware of your Master's thesis.

4. Standardized Test Scores:

   - The Graduate School of Engineering and Management graduate degree programs require applicants to submit standardized test scores applicable to the program requested.

   - The Graduate Record Examination (GRE) is acceptable for all master's and doctoral degree programs.

   - The GMAT is accepted by several masters and doctoral degree programs. Please contact Admissions if you cannot determine which standardized test is accepted under the academic department's web pages.

   - Examination scores should be sent directly to the Admissions Office by the appropriate testing agency. The Air Force Institute of Technology's institutional code for the GRE and GMAT is 1827, and we are listed in the GRE/GMAT booklets under the State of Ohio.

   - For more information about these tests, you may visit the GRE/GMAT website (www.gre.org or www.gmat.org) or write to the following addresses:

     Graduate Record Examinations
     Educational Testing Services
     BOX 6000 Princeton, NJ 08541-6000 USA
     (609) 771-7670

     Graduate Management Admissions Test
     Educational Testing Services
     Box 6103 Princeton, NJ 08541-6103 USA
     (609) 921-9000
Required Documentation for Certificate Programs and Non-Degree Seeking Applicants.

Each applicant must submit the following items, constituting a complete application package, to the Admissions Office:

1. A completed online application form.

2. An official transcript from the institution which granted the highest degree. In the event that the applicant holds equivalent level higher degrees, the most recently awarded degree transcript is required.

For certificate and non-degree-seeking applications some programs have specific prerequisite course(s) that are required for admission. If the prerequisite courses do not appear on the highest degree granting transcript, the applicant must also provide official transcripts from the school(s) where the prerequisite courses were completed.

Admissions tests (GRE/GMAT) are not required for certificate programs and non-degree-seeking applicants.

US Civilians – Non-Military

AFIT exists within the framework of the United States Air Force; therefore, with the exception of international military officers sponsored by their governments, all non-Department of Defense (DoD) students must provide proof of U.S. citizenship prior to being admitted to the AFIT Graduate School.

International Military Officers

Admission to the Graduate School of Engineering and Management is restricted to citizens of the United States and international military officers sponsored by their governments. The International Military Student Office at AFIT assists international military officers and international government civilian employees with the procedures of applying for admission to the AFIT Graduate School of Engineering and Management. Prospective international military students must apply for admission to the AFIT Graduate School of Engineering and Management through the United States Security Assistance Office (SAO) at the United States (US) Embassy in their home country.

Application Process for International Military Officers

Application packages for admission eligibility should arrive at the AFIT Graduate School's International Student Military Office no later than 1 April of each year, in preparation for entrance to the AFIT Graduate School the following September. The international military officer seeking admission to the AFIT Graduate School must have the following documents submitted:

1. Official academic transcripts, either in English or accompanied by an English translation, from every academic institution attended. The AFIT Graduate School strongly recommends that all official academic transcripts be accompanied by a foreign course-by-course credential evaluation by an independent evaluation service that is a member of the National Association of Credential Evaluation Services (NACES) in order for courses to be considered for credit at the AFIT Graduate School. In order for it to be considered official, the course-by-course evaluation must be sent directly from the NACES-affiliated evaluation service to the AFIT Graduate School or to the United States Security Assistance Office (SAO) at the United States Embassy in the international military officer's home country. A full list of NACES members is available online at
http://www.naces.org/members.htm. NACES members charge a fee for their services and applicants are responsible for the payment of that fee.

2. A satisfactory command of the English language is required for admission to the AFIT Graduate School. Therefore, international military officers from non-English speaking countries are required to validate their fluency in English through the Test Of English as a Foreign Language (TOEFL). Some countries, however, are exempted from the TOEFL requirement by the Defense Security Assistance Agency (DSSA) memorandum dated October 1, 2010. Those countries are: Antigua, Australia, Bahamas, Barbados, Belize, Brunei, Canada, Dominica, Grenada, Guyana, India, Ireland, Jamaica, Malta, Mauritius, Netherlands, New Zealand, Norway, Singapore, St. Kitts, St. Lucia, St. Vincent, Trinidad, and the United Kingdom. Students from Pakistan and Kenya scheduled for senior Professional Military Education courses are also exempt from the TOEFL requirement. When applying for a TOEFL examination, the AFIT identification code is 1827.

3. Under Internet-Based Testing, a minimum TOEFL score of 76 is required for admission to the AFIT Graduate School; under Computer-Based Testing, a minimum score of 207 is required for admission to the AFIT Graduate School.

4. An official score report from the Graduate Record Examination (GRE) or, if applicable to the particular program, the Graduate Management Aptitude Test (GMAT). The recommended GRE scores for a master's program are 153 verbal and 148 quantitative (or 500 verbal and 600 quantitative if taken prior to 1 Aug 2011). The recommended GMAT score is 550. The Educational Testing Service will be updating the GRE percentile ranks and test scores after 1 July 2012, thus minimum GRE scores may change. Special note: A satisfactory TOEFL score will satisfy the minimum GRE verbal score required for admission for non-English speaking country applicants.

5. For doctoral programs, GRE scores of at least 156 verbal and 151 quantitative (or 550 verbal and 650 quantitative if taken prior to 1 August 2011) or a GMAT score of 650 or higher. The Educational Testing Service will be updating the GRE percentile ranks, and possibly the test scores, after 1 July 2012, thus our GRE scores may change.

NOTE: The GMAT is only accepted in certain programs or not at all. Thus, taking the GRE is highly recommended, as it is accepted by all departments.

Send all score reports (GRE, GMAT, TOEFL) by using the AFIT school identification code of; 1827.

Applications for any master’s degree program will be considered by the Graduate School of Engineering and Management if GRE/GMAT scores are less than the scores published above, or not available, however the applicant’s academic record and TOEFL scores must be exceptionally strong. In addition, the academic departments reserve the right to ask for either test (GRE/GMAT) prior to making an admission decision. Thus, if the applicant chooses to submit an application without a GRE or GMAT it should be submitted no later than 1 March in the year of the desired program start date.

Doctoral program applicants must include all of the above documents. For required doctoral program test scores, see the Eligibility Criteria – Doctoral Degree section above. In addition, doctoral applicants must provide a clear and concise statement describing the area in which the student intends to concentrate his or her studies. Doctoral and IDE students cannot be admitted without a GRE (or GMAT if applicable to program).
Academic Waivers

Waivers to the above admission standards may be granted on an individual basis at the discretion of our faculty. Therefore, individuals whose academic credentials fall below any of the above entry criteria are encouraged to apply for a graduate program. Applicants who do not meet these criteria can be conditionally admitted and/or the department may grant individual waivers to the entrance requirements.

Applicants, such as military personnel, international military officers, and civilians who apply for full-time graduate study under the sponsorship (full pay and allowances) of a military service or government organization, but fall short of the admission standards mentioned above may be admitted after a review by the faculty in the appropriate department. Applicants who are accepted under these circumstances may be entered into a program that is longer than the nominal program length. The longer programs will include courses designed to remedy academic deficiencies and/or provide additional background preparation.

Other applicants who do not meet the standard admission criteria or receive a waiver may be able to enroll on a conditional basis. Full admission as a degree seeking student is granted upon successful completion of the conditions set forth in the applicant's admission letter.

The GRE (or GMAT, if applicable) is required for admission unless waived by the academic department. The Graduate School of Engineering and Management may evaluate applications for admission to master's degree programs for active duty service members who have not taken the GRE (or GMAT, if appropriate), provided the request to do so is made by their service's personnel agency based upon official agency needs, in which case, the Graduate School may waive the GRE or GMAT requirement for admission on a case-by-case basis based upon the strength of the applicant's record.

ADMISSION STATUSES

Full Admission

Students admitted to full (or unconditional) degree-seeking status must have submitted official transcripts from each college or university attended indicating a completed baccalaureate or master's degree from a regionally accredited institution, have submitted GRE or GMAT scores as appropriate to the program requested, and be otherwise fully qualified for the degree program requested in the judgment of the applicable academic department and the Graduate School of Engineering and Management.

For applicants seeking admission as non-degree-seeking students or into certificate programs, GRE/GMAT scores are not required. Also, see the "Required Documents" section regarding transcript submission requirements for these categories of applicants. In all cases (degree-seeking, certificate program, and non-degree-seeking), the student has met all the general requirements of the Institute and the specific program requirements of the department in which the student plans to pursue study.

Conditional Admission

Students may be admitted to a conditional status for the following reasons:

1. The applicant has not graduated from their undergraduate or master's program, yet is expected to do so within 9 months.
2. The applicant has not provided all official documents required by the graduate program or the Graduate School. For example, the applicant has completed the baccalaureate degree and/or the master's degree, but has yet to submit official verification of the last term's work and/or receipt of the degree. All official documents must be submitted prior to the completion of the first term of study; otherwise, the student will not be allowed to enroll in further coursework.

3. The applicant has majored in another field with a creditable record but has not yet clearly demonstrated abilities in the proposed new field.

4. The prerequisite coursework in the chosen field is insufficient.

5. The previous academic record is borderline (e.g. low cumulative GPA, low GRE/GMAT scores, etc.).

A student, while in conditional degree or conditional non-degree status due to academic issues, must meet the conditions set forth by the faculty in a predetermined time-frame prior to being fully accepted into a degree program. A student who fails to meet the academic conditions will not be allowed to continue studies in an advanced degree program. In the case of missing information, the student must submit all required official documentation (undergraduate and/or graduate degree transcripts and/or test scores) by the end of the first term of study. Otherwise, the student will not be allowed to register for courses in subsequent quarters and, depending on the situation, grades for completed classes will not be released.

**CHANGES AFTER ADMISSION**

**Change of Enrollment Status**

Non-degree or certificate-seeking Graduate School of Engineering and Management students who wish to become degree-seeking students must submit an Application for Change of Enrollment Status through the Admissions Office. Students requesting such a change must also meet the program entry requirements and provide all required documents, to include test scores, as necessary for full acceptance into a degree or certificate program. Here is the Internet link to the Application for Change of Enrollment http://www.afit.edu/en/admissions/officeinfo.cfm?a=changingprograms.

The academic department will determine the number of Graduate School course hours, or classes, of prior coursework it will accept based upon admission to the new program. The student will coordinate this with his/her academic advisor and the department. The department will notify the registrar of its decision.

**Changing Degree Programs**

Students who are admitted to any graduate program may change programs; this too, is considered a change of enrollment and requires faculty approval. (Air Force officers, other military personnel, and federal employees see below). A student wishing to change programs must consult with their academic advisor and request the change through the Admissions Office using the same Change of Enrollment form as above http://www.afit.edu/en/admissions/officeinfo.cfm?a=changingprograms. Once the academic review is completed, the student is notified of the department's decision.
Air Force officers, other military personnel, and federal employees filling developmental education positions are assigned to the Graduate School of Engineering and Management, at the Air Force Institute of Technology, based upon the needs of their respective service or agency, and thus changing a program requires approval from various agencies and personnel centers. Fully sponsored students who seek a program change must follow guidelines available within their department designed to insure the change continues to meet the needs of the Air Force or their particular service or agency. Any change of degree program will require written justifications and concurrences presented to the Office of Admissions prior to changing a degree program.

Termination

Admission status will terminate for students (excluding service sponsored military personnel) who are admitted either conditionally or unconditionally, who do not enroll in any course within one year from the term for which admission was requested.

For all students, both degree and non-degree seeking, who have taken at least one course, continuation in their enrollment status is at the discretion of the academic department, the chair of the graduate program, and the Dean of the Graduate School, consistent with the policies and practices of the Graduate School and the graduate program. Also see "Probation and Dismissal" under the Academic Information section of this catalog.

Registrar Division

Registrar Division Chief, Angela D. Fuerst, Ph.D.

AFIT/ENER
2950 Hobson Way, Building 641
Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-6234 x3127 (DSN 785-6234 x3127)
FAX: (937) 255-2791 (DSN FAX 785-2791)
E-mail address: registrar@afit.edu
Website: http://www.afit.edu/en/Ener/

Mission

- Incorporate best practices from major universities within the registrar's offices.
- Provide accurate, timely response to all requests for service and/or information.
- Upgrade technology as available and appropriate to ensure our ability to provide efficient and effective service to our customers.
Goals

To fulfill that mission, the Office of the Registrar has established the following goals:

1. To serve the constituency in an attentive and cordial manner.

2. To provide a well coordinated registration process that is student oriented, accurate and efficient.

3. To produce a quality course schedule in a timely manner that accurately reflects the offerings of our academic departments and the mission of the United States Air Force.

4. To maintain academic records that are accurate, easily understood, and available in a timely fashion.

5. To supply concise information regarding academic policies, transfer credit acceptability, grades, and graduation certification.

Release of Student Information

AFIT may release information concerning current or former students that appears in directories and publications available to the public without the student's consent except when requested by the student to hold such information confidential.

For currently enrolled students, this information includes the student's name; major field of study; dates of attendance and full or part-time status, degrees, honors, and certificates received or anticipated. For former students, this information may include the student's name; school, major field of study; dates of attendance and full- or part-time status; honors, and certificates, or degrees earned at AFIT.

Academic credentials presented to AFIT for the purpose of establishing academic eligibility become the property of AFIT and are not subsequently released to the student or to another individual or institution.

The academic data of students subject to the Uniform Code of Military Justice may be released to officials of various government agencies for the purpose of conducting background investigations or other official purposes without the consent of the student concerned. Additionally, information may be released under the authority of the Freedom of Information Act as determined appropriate by officials interpreting FOIA policy.

Transcript Release

The Registrar may release student academic information to organizations conducting studies for, or on behalf of, educational agencies or the Institute for the purpose of developing, validating, or administering predictive tests, improving instruction or to accrediting organizations in order to carry out their accrediting functions. Such studies must be conducted in such a manner as will not permit the personal identification of students by persons other than those conducting the study, and such information must be destroyed when no longer needed for the stated purpose.

Transcript Requests

An official transcript of each student's academic record is maintained by the Registrar's Office. The permanent record is considered confidential between the student and the Institute. Transcripts are not released, except to authorized government or school representatives who need these documents for conduct
of official business, without the written permission of the student. All transcripts that are issued to students will be stamped "ISSUED TO STUDENT".

There is no fee for transcript service.

Bring photo identification to our office, or you may obtain a transcript request form (Form ENER-TRF-01) by using the link: http://www.afit.edu/en/Ener/

If you are unable to download the PDF and wish to send a letter please make sure it contains the following information:

1. Your name, maiden name, and any other previous names (if applicable)
2. Social Security number/AFIT Student Identification number
3. Birth date
4. Dates of attendance
5. Complete address where you would like the transcript sent
6. Your current address and phone number in case we have questions
7. Your signature authorizing the release of the transcript

Send requests to:

AFIT/ENER
BUILDING 641, 2950 HOBSON WAY
WRIGHT PATTERSON AFB OH 45433-7765
Or email to: AFIT.ENERTR@afit.edu
Or fax to: (937) 255-2791 or (DSN 785-2791)

Research

Dean for Research: Heidi R. Ries, PhD
Phone: 937-255-3636 x4544

Director of Sponsored Programs: Michael J. Caylor, PhD
937-255-3636 x7104

Air Force Institute of Technology
Office of Research and Sponsored Programs, AFIT/ENR
2950 Hobson Way, Building 641, Room 100b
Wright Patterson AFB, OH 45433-7765
Fax: (937) 656-7139
E-mail address: research@afit.edu
Website: http://www.afit.edu/en/enr/

Overview

Research is the cornerstone of the dramatic advances in air, space, and cyber defense technology that are necessary to address today's international and homeland security issues; and research will be critical to the nation's ability to meet the challenges of tomorrow. Research is also an integral part of graduate education,
providing graduates with in-depth knowledge, critical thinking skills, and problem solving abilities. At AFIT, our faculty and students engage in research with the goal of cost-effectively sustaining the technological supremacy of the U.S. military.

AFIT welcomes the opportunity to conduct research on additional topics of interest to the USAF and other DOD organizations, when adequate manpower and financial resources are available and/or provided by a sponsor. In addition, AFIT provides research collaboration and technology transfer benefits to the public through Cooperative Research and Development Agreements (CRADAs).

Further Information

AFIT Annual Reports and Research Reports provide an overview of our departmental research efforts and include faculty contact information. The reports can be obtained at http://www.afit.edu/en/enr/index.cfm or by contacting the Office of Research and Sponsored Programs, Graduate School of Engineering and Management at 937-255-3633 or by email: research@afit.edu. The primary points of contact are Dr. Michael J. Caylor, Director of Sponsored Programs, 937-255-3636 x7104, and Dr. Heidi R. Ries, Dean for Research, 937-255-3636 x4544.

RESEARCH CENTERS

The Advanced Navigation Technology (ANT) Center

The Advanced Navigation Technology Center is a forward-looking navigation research center seeking to identify and solve tomorrow's most challenging navigation and autonomous and cooperative control problems. The ANT Center's goal is to develop navigation technology that ensures we can navigate anywhere, anytime, using anything. The ANT Center focuses on three research thrusts: Autonomous and cooperative systems, non-GPS precision navigation, and robust GPS navigation/NAVWAR. http://www.afit.edu/en/ant

The Center for CyberSpace Research (CCR)

The Center for Cyberspace Research, established in March 2002, conducts defense-focused cybersecurity research at the Master's and PhD levels. The CCR is a national Center of Academic Excellence in Information Assurance Education as designated by the Department of Homeland Security and the National Security Agency. The CCR is also a National Science Foundation CyberCorp institution. On June 19, 2008, the Secretary and Chief of Staff of the Air Force designated the Air Force Institute of Technology and the CCR as the Air Force's Cyberspace Technical Center of Excellence (CyTCoE). Under the AF CyTCoE charter, the Center works with the Air Force leadership to develop and maintain the cyberspace workforce via cutting-edge graduate and continuing education. The CCR is forward-looking and responsive to the changing educational and research needs of the Air Force, Department of Defense, and the federal government. The CCR affiliated faculty teaches and performs research focusing on understanding and developing advanced cybersecurity-related theories and technologies. These theory and technology advancements have included efforts in critical infrastructure protection, network intrusion detection and avoidance, insider threat mitigation, cyberspace situational awareness, malicious software detection and analysis, software protection, and anti-tamper technologies development. http://www.afit.edu/en/CCR/
The Center for Directed Energy (CDE)

The Center for Directed Energy supports Air Force and DoD agencies in transitioning high energy lasers and high power microwaves to the battlefield through vigorous scientific and engineering research, and diverse consulting activities, in conjunction with educational programs offered through the Department of Engineering Physics. The CDE developed the world's most comprehensive simulation package of atmospheric effects on the propagation of HELs. Called HELEEOS, for High Energy Laser End-to-End Operational Simulation, the simulation has over 100 DoD users and can model DE weapons of current genre or those still in HELEEOS to the analysis teams at the Air Force Research Laboratory and within the intelligence community. http://www.afit.edu/en/de/

The Center for Technical Intelligence Studies and Research (CTISR)

The Center for Technical Intelligence Studies and Research (CTISR), formerly known as the Center for MASINT Studies and Research (CMSR), is focused on Air Force (AF), Department of Defense (DOD), and the U.S. Intelligence Community (IC)’s scientific, technical, and operational activities through graduate research programs. CTISR has an active, interdisciplinary research portfolio of projects addressing DOD and Intelligence Community requirements. Our Advanced Geospatial-Intelligence IR/SAR Certificate Program (ACP), offered by the Department of Engineering Physics and the Department of Electrical and Computer Engineering, further supports the technical intelligence educational needs of its workforce and exemplifies the multidisciplinary nature of technical intelligence. CTISR's strategic partnerships with world-class intelligence and research organizations have allowed the CTISR to maintain relevancy to the requirements and needs of these communities. CTISR has truly become a national resource for the technical intelligence community for educating a new generation of technical intelligence professionals to assure the preeminence of our air and space, ground, and naval forces. http://www.afit.edu/en/ctISR/

The Center for Operational Analysis (COA)

The Center for Operational Analysis (COA) is dedicated to solving real-world operations and logistics challenges facing the Air Force, Department of Defense (DOD), and the Acquisition Community. The COA directly supports our collaboration sponsors with faculty-led student-driven operationally relevant research conducted by students and faculty within the Department of Operational Sciences. Civilian and military student development is extremely important to the Department of Operational Sciences. Additionally, the department is focused on keeping our military students connected to their respective services during their 12 – 36 month academic programs. Our faculty and students work directly with our sponsors to provide unique capabilities to attack tough operational and logistics problems and issues. The COA’s major research focus areas are: Mobility Modeling, Logistics Modeling and Analysis, Test and Evaluation, and Information and Irregular Warfare Modeling and Analysis. http://www.afit.edu/en/coa/
Library Services
Director, The D'Azzo Research Library, Laurene E. Zaporozhetz, MSL, Ph.D.

AFIT/ENWL
2950 Hobson Way, Bldg. 642, Room 1400B
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-4216 (DSN: 785-6565 ext 4216)
Fax: (937) 656-7746
E-mail address: laurene.zaporozhetz@afit.edu
Website: http://www.afit.edu/library/

Mission Statement

The primary mission of The D'Azzo Research Library is to support the educational, research and consulting programs of AFIT and AFRL.

Location

The D'Azzo Research Library is housed in a centrally located, modern 40,000 sq. ft. facility. In addition, the library maintains a 6,000 sq. ft. annex facility that stores retrospective journal titles. A faculty reserve room contains materials selected by faculty for students to use in conjunction with their courses. The facility features 12 student seminar rooms, two conference rooms, a computer classroom with 20 workstations, and 26 workstations in a public service area. The AV room houses a collection of audio visual material including microfiche readers and copiers.

Over a Million Items

In the aggregate, the library collection numbers more than a million items.

1. The book collection is primarily made up of titles that support the subject areas of aeronautics and astronautics, electrical and computer engineering, physics, mathematics and statistics, operational sciences and systems and engineering management.

2. The library holds or has access to over 34,000 (paper and electronic) foreign and domestic journal subscription titles covering the social, basic, and applied sciences. The collection is continuously being updated to add additional journal titles in electronic format.

3. A comprehensive collection of conference reports, proceedings, and transactions is available to library users. These reports are available in paper, electronic and microform formats.

4. The Library also holds a complete collection of the Institute's resident graduate student theses and dissertations.

5. A small, circulating collection of non-print media is also available to the library's patrons. This collection includes CDs, videos, DVDs and audio materials, as well as microforms in support of the mission of the Institute.
6. The Reference collection contains standard and specialized reference works for engineering and logistics, and also includes strong bibliographical collections for the identification of research materials that are not held by the Library. Such materials may be obtained on interlibrary loan (ILL) from national and regional cooperating libraries and bibliographic utilities.

7. Various materials relating to the Institute's history, including annual histories, accreditation reports, inspection reports and other special reports dating back to 1919, are held in the archival collection.

**Access to resources**

AFIT maintains databases and journals that are critical to support all Institute research requirements. They include:

1. The Aerospace and High Technology Database, INSPEC, Compendex, EBSCO, Defense Technical Information Center (DTIC) databases, IEEE/IEE Electronic Library, ACM Digital Library, Science Direct, Science Citation Index Expanded, MathSciNet. A complete list of databases and journals is available at the library's homepage [www.afit.edu/library](http://www.afit.edu/library)

2. Students, faculty and staff may use the library's interlibrary loan service to obtain materials that are not owned by The D'Azio Research Library. Registration for an interlibrary loan account is also available on the library homepage.

**Library instructional classes provided.**

Orientation programs and instructional classes on the use of library resources are provided to students and faculty throughout the year. Library liaisons are appointed to each major school and graduate department to ensure that students and faculty have a contact who can direct them to the library resources needed for their research.

**Consortia Memberships**

The D'Azio Research Library is a member of the Southwestern Ohio Council for Higher Education (SOCHE).

1. With identification, registered AFIT faculty members and students may borrow directly from most SOCHE member libraries.

2. Wright State University and the University of Dayton have the area's largest academic libraries, and provide Institute faculty members and full-time graduate students with borrowing privileges.

3. The D'Azio Research Library is a member of the On-line Computer Library Center (OCLC), an on-line bibliographic and interlibrary loan provider that enables the identification and retrieval of library and research materials on an international basis.
Financial Assistance

Director, Financial Management and Chief Financial Officer, Ann M. Marburger
AFIT/FM
2950 Hobson Way, Building 643, Room 209
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-8400 x3611 (DSN 785-8400 x3611)
Fax: (937) 656-4775 (DSN) 986-4775
E-mail address: ann.marburger@afit.edu

Students assigned to the Graduate School of Engineering and Management by the U.S. Air Force and other military organizations through the Air Force Education Requirements Board (AFERB) to pursue degrees full time incur no financial liability with regards to tuition. All other students are responsible for all their financial obligations including tuition. The current tuition rates are posted at the following website: http://www.afit.edu/en/Admissions/. Select "Information" on the top of the page; in the drop down select "Tuition".

Please forward a copy of your Registration Form and Approved Funding Documentation (i.e. SF 182, DAGSI Scholarship, and AF Form 1227) to the AFIT Bursar before the beginning of classes.

AFIT/FM
ATTN: Carol Autry, Bursar or Jordan West
Bldg 643, Room 209
2950 Hobson Way
Wright-Patterson AFB OH 45433-7765
937-255-8400, x3623 DSN 785-8400 x3623
carol.autry@afit.edu

Refund Policy

Tuition refunds can be made if a student drops a course during the quarter. For refund purposes, the effective date of cancellation is the date the student submits the completed drop form to the Registrar's Office, not the last day the student attends class.

In special circumstances, AFIT will consider an extended period for refund of tuition when withdrawal is certified by the individual's unit to be in the best interest of the Air Force to fulfill mission essential activities (such as deployments). In this case, the student's supervisor should contact the AFIT Bursar's Office with specific details.

Tuition refunds for Residential Students will otherwise be limited according to the following schedule:

- Prior to and during the first week of classes 100%
- During the second and third weeks of classes 70%
• After completion of the third week of classes 0%

Tuition refunds for Distance Learning Students will otherwise be limited according to the following schedule:

• Prior to the Monday beginning the fourth week of classes 100%
• After Monday, beginning the fourth week of classes 70%
• After the Monday of the fifth week of classes 0%

Research Assistantships (RA)

The Air Force Institute of Technology engages the services of Research Assistants who are pursuing a degree at other academic institutions through a contract with the Southwestern Ohio Council for Higher Education (SOCHE). Civilian students must be US citizens. To request additional information contact Ms. Marcia Hutcheson, (937)258-8894 or e-mail Marcia.Hutcheson@soche.org.

Scholarships

DAGSI makes scholarships and fellowships available to graduate students enrolled in engineering/computer science degree programs at its member institutions. Awards cover courses taken at Air Force Institute of Technology (AFIT), University of Dayton (UD), and Wright State University (WSU).

For further information, visit the DAGSI website: http://www.dagsi.org.

Various Scholarships are available to students attending AFIT who are not already fully funded by a federal government agency. To view information on these potential financial resources, go to http://www.afit.edu/en/Admissions/Docs/ScholarshipInfo2.pdf.

Tuition Assistance

Tuition Assistance can be used for AFIT courses on a limited basis and must be approved by the Base Education Office prior to registration. Please contact your local Base Education Office for more information.

VA Education Benefits

Eligibility for VA benefits is determined by federal regulation. In accordance with federal regulation CFR 21.5203 (covers Chapter 32), CFR 21.7142 (covers Chapter 30), CFR 21.3025 (covers Chapter 35), and CFR 21.7642 (covers Chapter 1606), payment of VA education benefits is prohibited if an individual is on active duty and is enrolled in a unit course or courses which are paid for in whole or part by the Armed Forces. Therefore, many AFIT students will not qualify for VA benefits. However, any student eligible for VA Education benefits under Chapters 30, 32, 35, or 1606 may use these benefits while attending AFIT. For Chapter criteria and actual monthly benefit information, students should visit the VA web site at www.GIBILL.va.gov or call the VA toll free number at 1-888-442-4551.

How to Apply for VA Education Benefits

Applications and assistance are available at the Admissions Office (Bldg 641, Room 102). Students applying for VA benefits must provide an initial degree plan and additional required documents dependent upon their
circumstances. The Admissions Office certifies the enrollment of students to the VA and must report any changes in the enrollment of such students in a timely manner. Therefore the veteran must notify the Admission's Office if a course is added or dropped. Processing and payment of the first check depends on the "enrollment season", however, expect approximately six to eight weeks before receipt of the first check. Students must validate their enrollment monthly on the VA web site above to continue payments. In accordance with AFIT's existing guidelines, any credit for previous education that is accepted toward AFIT degree requirements will shorten the degree program proportionately. The certifications of enrollment submitted to the VA will reflect this credit.

Academic Standards for VA Education Benefits

VA students not progressing at a rate that will permit timely graduation with a 3.0 GPA will be reported to the VA as not making satisfactory progress.

Computer Support

Director, Communications and Information, Lance A. Carmack, Lt Col, USAF
AFIT/SC
2950 Hobson Way, Building 642, Room 2200
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-6565 x4480 (DSN 785-6565 x 4480)
Fax: (937) 656-7080 (DSN 986-7080)
E-mail address: afit.sc@afit.edu
Website: http://www.afit.edu/sc

Mission Statement

The Air Force Institute of Technology's (AFIT) Directorate of Communications and Information (SC) provides a broad range of information resources and services to the students, faculty and staff of AFIT. Services provided by SC include network and voice communications, central and end-user computing support, information systems planning and support, Campus Help Desk, applications development, visual information support and information management. Additional information can be found at:
http://www.afit.edu/sc

Student, Staff and Faculty Support

SC establishes computer accounts for every enrolled student, faculty and staff member once computer security training is verified. This account enables use of electronic mail (e-mail), software application access, information and database storage and retrieval, network access and similar functions necessary for the conduct of classes. Accounts are to be used for AFIT related and official government business only by the person assigned the account. Most students will automatically be assigned a computer account upon arrival through SC's coordination with the Directorate of Admissions/Registrar. If you have not been automatically assigned a computer account, you'll need to submit a request to the AFIT Help Desk, through your faculty advisor.
Scientific workstations and computer programs available

AFIT’s computing capabilities include a variety of mathematical, statistical, simulation and modeling applications available on various Unix-, Linux- and Intel-based platforms. There is also a wide array of programming languages for use while completing class projects, assignments, theses and research projects. Over 300 dual/dual core - processor workstations throughout AFIT provide access to these applications and programming languages.

Help for computer concerns

In addition to the scientific workstations, AFIT also maintains over 2,000 desktop and notebook computer systems for general office automation functions such as e-mail, word processing, spreadsheet, database, and presentation software. Assistance and problem resolutions are available through the Campus Help Desk during normal duty hours. High-speed black-and-white and color laser printers for hard-copy output are readily available for coursework and thesis production.

Internet access

Internet access options are abundant. In addition to global e-mail capability, the Institute offers Internet and World Wide Web browsing applications, plus Secure Shell File Transfer Protocol and Secure Shell Telnet capability for research collaboration and data sharing. Additionally, secure VPN remote access is available for authorized users requiring access from home or other off-site locations. Also, campus wide wireless is available for authorized users. Our remote access capabilities permit access to private data storage areas, e-mail, the Internet and other services. You can also access your voice mail messages from home or while traveling.

Additional research computers available

AFIT is a member of the Ohio Higher Education Computing Council (OHECC) and the Ohio Academic Research Network (OARNET). Authorized students and faculty also have access to the supercomputing facilities at Wright-Patterson AFB’s Major Shared Resource Center (MSRC).
Student Services

Director: Richard Gammon, MBA
AFIT/ENES, Building 641, Room 102
2950 Hobson Way
Wright Patterson AFB OH 45433 -7765
Voice: (937) 255-6234 x4217 (DSN 785-6234 x4217)
FAX: (937) 255-2791 or DSN FAX 785-2791
E-mail address: studentservices@afit.edu; richard.gammon@afit.edu
Website: http://www.afit.edu/en/students/current

Student Support Division

Services provided to AFIT Students

The Student Support Division provides a wide range of services, and is the primary office of responsibility for numerous activities in the Graduate School. A sampling of their services and responsibilities are as follows:

• Student Handbook
• Newcomer orientation program
• Base access for non government employees
• Official student mail
• Fax service
• Access to special passes/safety forms/leave
• Loan deferments
• PhD cubicle assignments
• Training Reports and Supplemental Training Reports
• Graduation and Award Ceremonies
• Sponsorship program for incoming students
• Management of the Casual Flight
• Focal point for all early/late reporting and departure requests
• Focal point for the Oakridge Institute for Science and Education (ORISE) program

International Student Division

Director and International Military Student Officer (IMSO), Annette Rowell Robb, MAED
AFIT/ENES, Building 641, Room 113
2950 Hobson Way
Wright Patterson AFB OH 45433 -7765
Voice: (937) 255-6800 x4303 (DSN 785-6800 x4303)
FAX: (937) 255-9981 or DSN FAX 785-9981
E-mail address: annette.robb@afit.edu
Website: http://www.afit.edu/imso
The International Affairs Office provides all functions related to AFIT International Programs, starting with inquiries about AFIT programs, request for evaluations for admissions, and final admissions results which the IMSO sends back to country. Coordinates all training for foreign countries through the Air Force Security Assistance Training Command (AFSAT), embassies around the world, and the Office of the Secretary of the Air Force, International Affairs (SAF/IA).

The IMSO is the sole POC for answering questions concerning International Affairs at AFIT from the Security Assistance Officer (SAO) in the foreign country embassy, AFSAT, and SAF/IA. The International Officer is responsible for the cultural, social, and academic integration of military officers and their families into the community and AFIT environment once they arrive in the US.

Educates and supports international military officers’, Ministry of Defense personnel and their families.

Enables AFIT to accomplish US Security Assistance Objectives: teaching international recognized human rights, democracy, interrelationships of culture, ethics, economy, social diversity and free enterprise.

Maintains a critical academic International database, manages Invitational Travel Orders and is responsible for in-processing and out-processing international students.

Manage all aspects of disciplinary problems, academic issues, language concerns, medical problems, passport issues and leave requests.

Maintains academic records and training reports.

Manages a sponsor program and the congressionally mandated Field Studies Program.

AFIT Student Association

The AFIT Student Association (ASA) is a student-run, private, non-profit organization established to provide advocacy and services to AFIT graduate program students.

Membership

All AFIT students in graduate programs (resident or nonresident, full-time or part-time, masters or doctoral) are members of the ASA.

Purpose

To serve students by providing information on programs and events directly related to morale and services.

Services

Liaison between student body and AFIT leadership to plan special events and activities for students, input to awards given to faculty and staff and provide copiers for use in the library.

Primary Point of Contact

The student association web page (http://asa.afit.edu/) contains information on student events and a means to contact the current leadership with questions and/or ideas.
Aeronautics and Astronautics (ENY)

Department Head: Bradley S. Liebst, PhD
2950 Hobson Way, Building 640, Room 349
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-3069 (DSN 785-3069)
Fax: (937) 656-7053 (DSN 986-7053)
E-mail address: eny@afit.edu
Website: http://www.afit.edu/en/eny/

Introduction

The Department of Aeronautics and Astronautics, Air Force Institute of Technology (AFIT) provides educational expertise (through the doctoral level) in Aeronautical Engineering, Astronautical Engineering, Materials Science, Space Systems, Mechanical Engineering, and Engineering Mechanics. The major departmental effort is devoted to teaching and research in support of programs leading to the Master’s degree in the first four of these program areas and Doctoral studies in any area of departmental activity. The Master of Science programs in Aeronautical Engineering, Astronautical Engineering are accredited by the Accreditation Board for Engineering and Technology (ABET). The North Central Association of Colleges and Universities accredits all other Masters level degree programs.

Facilities

The Department of Aeronautics and Astronautics is equipped with Laboratories for the study of fluid mechanics, solid mechanics, and system dynamics and control. Laboratory facilities specifically support lecture courses, laboratory courses, faculty research, and student thesis research at Master, PhD, and postdoctoral levels.

The laboratory facilities are comprised of general instrumentation and equipment, which are shared by a variety of facilities. These research facilities are dedicated to specific research topics and have unique equipment and instrumentation requirements.

The facilities are housed in two different buildings. Building 640 has 13,000 square feet of general laboratory facilities, including the computational dynamics and design laboratory which is equipped with high-performance Linux workstations and access to local Linux-based computer clusters. Building 644 has 5246 square feet of laboratory space housing a 44” x 31” wind tunnel, 5 kip shaker with digital controller, Simulated Satellite (SIMSAT), vibration lab, an instrumentation lab, high pressure shock tube facility, 9 inch low velocity wind tunnel, and turbine cascade facility.
Support instrumentation and sensors include: digital data acquisition systems, schlieren, Moire, shadowgraph, high speed video recording equipment, one and three component laser velocimeter, hot wire anemometers with linearizers and signal conditioners, optical equipment, modal analyzers, frequency spectrum analyzers, multi-port pressure measuring systems, material test and characterizations facility, material preparation facility, and a full range of transducers (temperature, force, pressure, acceleration, displacement).

PROGRAMS

Master of Science

- Aeronautical Engineering (M.S.)
- Astronautical Engineering (M.S.)
- Materials Science (M.S.)
- Space Systems (M.S.)

Doctor of Philosophy

- Aeronautical Engineering (Ph.D.)
- Astronautical Engineering (Ph.D.)
- Materials Science (Ph.D.)
- Space Systems (Ph.D.)

Certificate

- Space Systems Certificate

FACULTY

Professor

Paul I. King propulsion and aerodynamics
Bradley S. Liebst dynamics and control
Shankar Mall structures and materials
Anthony Palazotto (Distinguished Professor) structural mechanics
Marina B. Ruggles-Wrenn structures and materials
William E. Wiesel astrodynamics

Associate Professor

Jonathan Black structural dynamics and control
Richard G. Cobb structural dynamics and control
Robert B. Greendyke fluid dynamics, physical chemistry, air weapons
Donald L. Kunz dynamics and control
Marc D. Polanka heat transfer and propulsion
Mark F. Reeder fluid dynamics
Assistant Professor

Jeremy S. Agte dynamics and control
Bradley J. Ayres dynamics and control
Michael J. Caylor dynamics, systems and control
Frederick Harmon dynamics and control
Carl R. Hartsfield propulsion and air weapons
Kevin J. LaRochelle solid mechanics and structures
David Liu propulsion and air weapons
Christopher L. Martin fluid dynamics and heat transfer
Timothy C. Radsick solid mechanics and structures
James L. Rutledge fluid mechanics and heat transfer
Ronald J. Simmons propulsion and dynamics
Eric Swenson solid mechanics and structures

Professor Emeritus

Delmar W. Breuer air weapons
Robert A. Calico dynamics and control
William C. Elrod propulsion
Milton E. Franke aerodynamics, propulsion, and weapons
Andrew J. Shine fluid dynamics
Peter J. Torvik dynamics

Aeronautical Engineering (M.S.)

Program Description

The Graduate Aeronautical Engineering program is a fully accredited program, leading to a Master of Science degree in Aeronautical Engineering. This program is designed for students from all branches of the U.S. military services as well as students from allied foreign military services, civilians and part-time students. Air Force quota students normally enter as a class in September and are scheduled to graduate in March after 18 months of study. Program entry date and length may vary for other students. See Department Brochure for further details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Program Educational Objectives (PEOs)

1. Our graduates will make direct contributions as a practicing engineer in the area of aeronautical engineering.

2. Our graduates will effectively communicate, evaluate, monitor and administer aeronautical research and development programs.
3. Our graduates will solve new technological challenges to meet the needs of the Air Force and other DoD organizations.

Program Outcomes

1. GAE graduates will demonstrate the ability to perform independent research, resulting in substantial contributions to the field of aeronautical engineering.

2. GAE graduates will demonstrate the ability to effectively communicate complex ideas and concepts both orally and in writing.

3. GAE graduates will be able to perform research that provides substantial and tangible value to the DoD.

Program Elements

(1) Core Aeronautical Engineering
(2) Mathematics (2)
(3) Specialty Sequences (2)
(4) Independent Investigation (i.e., Thesis Research)
(5) Electives
(6) 48 graduate quarter hours, minimum

See Department Brochure for further details regarding each of the above program elements.

School and Program Admission Criteria

DEGREE REQUIRED: Aeronautical, Astronautical, Aerospace, Mechanical, Systems Engineering or Engineering Mechanics from USAFA. Must have graduated from an ABET program.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

This program adheres to the general requirements for the MS degree established by the AFIT Graduate School of Engineering and Management. For more complete information and for the final authority on these requirements, the reader should consult Graduate School of Engineering and Management Operating Instruction (ENOI) 36-135, “Requirements for the Master of Science Degree,” and ENOI 36-135, “Degree Requirements for Two Masters' Degrees.” Degree requirements are 48 credit hours; however, the 6-quarter in-residence MS program normally includes a minimum of 72 quarter hours (12 hours per quarter is
considered full-time status). The requirement for 72 hours may be waived only by approval of the department head and the dean.

**Specialty Sequences**

Each student is required to take two specialty sequences. Each of these three-course sequences form a coherent body of knowledge in a particular area and provide the student with a strong theoretical background for thesis work and post-graduate assignments.

**Math Courses**

Each student must complete at least two graduate level courses containing a major emphasis in mathematics or statistics. This requirement can be satisfied by taking two courses offered by the Department of Mathematics and Statistics or one course from the same, plus a second course approved by the Department of Aeronautics and Astronautics. The department-approved second course may also be used simultaneously in satisfying other degree requirements.

**Core Aeronautical Engineering**

Each student who graduates with a Master of Science in Aeronautical Engineering must have a broad foundation in the theoretical and applied aspects of the fundamental disciplines of aeronautical engineering. This department offers courses in five aeronautics disciplines: 1) aeronautics, 2) aircraft stability and control, 3) air breathing or rocket propulsion, 4) structures and materials, and 5) air weapons. The department requires that each student take at least one department-offered course from three of the five disciplines.

**Thesis**

Each student is required to complete an independent investigation of a problem of current DoD interest. This investigation is conducted and documented by the student, with supervision of the faculty, then presented orally and in written form as a formal thesis. The thesis carries 12 credit hours, is graded, and contributes to the student's grade point average. See Department Brochure for details regarding thesis policies, procedures and requirements for AFIT and the Department of Aeronautics and Astronautics.

**Astronautical Engineering (M.S.)**

**Program Description**

The Graduate Astronautical Engineering (GA) program is a fully accredited program, leading to a Master of Science degree in Astronautical Engineering. The discipline of Astronautical engineering is dedicated to the design, testing and development of spacecraft, missiles, launch vehicles and related systems. Air Force quota students normally enter as a class in September and are scheduled to graduate in March after 18 months of study. Program entry date and length may vary for other students. See Department Brochure for further details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm
Program Educational Objectives

Make direct contributions to the area of astronautical engineering as a practicing engineer.

1. Evaluate, monitor, and administer astronautical research and development projects.

2. Understand how to approach and solve new technical challenges to meet the needs of the Department of Defense.

Program Outcomes

1. Graduates of the GA program will be able to apply sound engineering principles to solve Air Force and DoD problems.

2. Graduates of the GA program will be able to communicate technical information, via oral presentations and written documents, to a wide range of audiences, including engineering professionals and senior military officers.

3. Graduates of the GA program will understand the principles of orbital mechanics. Graduates will be able to describe Keplerian motion, major perturbations to Keplerian motion, and be able to plan orbital maneuvers.

4. Graduates of the GA program will be prepared to describe and discuss significant aspects of the space environment and their effect on Earth-orbiting spacecraft.

5. Graduates of the GA program will be able to model spacecraft attitude dynamics and synthesize control laws to control spacecraft attitude. Graduates will understand transformations due to coordinate frame translation and rotations.

6. Graduates of the GA program will have a basic understanding of modern communication principles as they relate to satellite communications. Graduates will recognize methods of modulation, multiplexing, and encoding. Graduates will be able to perform simple link margin analyses needed to establish initial design requirements.

7. Graduates of the GA program will be prepared to describe essential features of rocket propulsion including: performance parameters, propellant types, rocket staging, and fluid mechanics as it pertains to rocket propulsion.

8. Graduates of the GA program will be able to conduct basic analyses of space structures including deformation from tension, torsion, shear, and bending.

9. Graduates of the GA program will have a basic understanding of the remote sensing process, and be able to recognize key concepts relating to optical systems, imaging, spatial and spectral resolution, and atmospheric absorption and scattering.

Additional Information

The Graduate Astronautical Engineering program provides the student with a broad education in the scientific and engineering disciplines associated with Astronautical Engineering, as well as in-depth study in selected specialty areas.
The program’s core courses are designed to ensure graduates have a solid foundation in the areas of orbital mechanics, space environment, attitude determination and control, telecommunications, remote sensing, space structures, and rocket propulsion. Specialty sequences are available in, but not limited to, these important aspects of astronautical engineering.

The program leads to a Master of Science in Astronautical Engineering degree (ABET accredited). Students entering this program should possess an ABET undergraduate degree in a related engineering discipline such as aeronautical, astronautical, aerospace, or mechanical engineering. Students without the appropriate technical background may wish to consider the department’s Graduate Space Systems degree program. A special program in space facilities is offered for officers in the Civil Engineering career field to prepare them for roles in the development and operation of launch facilities and large permanent space facilities.

School and Program Admission Criteria

DEGREE REQUIRED: Aeronautical, Astronautical, Aerospace, Mechanical, Systems Engineering or Engineering Mechanics from USAFA. Must have graduated from an ABET program.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses

Each student who receives a Master of Science in Astronautical Engineering must have a foundation in the theoretical and applied aspects of the fundamental areas of astronautical engineering. These areas, and associated program outcomes, are specified by the Accreditation Board for Engineering Technology (ABET). Expected outcomes include competency in orbital mechanics, space environment, spacecraft attitude determination and control, telecommunications, space structures, space-related design, and rocket propulsion. A course in sensor systems is also required for all Air Force students.

Not all master’s students are required to take courses in each of these areas to complete the GA program. Prior to beginning their program, it is the dual responsibility of the student and faculty advisor to identify areas in which the student’s undergraduate degree does not satisfy ABET core requirements and ensure their graduate program will cover any deficiencies. Faculty advisors will evaluate undergraduate transcripts to determine the applicability of undergrad courses in meeting requirements, and will prepare an ABET degree form to document that each student will meet all ABET requirements upon satisfactory completion of their education plan.

In addition to meeting ABET core requirements, students are required to meet all GA Core requirements listed in the Department Brochure. These classes can be used to simultaneously meet other degree or ABET requirements. Students are strongly encouraged to take as many of the ABET courses as possible even if they have taken undergraduate courses in these areas. The graduate courses often go beyond similar
undergraduate courses in these subject areas, and are designed to provide a strong academic foundation for anyone planning a career in a space-related field.

Mathematics

Each student must complete at least two graduate-level mathematics courses. The particular courses each student takes are based upon background and area of specialization.

Nearly all students take math courses that cover the following topics: advanced calculus, complex variables, Fourier series, Laplace transforms, boundary value problems, linear algebra, numerical methods, and probability/statistics. Two courses specifically designed to cover most of these topics are: MATH 511 - Methods of Applied Math I and MATH 513 – Methods of Applied Math II. See Department Brochure for details regarding other courses complementing the GA curriculum.

Specialty Sequences

Each program must contain two specialty sequences. A specialty sequence, three or more courses in length, is an integrated presentation of a specific technical specialty. Air Force quota students are directed to the Department Brochure regarding the specific requirements imposed upon them by their assigned education specialty code.

Thesis

The thesis is an independent investigation of a problem of current DoD interest, conducted and documented by the student, with supervision by the faculty. The student presents the thesis both orally and in written form, and is graded on the outcome.

Materials Science (M.S.)

Program Description

The Materials Science program is under the joint supervision of the Department of Aeronautics and Astronautics (Structural Materials) and the Department of Engineering Physics (Non-structural Materials) and is carried out in cooperation with the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL). This program is normally six quarters in length. Five quarters are devoted to coursework, and one quarter is devoted to thesis research.

The program provides core preparation in thermodynamics and kinetics of materials; mechanical, electronic, and optical properties of materials; material characterization; material selection and processing; and mathematics. Each student is also required to take an in-depth study and perform research either in structural materials (metallic, composite, polymer, ceramics, etc.) or non-structural materials (electronics, optical, magnetic, dielectric, coating, etc.). Emphasis is placed on the application of fundamental knowledge to the design, development, test, and evaluation of materials for Air Force systems.
The goal of the Materials Science program is to provide a student who has a background in engineering or physical science with the knowledge of materials science and engineering necessary for work in the fields of structural and non-structural materials for aerospace systems. Such positions may range from those requiring very detailed and advanced level work in a specific discipline to those involving broad responsibilities and requiring interaction among many disciplines.

Program Educational Objectives

The program educational objectives of the Materials Science program ensure that graduates are prepared to perform the following tasks successfully:

1. Possess a solid background in the fundamental areas of materials science and engineering (structural and non-structural materials, thermodynamics and kinetics, materials characterization, and materials selection and processing).

2. Possess an in-depth knowledge in one specialty area.

3. Possess experience in conducting and documenting an independent investigation, a thesis, or a problem of Air Force interest.

Program Outcomes

The program outcome of the Materials Science program describes what students will know or be able to perform upon degree completion:

1. Apply engineering principles to solve Air Force and DoD problems.

2. Communicate technical information, via oral presentations and written documents, to a wide range of audiences including engineering professionals and senior military officers.

3. Demonstrate knowledge of significant aspects of both structural and non-structural materials used in the current and future aerospace and defense systems.

School and Program Admissions Criteria

Degree Required: Materials Science, Mechanical Engineering, Chemistry, Physics, or any Engineering degree. All degrees must contain the following courses: Introduction to Materials, Physical Chemistry, and Strength of Materials.

Mathematics Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q

GPA Required: Overall - 3.0; Mathematics – 3.0; Major - 3.0

USAF Education Codes: 4FYY, Materials Science and Engineering, General, and 4FBY, Electronic and Optical Materials.

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
Core Courses

Each student who graduates with a Master of Science (Materials Science) must have a foundation in the theoretical and applied aspects of the fundamental areas of materials. This foundation is laid through a core of courses taken by all materials science and engineering students.

Mathematics

Each student must complete at least one graduate level mathematics course. A second course is highly desirable. The particular courses each student takes are based upon background and area of specialization. Nearly all students take mathematics courses that cover the following topics; advanced calculus, complex variables, Fourier series and boundary value problems, linear algebra, numerical methods, and probability/statistics. Two courses specifically designed to cover most of these topics are: MATH 511 - Methods of Applied Math I, and MATH 513 - Methods of Applied Math II. In addition, students should consider courses in Statistics or Numerical Methods such STAT 527 - Introduction to Probability; STAT 537 - Introduction to Statistics; and MATH 508 - Numerical Methods.

Specialty Sequence

Each student is required to take one such sequence with the option of adding a second. These sequences, each composed of at least three courses, together form a coherent body of knowledge in a particular area and provide the student with a strong theoretical background for eventual applications in thesis work and post-graduation assignments. This sequence is normally dedicated to meeting Air Force requirements for specialized education, as indicated by a student's advanced-level education specialty code (Ed Code).

Students will enter the GMS program with the following Ed Codes:

4FAY Materials Science and Engineering-Structural Materials
4FBY Materials Science and Engineering-Electronic and Optical Materials
4FYY Materials Science and Engineering-General

Thesis

The thesis is an independent investigation of a problem of current Air Force interest, conducted and documented by the student, with supervision of the faculty. This independent study may be done under the direction of either the Department of Aeronautics and Astronautics (for structural materials) or the Department of Engineering Physics (for non-structural materials) and can be carried out either at AFIT or at a directorate of the Air Force Research Laboratory. Theses by GMS students can be theoretical, experimental, or numerical. Topics will be proposed by Air Force research and development organizations, particularly the
Materials and Manufacturing Directorate of the Air Force Research Laboratory. Flexibility in the program is maintained in order to take full advantage of the varied backgrounds and abilities of individual students.

Space Systems (M.S.)

Program Description

The Graduate Space Systems program is designed to provide officers with a broad knowledge of space systems engineering and space science. Education in the fundamentals of these areas will increase military officer’s effectiveness in planning, executing, and evaluating space systems and operations. Each student completes a research thesis on some aspect of space systems (engineering, science, or operations). The Space Systems graduate is ready to participate actively in organizations responsible for the selection, planning, management, operation, and evaluation of space systems for the DoD. Most graduates will receive a Master of Science (Space Systems); however, students with adequate background may pursue an alternate degree as long as the GSS requirements detailed below are satisfied. Full-time quota students enter as a class in September and are scheduled to graduate in March, approximately 18 months later. Program entry date and length may vary for other students; see Department Brochure for further details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Program Educational Objectives

This program provides the student with a broad education in the scientific and engineering disciplines associated with space systems engineering and space science. Our PEOs are to provide graduates who:

1. Make direct contributions to the area of space systems engineering and space science as a practicing engineer.
2. Successfully evaluate, monitor, and administer space systems research and development projects.
3. Use their AFIT education to approach and solve new technological challenges to meet the needs of the Department of Defense.

Program Outcomes

1. Space Programs: Be knowledgeable about current and past US and international space programs. Understand the objectives of these programs and how they fit into military operations. Understand the basic technical means through which these objectives are achieved.
2. Spaceflight Dynamics: Understand the physics of orbital mechanics and what impact it has on orbital mission operations. Be able to calculate orbital maneuvers and understand the basics of orbit control in the presence of perturbations. Understand the basics of torque-free spacecraft attitude dynamics.
3. Satellite Communications: Understand modern communication principles with particular emphasis on applications to satellite and space communication systems including modulation, signals,
multiplexing, demodulation, multiple access, coding, look angles, satellite hardware, earth station hardware, and link analysis.

4. Space Environment: Understand the physics of radiation, particles, and general conditions encountered in space. Understand spacecraft thermal equilibrium, orbit decay, spacecraft charging, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena.

5. Remote Sensing: Attain understanding of the remote sensing process with an emphasis on visible light and infrared systems. Understand the physics of interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors.

6. Spacecraft Engineering: Be knowledgeable of the design issues related to complex space systems. Understand the key elements and subsystems of important classes of space systems. Gain experience with the systematic approach necessary to effectively design space systems through a group design process.

School and Program Admission Criteria

DEGREE REQUIRED: BS degree in any discipline that includes: calculus-based general physics, statics and dynamics, differential and integral calculus, differential equations and computer programming. (Typically engineering, physics, or mathematics majors, but other degrees may also meet criteria.).

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

GPA REQUIRED: OVERALL - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Mathematics

The mathematics courses provide the student with the tools to perform the quantitative analysis of the engineering, physics and operations courses. At least one math course is required. Additional math courses may be needed as prerequisites for other classes.

Core Courses

The core program assures that students have a broad background in the engineering and science of space systems and operations. The core program includes courses in orbit and attitude dynamics, sensor systems, telecommunications, space environment, spacecraft engineering, and space programs.
Specialty Sequence

A three-course specialty sequence is required for each student. This sequence is intended to provide depth in order to support the thesis effort and/or follow-on assignment requirements. The courses comprising particular specialty sequences are specified in the Department Brochure.

Thesis

The thesis is an independent investigation of a space-related problem of current DoD interest, conducted and documented by the student, under supervision of the faculty advisor. Thesis requirements will be determined by the department of the faculty member serving as the thesis advisor.

Aeronautical Engineering (Ph.D.)

Program Description

Students are admitted to a study leading toward the PhD degree in Aeronautical Engineering with a concentration in one of the three major divisions of the Department of Aeronautics and Astronautics. A program advisor will be appointed by the Department to assist each full-time student in program planning. Additionally, each fully-funded officer student has an educational code, the requirements of which are to be met within the appropriate division. See Department Brochure for additional details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Program Educational Objectives

Typically, a PhD degree program in the Department consists of two phases:

PHASE ONE: Course work and examination period of 6 academic quarters. All requirements for admission to candidacy (course work, examinations, and approval of research prospectus) are met.

PHASE TWO: Dedicated to research. This phase usually lasts 18 - 24 months, and the students devote their full attention to a research problem investigated under the direction of an approved member of the faculty of the Graduate School of Engineering and Management.

School and Program Admission Criteria

DEGREE REQUIRED: Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering (ABET accredited).

GRE REQUIRED: 156V/151Q

GPA REQUIRED: 3.50 (MS); 3.00 (BS)

Additionally, it is desirable for applicants seeking admission to the Department's PhD program to have successfully completed a MS thesis and obtained endorsement by their MS faculty, especially the MS thesis advisor.
Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements**

**Major** 24 hours

**Mathematics** 12 hours

**Dissertation Research** 48 hours

**Admission to candidacy** One year before graduation

In-residence study 3 successive quarters

Present Dissertation at a Public Defense

**Astronautical Engineering (Ph.D.)**

**Program Description**

Students are admitted to a study leading toward the PhD degree in Astronautical Engineering. A pro-tem advisor will be appointed by the Department to assist each full-time student in program planning. Additionally, each fully-funded officer student has an educational code, the requirements of which are to be met within the appropriate division. See Department Brochure for additional details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

**Program Educational Objectives**

Typically, a PhD degree program in the Department consists of two phases:

**PHASE ONE:** Course work and examination period of 6 academic quarters. All requirements for admission to candidacy (course work, examinations, and approval of research prospectus) are met.

**PHASE TWO:** Dedicated to research. This phase usually lasts 18 - 24 months, and the students devote their full attention to a research problem investigated under the direction of an approved member of the faculty of the Graduate School of Engineering and Management.
School and Program Admission Criteria

**DEGREE REQUIRED:** Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering (ABET accredited).

**GRE REQUIRED:** 156V/151Q

**GPA REQUIRED:** 3.50 (MS); 3.00 (BS)

Additionally, it is desirable for applicants seeking admission to the Department's PhD program to have successfully completed a MS thesis and obtained endorsement by their MS faculty, especially the MS thesis advisor.

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements**

Major

24 hours

**Mathematics**

12 hours

**Dissertation Research**

48 hours

Admission to candidacy

One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

**Materials Science (Ph.D.) - Structural**

**Program Description**

Students are admitted to a study leading toward the PhD degree in Materials Science. A pro-tem advisor will be appointed by the Department to assist each full-time student in program planning. Additionally, each
fully-funded officer student has an educational code, the requirements of which are to be met within the appropriate division. See Department Brochure for additional details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Program Educational Objectives

Typically, a PhD degree program in the Department consists of two phases:

**PHASE ONE:** Course work and examination period of 6 academic quarters. All requirements for admission to candidacy (course work, examinations, and approval of research prospectus) are met.

**PHASE TWO:** Dedicated to research. This phase usually lasts 18 - 24 months, and the students devote their full attention to a research problem investigated under the direction of an approved member of the faculty of the Graduate School of Engineering and Management.

School and Program Admission Criteria

**DEGREE REQUIRED:** Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering (ABET accredited).

**GRE REQUIRED:** 156V/151Q

**GPA REQUIRED:** 3.50 (MS); 3.00 (BS)

Additionally, it is desirable for applicants seeking admission to the Department's PhD program to have successfully completed a MS thesis and obtained endorsement by their MS faculty, especially the MS thesis advisor.

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

**Major** 24 hours

**Mathematics** 12 hours

**Dissertation Research** 48 hours

**Admission to candidacy** One year before graduation

**In-residence study**

3 successive quarters

Present Dissertation at a Public Defense
Space Systems (Ph.D.)

Program Description

Students are admitted to a study leading toward the PhD degree in Space Systems. A pro-temp advisor will be appointed by the Department to assist each full-time student in program planning. Additionally, each fully-funded officer student has an educational code, the requirements of which are to be met within the appropriate division. See Department Brochure for additional details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Program Educational Objectives

Typically, a PhD degree program in the Department consists of two phases:

**PHASE ONE:** Course work and examination period of 6 academic quarters. All requirements for admission to candidacy (course work, examinations, and approval of research prospectus) are met.

**PHASE TWO** is dedicated to research. This phase usually lasts 18 - 24 months, and the students devote their full attention to a research problem investigated under the direction of an approved member of the faculty of the Graduate School of Engineering and Management.

School and Program Admission Criteria

**DEGREE REQUIRED:** Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering (ABET accredited).

**GRE REQUIRED:** 156V/151Q

**GPA REQUIRED:** 3.50 (MS); 3.00 (BS)

Additionally, it is desirable for applicants seeking admission to the Department's PhD program to have successfully completed a MS thesis and obtained endorsement by their MS faculty, especially the MS thesis advisor.

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

**Major** 24 hours

**Mathematics** 12 hours

**Dissertation Research** 48 hours
Admission to candidacy One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

Space Systems Certificate

Program Description

For those students not enrolled in the Space Systems Master of Science (MS) degree program, AFIT now offers a Graduate Space Systems Certificate Program. This program consists of four courses, three core and one elective. The core courses cover the areas of spacecraft dynamics, space environment, and spacecraft design. The elective course may be in the area of space communications or remote sensing fundamentals.

Program Educational Objectives (PEOs)

The Graduate Space Systems Certificate Program is designed for students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively approach and analyze complex space-related problems, design feasible solutions, and select an appropriate solution.

Specific objectives are as follows:

1. A graduate will have a general understanding of the purpose and requirements for all spacecraft subsystems and how these subsystems relate to the spacecraft payload and mission.

2. A graduate will have a thorough understanding of orbital mechanics and the space environment and how these might affect the spacecraft mission.

3. A graduate will have the skills to effectively participate in the evaluation of both competing designs as well as proposed processes from competing contractors.

School and Program Admission Criteria

DEGREE REQUIRED: Any accredited B.S. degree, but courses are designed for students with a science or engineering undergraduate degree. Regardless of undergrad degree, a calculus-based physics course and a course in dynamical systems (circuits or engineering dynamics) is also required.
MATHEMATICS REQUIRED: Ordinary Differential Equations
TEST REQUIRED - None
GPA REQUIRED: OVERALL - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Certificate Requirements

Certificate Courses 15 hours

- ASYS 631 - Spacecraft Systems Engineering
- MECH 532 - Introductory Space Flight Dynamics
- PHYS 519 - The Space Environment

And one of the following:

- EENG 571 - Satellite Communications
  Or
- OENG 530 - Fundamentals of IR and MASINT Technology

Electrical and Computer Engineering (ENG)

Department Head: Nathaniel J. Davis IV, PhD

2950 Hobson Way, Building 640, Room 315
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-2024 (DSN 785-2024)
Fax: (937) 656-7061 (DSN 986-7061)
E-mail address: eng@afit.edu
Website: http://www.afit.edu/en/eng

The Department of Electrical and Computer Engineering is home to graduate programs in Electrical Engineering, Computer Engineering, Computer Science, Cyber Operations, and Cyber Warfare. The Department has a 50-year record of outstanding academic support to the Air Force, the Department of Defense, and the professional science and engineering community. In recent years, the Department has experienced significant growth in its research programs, as well as the demand for its graduates. The Department will continue to grow by focusing on the following six academic areas that are of critical importance to the Air Force:
AFIT Graduate School of Engineering and Management Catalog 2012-2013

- Cyber, to include computer systems, computer networks, and system and information security
- Communications, radar, and signal processing
- Guidance, navigation, and control
- Microelectronics and nanotechnology
- Electromagnetics and low observables
- Electro-optics

FACILITIES

The Department of Electrical and Computer Engineering operates an extensive complex of laboratory and computing facilities in support of its academic and research programs. The laboratory facilities include the following dedicated areas:

- Advanced Navigation Technology (ANT) Center
- Atmospheric and Adaptive Optics Laboratory
- Center for Cyber Research (CCR)
- Cyber Defense Network
- Laboratory for Information Systems and Development (LISSARD)
- Communication/Radar Laboratory
- Cyber Adaptive Network in Mobile Applications
- Digital Logic and Microprocessor Laboratory
- Low Observables Radar and Electromagnetics Network (LOREnet) Laboratory
- LORE Radar Cross Section (RCS) Laboratory
- Microprocessor Networks Laboratory
- Microsystems Design and Simulation Laboratory
- Micro and Nano-Devices and Systems Cleanroom
- Microsystems Test and Characterization Laboratory
- Parallel Computing Laboratory
- Pattern Recognition Laboratory
- Signal and Information Processing Laboratory
- Wireless Information Networking and Security (WINS)

The computer facilities available in the Department cover the broad range of capabilities from microprocessors evaluation systems to general purpose computing systems to high-performance supercomputers. A vast number of computing resources, with supporting peripherals and a variety of general purpose software are available for student and faculty use.

PROGRAMS

Master of Science

- Computer Engineering (M.S.)
- Computer Science (M.S.)
Cyber Operations (M.S.)
Cyber Warfare (IDE) (M.S.)
Electrical Engineering (M.S.)

Doctor of Philosophy

Computer Engineering (Ph.D.)
Computer Science (Ph.D.)
Electrical Engineering (Ph.D.)

Certificate

Information Assurance Certification

FACULTY

Professor

Rusty O. Baldwin Computer architecture, queuing theory, wireless (sensor) networks security models, information warfare

Nathaniel J. Davis IV Computer networks, computer security, computer architectures, and parallel computing systems, computer modeling

Gary B. Lamont Artificial intelligence, computer science, computer engineering, digital control systems, parallel and distributed computation, software engineering, network security, UAVs

Meir N. Pachter Integrated & networked navigation systems, inertial navigation, guidance, vision based navigation

Richard A. Raines Networks and information security, computer communication networks, satellite and mobile communications, biometrics and pattern recognition

Michael A. Temple Communication systems, radar systems, electromagnetic propagation

Associate Professor

Stephen C. Cain Digital systems, image processing, optics

Peter J. Collins Low observables, electromagnetic materials design and remote sensing along with the underlying foundational disciplines of electromagnetic theory, computational electromagnetics, and signature metrology
Michael J. Havrilla  Electromagnetism guided waves, material characterization, and low observables

Kenneth M. Hopkinson  Wired, and wireless networking, fault tolerant and reliable distributed systems, middleware, operating systems, middleware, operating systems net-centric warfare, network security, the networks to enhance critical use of infrastructures

Mary Y. Lanzerotti  VLSI design, microelectronics

Richard K. Martin  Signal processing, communication, navigation, source localization, and laser radar

Robert F. Mills  Radar, communication systems, signal processing, information assurance, network management

Barry E. Mullins  Cyber operations, computer/network security, computer communication networks, embedded (sensor) and wireless networking, malware analysis, reverse code engineering, and reconfigurable computing systems

Gilbert L. Peterson  Uncertainty in artificial intelligence, robotics, machine learning, data mining

John F. Raquet  Global positioning system (GPS), inertial navigation system/GPS integration, GPS carrier-phase ambiguity resolution, GPS reference receiver networks

Andrew J. Terzuoli  Remote sensing and communications, antennas, electromagnetics, object recognition, model-based vision computer methods, LO-CLO-CCLO

Assistant Professor

Geoffrey A. Akers  Signal Processing, communication, navigation, source localization, and laser radar

Todd R. Andel  Formal methods, networks modeling and simulation, secure routing protocols, wireless ad hoc, networks, VLSI design, and computer architecture,

Brett J. Borghetti  Artificial intelligence, opponent modeling, machine learning, agents, multi-agent systems, mechanism design

Jonathan W. Butts  Critical infrastructure protection, malware analysis, protocol verification and operationalizing military actions in cyberspace, and national cyberspace policy/strategic communications

Jeffrey D. Clark  Artificial Intelligence, machine learning, pattern recognition, hyper-spectral imaging

Ronald A. Coutu Jr  Microelectronics fabrication, MEMS, Metamaterials, Terahertz, micro-contacts, carbon nanotubes

Kenneth A. Fisher  Cooperative navigation and parameter estimation

Thomas E. Dube  Information assurance, cyber operations, reverse engineering, software engineering, machine learning, artificial intelligence
Jeffrey M. Hemmes  Cooperative computing, design of mobile distributed systems, software architecture, software engineering systems

Douglas D. Hodson  Software engineering

Jeffrey W. Humphries  Cryptography, data security, information security

Milo W. Hyde  Material characterization, RF optical guided wave theory, scattering optics

Julie A. Jackson  Radar signal processing, electromagnetics, automatic target recognition, multi-state radar, novel image formation techniques, sensor fusion

Timothy H. Lacey  (Adjunct) Software protection, reverse engineering techniques, and network security

Kennard Laviers  Artificial Intelligence, game search optimization, move prediction, multi-agent learning, android and ios systems (security, systems integration), information security and cloud computing

Michael C. Pochet  Techniques for high speed direct modulation of novel semiconductor laser structures and their application in optical communication system, and development of cathode materials for high power microwave sources

David J. Robinson  Quantitatively defining aspects of cyber space, characterization, prediction of users cyber behaviors (cyber-based behavioral modeling), botnets, and proactive network defense

Mark D. Silvius  Communication, signal processing

Lavern A. Starman  Carbon nanotubes, thin film material characterization, MEMS sensors & actuators

Michael J. Stepaniak  Guidance, navigation, and control

Professor Emeritus

Constantine H. Houpis  Guidance, navigation, control systems

Peter S. Maybeck  Guidance, navigation, control, stochastic processes

Henry B. Potoczny  Computer and data security, cryptography

Vittal P. Pyati  Electromagnetics, radar, electronic warfare

Associate Professor Emeritus

Thomas C. Hartrum  Computer database systems, software engineering

Computer Engineering (M.S.)

Program Description

In the Computer Engineering program, the student is provided with the challenging opportunity of pursuing a versatile course of study reflecting the student's desires, background, and future responsibilities. The student selects from a variety of specialties which are covered in depth and probe the frontiers of engineering and
scientific knowledge. Special study courses are available to study emerging technology and its application for solving problems. Advanced concepts and applications are emphasized throughout the program and in the thesis research.

Program Educational Objectives (PEOs)

1. Breadth. Apply foundational scientific concepts and sound engineering principles to efficiently and effectively advance Air Force and DoD technological capabilities.
2. Depth. Are well-educated, highly valued, and successful engineers and scientists.
3. Teamwork. Significantly contribute to technical interdisciplinary team projects.
5. Lifelong Learning. Continue to pursue lifelong multidisciplinary learning as professional engineers and scientists.

Program Outcomes (POs)

1. Graduates will demonstrate an in-depth understanding of computer engineering.
2. Graduates will be able to communicate technical information clearly by written and oral means.
3. Graduates will conduct independent research on topics related to computer engineering, including identifying and scoping a problem. Locating and synthesizing relevant published prior to work, planning and executing valid research, documenting results, and publishing them.
4. Graduates will be applying the scientific method and use reliable standards of evidence for conclusions reached.
5. Graduates will independently learn technical details for which they are responsible.

School and Program Admissions Criteria

DEGREE REQUIRED: ABET accredited BS in Computer Engineering or Electrical Engineering (with concentration in computer engineering).
MATHEMATICS REQUIRED: Discrete mathematics, ordinary differential equations
TEST REQUIRED: GRE - 153V/148Q
GPA REQUIRED: OVERALL - 3.0; MATHEMATICS - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 16 hours

- CSCE 586- Design and Analysis of Algorithms
Computer Science (M.S.)

Program Description

In the Computer Science program, the student is provided with the challenging opportunity of pursuing a versatile course of study reflecting the student’s desires, background, and future responsibilities. The student selects from a variety of specialties, which are covered in depth and which probe the frontiers of engineering and scientific knowledge. Special-study courses are available to study emerging technology and its application for solving problems. Advanced concepts and applications are emphasized throughout the program and the thesis research.

Program Educational Objectives (PEOs)

1. Breadth. Apply foundational scientific concepts and sound engineering principles to efficiently and effectively advance Air Force and DoD technological capabilities.
2. Depth. Are well-educated, highly valued, and successful engineers and scientists.
3. Teamwork. Significantly contribute to technical interdisciplinary team projects.
5. Lifelong Learning. Continue to pursue lifelong multidisciplinary learning as professional engineers and scientists.

Program Outcomes (POs)

1. Provide an in-depth and comprehensive understanding of Computer Science.
2. Enhance the ability of students to learn, on their own, technical details for which they are responsible.
3. Enhance the ability of a student to apply the knowledge learned to solve technical problems that arise in research they conduct or supervise.
4. Enhance the ability of a student to study an issue, identify and evaluate alternative actions, and propose an optimal course of action.
5. Enhance the ability of a student to prepare technical point papers, brief their seniors, and defend their conclusions.

School and Program Admissions Criteria

DEGREE REQUIRED: BS in Computer Science, or a BS in an engineering, science or mathematical field with extensive course work (24 semester hours) in computer science
MATHEMATICS REQUIRED: Discrete mathematics, differential and integral calculus
TEST REQUIRED: GRE - 153V/148Q
GPA REQUIRED: OVERALL - 3.0; MATHEMATICS - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 16 hours

- CSCE 586 Design and Analysis of Algorithms
- CSCE 593 Introduction to Software Engineering
- CSCE 686 Advanced Algorithm Design

Plus one of the following:

- CSCE 689 Distributed Software Systems
- CSCE 692 Design Principles of Computer Architecture

Mathematics 4 hours

Theory 4 hours

Application Sequence 12 hours

Thesis 12 hours

For a detailed discussion of degree requirements, see the Department Student Guide at: http://www.afit.edu/en/eng/current_students.cfm?a=studentguide
Cyber Operations (M.S.)

Program Description

Information Operations (IO) are those actions to affect an adversary's information as well as information systems while defending own information and information systems. Cyber Operations (CO) encompasses most of the technological aspects of IO. To support CO, professionals must be cognizant of the tools, techniques, and practices required to defend, attack and exploit these resources. At the technical level, CO encompasses multiple scientific disciplines that ensure the security of critical infrastructures such as: computer and network defense, attack and exploitation cryptography, computer forensic, systems security engineering and operations, application software security, and threat and vulnerability assessments/analysis. Cyber Operations also encompasses managerial aspects such as strategic and tactical planning for INFOSEC, managerial and engineering ethics, legalities, managerial roles and responsibilities, risk management, information assurance systems, and product acquisition.

Program Educational Objective (PEO)

1. Breadth. Apply foundational scientific concepts and sound engineering principles to efficiently and effectively advance Air Force and DoD technology capabilities.
2. Depth. Are well-educated, highly-valued, and successful engineers and scientists.
3. Teamwork. Significantly contribute to technical interdisciplinary team projects.
5. Lifelong Learning. Continue to pursue lifelong multidisciplinary learning as professional engineers.

Program Outcomes (POs)

1. Graduates will demonstrate an in-depth understanding of cyber operations.
2. Graduates will be able to communicate technical information clearly by written and oral means.
3. Graduates will conduct independent research on topics related to cyber operations, including identifying and scoping problem, locating and synthesizing relevant published prior to work, planning and executing valid research, documenting results, and publishing them.
4. Graduates will independently learn technical details for which they are responsible.

School and Program Admissions Criteria

DEGREE REQUIRED: BS in Computer Science or Computer Engineering. Applicants with computer-oriented technical degrees in other fields may be considered. Some applicants may need to complete matriculation requirements to address any weaknesses in their backgrounds. Students must possess the following background knowledge prior to fully engaging in the program: proficiency in software programming and code development; knowledge and application of data structures, computer architecture, and operating systems. Must be a U.S. citizen.

MATHEMATICS REQUIRED: Differential and Integral Calculus
TEST REQUIRED: GRE - 153V/148Q
GPA REQUIRED: OVERALL - 3.0; MATHEMATICS - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements 16 hours

Core Courses 16 hours

- CSCE 525 Introduction to Information Warfare
- CSCE 526 Secure Software Design and Development
- CSCE 544 Data Security
- CSCE 625 Information Systems Security, Assurance and Analysis I

Mathematics 4 hours

Cyber Operations Breadth 16 hours

Thesis 12 hours

(For a detailed discussion of degree requirements, see the Department Student Guide at: http://www.afit.edu/en/eng/current_students.cfm?a=studentguide)

Cyber Warfare (IDE) (M.S.)

Program Description

The Intermediate Developmental Education (IDE) Cyber War program was developed in response to the 7 Dec 05 Air Force Vision Statement that established cyberspace as one of the domains in which the Air Force would organize, train, and equip forces to operate.

Program Educational Objectives (PEOs)

1. Breadth. Graduates will have a broad background in cyber warfare theory and application.

2. Depth. Graduates will have sufficient technical depth to better understand, develop, acquire, manage, and employ cyber-based capabilities now and in the future.

3. Teamwork. Significantly contribute to technical interdisciplinary team projects.
4. Professionalism. Graduates will demonstrate the ability to communicate complex topics effectively and clearly via written and oral means.

5. Lifelong Learning. Graduates will continue to pursue lifelong multidisciplinary learning as cyber operations professionals. This is an especially important objective, given the dynamic nature of the cyberspace domain.

Program Outcomes (POs)

1. Demonstrate technical understanding of capabilities and limitations of cyber operations and warfare. Graduates will have sufficient technical foundation to better understand, develop, acquire, manage, plan, and employ offensive and defensive cyberspace capabilities.

2. Demonstrate the ability to independently learn technical details and concepts for which they are responsible.

3. Apply knowledge learned to solve complex, systems-level problems for which they are responsible.

4. Study an issue, identify and evaluate alternative actions, propose an optimal course of action.

5. Prepare technical point papers and presentations for leadership, subject matter experts, and peers. Support and defend conclusions and recommendations.

Additional Information

This degree program is only available to U.S. military personnel and DoD civilians (U.S. citizens) selected by their service component. This program is not strictly limited to technical officers. However, students will need to be comfortable with advanced topics in computers and communications systems. Candidates with a bachelor’s degree in computer science, engineering, math or physical sciences with a GPA of 3.0 or higher, should have few problems with the program.

School and Program Admissions Criteria

FOR IDE STUDENTS ONLY: This degree program is only available to military personnel and DoD civilians selected by their service component for the resident Intermediate Developmental Education (IDE) program. Students must have a Top Secret Security Clearance with Special Compartmental Information (TS/SCI).

DEGREE REQUIRED: BS in Computer Science or Computer Engineering is preferred; applicants with significant academic or operational experience in cyber war activities such as network security/operations, electronic warfare, C4ISR, programming, and systems acquisition/integration are encouraged to apply and will be considered on a case-by-case basis. Some applicants may need to complete articulation requirements to address any weaknesses in their backgrounds. At a minimum, students must possess the following background knowledge prior to fully engaging in the program: proficiency in software programming and code development; knowledge and application of data structures, computer architecture and operating systems.

TEST REQUIRED: GRE - 153V/148Q

GPA REQUIRED: OVERALL - 3.0; MATHEMATICS - 3.0; MAJOR - 3.0
Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements** 28 hours

- CSCE 525 Introduction to Information Warfare
- EENG 509 Fundamentals of Electronic Warfare
- CSCE 560 Introduction to Computer Networks
- CSCE 528 Cyber Defense and Exploitation I
- CSCE 628 Cyber Defense and Exploitation II
- CSCE 629 Cyber Attack
- CSCE 729 Cyber Operations Capstone

**Electives** 8 hours

- CSCE 526 Secure Software Design and Development
- CSCE 527 Cyber Forensics
- CSCE 544 Data Security (May be used as a Math course)
- CSCE 644 Cryptanalysis
- CSCE 654 Computer Communication Networks
- CSCE 625 Systems Security Analysis
- IMGT 684 Strategic Information Management
- IMGT 687 Managerial Aspects of Information Warfare
- IMGT 688 Security and Ethics in the Information Age

**Mathematics** 4 hours

- CSCE 531 Discrete Mathematics
- CSCE 554 Fundamentals of Performance Analysis and Experimental Design

**Project** 8 hours

For a detailed discussion of degree requirements, see the Department Student Guide at: http://www.afit.edu/en/eng/current_students.cfm?a=studentguide

**Electrical Engineering (M.S.)**

**Program Description**

In the Electrical Engineering program, the student is provided with the challenging opportunity of pursuing a versatile course of study reflecting the student’s desires, background, and future responsibilities. The student
selects from a variety of specialties which are covered in depth and which probe the frontiers of engineering and scientific knowledge. Special-study courses are available to study emerging technology and its application for solving problems. Advanced concepts and applications are emphasized throughout the program and the thesis research.

Program Educational Objectives (PEOs)

After completing the Electrical Engineering program, our graduates will meet the following objectives:

1. **Breadth.** Apply foundational scientific concepts and sound engineering principles to efficiently and effectively advance Air Force and DoD technological capabilities.

2. **Depth.** Are well-educated, highly-valued, and successful engineers and scientists.

3. **Teamwork.** Significantly contribute to technical interdisciplinary team projects.

4. **Professionalism.** Professionally communicate technical solutions and results.

5. **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning as professional engineers and scientists.

Program Outcomes (POs)

1. Demonstrate an in-depth understanding in their specialty area within electrical engineering.

2. Be able to communicate technical information clearly by written and oral means.

3. Conduct independent research on topics related to electrical engineering, including identifying and scoping a problem, locating and synthesizing relevant published prior work, planning and executing valid research, documenting results, and publishing them.

4. Be able to apply the scientific method and use reliable standards of evidence for conclusions reached.

School and Program Admissions Requirements

**DEGREE REQUIRED:** ABET accredited BS degree in Electrical Engineering or Computer Engineering

**MATHEMATICS REQUIRED:** Ordinary Differential Equations

**TEST REQUIRED:** GRE - 153V/148Q

**GPA REQUIRED:** OVERALL - 3.0; MATHEMATICS - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements** 36 hours

**Coursework** 24 hours
Specific courses are determined based on the student’s selected area of specialization/emphasis. In general, each area has a defined set of core courses and follow-on elective "emphasis" courses. Typical emphasis areas include the following:

- Electromagnetic Engineering
- Electronic Circuits and Devices
- Software Engineering
- Digital Engineering
- Communications
- Digital Communications Networks
- Radar
- Guidance, Navigation, and Control
- Electro-Optics
- Observables Reduction
- Signal Processing

**Mathematics** 8 hours

**System Engineering** 4 hours

**Thesis** 12 hours

For a detailed discussion of degree requirements, see the Department Student Guide at: http://www.afit.edu/en/eng/current_students.cfm?a=studentguide

**Computer Engineering (Ph.D.)**

**Program Description**

The Department of Electrical and Computer Engineering offers doctoral programs in Computer Engineering that lead to the award of a Ph.D. The Doctor of Philosophy degree is a research degree that recognizes mastery of a field of study, a demonstrated ability to conduct independent research, and the dissemination of significant and original contributions to the body of knowledge in that field. The Graduate School of Engineering and Management specifies the degree requirements for the school’s doctoral program. The doctoral programs offered within the Department are differentiated from one another based on the area of research specialization chosen by each student.
School and Program Admissions Criteria

DEGREE REQUIRED: MS in relevant area (or BS in relevant area, if applying directly to the Ph.D. program after completing a BS degree)
TEST REQUIRED: GRE - 156V/151Q
GPA REQUIRED: 3.50

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Coursework

A minimum of 36 hours (post-MS) consisting of 28 hours of integrated coursework which supports the student’s area of research specialization and 8 hours of mathematics. This coursework will normally be at the 600-level or above. Up to 12 hours of the required 36 hours can be waived based on courses taken since the undergraduate degree.

Dissertation

At least 48 hours of the following courses, Dissertation Research, leading to the successful completion of the Ph.D. dissertation.

- CSCE 999 - Dissertation Research
- EENG 999 - Dissertation Research

Computer Science (Ph.D.)

Program Description

The Department of Electrical and Computer Engineering offers doctoral programs in Computer Science that lead to the award of a Ph.D. The Doctor of Philosophy degree is a research degree that recognizes mastery of a field of study, a demonstrated ability to conduct independent research, and the dissemination of significant and original contributions to the body of knowledge in that field. The Graduate School of Engineering and Management specifies the degree requirements for the school’s doctoral program. The doctoral programs offered within the Department are differentiated from one another based on the area of research specialization chosen by each student.
DEGREE REQUIRED: MS in relevant area (or BS in relevant area, if applying directly to the Ph.D. program after completing a BS degree)

TEST REQUIRED: GRE - 156V/151Q

GPA REQUIRED: 3.50

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirement

Coursework

A minimum of 36 hours (post-MS) consisting of 28 hours of integrated coursework which supports the student’s area of research specialization and 8 hours of mathematics. This coursework will normally be at the 600-level or above. Up to 12 hours of the required 36 hours can be waived based on courses taken since the undergraduate degree.

Dissertation

At least 48 hours of the following courses, Dissertation Research, leading to the successful completion of the Ph.D. dissertation.

- CSCE 999 - Dissertation Research
- EENG 999 - Dissertation Research

Electrical Engineering (Ph.D.)

Program Description

The Department of Electrical and Computer Engineering offers doctoral programs in Electrical Engineering that lead to the award of a Ph.D. The Doctor of Philosophy degree is a research degree that recognizes mastery of a field of study, a demonstrated ability to conduct independent research, and the dissemination of significant and original contributions to the body of knowledge in that field. The Graduate School of Engineering and Management specifies the degree requirements for the school’s doctoral program. The doctoral programs offered within the Department are differentiated from one another based on the area of research specialization chosen by each student.

School and Program Admissions Criteria

DEGREE REQUIRED: MS in relevant area (or BS in relevant area, if applying directly to the Ph.D. program after completing a BS degree)
TEST REQUIRED: GRE 156V/151Q
GPA REQUIRED: 3.50

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria may apply.

Degree Requirements

Coursework

A minimum of 36 hours (post-MS) consisting of 28 hours of integrated coursework which supports the student’s area of research specialization and 8 hours of mathematics. This coursework will normally be at the 600-level or above. Up to 12 hours of the required 36 hours can be waived based on graduate courses taken since the undergraduate degree.

Dissertation

At least 48 hours of the following courses, Dissertation Research, leading to the successful defense of the Ph.D. dissertation.

- CSCE 999 - Dissertation Research
- EENG 999 - Dissertation Research

Information Assurance Certification

Program Description

The Information Assurance Certificate Program (IACP) is a subset of Master of Science programs in Cyber Operations. This certificate provides the required Information Assurance training for Senior Systems Managers (SSMs) of national security systems. The course subject area contains the managerial aspects of security: security awareness, training, and education; policy development; risk management; resource allocation; budgeting; the role of information resource management in the management of information warfare, vulnerability and threat assessment, planning, directing, and controlling resources. To be eligible for award of the 4011, 4012, and/or 4016 certifications, the student must complete the listed courses with a grade of "B" or better in each course.

School and Program Admission Criteria

Must possess undergraduate coursework in operating systems, probability, and statistics.

Degree Requirements

Certificate Elements for Information Systems Security Professionals Under National Training Standard NSTISSI Number 4011
Core Courses 20 hours

- CSCE 544 - Data Security
- CSCE 625 - System Security Analysis
- CSCE 689 - Distributed Software Systems
- CSCE 725 - Reverse Code Engineering

Choose one of the following

- CSCE 560 - Introduction to Computer Networking
- CSCE 654 - Computer Communication Networks
- IMGT 657 - Data Communications for Managers

Degree Requirements

Degree requirements: Certificate Elements for CNSSI Number 4012

Core Courses 11 hours

- IMGT 684 - Strategic Information Management

Choose one from the following:

- CSCE 525 - Introduction to Information Warfare
- IMGT 687 - Managerial Aspects of Information Warfare (IW)

Degree Requirements

Certificate Elements for CNSSI Number 4016 National Information Assurance Training Standard for Risk Analysts

Core Courses 15 hours

- IMGT 657 - Data Communications for Managers
- IMGT 684 - Strategic Information Management
• QMGT 680 - Project Risk Analysis

Core Courses Choose one of the following

• CSCE 525 - Introduction to Information Warfare
• IMGT 687 - Managerial Aspects of Information Warfare (IW)

Engineering Physics (ENP)

Department Head: Nancy C. Giles, Ph.D.
2950 Hobson Way, Building 640, Room 219
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-3636 x4601 (DSN 785-3636)
Fax: (937) 656-6000 (DSN 986-6000)
E-mail address: enp@afit.edu
Website: http://www.afit.edu/en/enp/

Introduction

The Department of Engineering Physics provides Department of Defense-focused graduate education and research through Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) programs in Applied Physics, Optical Sciences and Engineering, Nuclear Engineering, and Materials Science. Furthermore, it offers a M.S. degree in Combating Weapons of Mass Destruction and certificate programs in Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar, Combating Weapons of Mass Destruction, and Nuclear Weapons Effects, Policy, and Proliferation. The Department of Engineering Physics is the Air Force's primary provider of graduate education in physics and nuclear engineering. Military officers from sister services and civilians may also qualify for admission.

Facilities

The Department of Engineering Physics is one of six engineering departments in the Graduate School of Engineering and Management of the Air Force Institute of Technology (AFIT) located on Wright-Patterson Air Force Base (WPAFB) Ohio. The AFIT campus is comprised primarily of a series of interconnected buildings in Area B of WPAFB. The Department of Engineering Physics is located in Building 640 with in-residence courses taught primarily in Building 640 and the adjoining Building 646.

In addition to department offices and classrooms, the Department of Engineering Physics utilizes laboratories in Buildings 640, 644, 470, and 194. The laboratories in Building 640 consist primarily of instructional laboratories, as well as research facilities dedicated to semiconductor characterization, photoluminescence excitation and emission, and image-based bi-directional reflectance distribution functions. Building 640 also
houses a modeling and simulation facility devoted to research analysis of naturally occurring electrically charged gases (also known as geoplasmas) in the outer reaches of the Earth's atmosphere. Research in this field is of growing concern to military operations. Faculty and students have acquired many of the leading space weather models within the Department of Defense (DOD) and scientific communities, along with the supporting data and software necessary to pursue publishable research.

Building 644 is a 29,914 gross square foot engineering research laboratory connected to the southeast corner of Building 640. The Department of Engineering Physics operates laboratories within this facility to support faculty and student research at the M.S. and Ph.D. levels in laser spectroscopy, optics, solid state physics, Mössbauer spectrometry, nuclear radiation detection, nuclear effects, and environmental engineering. The instructional laboratories complement courses of study in engineering physics, optical observables, nuclear radiation detection and instrumentation, nuclear and environmental engineering, space weather, optics, and lasers and optical diagnostics. Equipment is continually updated to remain abreast of the state-of-the-art in engineering physics, optical engineering, space weather, and nuclear engineering. There also exists a suite of three environmental science laboratories that provide research in remediation technologies, environmental sampling, remote sensing, and microbiology in support of the department's research in nuclear proliferation and combating weapons of mass destruction.

Building 644 contains a clean room suite (class 1000) that enables the fabrication of microelectromechanical systems (MEMS) and micro-and opto-electronic devices, and integrated systems. The Clean Room supports basic research on advanced electronic and photonic materials. Coupled with the Clean Room is the Electronic Devices and Materials (Microelectronics) Laboratory, which contains an array of integrated circuit fabrication equipment and state-of-the-art diagnostic instrumentation. The fabrication facilities encompass complete photolithography, mask printing, thermal oxidation, dopant diffusion, and metallization capabilities. The diagnostic facilities include a sub-micron probe station, scanning electron microscope, atomic force microscope, cathodoluminescence, profilometer, and probe station.

Building 470, located apart from the AFIT complex, houses teaching and research laboratories that support our nuclear engineering program. These laboratories have state-of-the-art equipment for detecting and measuring sources of alpha, beta, gamma, and neutron radiation, and these capabilities are updated constantly. Areas of focus include neutron and gamma-ray spectroscopy, gamma imaging, detection of nuclear fuels in trace quantities, and studies of radiation effects on materials and electronics. Data acquisition and analysis are carried out with a network of high-end PCs, complete with multi-channel analyzer software interfaced to computer-controlled nuclear electronics components. This system provides state-of-the-art data acquisition and data sharing between measurement stations. A radiochemistry laboratory and radio-nuclide storage facility support these laboratories. In addition, environmental measurement tools for laboratory and field characterization of pollutants are being enhanced, excellent equipment for nuclear analytical measurements is available, and a complete range of semiconductor characterization tools are available for studies of radiation effects on electronics.

Building 194 is also located apart from the AFIT complex and houses additional research facilities supporting remote sensing, optics, materials characterization, laser propagation in the atmosphere, advanced geospatial intelligence gathering, and nuclear engineering.
PROGRAMS

Master of Science

- Applied Physics
- Combating Weapons of Mass Destruction
- Materials Science
- Nuclear Engineering
- Optical Science and Engineering

Doctor of Philosophy

- Applied Physics
- Materials Science
- Nuclear Engineering
- Optical Sciences and Engineering

Certificate Programs

- Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar
- Combating Weapons of Mass Destruction
- Nuclear Weapons Effects, Policy, and Proliferation (DL)

FACULTY

Professor

Larry W. Burggraf computational and materials chemistry, optical/nuclear spectroscopy, exotic particles

Nancy C. Giles experimental solid state physics, photoluminescence, absorption, Raman, and magnetic resonance (EPR) spectroscopy

Gordon D. Hager research faculty, chemical physics

Robert L. Hengehold experimental solid state physics, electrical and optical characterization of semiconductors, electro-optics

Kirk A. Mathews computational nuclear engineering, nuclear weapons

Glen P. Perram laser physics, chemical kinetics, molecular spectroscopy

David E. Weeks computational chemical physics

Paul J. Wolf atomic, molecular and optical physics, Associate Dean of Academic Affairs
Yung K. Yeo electrical and optical characterization of semiconductors

Associate Professor

William F. Bailey plasma physics, space physics

Christoph Borel-Donohue research faculty, image processing

Steven T. Fiorino research faculty, atmospheric physics, microwave remote sensing

Michael A. Marciniak optical/infrared signatures, electro-optics

James C. Petrosky nuclear engineering, radiation effects on materials

Heidi R. Ries nonlinear optical materials, electron paramagnetic resonance imaging spectroscopy, laser processing of materials, Dean for Research

Ronald F. Tuttle measurement and signature intelligence

Assistant Professor

Ariel O. Acebal space physics, space weather

David J. Bunker research faculty, advanced technical intelligence applications

Salvatore J. Cusumano high energy lasers, directed energy systems, adaptive optics, beam control

Anthony Franz lasers, optics

Professor Emeritus

Charles J. Bridgman nuclear weapons effects

George John mossbauer spectroscopy, nuclear radiation detection

Adjunct Faculty

Christian R. Benjamin radiation and health physics

Matthew J. Bohn lasers, nonlinear optics, materials, THz spectroscopy and applications

Xiaofeng Frank Duan computational chemistry and materials science

Michael T. Eismann hyperspectral imaging

Alan Garscadden plasma physics, directed energy
Applied Physics (M.S.)

Program Description

The Applied Physics program is conducted by the Department of Engineering Physics and provides each student with a broad, graduate-level foundation in applied physics with a focus in one of three educational tracks: engineering physics, optical physics, or space physics. Laboratory techniques and computational methods are emphasized in all tracks, providing a balanced exposure to experimental and theoretical practices.

This program is normally six quarters in length. The first two quarters of the program stress foundational physics and mathematics. During the remaining four quarters, the student concentrates on applied and specialized courses and pursues research in his or her area of specialization.

Research is conducted at the Air Force Institute of Technology (AFIT) or Air Force Research Laboratory (AFRL) under a cooperative research program. Each student must complete an independent study/thesis and a significant number of courses in the area of specialization. Flexibility in the program is maintained to take full advantage of the varied backgrounds and abilities of individual students. The specific courses in the curriculum vary depending on the specialization pursued and, in the case of an Air Force officer, the requirements associated with the officer’s Air Force education code.

Concentration in the three tracks is as follows:

1. **The engineering physics track** concentrates on a broad range of applied physics topics, including the areas of laser physics, solid state physics, and plasma physics. Emphasis is placed on application of the basic physics to a variety of engineering areas, such as directed energy weapons, remote sensing, molecular dynamics, photonics surveillance and countermeasures, etc.

2. **The optical physics track** builds a strong concentration in a range of applied optics topics on a basic physics core. Potential areas of study include radiometry, optical detection, nonlinear optics, infrared systems, remote sensing, high energy lasers, ultrashort pulsed lasers, and semiconductor lasers.
3. The space physics track encompasses the variations in the Earth’s magnetosphere and ionosphere and the subsequent effects of the space environment on the propagation of electromagnetic waves, communications, space operations, and manned space flight. An understanding of solar effects on the near-earth environment and ramifications on military operation is achieved.

In all three tracks, emphasis is placed on applying basic physical principles together with current state-of-the-art computational and experimental techniques to Air Force problems.

Program Educational Objectives (PEOs)

The PEOs of the Applied Physics program ensure that graduates are prepared to perform the following tasks successfully:

1. Direct or perform basic research; conduct and evaluate design and analysis; and communicate their work clearly, working independently and in groups, with a focus on applications of interest to the Commands for which they are assigned after graduation.

2. Learn the details of programs and technologies in their new areas of responsibility and apply the skills and tools learned at AFIT to these tasks.

3. Apply their knowledge and skills to solve problems that arise in the technical work they conduct or supervise.

4. Study an issue, identify and evaluate alternative actions, propose appropriate courses of action, and identify optimal choices.

5. Develop and implement programs, working within their organizations, to implement the chosen solutions.

6. Write, edit, and/or supervise the preparation by contractors or subordinates of written reports, journal articles, military briefings, and professional presentations that clearly communicate their work and support the needs of decision makers; present their ideas effectively and defend them appropriately.

7. Develop and implement, or sustain and improve, programs that entail multidisciplinary research, simulation, modeling, engineering design, production, and/or fielding of engineered systems.

Program Outcomes (POs)

The POs of the Applied Physics program describe what students will know or be able to perform upon degree completion:
1. Apply advanced concepts in mathematics and physics, including analytic and computational methods, electrodynamics, quantum mechanics, and statistical physics, to applications in the areas of solid state physics, plasma physics, space physics, and laser/optics technology.

2. Perform research, design, and analysis, working independently and in groups, with a focus on applications of interest to the Commands for which they are assigned after graduation.

3. Understand and critically evaluate technical communications in the form of journal articles, research proposals, and conference presentations and contribute and communicate their results and understanding in these same forums.

School and Program Admissions Criteria

**Degree Required:** Physics or a major with at least 24 semester hours of physics. Academy graduates with Engineering Mechanics or Engineering Science are eligible. Undergraduate majors in Engineering, Meteorology, Astronomy, or Chemistry may also be approved by faculty review.

**Mathematics Required:** Ordinary Differential Equations

**Test Required:** GRE - 500V/600Q

**GPA Required:** Overall - 3.0; Mathematics - 3.0; Major - 3.0

**USAF Education Codes:** 8HYY, Physics, General; 8HCY, Atomic and Molecular Physics; 8HEY, Electromagnetism; 8HFY, Electronics; 8HHY, Engineering Physics; 8HKY, Nuclear Effects Physics; 8HLY, Nuclear Physics; 8HMY, Optics; 8HMY, Lasers; 8HNY, Physics of Fluids (Plasmas); 8HOY, Solid State Physics; 8HFG, Physics, Semiconductor Devices; 8HMA, Physics, Atmosphere and Space Optics; 8HMH, Physics, Infrared, Incompressible Fluid Dynamics; 8HNI, Plasma Physics; 8FDA, Aeronomy; 8FDD, Ionospheric Environment; 8FYY, Solar and Space Sciences

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

**Combating Weapons of Mass Destruction (M.S.)**

**Program Description**

The Combating Weapons of Mass Destruction (WMD) program provides students with a broad technical foundation in combating these weapons and the opportunity to conduct independent research in a specialized area of combating WMD. The unique combination of coursework and research provides students with the background needed for work involving the proliferation of WMD, WMD detection and WMD effects.

The educational objective of this program is to develop a graduate who has an advanced knowledge of chemical, biological, and nuclear weapons technology. Graduates of the program will demonstrate the full spectrum of cognitive learning including application, analysis, synthesis and evaluation through their Master's research project.
AFIT Graduate School of Engineering and Management Catalog 2012-2013

This program is normally six quarters in length. The program includes a research thesis. Courses that are taken during the first quarter stress fundamentals applicable to all areas of combating WMD. Courses taken during subsequent quarters and research emphasize particular areas of combating weapons of mass destruction that include nuclear, chemical, and biological technologies.

Program Educational Objectives (PEOs)

The PEOs of the Combating Weapons of Mass Destruction program identify desired capabilities and anticipated activities of our graduates three years after graduation:

1. Apply knowledge of chemical, biological, and nuclear weapons technology and effects to problems of interest to the Air Force and Department of Defense.
2. Be a subject matter expert in a specific area of WMD technology and effects.
3. Analyze issues in combating WMD and effectively communicate that analysis orally and in writing.

Program Outcomes (POs)

AFIT Combating Weapons of Mass Destruction program graduates will have demonstrated:

1. A basic knowledge of the full spectrum of chemical, biological, and nuclear weapons technology and effects.
2. The ability to develop and conduct research related to combating WMD to meet a specific objective or goal.
3. The ability to measure, analyze, and report results of research related to combating WMD.

School and Program Admissions Criteria

Degree Required: A Bachelor's degree in a technical area (Engineering, Math, or Science) or one with sufficient technical content (e.g., USAFA or USMA core). Example technical degrees include Physics; Biology; Chemistry; Industrial Hygiene; or a medical field related to Physiology, Epidemiology, or Health Sciences

Mathematics Required: Mathematics courses through Integral Calculus with a GPA on all mathematics courses of at least 3.0 (on a 4.0 scale).

Test Required: GRE – 500V/550Q

GPA Required: Overall - 3.0; Mathematics - 3.0; Major - 3.0

USAF Education Code: 0WMB, Combating Weapons of Mass Destruction, Biological Weapons; 0WMC, Combating Weapons of Mass Destruction, Chemical Weapons; 0WMD, Combating Weapons of Mass Destruction, General; 0WMN, Combating Weapons of Mass Destruction, Nuclear Weapons

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
Materials Science (M.S.)

Program Description

The Materials Science program is under the joint supervision of the Department of Aeronautics and Astronautics (Structural Materials) and the Department of Engineering Physics (Non-structural Materials) and is carried out in cooperation with the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL). This program is normally six quarters in length. Five quarters are devoted to coursework, and one quarter is devoted to thesis research.

The program provides core preparation in thermodynamics and kinetics of materials; mechanical, electronic, and optical properties of materials; material characterization; material selection and processing; and mathematics. Each student is also required to take an in-depth study and perform research either in structural materials (metallic, composite, polymer, ceramics, etc.) or non-structural materials (electronics, optical, magnetic, dielectric, coating, etc.). Emphasis is placed on the application of fundamental knowledge to the design, development, test, and evaluation of materials for Air Force systems.

The goal of the Materials Science program is to provide a student who has a background in engineering or physical science with the knowledge of materials science and engineering necessary for work in the fields of structural and non-structural materials for aerospace systems. Such positions may range from those requiring very detailed and advanced level work in a specific discipline to those involving broad responsibilities and requiring interaction among many disciplines.

Program Educational Objectives

The program educational objectives of the Materials Science program ensure that graduates are prepared to perform the following tasks successfully:

4. Possess a solid background in the fundamental areas of materials science and engineering (structural and non-structural materials, thermodynamics and kinetics, materials characterization, and materials selection and processing).

5. Possess an in-depth knowledge in one specialty area.

6. Possess experience in conducting and documenting an independent investigation, a thesis, or a problem of Air Force interest.

Program Outcomes

The program outcome of the Materials Science program describes what students will know or be able to perform upon degree completion:
4. Apply engineering principles to solve Air Force and DoD problems.

5. Communicate technical information, via oral presentations and written documents, to a wide range of audiences including engineering professionals and senior military officers.

6. Demonstrate knowledge of significant aspects of both structural and non-structural materials used in the current and future aerospace and defense systems.

School and Program Admissions Criteria

Degree Required: Materials Science, Mechanical Engineering, Chemistry, Physics, or any Engineering degree. All degrees must contain the following courses: Introduction to Materials, Physical Chemistry, and Strength of Materials.

Mathematics Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q

GPA Required: Overall - 3.0; Mathematics – 3.0; Major - 3.0

USAF Education Codes: 4FYY, Materials Science and Engineering, General, and 4FBY, Electronic and Optical Materials.

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details:

http://www.afit.edu/en/ENY/bluebook_resources.cfm

Core Courses

Each student who graduates with a Master of Science (Materials Science) must have a foundation in the theoretical and applied aspects of the fundamental areas of materials. This foundation is laid through a core of courses taken by all materials science and engineering students.

Mathematics

Each student must complete at least one graduate level mathematics course. A second course is highly desirable. The particular courses each student takes are based upon background and area of specialization. Nearly all students take mathematics courses that cover the following topics; advanced calculus, complex variables, Fourier series and boundary value problems, linear algebra, numerical methods, and probability/statistics. Two courses specifically designed to cover most of these topics are: MATH 511 - Methods of Applied Math I, and MATH 513 - Methods of Applied Math II. In addition, students should consider courses in Statistics or Numerical Methods such STAT 527 - Introduction to Probability; STAT 537 - Introduction to Statistics; and MATH 508 - Numerical Methods.

Specialty Sequence
Each student is required to take one such sequence with the option of adding a second. These sequences, each composed of at least three courses, together form a coherent body of knowledge in a particular area and provide the student with a strong theoretical background for eventual applications in thesis work and post-graduation assignments. This sequence is normally dedicated to meeting Air Force requirements for specialized education, as indicated by a student’s advanced-level education specialty code (Ed Code).

Students will enter the GMS program with the following Ed Codes:

- 4FAY: Materials Science and Engineering-Structural Materials
- 4FBY: Materials Science and Engineering-Electronic and Optical Materials
- 4FYY: Materials Science and Engineering-General

**Thesis**

The thesis is an independent investigation of a problem of current Air Force interest, conducted and documented by the student, with supervision of the faculty. This independent study may be done under the direction of either the Department of Aeronautics and Astronautics (for structural materials) or the Department of Engineering Physics (for non-structural materials) and can be carried out either at AFIT or at a directorate of the Air Force Research Laboratory. Theses by GMS students can be theoretical, experimental, or numerical. Topics will be proposed by Air Force research and development organizations, particularly the Materials and Manufacturing Directorate of the Air Force Research Laboratory. Flexibility in the program is maintained in order to take full advantage of the varied backgrounds and abilities of individual students.

**Nuclear Engineering (M.S.)**

**Program Description**

The Nuclear Engineering program is conducted by the Department of Engineering Physics and provides each student with a broad, graduate-level foundation in nuclear engineering with an emphasis on nuclear weapon technology. A combination of coursework and laboratory practice provides the background for work involving nuclear detection, nuclear weapon effects, the nuclear fuel cycle, nuclear proliferation, and nuclear power.

This program is normally six quarters in length. Five quarters are devoted to coursework, and one quarter is devoted to thesis research. Research is normally conducted at the Air Force Institute of Technology (AFIT). The first two quarters of work stress fundamentals in mathematics and physics. The next two quarters provide advanced courses in nuclear applications areas and prepare the student for thesis research in one of these areas. The fifth quarter is devoted to independent research for the thesis. In the final quarter, the thesis is defended and revised, as necessary, while final courses cover additional application areas.
The Commission on Institutions of Higher Education of the North Central Association of Colleges and Schools accredits the Air Force Institute of Technology through the doctoral level. The Engineering Accreditation Commission of the Accreditation Board for Engineering and technology (ABET) also accredits its engineering programs. The nuclear engineering program is ABET accredited and satisfies the Air force education codes 4QYY (Nuclear Engineering) with subspecialties, as well as 8HKY (Nuclear Effects Physics) and 8HLY (Nuclear Physics). To meet ABET criteria, students must satisfy specific ABET requirements at the advanced level. This is usually possible only for a graduate of an ABET accredited undergraduate engineering program. Students satisfying the ABET criteria are awarded the degree of Master of Science in Nuclear Engineering, while those not satisfying the ABET criteria are awarded the Master of Science degree.

Flexibility in the program is maintained to take full advantage of the varied backgrounds and abilities of individual students. The specific courses in the curriculum vary depending on the specialization pursued and, in the case of an Air Force officer, the requirements associated with the officer's Air Force education code.

Program Educational Objectives (PEOs)

The PEOs of the Nuclear Engineering program ensure that graduates are prepared to perform the following tasks successfully:

1. Develop technical skills; apply their understanding of mathematics, computational modeling, science, and engineering to problems of interest to the Air Force and Department of Defense (DOD).
2. Perform analysis; conduct measurements and experiments and interpret results.
3. Communicate technical subjects orally and in writing with peers and to supervisors.
4. Apply their education to meet the defense needs of their organization and the nation.

Program Outcomes (POs)

The POs of the Nuclear Engineering program describe what students will know or be able to perform upon degree completion:

1. Demonstrate a high level of understanding of mathematics, science, and engineering as it applies to nuclear weapons and effects areas.
2. Research, develop, and conduct nuclear science- and engineering-related research to meet a specified object or goal.
3. Demonstrate the ability to measure, analyze, and report results of nuclear and radiation processes and measurements.
4. Adapt their education to meet future defense needs of the nation as those needs become known.
School and Program Admissions Criteria

**Degree Required:** Nuclear, Mechanical, Electrical, or Chemical Engineering or Physics. Some other Engineering and Math majors may also be approved by departmental review. Note: In addition to the academic criteria, this program also requires a SECRET security clearance and appropriate certification to need to know. Interested students should contact the Department of Engineering Physics for details.  

**Mathematics Required:** Ordinary Differential Equations  

**Test Required:** GRE - 500V/600Q  

**GPA Required:** Overall - 3.0; Mathematics - 3.0; Major - 3.0  

**USAF Education Codes:** 4QYY, Nuclear Engineering, General; 4QCY, Nuclear and Radiation Effects; 4QDY, Nuclear Weapons of Mass Destruction; 68HKY, Nuclear Effect Physics; 8HLY, Nuclear Physics

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

**Optical Science and Engineering (M.S.)**

**Program Description**

The Optical Science and Engineering program is conducted by the Department of Engineering Physics and is a multi-disciplinary study designed to provide a student who has a background in engineering or physical sciences with the knowledge of optics and laser technology necessary for work in the field of optical science and engineering.

The coursework in this program is in the areas of optical physics and engineering with emphasis on the application of fundamental knowledge in the design, development, test, and evaluation of Air Force systems.

This program is normally six quarters in length for a full-time Air Force student. Each student must complete an independent study, i.e., thesis, in an area related to optical science and engineering and selected from topics proposed by Air Force Institute of Technology (AFIT) faculty and solicited from Air Force research and development organizations. Research toward the Master's thesis is typically conducted at AFIT but may also be conducted under a cooperative research program at one of the Air Force laboratories. This independent study may be done under the direction of either the Department of Engineering Physics or appropriate Department of Electrical and Computer Engineering faculty. Flexibility in the program is maintained to take full advantage of the varied backgrounds and abilities of individual students.

**Program Educational Objectives (PEOs)**

The PEOs of the Optical Science and Engineering program ensure that graduates are prepared to perform the following tasks successfully:
1. Primarily within, but not limited to, the field of optical science and engineering, direct or perform basic or applied research, conduct and/or evaluate design and analyses, and work independently and in groups.

2. Communicate their work clearly, both orally and in writing (this includes writing, editing, and/or supervising the preparation of subordinates’ or contractors’ written reports, journal articles, briefings, and professional presentations to communicate their work clearly).

3. Effectively interpret/translate between optical physicists and engineers who may not always understand each other's technologies and jargon.

4. Understand the details of technologies and programs in their area of responsibility.

5. Study an issue, identify and evaluate alternative actions, propose appropriate courses of action, and develop programs to implement optimal solutions.

6. Develop and implement, or sustain and improve, programs that entail multidisciplinary research, simulation, modeling, engineering design, production, and/or fielding of engineered optical systems.

Program Outcomes (POs)

The POs of the Optical Science and Engineering program describe what students will know or be able to perform upon degree completion:

1. Apply advanced concepts in mathematics and optical physics and engineering, including analytic, experimental, and computational methods, to a particular application in the field of optical science and engineering.

2. Perform optical science and engineering research, design, and analysis, working independently or in groups, limited to a particular problem or problems of interest with which they have experience.

3. Communicate optical science and engineering research, design, and analysis effectively, working independently or in groups, limited to a particular problem or problems of interest with which they have experience.

4. Understand and critically evaluate technical communications in the form of journal articles, research proposals, and conference presentations and contribute and communicate their results and understanding in these same forums.

School and Program Admissions Criteria

**Degree Required:** Engineering or Physical Science with approval from the department  
**Mathematics Required:** Ordinary Differential Equations  
**Test Required:** GRE - 500V/600Q  
**GPA Required:** Overall - 3.0; Mathematics - 3.0; Major - 3.0  
**USAF Education Codes:** TBD

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
Applied Physics (Ph.D.)

Program Description

The Ph.D. program in Applied Physics, initiated in 1965, is typically 36 months in length (beyond the M.S. degree) with a total of 36 to 60 credit hours plus dissertation. The program is under the supervision of the Department of Engineering Physics with specializations available in lasers, optics and optical systems, optical processing, remote sensing and signature analysis, semiconductor physics and devices, photonics, plasma physics and processing, and chemical physics.

A program of study is largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research in his or her chosen specialization. Program content and length are embodied in the student's "approved program" and reflect departmental guidelines, as well as the school's doctoral degree requirements.

School and Program Admissions Criteria

Degree Required: A Master's degree in a physical science or engineering
GPA Required: B.S., 3.0 or higher; M.S., 3.5 or higher
Test Required: GRE 550V/650Q or higher
USAF Education Codes: 8HYY, Physics, General; 8HCY, Atomic and Molecular Physics; 8HEY, Electromagnetism; 8HFY, Electronics; 8HY, Engineering Physics; 8HKY, Nuclear Effects Physics; 8HLY, Nuclear Physics; 8HMY, Optics; 8HMY, Lasers; 8HNY, Physics of Fluids (Plasmas); 8HOY, Solid State Physics; 8HGG, Physics, Semiconductor Devices; 8HMA, Physics, Atmosphere and Space Optics; 8HMH, Physics, Infrared, Incompressible Fluid Dynamics; 8HNB, Plasma Physics; 8FDA, Aeronomy; 8FDD, Ionospheric Environment

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

Degree Requirements

The Ph.D. degree requirements adhere to standards defined by the Graduate School of Engineering and Management faculty. These basic requirements include completion of at least 36 credit hours of courses, including 24 credit hours in a specialty area, 8 credit hours in math, successful completion of an exam in the specialty area, a prospectus examination, and successful completion of a dissertation. Courses that constitute a program of study will be determined by the Research Advisor and must be approved by the Department Head. A typical program of study will consist of an in-depth sequence of courses at the 6XX, 7XX, and 8XX
Materials Science (Ph.D.) - Electronic/Photonic

Program Description

The Ph.D. program in Materials Science (Electronic and Photonic Materials) is typically 36 months in length (beyond the M.S. degree) with a total of 36 to 60 credit hours plus dissertation. The program is under the supervision of the Department of Engineering Physics with specializations available in various aspects of electronic and optical materials or in the chemistry of materials.

A program of study is largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research in his or her chosen specialization. Program content and length are embodied in the student's "approved program" and reflect departmental guidelines, as well as the school's doctoral degree requirements.

Program Educational Objectives (PEOs)

1. This program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating materials research at the frontiers of knowledge.

2. The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.

School and Program Admissions Criteria

Degree Required: A Master's degree in a physical science or engineering  
GPA Required: B.S., 3.0 or higher; M.S., 3.5 or higher  
Test Required: GRE 550V/650Q or higher  
USAF Education Codes: 4FY, Materials Science and Engineering, General, and 4FBY, Electronic and Optical Materials

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).
Degree Requirements

The Ph.D. degree requirements adhere to standards defined by the Graduate School of Engineering and Management faculty. These basic requirements include completion of at least 36 credit hours of courses, including 24 credit hours in a specialty area, 8 credit hours in math, successful completion of an exam in the specialty area, a prospectus examination, and successful completion of a dissertation. Courses that constitute a program of study will be determined by the Research Advisor and must be approved by the Department Head. A typical program of study will consist of an in-depth sequence of courses at the 6XX, 7XX, and 8XX level and will establish a foundation of knowledge suitable for pursuing dissertation research and meeting general academic expectations for the major area of study.

Nuclear Engineering (Ph.D.)

Program Description

The Ph.D. program in Nuclear Engineering, initiated in 1965, is typically 36 months in length (beyond the M.S. degree) with a total of 36 to 60 credit hours plus dissertation. The program is under the supervision of the Department of Engineering Physics with specializations available in nuclear weapons effects, counterproliferation, radiation detection, radiation effects on electronics, and neutral particle transport.

A program of study is largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research in his or her chosen specialization. Program content and length are embodied in the student's "approved program" and reflect departmental guidelines, as well as the school's doctoral degree requirements.

Program Educational Objectives (PEOs)

1. The program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating nuclear weapons and effects research at the frontiers of knowledge.

2. The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.

School and Program Admissions Criteria

Degree Required: A Master's degree in Nuclear Engineering, Mechanical Engineering, Chemical Engineering, or Physics. Note: In addition to the academic criteria, this program also requires a SECRET security clearance and appropriate certification to need to know. Interested students should contact the Department of Engineering Physics for details.

GPA Required: B.S., 3.0 or higher; M.S., 3.5 or higher

Test Required: GRE 550V/650Q or higher
USAF Education Codes: 4QYY, Nuclear Engineering, General; 4QCY, Nuclear and Radiation Effects; 4QDY, Nuclear Weapons of Mass Destruction; 68HKY, Nuclear Effect Physics; 8HLY, Nuclear Physics

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

Degree Requirements

The Ph.D. degree requirements adhere to standards defined by the Graduate School of Engineering and Management faculty. These basic requirements include completion of at least 36 credit hours of courses, including 24 credit hours in a specialty area, 8 credit hours in math, successful completion of an exam in the specialty area, a prospectus examination, and successful completion of a dissertation. Courses that constitute a program of study will be determined by the Research Advisor and must be approved by the Department Head. A typical program of study will consist of an in-depth sequence of courses at the 6XX, 7XX, and 8XX level and will establish a foundation of knowledge suitable for pursuing dissertation research and meeting general academic expectations for the major area of study.

Optical Science and Engineering (Ph.D.)

Program Description

The Ph.D. program in Optical Science and Engineering is typically 36 months in length (beyond the M.S. degree) with a total of 36 to 60 credit hours plus dissertation. The program is under the supervision of the Department of Engineering Physics. Specialization in the area of optical science and engineering, formally known as electro-optics, was added in the mid-1970s with emphasis on the areas of lasers, optics and optical systems, optical processing, remote sensing and signature analysis, laser beam propagation and control, and photonics.

A program of study is largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research in his or her chosen specialization. Program content and length are embodied in the student's "approved program" and reflect departmental guidelines, as well as the school's doctoral degree requirements.

Program Educational Objectives (PEOs)

1. The program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating research in electro-optics and photonics at the frontiers of knowledge.

2. The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.
School and Program Admissions Criteria

**Degree Required:** A Master's degree in a physical science or engineering  
**GPA Required:** B.S., 3.0 or higher; M.S., 3.5 or higher  
**Test Required:** GRE 550V/650Q or higher  
**USAF Education Codes:** TBD

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

**Degree Requirements**

The Ph.D. degree requirements adhere to standards defined by the Graduate School of Engineering and Management faculty. These basic requirements include completion of at least 36 credit hours of courses, including 24 credit hours in a specialty area, 8 credit hours in math, successful completion of an exam in the specialty area, a prospectus examination, and successful completion of a dissertation. Courses that constitute a program of study will be determined by the Research Advisor and must be approved by the Department Head. A typical program of study will consist of an in-depth sequence of courses at the 6XX, 7XX, and 8XX level and will establish a foundation of knowledge suitable for pursuing dissertation research and meeting general academic expectations for the major area of study.

**Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar Certificate**

**Program Description**

The Advanced Geospatial Intelligence (AGI) Infrared/Synthetic Aperture Radar (IR/SAR) Certificate Program is a 10-week educational series in the technical aspect of collecting, processing, and exploiting non-literal, remotely sensed IR and SAR intelligence data. The program provides an understanding of the origins of source signatures and how their measurement leads to the identification and assessment of targets and events of interest to the military services and intelligence agencies.

The program consists of 4, three-credit hour academic courses focused on the technical basis of AGI IR/SAR; 4, one-credit hour laboratories introducing current data processing and exploitation algorithms and techniques; and 1, one-credit hour seminar.

All students successfully completing the four courses, four laboratories, seminar (17 credit hours), and comprehensive exit examination will receive a Certificate in AGI IR/SAR technologies and have this fact recorded on their Air Force Institute of Technology transcript.
Program Educational Objectives (PEOs)

1. Apply knowledge and skills to solve problems that arise in the technical work they conduct or supervise.

2. Interpret or perform analysis, conduct collection efforts, and communicate their work clearly, working independently and in groups, to provide up-to-date information to the warfighter.

3. Learn the details of programs and technologies in new areas of responsibility and apply skills and tools learned at the Air Force Institute of Technology to these tasks.

4. Understand the science, phenomenology, and technology involved in IR, OPIR, MSI/HIS, and SAR.

5. Be familiar with common and experimental exploitation tools and technologies.

Program Outcomes (POs)

1. Understand the science, phenomenology, and technology involved in IR, OPIR, MSI/HIS, and SAR.

2. Apply advanced concepts to applications in the areas of IR, OPIR, MSI/HIS, and SAR.

3. Perform analysis on data, working independently and in groups, with a focus on applications in specific intelligence areas of interest.

4. Be able to contribute and communicate their results and understanding in the form of journal articles, research proposals, and conference presentations.

Program Prerequisites

A Bachelor’s degree in Mathematics, Physical Science, Engineering, or Computer Sciences or significant work-related experience in AGI or Measurement and Signatures Intelligence (MASINT) is necessary. Attendees must provide official college transcripts with a minimum GPA of 3.0. Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply. A United States Government security clearance is required (collateral SECRET).

Special Admission Requirements

Attendees will be nominated to the AGI IR/SAR Certificate Program by the military services and Government agencies. This program is open only to citizens from the United States, United Kingdom, Australia, and Canada who are sponsored by their respective governments or by an organization supporting United States national security matters. Attendees must send the following materials four weeks before the start of a session:
1. AGI IR/SAR Certificate Program Enrollment Form. This can be found at http://www.afit.edu/en/cmsr/acppprograms.cfm
3. Collateral SECRET United States Government security clearance. This should be forwarded to the Air Force Institute of Technology Security Office (AFIT/XPQ).

Transportation and TDY costs are the responsibility of sponsoring organizations. Textbooks and materials are furnished.

**Combating Weapons of Mass Destruction Certificate**

**Program Description**

The Combating Weapons of Mass Destruction Certificate Program is an intensive 10-week educational program targeting the technical aspects of combating weapons of mass destruction (WMD). The program provides the fundamental biology, chemistry, and physics necessary for follow-on study of the production, utilization, effects, and mitigation of WMD. It consists of four academic courses: biological weapon technology, chemical weapon technology, nuclear weapon technology, and physiological effects of WMD.

Students satisfactorily completing the courses are awarded a graduate certificate in Combating Weapons of Mass Destruction. The certificate represents knowledge of the technical aspects of combating WMD and prepares students for a wide variety of jobs and missions in combating WMD-related fields.

The goal of the certificate program is to provide students with the knowledge, comprehension, and application levels of cognitive learning in combating WMD through the four previously mentioned academic courses. All students successfully completing the four-course sequence (16 credit hours) will receive a certificate in Combating Weapons of Mass Destruction.

**Program Educational Objectives (PEOs)**

1. Apply their knowledge and skills to solve problems that arise in the technical work they conduct or supervise.
2. Interpret or perform analysis, conduct collection efforts, and communicate their work clearly, working independently and in groups, to provide up-to-date information to the warfighter.
3. Learn the details of programs and technologies in their new areas of responsibility and apply the skills and tools learned at the Air Force Institute of Technology (AFIT) to these tasks.
4. Understand the science, phenomenology, and technology involved in combating WMD.
5. Be familiar with common and experimental exploitation tools and technologies.

**Program Outcomes (POs)**

1. Understand the science, phenomenology, and technology involved in combating WMD.
2. Apply advanced concepts to applications in the area of combating WMD.
3. Perform analysis on data, working independently and in groups, with a focus on applications to combating WMD.

4. Be able to contribute and communicate their results and understanding in the form of journal articles, research proposals, and conference presentations.

Program Prerequisites

A Bachelor's degree in a science, engineering, or medical-related field (Physics, Biology, Chemistry, Nuclear Engineering, Industrial Hygiene, Environmental Science, Physiology, or Epidemiology) is necessary. Math courses, including Calculus, are required. Students must have a cumulative undergraduate GPA of 3.0 (on a 4.0 scale). Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Special Admission Requirements

U.S. citizenship

Please refer to the latest version of the Department Brochure for complete program details (available upon request).

Nuclear Weapons Effects, Policy, and Proliferation Certificate (DL)

Program Description

The Nuclear Weapons Effects, Policy, and Proliferation (NWEPP) Certificate Program is an educational series in the informative approach of educating non-science/non-engineering students in a broad range of nuclear weapons topics. This program is targeted for senior Captains and junior Majors assigned to nuclear-weapons-related jobs that will conduct nuclear operations, maintenance, security, logistics, and comprise the bulk of the nuclear enterprise.

The program consists of three, 4-credit hour courses. Focus topics included will be: the historical and current state of the US nuclear policy and the implementation of that policy, the elements and technology involved in building nuclear weapons capabilities, and the unique effects of nuclear weapon detonations.

All students successfully completing and maintaining a GPA of at least 3.0 in the NWEPP program (12 credit hours) will receive a certificate and have the completed certificate noted on their Air Force Institute of Technology graduate transcript.

Program Educational Objectives (PEOs)

1. Apply knowledge and skills to solve problems that arise in the technical work they conduct or supervise.
2. Understand the science, phenomenology, and technology involved in nuclear weapons effects, nuclear weapons proliferation, and nuclear policy.

3. Communicate technical subjects orally and in writing, perform analysis, and interpret results.

4. Apply their knowledge to meet the defense needs of their organization and the nation.

5. Understand the international political environment as it applies to the interplay among technology, national objectives, and adversary postures that shape nuclear policy.

Program Outcomes (POs)

1. Understand the science, phenomenology, and technology involved in the areas of nuclear weapons effects, nuclear policy, and nuclear proliferation.

2. Apply advanced concepts in the areas of nuclear weapons effects, nuclear policy, and nuclear proliferation.

3. Perform analysis on data, working independently and in groups, with a focus on applications to nuclear weapons effects, nuclear policy, and nuclear proliferation.

4. Demonstrate the ability to quantify and estimate various nuclear effects in a scenario.

5. Demonstrate the ability to analyze nuclear policy decisions and ramifications.

6. Demonstrate the ability to identify and analyze nuclear proliferation areas of concern.

Program Prerequisites

A Bachelors degree is required and candidates must have taken a course in college-level algebra. Certificate is available to US citizens only.

Admissions

A completed application form and submission of transcripts is required at least 6 weeks prior to start of entering quarter. Academic eligibility does not guarantee admission. Candidates will be nominated to the program by AETC/A10 in consultation with Air Force Global Strike Command (AFGSC) and AETC/A10.
The Department of Mathematics and Statistics offers the Master of Science (MS) and Doctor of Philosophy (PhD) degree programs in applied mathematics. Specialization can be from a variety of areas within mathematical analysis, including numerical analysis and statistics.

FACULTY

Professor

Alan V. Lair partial differential equations, functional analysis

Mark E. Oxley partial differential equations, wavelets, information fusion

Aihua W. Wood partial differential equations, electromagnetics, rarefied gas dynamics

Associate Professor

William P. Baker, asymptotic and perturbation methods, wave propagation

Dursun A. Bulutoglu, design of experiments, combinatorial optimization

Matthew C. Fickus, fourier series, wavelets, applied harmonic analysis

Edward D. White, III, biostatistics, design of experiments, regression

Assistant Professor

James D. Cordeiro Jr., queuing theory, markov decision processes

Shay R. Capehart, design of experiment, optimization

Patrick Chapin, design of experiments, MCMC simulation, bayesian statistics

James D. Cordeiro, Jr., queuing theory, markov decision processes

John R. Dea, wave propagation, numerical partial differential equations

Brian K. McBee, numerical partial differential equations, fluid dynamics, geodetic science
Kevin R. Pond, numerical analysis, uncertainty quantification

Christine M. Schubert Kabban, biostatistics, classification methods, information fusion

Richard L. Warr, bayesian statistics, applied semi-markov models, model fit assessment

Instructor

Roger A. Erich, biostatistics, survival and reliability analysis, threshold regression models

Professor Emeritus

David R. Barr, stochastic process

Dennis W. Quinn, partial differential equations

Daniel E. Reynolds, environmental statistics

PROGRAMS

Master of Science

- Applied Mathematics

Doctor of Philosophy

- Applied Mathematics

Applied Mathematics (M.S.)

Program Description

The aim of this master’s degree program is to provide a balanced foundational education in mathematical and statistical analysis, an understanding of appropriate applications of the theory, and some depth in an area of specialization. The program, which requires a thesis, usually takes 18 months to complete and is designed for students who have completed an undergraduate major in mathematics or statistics. However, students from other disciplines who have a strong record in mathematics will usually find their preparation to be adequate. For those with weaker mathematics backgrounds, completing the program will normally take longer than 18 months.
The core courses common to all Applied Mathematics master of science degree options are STAT 601 (Theory of Probability), STAT 602 (Mathematical Statistics), MATH 601 (Complex Analysis), and either MATH 600 (Mathematical Analysis) or MATH 602 (Modern Applied Mathematics I). The student will specialize in analysis, statistics, or numerical analysis by taking three courses within the specialty area.

The department believes that the applied nature of the program is enhanced by interaction with at least one other department in the Graduate School of Engineering and Management. Therefore, an out-of-department sequence (minimum of eight hours) taken from another department is required, and serves to help the future applied mathematician gain an appreciation for communicating with other scientists and engineers. In addition, the thesis project is invariably linked to an Air Force or defense department organization, further enhancing the student’s appreciation for and experience in working with the non-mathematician.

Program Educational Objectives (PEO)

Graduates are well-prepared to use mathematical and statistical techniques to make significant progress toward solving problems of interest to the AF, DoD and DHS. They are equipped to collaborate with the science and technology community to address questions of national defense and security.

Program Outcomes (PO)

Graduates will be able to understand an applied problem well enough to give a mathematical formulation of it.

Graduates will be able to analyze a new problem rigorously and propose credible solutions.

Graduates will communicate mathematical concepts effectively by written and oral means.

School and Program Admission Criteria

DEGREE REQUIRED: Bachelor’s in mathematics or statistics, or in science or engineering with a strong background in mathematics.

MATHEMATICS REQUIRED: A senior-level mathematical analysis course.

TEST REQUIRED: GRE - 500V/600Q

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 16 hours

- STAT 601 - Theory of Probability
  and
- STAT 602 - Mathematical Statistics
  and
AFIT Graduate School of Engineering and Management Catalog 2012-2013

- MATH 601 - Complex Analysis
  and
- MATH 600 - Mathematical Analysis
  or
- MATH 602 - Modern Applied Mathematics I

Out-of-Department sequence 8 hours

Specialization 12 hours

Thesis 12 hours

Applied Mathematics (Ph.D.)

Program Description

The aim of the doctoral program is to provide comprehensive knowledge of existing theory and how it applies to problems in science and engineering along with the opportunity to extend the world’s knowledge significantly beyond those bounds. A student seeking a Doctor of Philosophy degree should have a master’s degree in mathematics, statistics, science, or engineering. Being an applied program, particular emphasis is placed on educating students to recognize the relevance of analytical and numerical methods to the solution of specific problems and to enable them to develop new methods when they are needed. The education aims to produce an applied mathematician or applied statistician with the ability to develop new theoretical results and apply them as the need arises. Central to this goal is the research part of the program. Both the ability to conduct the research successfully and to report it in a coherent and fully documented dissertation is essential to the program. The program is kept sufficiently flexible, however, to permit students to develop their own specific interests.

Program Educational Objectives (PEO)

Graduates are experts in their respective specialty area of mathematics and statistics and are able to develop new theory and solution methods for problems of interest to the AF, DoD, DOE, and DHS. They are equipped to lead joint research efforts with other scientists and engineers to address questions of national defense and security.

Program Outcomes (PO)

Graduates will be able to formulate mathematically an applied or theoretical problem.

Graduates will be able to investigate mathematically a new problem and develop methods for solving it.

Graduates will be able to produce research results which are publishable in high-quality archival journals.

Graduates will be able to communicate mathematical concepts and solutions effectively to diverse audiences in both oral and written presentations.
School and Program Admissions Criteria

DEGREE REQUIRED: Master’s in mathematics or statistics, or in science or engineering with a strong background in mathematics or statistics.

TEST REQUIRED: GRE - 550V/650Q

GPA REQUIRED: 3.5 in Master’s

Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Completion of at least 36 hours of coursework beyond the master’s degree to include:

Specialization 24 hours

Out-of-Department Requirements 8 hours

Dissertation Research 48 hours

Admission to candidacy One year before graduation

In-residence study

Three (3) quarters of full-time study in residence during any contiguous four-quarter period

Present Dissertation at a Public Defense

Operational Sciences (ENS)

Department Head: Dr. Joseph J. Pignatiello
2950 Hobson Way, Building 641, Room 201
Wright Patterson AFB, OH 45433-7765
Phone: (937) 255-3636, Extension 2549
Fax: (937) 656-4943 (DSN 986-4943)
E-mail address: ens@afit.edu
Website: http://www.afit.edu/en/ens/

Introduction

The Department of Operational Sciences offers world class graduate programs in operations research and logistics. Our faculty is comprised of experts in all major areas of operations research and logistics and supply chain management whose research has been substantially funded by Department of Defense,
government, and industry sources. Members of the department are recognized leaders in the advancement of the methodology and application of operations research and logistics management.

Our faculty and staff are dedicated to:

- offering degree programs that prepare the next generation of defense and industry analysts and leaders,
- creating cutting edge knowledge that contributes to solving the major problems facing modern society, focusing on the defense of that society,
- responding to the needs of all of our customers and research partners, and
- providing an environment of rigor and mentorship that fosters academic excellence.

Facilities

The Department of Operational Sciences is home to two AFIT Centers of Excellence.

The Center for Operational Analysis (COA) is a multidisciplinary research and education center focused on defense-related operational modeling and analysis. The COA was formally recognized in March of 2003. Expanding the mission of the former Center for Modeling, Simulation, and Analysis, the COA is dedicated to research and education in operational analysis with an emphasis on enhancing warfighter efficiency and effectiveness at all levels.

Visit the COA on line at http://www.afit.edu/en/COA/index.cfm.

The Scientific Test and Analysis Techniques in Test and Evaluation Center of Excellence (COE) received its initial funding in 2012, following a request by the Office of the Deputy Assistant Secretary of Defense, Developmental Test and Evaluation (DASD, DT&E) that Air Education and Training Command designate such a center within the AFIT Graduate School. This request reflects acknowledgement of AFIT as a leader in the field of Test and Evaluation (T&E). Goals of the new COE are to improve T&E planning, execution, and assessment, and to develop more rigorous, scientific, and statistically based T&E design methodologies.

In addition to the COA and the COE, three research-focused laboratories reside within the department, providing tools, methods, and analysis to support students and their research:

- Combat Modeling Laboratory http://www.afit.edu/en/ens/combatingmodelinglab.cfm
- Future Operations Investigation Laboratory http://www.afit.edu/en/ens/futureoperations.cfm
- Sensor Fusion Laboratory http://www.afit.edu/en/ens/sensorfusionlab.cfm

Programs

Master of Science

- Logistics and Supply Chain Management
- Operations Research
AFIT Graduate School of Engineering and Management Catalog 2012-2013

- Logistics (IDE)
- Logistics (IDE Air Mobility)
- Operations Analysis (IDE)

Doctor of Philosophy

- Logistics
- Operations Research

Graduate Certificate

- Supply Chain Management (distance learning)
- Test and Evaluation (distance learning)

FACULTY

Professor - Expertise

Kenneth W. Bauer, Jr. - pattern recognition, multivariate statistics

Jeffery K. Cochran - applied statistics, complex optimization, decision analysis, empirical modeling and analysis, heuristics and simulation, queuing networks, queuing systems analysis, stochastic modeling and analysis

William A. Cunningham, III - balanced scorecard, consolidation analysis, costing, customer service operations, economics, facility location, logistics management and analysis, modal choices, theory of constraints, transportation

Richard F. Deckro - behavioral modeling, decision analysis, information operations, large-scale optimization, mathematical programming and optimization, multicriteria analysis, risk and decision analysis, scheduling, social network analysis, irregular warfare

Raymond R. Hill, Jr. - applied statistics, empirical modeling and analysis, experimental design, heuristic methods for optimization, integer programming, mathematical programming and optimization, simulation modeling and analysis

Joseph J. Pignatiello - statistical process monitoring, statistical methods for test and evaluation, statistical design and analysis of experiments, applied statistics, empirical modeling and analysis, six sigma methods, reliability engineering, robust design, response surface methods

Marlin U. Thomas - stochastic modeling and reliability, modeling and evaluating military contingency logistics
Associate Professors  -  Expertise

James W. Chrissis - design optimization, mathematical programming and optimization, simulation modeling and analysis, stochastic systems analysis

Alan W. Johnson - acquisition logistics, lifecycle management, maintainability, metaheuristics, mobility modeling, reliability modeling and analysis, reverse logistics, simulation modeling and analysis

John O. Miller - applied statistics, combat models, network centric warfare, simulation modeling and analysis

Jeffrey A. Ogden - logistics management, operations management, procurement, supply chain integration, supply chain management

Kenneth L. Schultz - operations management, lean manufacturing, work design, work motivation

Jeffery D. Weir - decision analysis, experimental design, graph theory, integer programming, large-scale optimization, mathematical programming and optimization, response surface methods

Assistant Professors  -  Expertise

Darryl K. Ahner - dynamic programming, integer programming, mathematical programming, computational mathematics and optimization, simulation modeling and analysis, stochastic processes

Bradley E. Anderson - energy chains, alternative energy, petroleum management, operations management, supply chain management, forecasting, inventory, warehousing, international business agreements, strategic planning, business process reengineering, scheduling

Kevin E. Burns - applied operations research, mathematical modeling, air mobility operations

Mark A. Friend - pattern recognition, multivariate statistics, simulation modeling and analysis

Sharon G. Heilmann - survey design and analysis, research methods, organizational behavior, human resource management

Daniel D. Mattioda - acquisition logistics, logistics management, project management, simulation modeling and analysis, supply chain management

Christian E. Randall - simulation, network analysis, supply chain management

Matthew J. Robbins - applied statistics, decision analysis, game theory, simulation modeling and analysis

Doral E. Sandlin - logistics management, supply chain management, transportation, inventory
Adjunct Faculty - Expertise

Stephen P. Chambal - applied statistics, decision analysis, simulation modeling and analysis

Martha C. Cooper - supply chain management, partnership and other inter-firm relationships, the role of customer service in corporate strategy, international logistics

Steven L. Forsythe - applied statistics, empirical modeling and analysis, experimental design, heuristic methods for optimization, integer programming, decision analysis, simulation modeling and analysis

Mark A. Gallagher - applied statistics, forecasting, decision analysis, linear programming

Shane N. Hall - dynamic programming, heuristic methods or optimization, heuristics, integer programming, mathematical programming and optimization, multicriteria analysis, optimization

Timothy J. Pettit - lean, risk and decision analysis, simulation modeling and analysis, supply chain management, logistics strategy

D. Lance Revenaugh - business systems analysis/redesign, IS/IT strategy development and implementation, change management, statistical and informational analysis

August G. Roesener - complex optimization, experimental design, heuristics, integer programming, metaheuristics

James R. Simpson - quality engineering, statistically designed experiments, response surface methods, statistical process control, robust regression methods, engineering statistics, simulation, operations research, and supply chain management

Joseph B. Skipper - logistics information systems, logistics management, supply chain management, transportation

James W. Wisnowski - business intelligence, project management, operations research methods, strategic planning, quality management, lean six sigma, statistical data mining, performance metrics, test and evaluation, modern design of experiments, decision analysis

Daniel J. Zalewski - applied statistics, modeling and simulation, quantitative forecasting

Logistics and Supply Chain Management (M.S.)

Program Description

The Graduate Logistics and Supply Chain Management program provides students with the opportunity to learn and exercise state-of-the-art management knowledge and tools to solve defense acquisition and logistics problems. The curriculum includes courses in statistics, operations research, organization and management theory, inventory systems, transportation and strategic mobility, maintenance and production management, financial management, and economics. In addition, students have the opportunity to pursue a systems view of
logistics management, or to specialize in a specific area such as acquisition logistics, transportation management, or supply management.

**Program Educational Objectives (PEOs)**

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

1. **Breadth.** Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force, DoD, and other employer logistics and supply chain management capabilities.

2. **Depth.** Are well educated, highly-valued, and successful logisticians and supply chain experts.

3. **Professionalism.** Professionally communicate technical solutions and results.

4. **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning.

**Program Outcomes (POs)**

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

1. **Critical thinking skills.** Can critically analyze situations, information, and data.

2. **Problem solving skills.** Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world.

3. **Communication skills.** Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing.

4. **Logistics specific knowledge.** Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area.

**School and Program Admissions Criteria**

**DEGREE REQUIRED:** Any Field  
**MATHEMATICS REQUIRED:** College Algebra  
**TEST REQUIRED:** GMAT – 550; or GRE Scores of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 June 2012), or 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.  
**GPA REQUIRED:** OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
Degree Requirements

Each student who graduates with a Master of Science in Logistics and Supply Chain Management must have a foundation in the theoretical and applied aspects of business, as specified by the International Association for Management Education (AACSB), consisting of: calculus, applied statistics (probability and distributions), managerial economics, and organization and management theory. If a student can demonstrate successful completion of a course in an undergraduate or previous graduate program, a waiver may be granted for those prerequisites. Otherwise, students identified with deficiencies are expected to fulfill this requirement by taking (as appropriate) MATH 291, STAT 525, STAT 535, LOGM 520, and ORSC 542.

Detailed current information on this program, a complete Program Guide, sample curriculum, and degree requirements are available at http://www.afit.edu/en/ens/logisticssupply.cfm.

Management Core 11 hours

- LOGM 590 - Computer Simulation for Managers
- LOGM 620 - Activity Based Costing/Management
- OPER 501 - Quantitative Decision Making

Logistics and Supply Chain Management Core 17 hours

- LOGM 570 - Principles of Inventory Management
- LOGM 569 - Maintenance and Production Management
- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 627 - Supply Chain Management
And one of the following:
- LOGM 565 - Strategic Sourcing
  (For OL/OM/PM, NL Specializations)
  or
  Air Force personnel selected for Academic Specialty Code IAMJ Life Cycle Logistics (program specialization LC) must take a contracting/acquisition management course to be determined.

Specialty Sequence 6 hours (15 hours, NL only)

Two courses from an approved specialty sequence are required. Specialty sequences are listed below. Required courses for each specialty are listed in the Program Guide, available at http://www.afit.edu/en/ens/logisticssupply.cfm.

Life Cycle Logistics (AL), Nuclear Logistics (NL), Operational Logistics (OL), Operational Maintenance (OM), and Petroleum Management (PM)

Research Foundation 4 hours

- LOGM 601 - Principles and Methods of Research
Operations Research (M.S.)

Program Description

Operations Research is the discipline of applying advanced analytical methods to help make better decisions. It provides rational bases for decision making by seeking to understand and structure complex problems and to use this understanding to predict system behavior and improve system performance. Much of this work is done using analytical and numerical techniques to develop and manipulate mathematical and computer models of organizational and operational systems composed of people, equipment, and procedures. Operations Research draws upon ideas from engineering, management, mathematics, and psychology to contribute to a wide variety of application domains; the field is closely related to several other fields in the “decision sciences” — applied mathematics, decision analysis, computer science, economics, industrial engineering, and systems engineering. Operations research is distinguished by its broad applicability and by the wide variety of career opportunities and work styles it embraces. Within the field, some OR professionals remain generalists while others specialize in particular tools or problem domains.

Program Educational Objectives (PEOs)

Our Program Education Objectives (expectations two or more years beyond graduation) are to produce graduates who:

1. Breadth. Apply foundational operations research analysis techniques to efficiently and effectively advance Air Force, DoD, and other government inter-agency organizations, as well as other employer capabilities.

2. Depth. Are well educated, highly-valued, and successful operations research analysts.

3. Professionalism. Professionally communicate technical analytical assessments, solutions, and results.


Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduates who:

1. Critical thinking and problem solving skills. Have the ability to classify, formulate, and solve operations research problems.

2. Operations research specific knowledge. Have knowledge of operations research areas such as

Thesis 12 hours (minimum, calculating in the submission and oral defense of a major research report (thesis))

- OPER 799 - Thesis Research
probabilistic modeling, applied statistics, mathematical programming, simulation, and decision analysis to directly support decision and policy making activities.

3. **Communication Skills.** Develop written and oral communications skills necessary to present complex problems to a decision-making audience: problem definition, modeling methodologies, including solution advocacy that utilizes rigorous analytical support.

**School and Program Admissions Criteria**

**DEGREE REQUIRED:** Baccalaureate degree in operations research, mathematics (not math education), engineering, physics, computer science, or quantitative economics, or other quantitative discipline, provided in each case that curriculum includes sufficient mathematics as noted below.

**MATHEMATICS REQUIRED:** Calculus I & II (integral and differential calculus), and an advanced calculus course, (i.e. multivariable calculus).

**TEST REQUIRED:** GRE Scores of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 June 2012), or 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.

**GPA REQUIRED:** OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements**

Detailed current information on this program, a complete Program Guide, sample curriculum, and degree requirements are available at [http://www.afit.edu/en/ens/operationsresearch.cfm](http://www.afit.edu/en/ens/operationsresearch.cfm).

**Core Courses** 33 hours

- MATH 523 - Numerical Analysis and Linear Algebra
- OPER 510 - Deterministic Operations Research
- OPER 540 - Stochastic Modeling and Analysis I
- OPER 543 - Decision Analysis
- OPER 544 - Operational Decision Support Systems
- OPER 561 - Discrete-Event Simulation
- OPER 638 - Assessing Operational Cost and Risk
- OPER 679 - Empirical Modeling
- STAT 587 - Applied Probability and Statistical Analysis

**Elective** At minimum, a 3 hour elective course must be taken.

**Thesis** 12 hours

Minimum, culminating in the submission and oral defense of a major research report (thesis).
Specialty Sequence (Optional)

In addition to the core and thesis requirements, all students are encouraged to develop in-depth knowledge in at least one specialty area. A specialty sequence consists of at least three courses selected from one of the following specialty areas:

- Deterministic Operations Research
- Probabilistic Operations Research
- Simulation
- Decision Analysis
- Applied Statistics
- Information Operations/Information Warfare (IO/IW)
- Operational Modeling

A list of courses supporting each specialty sequence is available in the Program Guide at http://www.afit.edu/en/ens/operationsresearch.cfm.

Logistics (IDE) (M.S.)

Program Description

The IDE Logistics program (LOGSCI) provides students with the opportunity to learn and exercise state-of-the-art management knowledge and tools to solve defense acquisition and logistics problems. In addition, students have the opportunity to pursue a systems view of logistics management. For DoD-sponsored full-time students, the LOGSCI program requires 12 months (4 academic quarters) of full-time study and begins in June of each year, and is open only to military and DoD civilians selected for Intermediate Development Education (IDE) in residence. This program leads to a Master of Science in Logistics.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

1. Breadth. Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force and DoD logistics capabilities.

2. Depth. Are well educated, highly-valued, and successful logisticians.


Program Outcomes (POs)

Our Program Outcomes (student/knowledge/skills/abilities upon graduation) produce graduates who:
1. **Critical thinking skills.** Can critically analyze situations, information, and data.

2. **Problem solving skills.** Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world.

3. **Communication skills.** Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing.

4. **Logistics specific knowledge.** Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area.

**Additional Information**

All Logistics Management students are required to complete a research paper under the direction of a faculty advisor. This independent study requirement (LOGM 699) provides an introduction to the research process, strengthens the LOGSCI students writing skills, and augments the AFIT/ENS research program.

**School and Program Admissions Criteria**

**DEGREE REQUIRED:** Any Field  
**MATHEMATICS REQUIRED:** College Algebra  
**TEST REQUIRED:** GMAT – 550; or GRE Scores of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 June 2012), or 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.  
**GPA REQUIRED:** OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements**

Detailed current information on this program, including degree requirements and suggested course sequence by term, is contained in the complete Program Guide at http://www.afit.edu/en/ens/departprograms.cfm?a=nonthesis.

**Core Courses** 26 hours

- LOGM 520 - Managerial Economics  
- LOGM 567 - Lean Operations Management  
- LOGM 570 - Principles of Inventory Management  
- LOGM 617 - Transportation Systems and Strategic Mobility  
- LOGM 620 - Activity Based Costing/Management  
- LOGM 660 - Strategy for Logistics  
- ORSC 542 - Management and Behavior in Organization
Tools 8 hours

- OPER 501 - Quantitative Decision Making
- STAT 521 - Applied Statistical Data Analysis

Capstone 4 hours

- LOGM 627 - Supply Chain Management

Graduate Warfighter Project 10 hours

- OPER 791 - Research Project for Operational Sciences
- LOGM 601 - Principles and Methods of Research

Logistics (IDE Air Mobility) (M.S.)

Program Description

The Air Mobility program is the formal graduate study portion of the Advanced Study in Air Mobility (ASAM) program sponsored by the US Air Expeditionary Center (USAF EC) at Fort Dix, New Jersey. The goal of the ASAM program is to cultivate a core of mobility officers with an in-depth education in air mobility operations to lead the Air Mobility Command (AMC) in the future. The ASAM program consists of the degree portion, plus additional USAF EC professional courses combined with trips to the joint and major commands around the globe. As such, this enhances the AFIT degree portion of the program, providing the military with a professional, degree-granting program, similar to executive management degree programs in civilian institutions. The curriculum consists of 13 required courses in the areas of transportation, logistics, quantitative decision making, and organizational management. Courses are taught individually in a compressed schedule, typically two weeks in length. The program also requires a graduate research paper that examines a topic pertaining to mobility operations. Satisfactory completion of the curriculum and the graduate research paper leads to the award of a Master of Science in Logistics.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

1. Breadth. Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force and DoD air mobility capabilities.

2. Depth. Are well educated, highly-valued, and successful logisticians and air mobility officers.


**Program Outcomes (POs)**

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

1. Critical thinking skills. Can critically analyze situations, information, and data.

2. Problem solving skills. Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world.

3. Communication skills. Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing.

4. Logistics specific knowledge. Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area.

**Additional Information**

The program is 13 months long (four academic quarters) and involves a Permanent Change of Station (PCS) to McGuire AFB, New Jersey. Classes begin each year in June, with class size limited to 16 students. Students typically come from operational and support AFSCs in the Air Force. Typical students in the ASAM program are rated or support officers with nine to thirteen years commissioned time in service (i.e., senior captains or junior majors) and have experience in mobility operations. Rated officers must be qualified in their assigned weapons systems. All applicants must possess or be eligible to obtain a top secret (TS-SSBI) clearance. Attendees are picked by a central selection board each year during the Air Force's Intermediate Developmental Education selection process. Employing a “whole person” concept, the selection board picks only the best persons for this rigorous program. All applicants must be proven leaders worthy of future consideration for command.

**School and Program Admissions Criteria**

**DEGREE REQUIRED:** Any Field  
**MATHEMATICS REQUIRED:** College Algebra  
**TEST REQUIRED:** GMAT – 550; or GRE Scores of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 June 2012), or 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.  
**GPA REQUIRED:** OVERALL - 3.00; MATH - 3.00

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
AFIT Graduate School of Engineering and Management Catalog 2012-2013

Degree Requirements

Detailed current information on this program, including degree requirements and suggest course sequence by term, is contained in the complete Program Guide at http://www.afit.edu/en/ens/departmentprograms.cfm?a=nonthesis.

Logistics 13 hours

- LOGM 568 - Introduction to Supply Chain Management
- LOGM 627 - Supply Chain Management
- LOGM 634 - Reliability, Maintainability, and Supportability
- LOGM 636 - Service Operations Management

Transportation 12 hours

- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 619 - Transportation Policy and Strategic Mobility
- LOGM 621 - Air Transportation Management
- OPER 674 - Joint Mobility Modeling

Organizational Management 7 hours

- ORSC 542 - Management and Behavior in Organizations
- IMGT 669 - Business Process Improvement

Research Foundation 11 hours

- LOGM 525 - Statistics for Mobility Managers
- OPER 501 - Quantitative Decision Making
- LOGM 601 - Principles and Methods of Research

Graduate Research Paper 6 hours

- LOGM 791 - Research Project for Mobility Managers

Operations Analysis (IDE) (M.S.)

Program Description

The purpose of the Operations Analysis program is to educate qualified military members in the practice of operations analysis, with emphasis on the application of quantitative analysis techniques to defense decision
making. Specific topics of study include mathematical modeling, operational modeling, simulation, statistical analysis, stochastic modeling and analysis, and cost analysis. The program is open to military and civilians selected for Intermediate Development Education. This program leads to a Master of Science in Operational Analysis.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

1. Breadth. Apply foundational operational analysis techniques to efficiently and effectively advance Air Force and other employer capabilities.

2. Depth. Are well educated, highly-valued, and successful operational analysts.

3. Professionalism. Professionally communicate technical analytical assessments, solutions, and results.


Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

1. **Critical thinking and problem solving skills.** Can discern key aspects of complex problems, problem definitions, decision criteria, success measures, as well as potential solution generating algorithms.

2. **Operations analysis specific knowledge.** Have developed foundational knowledge in fundamental operations research methods and associated disciplines.

3. **Communication skills.** Have developed written and oral communications skills necessary to present complex problems to a decision-making audience: problem definition, modeling methodologies, including solution advocacy that utilizes rigorous analytical support.

Additional Information

All Operations Analysis students complete a Graduate Research Project (GRP) under the direction of a faculty advisor. This independent study requirement (OPER 791) provides an introduction to the research process, strengthens the Operations Analysis students writing skills and augments the Operational Sciences research program.

Detailed information on GRP objectives, requirements, and evaluation is available in the ENS document, Policy on Graduate Research Papers, available upon request. Students present their completed research results to interested faculty and students in an informal briefing, usually during week 9 or 10 of their last quarter. The OPER 497 course, taken for undergraduate credit, is conducted during the second quarter and prepares the student for GRP research. The first five weeks of the course takes place in the classroom and
foc
uses on research methodology and policies. The student then teams with a faculty advisor for the remainder of the course, focusing on the preparation of a research proposal that is approved by the faculty research advisor.

School and Program Admissions Criteria

**DEGREE REQUIRED:** Engineering, science, mathematics, or other quantitative discipline.

**MATHEMATICS REQUIRED:** Calculus I & II (integral and differential calculus)

**TEST REQUIRED:** GRE Scores of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 June 2012), or 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.

**GPA REQUIRED:** OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Detailed current information on this program, including degree requirements and suggested course sequence by term, is contained in the complete Program Guide at http://www.afit.edu/en/ens/departprograms.cfm?a=nonthesis.

**Core Courses** 35 hours

- MATH 509 - Mathematical Methods in the Physical Sciences
- OPER 503 - Deterministic Modeling
- OPER 504 - Probabilistic Modeling
- OPER 543 - Decision Analysis
- OPER 561 - Discrete-Event Simulation
- OPER 595 - Issues in Defense Analysis
- OPER 638 - Assessing Operational Cost and Risk
- OPER 671 - Combat Modeling I
- STAT 583 - Introduction to Probability and Statistics
- STAT 696 - Applied General Linear Models

**Research Project for Operational Sciences** 7 hours

Taken in the third quarter for 3 quarter hours and in the fourth quarter for 4 quarter hours.

- OPER 791 - Research Project for Operational Sciences

**Electives** 6 hours
Students will take two electives, one of which must be an OPER course. Electives may be taken in the second, third, or fourth quarters.

**Logistics (Ph.D.)**

**Program Description**

The Doctor of Philosophy (Ph.D.) degree entails completion of rigorous coursework requirements that prepare the student for advanced research and analysis in a chosen field of study. The doctoral degree is generally characterized as a research degree with substantial emphasis placed on the completion of the dissertation research. The Ph.D. program in Logistics is typically 36 months in length beyond the MS degree. It entails completion of rigorous coursework requirements that prepare the student for advanced research and analysis in a chosen field of study. The degree builds on an analytical core with a flexible program that can accommodate supply chain management, acquisition, inventory theory, transportation, and operations management thrust areas. The degree has strong interdisciplinary support, with typical technical methods options in reliability, optimization, applied statistics, or systems engineering areas.

**Program Outcomes (POs)**

Our Program Outcomes (student knowledge/skills/abilities) produce graduates who:

1. Will be able to understand and evaluate critically the literature of the field.
2. Will be able to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge.
3. Will have acquired the knowledge, skills, ethics, and independence of thought and action expected of a scholar.
4. Will have extended and effectively communicated knowledge in his or her field.

**School and Program Admission Criteria**

**Degree Required:** M.S. degree in logistics, supply chain management, operations research, operations management, industrial engineering, or other relevant field. Successful completion of a master's thesis is very desirable.

**Test Required:** GRE scores of at least 156 (verbal) and 151 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 Jun 2012) or 550 (verbal) and 650 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.

**GPAs Required:** A quality bachelor's degree with grades averaging at least 3.0 on a 4.0 scale. A quality master's degree with grades averaging at least 3.5 on a 4.0 scale.
A baccalaureate-to-doctoral admission may also be granted in some circumstances to applicants who are entering directly from an undergraduate program without a master's degree. In such case, the requirement to hold a master's degree will be met during the student's Ph.D. program. All applications are referred to the Logistics faculty of the Department of Operational Sciences for review and recommendation. Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

**Degree Requirements**

Requirements for the Ph.D. degree include 36 quarter-hours of coursework beyond the master's degree and a period of full-time research leading to successful completion of the doctoral dissertation. In addition to the Core courses (18 hours), the three required coursework areas are: technical methods (6 hrs), mathematics requirement (8 hrs), and an elective (4 hrs).

Detailed current information on this program, a complete Program Guide, and degree requirements are available at http://www.afit.edu/en/ens/logisticsphd.cfm.

**Residency Requirement**

The residency requirement for the Ph.D. program is three quarter hours of full-time study in residence during any contiguous four-quarter period.

**Core Courses** 18 hours

- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 627 - Supply Chain Management
- LOGM 636 - Service Operations Management
- OPER 674 - Joint Mobility Modeling
- LOGM 768 - Advanced Topics in Logistics
- LOGM 770 - Advanced Inventory Theory

**Technical Methods and Electives**

6 hours minimum (technical methods)
4 hours (elective)

The technical methods and electives courses together foster interdisciplinary opportunities in areas such as operations research, statistics, and systems engineering. A particular choice of technical and elective courses constitute an area of specialty. Typical areas of specialty include: Reliability, Optimization, Applied Statistics, and Systems Architecture. A program of study would be tailored to the student’s research thrust, and is established in consultation with the Advisor. Technical methods area courses may consist of courses from more than one department as long as these courses form an integrated program designed to make the student an expert in the chosen area of research. In some cases this may require more than 6 hours. These specialty courses normally build on the individual student's MS program and will include a minimum of first year graduate courses.
A list of courses supporting the technical methods requirement is available in the Program Guide at http://www.afit.edu/en/ens/logisticsphd.cfm.

Mathematics Required

8 hours (minimum) selected from:

- MATH 621 - Linear Algebra
- MATH 633 - Graph Theory
- STAT 694 - Design of Experiments
- STAT 696 - Applied General Linear Models

Dissertation Research

As with all doctoral programs, the AFIT resident Ph.D. program requires completion of a doctoral dissertation. The dissertation research consists of at least 48 quarter hours of supervised research and should result in a significant and original archival contribution to the literature of the field. The AFIT dissertation is also generally oriented toward a topic of relevance to the US Air Force.

Operations Research (Ph.D.)

Program Description

The Doctor of Philosophy (Ph.D.) degree in Operations Research entails completion of rigorous coursework requirements that prepare the student for advanced research and analysis in the field. The doctoral degree is characterized as a research degree with substantial emphasis placed on the completion of the dissertation research. Close interaction between the student and his/her research advisory committee plays a pivotal role in the successful completion of the Ph.D. program. Equally important is the discipline and dedication of the student, as independent study is a critical element for timely completion of the program.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

1. Will be able to understand and evaluate critically the literature of the field.

2. Will be able to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge.

3. Will have acquired the knowledge, skills, ethics, and independence of thought and action expected of a scholar.
4. Will have extended and effectively communicated knowledge in his or her field.

School and Program Admission Criteria

**DEGREE REQUIRED:** M.S. degree in operations research, mathematics, engineering, statistics, or other highly quantitative area of study. Successful completion of a master's thesis is very desirable.

**TEST REQUIRED:** GRE scores of at least 156 (verbal) and 151 (quantitative) on the Education Testing Service (ETS) new GRE score scale effective August 2011 (Concordance table for test scores 1 Nov 2011 - 30 Jun 2012) or 550 (verbal) and 650 (quantitative) for GRE tests taken/scored under the old scale used by ETS prior to August 2011.

**GPA REQUIRED:** A quality bachelor's degree with grades averaging at least 3.0 on a 4.0 scale. A quality master's degree with grades averaging at least 3.5 on a 4.0 scale.

A baccalaureate-to-doctoral admission may also be granted in some circumstances to applicants who are entering directly from an undergraduate program without a master's degree. In such case, the requirement to hold a master's degree will be met during the student's Ph.D. program. All applications are referred to the Operations Research faculty of the Department of Operational Sciences for review and recommendation. Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Requirements for the Ph.D. degree include 41 (for a well prepared student not needing to take the Core courses) to 53 quarter-hours of coursework beyond the master's degree and a period of full-time research leading to successful completion of the doctoral dissertation. In addition to the Core courses, the three required coursework areas are: specialty area requirements (24 hrs), minor area requirements (9 hrs), and mathematics requirements (8 hrs).

Detailed current information on this program, a complete Program Guide, and degree requirements are available at [http://www.afit.edu/en/ens/operationsresearchphd.cfm](http://www.afit.edu/en/ens/operationsresearchphd.cfm).

Residency requirement

The residency requirement for the Ph.D. program is three quarters of full-time study in residence during any contiguous four-quarter period.

Core Courses

- OPER 612 - Nonlinear Programming
- OPER 641 - Stochastic Modeling and Analysis II
- OPER 660 - Statistical Aspects of Simulation: Input Analysis
- OPER 683 - Response Surface Methodology
Specialization Areas 24 hours

Typical choices for area of specialization are: optimization, stochastic operations research, simulation, applied statistics, or decision analysis. A list of courses supporting each specialization area is available in the Program Guide at http://www.afit.edu/en/ens/operationsresearchphd.cfm.

Minor Courses 9 hours

This sequence is intended to broaden the student’s exposure to graduate coursework. Successful completion of the minor area of study may also include completion of a minor examination requirement. Operations Research Ph.D. students have considerable flexibility when establishing a minor area of study. A student may choose an area within Operations Research other than his or her specialty area or the minor may also originate in another department (provided that the minor is acceptable to the other Department and that it is supported by that Department). Some examples of minor areas may include applied statistics, mathematics, or computer science. A list of Department of Operational Sciences minors and courses supporting those minors is available in the Program Guide at http://www.afit.edu/en/ens/operationsresearchphd.cfm.

Mathematics Required 8 hours

- MATH 600 - Mathematical Analysis
- MATH 621 - Linear Algebra

Dissertation Research 48 hours

As with all doctoral programs, the AFIT resident Ph.D. program requires completion of a doctoral dissertation. The dissertation research consists of at least 48 quarter hours of supervised research and should result in a significant and original archival contribution to the literature of the field. The AFIT dissertation is also generally oriented toward a topic of relevance to the US Air Force.

Supply Chain Management Certificate (DL)

Program Description

The Graduate Certificate in Supply Chain Management was developed to provide the students with graduate level education in the fundamentals of Supply Chain Management (SCM), with particular emphasis on Department of Defense (DoD) and Air Force specific applications. In addition, lean operations related to Air Force Smart Operations for the 21st Century (AFSO21) will be covered. Finally, statistical data analysis and basic quantitative modeling, to include linear programming, simulation analysis, and heuristics, are included. The objectives of this program are to educate Air Force logisticians in the above topics and to enable them to apply state of the art analytical and problem solving techniques to Air Force and DoD specific supply chain management problems, as well as enabling them to use the concepts of lean in similar situations.
Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduate certificate conferees who exhibit:

1. The acquisition of a broad understanding of the principles and concepts of supply chain management and statistical concepts.
2. The ability to apply analytical techniques to SCM problems in the DoD environment.
3. Improved problem solving ability, critical thinking skills, and the ability to communicate.

School and Program Admissions Criteria

**DEGREE REQUIRED:** Bachelors Degree or equivalent
**MATHEMATICS REQUIRED:** College Algebra
**Test Required:** None
**GPA REQUIRED:** OVERALL - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Related Program

The Supply Chain Certificate program includes courses that may be applied to Department of Operational Sciences logistics master's degree programs, depending upon the specific course and program.

Certificate Completion Requirements

Successful completion of the Supply Chain Certificate program requires a cumulative grade point average on all course work of a 3.0 (based on a 4.0 scale). Time to completion is 5 quarters. There is no exit examinations required, and no final project. However, there are numerous projects and assignments required in the various courses that give an opportunity for the student to apply their knowledge to broad problems.

Detailed current information on this program is available at http://www.afit.edu/en/ens/supplychainmanagement.cfm.

Core Courses 17 hours

- LOGM 565 - Strategic Sourcing
- LOGM 567 - Lean Operations Management
- LOGM 568 - Introduction to Supply Chain Management
- OPER 501 - Quantitative Decision Making
- STAT 583 - Introduction to Probability and Statistics
Test and Evaluation Certificate (DL)

Program Description

The Test and Evaluation Certificate Program (TECP) is a graduate level education program focused on the application of operational analysis techniques and methodology as applied to the Test and Evaluation (T & E) Community. The program provides an understanding of planning and analysis tools dedicated to supporting the evaluation of test data, test design, and results from test execution. Particular emphasis is given to incorporating past, present, and future DoD T & E examples from all aspects of test (developmental, operational, etc.) into the curriculum to tailor the applications of the methodology and approaches within each course. Current T & E focus in design of experiments (DOE) and reliability, maintainability, and availability (RM&A) analysis are addressed in required courses to complete the program.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduate certificate conferees who exhibit:

1. The ability to identify and apply basic concepts required for supporting statistical analysis within the T & E Community.

2. The ability to design experiments and conduct reliability, maintainability, and availability analysis in response to the operational needs of the Air Force and Department of Defense.

3. Improve problem solving ability, critical thinking skills, and test planning skills.

School and Program Admission Criteria

**Degree Required:** Bachelor's degree or equivalent in an appropriate engineering or scientific discipline (mathematics, physical science, engineering, or computer science is highly desirable.)

**Mathematics Required:** Calculus I and II

**Test Required:** None

**GPA Required:** Overall - 3.0; Math - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Related Programs

The TECP includes courses that comprise the Applied Statistics specialty in the Graduate Operations Research in-resident master's degree program. The TECP is also a specialty area in the distance learning and in-residence Systems Engineering master's degree program.
Certificate Completion Requirements

Students must attain a grade point average of at least 3.0 (on a 4.0 scale) for all graded courses comprising the certificate, and complete the independent study capstone project with direct support of an AFIT faculty-mentor or AFIT-identified on-site designee.

Detailed current information on this program is available at http://www.afit.edu/en/ens/testevaluation.cfm.

Core Courses

- STAT 583 - Introduction to Probability and Statistics
- OPER 679 - Empirical Modeling
- OPER 688 - Operational Experimentation
- LOGM 634 - Reliability, Maintainability, and Supportability
- OPER 791 - Research Project for Operational Sciences

Systems and Engineering Management (ENV)

Department Head: Adedeji B. Badiru, PhD, PE
2950 Hobson Way, Building 640, Room 101
Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-2998 (DSN 785-2998)
Fax: (937) 656-4699 (DSN 986-4699)
E-mail address: env@afit.edu
Website: http://www.afit.edu/en/env/

The Department of Systems and Engineering Management provides graduate education and applied research to address the needs of various US Air Force career fields. The department has thrust areas in Engineering and Technology Management, Environmental Engineering and Science and Industrial Hygiene, and Systems Engineering. Within these three thrust areas, Master of Science degrees are offered in five major multidisciplinary fields: Systems Engineering, Cost Analysis, Engineering Management, Environmental Engineering and Science, and Industrial Hygiene.

FACILITIES

- Systems Integration Laboratories
- Field Research Platform: Field Scale Constructed Vertical Flow Wetland for Remediation of Chlorinated Ethene Contamination
- Analytical Chemistry Laboratory
- Environmental Microbiology Laboratory
- Environmental Remediation Laboratory
- Industrial Hygiene Laboratory
PROGRAMES

Master of Science

- Cost Analysis (M.S.)
- Engineering Management (M.S.)
- Environmental Engineering & Science (M.S.)
- Industrial Hygiene (M.S.)
- Systems Engineering (IDE) (M.S.)
- Systems Engineering (M.S.)

Doctoral Programs

- Systems Engineering

Certificates

- Human Systems Certificate
- Operational Technology Certificate
- Systems Engineering Certificate

FACULTY

Professor

Adedeji B. Badiru project management, economic analysis, simulation, mathematical modeling

Mark N. Goltz environmental engineering, environmental modeling, environmental technology transfer, fate and transport of contaminants

Michael L. Shelley system dynamics modeling, systems analysis, environmental science, environmental engineering

Associate Professor

Alan R. Heminger information resource management, strategic information management, organizational information sharing, knowledge management, CIO roles and responsibilities, business process improvement

Michael R. Grimaila computer system design, information/network security, mission assurance, modeling and simulation, systems engineering

Assistant Professor

John M. Colombi systems engineering, architecture (DoDAF), interoperability, complex systems, human-systems integration (HSI)
Paul Cotellesso civil engineering, engineering management, construction management

Willie F. Harper, Jr Water quality, Biosensing, Biofuels, Unit Process Modeling, Quantum Chemical Computations, Sustainability

David R. Jacques systems engineering, DoDAF, interoperability, human systems integration (HSI)

Tay W. Johannes engineering management, emergency management, risk analysis, project management, geographical information systems, business organization continuity

Brent T. Langhals systems engineering, human systems integration (HSI), information systems, network design and analysis, information resourcemangement, knowledgemanagement

Michael E. Miller human systems integration (HSI), human factors, human machine interfact design, lighting and display design

Leeann Racz environmental engineering, environmental microbiology, environmental health and science

Jonathan D. Ritchsel cost analysis, economic institutional analysis, acquisition reform, public choice

Alfred E. Thal, Jr environmental policy/management, facility/infrastructure management, engineering management, project management, risk management, economic analysis, innovation, sustainability, lean six sigma


Dirk Yamamoto Industrial hygiene, pharmacokinetic modeling, air sampling, burn pit emissions

Instructor

John J. Elshaw technology impact on individual and group behavior, organizational causes of high-consequence errors, workgroup and team effectiveness, organizational climate and culture, personality, helping behaviors, employee-employer relationships, organizational justice

Garth McMurray systems engineering, cognitive systems engineering, human-systems integration

Adjunct Faculty

David K. Vaughn technical communication
Programs

Cost Analysis (M.S.)

Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Master of Science with major in Cost Analysis. The Cost Analysis program is designed to provide students with the knowledge and skills needed to effectively estimate program resources within the Department of Defense (DoD) and Air Force (USAF) acquisition management community. The curriculum integrates a strong foundation in quantitative concepts and techniques with specific DoD and USAF cost-related topics and knowledge to prepare students to contribute effectively in a variety of complex and challenging roles within the military acquisition system. The curriculum includes courses in cost management, statistics, quantitative decision making, economics, forecasting, cost estimating, finance, and lifecycle-costing.

Program Educational Objective (PEO)

Graduates of the GCA program are well-prepared to use analytical techniques to make significant progress toward solving problems of interest to the Air Force, DoD and Homeland Security. Graduates will be independent, trusted advisors in proposing, developing, and implementing policy as judged by their immediate supervisors in the areas of financial management, cost estimation, and cost analysis as a result of excellent and consistent application of decision making and research tools to real issues confronting the staff.

Program Outcomes (POs)

1. Effectively communicate using both oral and written communications.
2. Apply concepts of statistics to analyze problems under conditions of risk and uncertainty.
3. Apply concepts of cost estimating to analyze problems in a program acquisition context.
4. Apply concepts from a wide range of disciplines to analyze problems of DoD resource estimation.
5. Conduct and present methodical research to solve problems and support decisions.
6. Understand the foundations financial management, cost estimation, and cost analysis sufficiently to develop command decision and policy making skills while working within the Financial Management career field and applying the above outcomes.

School and Program Admissions Criteria

**DEGREE REQUIRED:** Business, Economics, Finance or Math preferred  
**MATHMATICS REQUIRED:** Calculus I preferred, but Business Calculus is acceptable if individual meets all other requirements  
**TEST REQUIRED:** GMAT- 550 (28 - Verbal, 37 - Quantitative, 4.5 - analytical writing); GRE -
GPA REQUIRED: OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 24 hours

- COST 669 - Advanced Cost Analysis
- COST 671 - Defense Cost Modeling
- COST 674 - Seminar in Cost Analysis
- ECON 520 - Managerial Economics
- FMGT 510 - Finance Theory I
- QMGT 680 - Project Risk Analysis

Analytical Methods Core 12 hours

- ECON 580 - Fundamental Methods of Mathematical Economics
- STAT 525 - Applied Statistics for Managers I
- STAT 535 - Applied Statistics for Managers II

Thesis 12 hours

Engineering & Technology Management Thrust Area

The Graduate School of Engineering and Management, Department of Systems and Engineering Management offers two programs in the Engineering & Technology Management thrust area. The two programs, which offer Master of Science degrees in Engineering Management and Cost Analysis are described below

Engineering Management Program (M.S.)

Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Master of Science in Engineering Management. The degree enjoys full accreditation from the Accreditation Board for Engineering and Technology (ABET) for those students who hold prerequisite qualifications for the ABET designation. The non-ABET degree title is Master of Science (Engineering Management). The degree reflects the importance of enhancing the interface between technology and management in environments dominated by Science, Technology, Engineering, and Mathematics (STEM) fields. Upon completion of the degree, students will have a better appreciation of the broad field of engineering management and a better understanding of the integrative nature of processes and relationships inherent in most technology-driven organizations. This will prepare them to manage both
existing and emerging technologies while guiding innovative solutions to the complex problems their organizations face.

This program is thus designed for individuals operating in a technical environment who want to be more prepared to integrate technical and managerial skills within a decision-making context. Students will learn to define problems, formulate approaches to investigate the problems, collect and analyze data with appropriate analytical tools, and interpret findings for managerial action. With coursework in management science, project management, decision and risk analysis, systems analysis, and behavioral science, students are able to develop their management proficiency within their area of technical specialization. The strength of the program is thus its multidisciplinary approach in which core management principles are integrated with graduate-level technical education.

Students will be able to apply the appropriate concepts, methods, and tools related to fundamental engineering management responsibilities (i.e., planning, organizing, leading, and controlling resources) in a technical environment. The curriculum includes a foundation based on effective and efficient organizational processes, related managerial decision-making skills, and the importance of an integrated systems perspective. Upon completion of the program, students will be well prepared to conduct and present methodical research to solve problems and support decisions. Since the program is designed to appeal to students from different disciplinary backgrounds and technical environments, the core tools taught in the program provide breadth in the area of principled management. To provide flexibility for meeting individual objectives of depth, the program includes a concentration sequence that allows students to develop expertise in a particular specialization area.

**Program Educational Objective (PEO)**

Graduates will be able to propose, develop, and implement effective policy in their area of specialization as judged by their immediate supervisors. They will be well positioned to lead in a technical environment, both independently and collaboratively, while applying decision-making and analytical tools to solve operational problems.

**Program Outcomes (POs)**

Upon graduation, students should be able to:

1. Use effective oral and written communications.

2. Understand and describe the integrative nature of processes and relationships within the engineering management field and within their respective technical environments.

3. Understand and apply the concepts, methods, and tools related to planning, organizing, leading, and controlling resources and processes in a technology-focused organization.

4. Understand and apply principles of organizational behavior to manage people-centric processes in a technology-focused organization.

5. Understand and apply critical thinking skills and appropriate analytical techniques to support more informed decisions.
6. Conduct and present methodical research, using a systems thinking approach, to analyze problems and recommend solutions.

Program graduates are well grounded in managerial concepts and technical coursework related to their particular specialization areas. For Air Force students, there are several advanced academic degree (AAD) codes associated with the program: 0IYY (Information Systems Technology), 1AGE (Engineering and Environmental Management), 1AGY (Engineering Management), 1AME (Management Information Systems), 1APY (R&D Management), 1AUY (Information Management), and 4LCY (Human Factors Engineering). Additional AAD codes may be applicable for students from other engineering environments. A new set of codes is being implemented to reflect the integration and synergy within the program; the tentative codes are shown below.

- 4JM – General Engineering (Engineering Management)
- 4JME – Engineering and Environmental Management
- 4JMF – Facility and Infrastructure Management
- 4JMH – Human Factors
- 4JMI – Information & Technology Management
- 4JMS – Science & Technology Management

Program Admission Criteria

All students working in a STEM-related environment are welcome to apply, to include those from industry and the public sector. Although the core elements of the program do not require specific knowledge from any particular engineering discipline, students must be comfortable with technical concepts and topics. The general requirements for admission to the Master of Science program in Engineering Management are shown below.

DEGREE REQUIRED: An undergraduate degree in an appropriate area of engineering or science; an undergraduate degree from another STEM-related discipline will be acceptable provided it contains significant technical coursework or is accompanied by work experience in a technology-focused organization.

MATHEMATICS REQUIRED: Mathematics courses to include at least one year of college-level calculus and a course in probability and statistics. Applicants without a previous course in probability and statistics, and who otherwise have strong academic backgrounds, may be provisionally admitted and required to take a probability and statistics course in their initial quarter.

REQUIRED GPA: A cumulative undergraduate GPA of 3.0 (on a 4.0 scale); the GPA in mathematics-related courses should be at least 3.0.

REQUIRED TESTS: Either the Graduate Record Examination (GRE) or Graduate Management Admissions Test (GMAT) are required. For the GRE, a score of at least 1100 (with a minimum 500 verbal and 600 quantitative) is required. Under the revised GRE format, the equivalent scores are a minimum 153 verbal and 150 quantitative. Weaknesses in one area may be offset by strengths in the other area, provided the combined score exceeds 305. For the GMAT, a score of at least 550 is required.
Deficiencies in any of these areas may be waived on a case-by-case basis, or corrected through additional coursework, as approved by the Curriculum Committee. Students in the Wright-Patterson area who do not meet these criteria may register for individual courses as a part-time student (space available) but are expected to meet the above criteria prior to being granted candidacy for the degree.

Curriculum Description

Because of its flexibility, the Graduate Engineering Management (GEM) program may be viewed either as a terminal degree program with a professional focus or as preparation for more advanced graduate work. The program is typically completed in six academic quarters and a short term (18 total months, beginning in September) for full-time students. The GEM program requires a minimum of 48 credit hours. The minimum curriculum satisfying the degree requirements consists of two methods courses (8 hrs), four engineering management core courses (14 hrs), an approved focus sequence comprising at least 14 hrs, and 12 hours of thesis research.

a) The methods courses provide a strong background central to informed decision-making, which prepares students for follow-on coursework and research efforts. A foundation in probability helps students better understand and describe the nature of uncertainty in real-world decision-making, while statistics prepares the student for rigorous problem solving. The methods courses include STAT 535 and RSCH 630.

b) The engineering management core provides both quantitative and qualitative concepts concerned with the many facets of engineering management. These concepts include courses in organizational behavior, systems approach to analyzing and solving problems, project management, engineering economics, business process improvement, and analytical tools. These core areas represent an interdisciplinary approach to the degree and establish a framework to help integrate courses and research streams within both the program and the department. The engineering management core includes ORSC 542, SENG 610, EMGT 550, and IMGT 669 (or EMGT 670).

c) The focus sequence may be based on disciplinary specialization providing technical depth or functional specialization providing breadth across multiple disciplines integrated in a technology-focused area. Both approaches are intended to prepare the student for future leadership roles in a technology-focused organization. Example sequences are provided in the next section. More information regarding the sequences is provided in the next section.

d) The thesis must address a real-world problem involving engineering management. The principal purposes of the thesis are to demonstrate the student's ability to integrate concepts and techniques acquired through coursework and to demonstrate scholarly pursuit of a focused research question, all of which leads to enhanced analytical and decision-making skills for graduates. In some cases, thesis topics may be provided by faculty working in one of the respective focus areas, often in concert with DoD and USAF agencies interested in sponsoring student research in areas of practical concern. Students are expected to participate in no-credit colloquiums throughout the year that will assist them in the identification, development, and execution of their research; these colloquiums also provide students a forum to share their research with their peers and engage in scholarly discussions.

e) Electives are offered in addition to strict degree requirements and broaden the student's horizons and/or provide more in-depth knowledge in a specific area of interest. Electives may also be required by the thesis advisor in order to adequately complete the required thesis research.
In addition to degree requirements, and to demonstrate full-time status, all DoD-sponsored full-time students must complete an average of 12 credit hours per quarter (i.e., 72 total credit hours). The additional credit hour requirement may be achieved by taking additional courses of interest, participating in internships, engaging in directed readings courses, or conducting additional research. Sponsored students may also be required to take additional courses to satisfy the education needs of the sponsor, qualify for the award of an additional advanced degree code, or gain certifications. In no instance will more than 12 credit hours of graded thesis registration be allowed.

Example Focus Sequences

Described below are example focus sequences for specific concentration areas. Provisions are available to tailor sequences to meet specific student and research requirements.

Facility and Infrastructure Management

Intended primarily for the Air Force Civil Engineer (CE) community, this focus sequence provides students with an in-depth study of the unique challenges associated with the management of resources and processes dedicated to facility and infrastructure assets. The primary objective is for students to better understand the unique nature of the built environment, enhance their technical and managerial skills, and prepare themselves to effectively lead applicable engineering efforts. Shown below are the courses included in this sequence, which fulfills the requirements for the 1AGE and 1AGY AAD codes.

Required for all students in this sequence

- EMGT 641 (Construction Law)
- EMGT 680 (Advanced Project Mgmt and Risk Analysis)

Concentration areas: Students may choose the initial course in each concentration area to develop breadth or take all three courses in a concentration area to develop depth. Quota students will be expected to complete one concentration area and take the initial course in each of the other concentration areas.

- EMGT 611/712/713 (Crisis Mgmt Concentration)
- EMGT 621/622/723 (Asset Mgmt Concentration)
- EMGT 631/632/733 (Construction Mgmt Concentration)

S&T Management

This sequence provides students with an in-depth study of the unique challenges associated with management and leadership responsibilities in the science and technology (S&T) community, particularly within the Department of Defense (DoD) and Air Force. The primary objective is for students to better understand the unique nature of the S&T community, build their technical and managerial skills, and prepare themselves to effectively lead S&T efforts. Shown below are the required courses included in this sequence, which fulfills the requirements for the 1APY AAD code.

- RDMT 554 (Mgmt in R&D Organizations)
- RDMT 654 (Capstone)
- RDMT 541 (Operational Technology and Innovation)
Information Systems

The Information Systems (IS) sequence is designed to provide students with the perspective, knowledge and skills needed to develop, manage, and integrate enterprise-wide information systems for the Air Force, DoD, and allied military organizations in future assignments as middle and upper-level managers and leaders. Focus on IS will improve the student’s understanding of DoD information systems, cyber-computer networks, organizational and enterprise systems-related issues, including strategy formulation and application, architecture analysis and design, cyber security issues and practices, technological systems design/development/acquisition and related business process support. Shown below are the required courses included in this sequence, which fulfills the requirements for the 0IYY, 1AUY, and 1AME AAD codes.

- SENG 520 (Systems Engineering)
- IMGT 561 (Database Mgmt)
- IMGT 657 (Data Communications)
- SENG 640 (Systems Architecture)

Human Factors Engineering

The Human Factors Engineering sequence is designed to provide students with the knowledge and skills needed to lead the development of systems with a significant human interface component within the Air Force, DoD, and allied military organizations while providing skills to enable future assignments as middle and upper-level managers. The focus of the sequence is on providing graduate level education in the fundamentals of Human Factors Engineering with an understanding of Human Systems Integration. Shown below are the required courses included in this sequence, which fulfills the requirements for the 4LCY AAD code.

- SENG 560 (Human Systems Integration)
- HFEN 560 (Human Factors Engineering)

Two of the following three courses:

- HFEN 610 (Human Performance Measurement)
- HFEN 670 (Human Interaction Technologies)
- IMGT 663 (Human-Computer Interaction)

Degree Requirements

Core Courses 17 hours

- IMGT 669 - Business Process Improvement
- EMGT 680 - Advanced Project Management with Risk Analysis

151
Environmental Engineering and Science and Industrial Hygiene Thrust Area

The Graduate School of Engineering and Management, Department of Systems and Engineering Management offers two programs in the Environmental Engineering and Science and Industrial Hygiene thrust area. The two programs, which offer Master of Science degrees in Environmental Engineering and Science and Industrial Hygiene, are described below.

ENVIRONMENTAL ENGINEERING AND SCIENCE PROGRAM

Program Educational Objective: The Environmental Engineering and Science Program was designed to provide DoD career professionals with relevant graduate education in the principles of environmental engineering and science. The educational objective of the environmental engineering and science program is that within 3-5 years of program completion, graduates, who would be serving as DoD officers and career professionals, will demonstrate that they can apply the principles of environmental engineering and science (encompassing air, water, and soil media) to successfully accomplish their duties across the spectrum of DoD environmental consulting and management duties. These abilities may be validated through voluntary professional certification, as appropriate (e.g., PE, CEM, BCEEM, QEP).

Student Outcomes: Upon graduation, students will be able to:

1. Conduct and present methodological research to solve problems and support decisions.
2. Critically analyze studies within the current literature.
3. Demonstrate an in-depth knowledge within a chosen environmental emphasis area.
This program was developed considering guidelines established by the Accreditation Board for Engineering and Technology (ABET) and subject areas from the Professional Engineering Exam for Environmental Engineering. Students matriculating with an Engineering Accreditation Commission (EAC) of ABET accredited undergraduate degree will receive the degree Master of Science in Environmental Engineering and Science upon successful completion of all graduation requirements. Those students who do not have an EAC of ABET accredited undergraduate degree will receive the degree Master of Science.

The Environmental Engineering and Science program was also developed in coordination with an Industrial Hygiene Degree previously offered at the Uniformed Services University for the Health Sciences (USUHS) in Bethesda, MD and now offered at AFIT. Both programs were motivated by a request from the AF Bioenvironmental Engineering (BEE) career field. The Environmental Engineering and Science program was offered for the first time in the Fall of 2003 and capitalizes on existing coursework and research thrusts present in several AFIT departments. The curriculum includes department core course offerings in statistics, risk analysis, and sustainable design along with program courses in chemical fate and transport in the environment, water chemistry, environmental sampling, air resources, and water and wastewater treatment. In addition, students take a three-course specialty sequence intended to develop in-depth knowledge of a specific area of environmental engineering and science.

Admission Standards and Procedures

The general requirements for admission to the Master of Science program in Environmental Engineering and Science are:

1. A Bachelor’s degree from an ABET accredited engineering program or a B.S. degree in a science related to environmental science, such as physics, biology, chemistry or industrial hygiene.

2. Math courses including an introductory statistics course and calculus through ordinary differential equations.

3. An introductory environmental engineering course.

4. A cumulative undergraduate GPA of 3.0 (on a 4.0 scale), 1100 GRE combined verbal and quantitative score.

NOTE: Deficiencies in the above areas may be waived or corrected through additional coursework on a case-by-case basis by the Department of Systems and Engineering Management.

INDUSTRIAL HYGIENE PROGRAM

Program Educational Objectives:

1. Our graduates have achieved positions of leadership as occupational/environmental health consultants, instructors, or similar positions of responsibility.

2. Our graduates have applied their education to address difficult technical problems for the Air Force, sister service, civilian, or foreign industrial and community environments.
3. Our graduates have attained voluntary professional board certification as Certified Industrial Hygienists.

**Student Outcomes:** Upon graduation:

1. The student shall be able to anticipate and recognize agents, factors, and stressors.
2. The student shall be able to evaluate agents, factors, and stressors for hazard potential.
3. The student shall be able to control hazards presented by agents, factors, and stressors.

This program was developed considering guidelines established by the Accreditation Board for Engineering and Technology and subject areas from the Certified Industrial Hygienist exam from the American Board of Industrial Hygiene. In addition, the Industrial Hygiene program was developed in coordination with the Environmental Engineering and Science degree program. Both programs were motivated by a request from the AF Bioenvironmental Engineering (BEE) career field. The Environmental Engineering and Science program was offered for the first time in the Fall of 2003, while the Industrial Hygiene program began later in the Fall of 2006. The curriculum includes department core course offerings in statistics, risk analysis, and sustainable design. The program curriculum includes course offerings in industrial hygiene anticipation/recognition/evaluation/control, radiation protection, environmental transport, epidemiology, physiology, and toxicology.

**Admission Standards and Procedures**

The general requirements for admission to the Master of Science program in Industrial Hygiene are:

1. A Bachelor’s degree from an ABET accredited engineering program or a B.S. degree in a science related to environmental science, such as physics, biology, chemistry or industrial hygiene.

2. Math courses including an introductory statistics course and calculus through ordinary differential equations.

3. An introductory environmental engineering course.


5. A cumulative undergraduate GPA of 3.0 (on a 4.0 scale), 1100 GRE combined verbal and quantitative score.

    NOTE: Deficiencies in the above areas may be waived or corrected through additional coursework on a case-by-case basis by the Department of Systems and Engineering Management.
Systems Engineering (IDE) (M.S.)

Program Description

Systems Engineering (SE) is the process by which a customer’s needs are satisfied through the conceptualization, design, modeling, testing, implementation, and operation of a working system. There are a range of levels of systems engineering, from product systems engineering used for a standalone product or vehicle platform, to design and integration of so-called “systems of systems” (such as an air operations center or missile defense system), to enterprise wide systems engineering that span an entire organization (such as mobility forces or space command).

The focus on SE becomes especially important in the analysis and synthesis of large and complex systems, such as those that arise regularly in Department of Defense and Air Force problems. Such examples include space systems, missile defense, Battle Management/Command and Control, network-centric systems, and generally most business and combat support Information systems. Over the last few decades, Systems Engineering has matured into its own discipline, with a foundation on system science using tools and repeatable processes from product development and systems engineering management. Recently, with the pervasive deployment of complex interconnected networked systems, the use of architecture has taken a central role in communicating the system of systems and enterprise-wide solutions.

The Intermediate Development Education (IDE) Graduate Systems Engineering (ISE) program is an ABET accredited resident program leading to a Master of Science (MS) degree in Systems Engineering. The ISE program requirements are identical to the Graduate Systems Engineering (GSE) program with the exception that a thesis is not required. In place of the thesis, the ISE program requires a group project (9 credit hours). The ISE program is nominally a four quarter (12 month) program, with students typically entering in May and graduating in the following June. The ISE program is only for in-residence IDE students.

Program Educational Objectives (PEOs)

The SE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. Specific Program Educational Objectives (PEOs) are as follows:

1. Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director.

2. Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk management, requirements management, architecture definition/evaluation and capability assessment.
Program Outcomes (POs)

The Systems Engineering program provides a substantial technical foundation in system architecture, analysis and design as well as opportunity for specialization within a traditional engineering discipline. The program culminates with an individual thesis or group design project typical of a defense system project. In the design study, the student will apply their individual technical expertise, exercise their system design skills, and experience the group dynamics of a team design effort while solving a realistic defense system problem. Finally, the program provides the necessary education to qualify full-time quota students for the academic degree code assigned to them on entry into the program. Program Outcomes (POs), those competencies that students are expected to achieve by the completion of the program, are as follows:

1. AFIT SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.

2. AFIT SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.

3. AFIT SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning.

4. SE graduates will be able to identify deficiencies and/or gaps in the current SE body of knowledge, and will be capable of proposing new approaches to bridge these gaps.

5. SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.

6. SE graduates will develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, and cyber-warfare, among others.

Focus Areas

In order to best meet the needs of our customers, discussions with warfighter integration, capability planning, acquisition, product and logistics centers and MAJCOM requirements organizations have focused our Systems Engineering program. For example, Systems Engineers working within the space community, should know the physics of space surveillance and/or the space environment, be knowledgeable in the wealth of unclassified and classified space technologies and systems and apply lessons learned through a sponsored space-related Capstone project. We achieve this requested focus with a set of specified electives and technical specialty courses.

Student will usually satisfy the AFIT SE degree requirements by choosing a focus area. Based on the current needs of the DoD and the Air Force, our primary focus areas are as follows:

• **Space Systems:** Military space vehicles or a satellite are not “contained” systems, because it is functionally part of a networked constellation of satellites and ground stations synergistically performing a needed mission, providing warfighter capability and creating desired effects. The extreme environments in which these systems operate necessitate unique design and development processes.
• **Airborne Systems**: Performance and design analysis of manned and unmanned aircraft will be examined, as well as major subsystems on our aeronautical systems. These include guidance, navigation, C4, radar, propulsion and structures, and include munitions and their effects.

• **Cyber Warfare**: The Cyber Warfare sequence is designed to study, analyze and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Students develop technical expertise and a technical foundation to better understand and analyze communications/ networks, policy, operations, systems and technologies.

• **Human Systems**: The Human Systems sequence is designed to provide students with graduate level education and the fundamentals of human factors engineering with an understanding of human systems integration and particular emphasis on the Department of Defense applications.

**School and Program Admission Criteria**

**FOR IDE STUDENTS ONLY**: This degree program is only available to military personnel and DoD civilians selected by their service component for the resident Intermediate Developmental Education (IDE) program. Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

The general requirements for admission to the Master of Science in Systems Engineering program are as follows:

**DEGREE REQUIRED**: Any engineering degree (Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. A degree in science (e.g. physics), math or computer science will be considered for admission to a non-ABET Master of Science program on a case-by-case basis. Courses in calculus-based physics and dynamical systems (circuits or engineering dynamics) are required.

**MATHEMATICS REQUIRED**: Ordinary Differential Equations

**TEST REQUIRED**: GRE - 500V/600Q

**GPA REQUIRED**: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management.

**Program Elements**

The ISE program requires a minimum of 48 credit hours covering the following program elements: core courses, mathematics or math science requirement, a distribution course requirement, engineering depth to include an applicable education code sequence, an individual thesis or group project, and any additional Air Force and/or ABET requirements. The program elements are discussed below.

1. **Core Courses**: There are four Systems Engineering core courses. These are:

   - SENG 520  Systems Engineering Design
   - CSCE 590  Engineering Software Intensive Systems
   - SENG 640  System Architecture
These courses provide a common breadth of knowledge and the basic building blocks for all Air Force and DoD Systems Engineers. All core courses are 4 credit hours.

2. **Mathematic Requirements:** Students must complete at least one course in graduate mathematics or math science (3-4 credit hours). Students without a background course in probability and statistics must take a course in this area. Appropriate probability and statistics course is:

- STAT 583 Introduction to Probability and Statistics

3. **Distribution Requirement:** The distribution requirement includes one analysis-related course. Appropriate courses (3-4 credit hours) include:

- OPER 543 Decision Analysis (3 credit hours)
- QMGT 680 Project Risk Analysis (3 credit hours)
- LOGM 590 Computer Simulation (4 credit hours)

4. **Engineering Depth:** Systems engineering students will also take appropriate engineering and/or applied science courses in the technology area of their thesis or group design project as recommended by their program and/or thesis advisor. While the number of courses in the engineering depth sequence may vary, it is typically three or more courses (technical electives) for 12 or more credit hours.

Candidate technical (or specialty) sequences will be developed by the student and the academic advisor and approved by the curriculum chair. A candidate sequence should be a cohesive group of classes in a single discipline area with at least one 600-level (or above) course. Our focused program sequences include, but are not limited to, the following:

- Airborne Systems
- Space Systems
- Cyber Warfare
- Human Systems

5. **Capstone Design Project / Graduate Warfighter Project (GWP):** The breadth of the systems engineer is generally captured through an understanding of processes, ranging from general systems engineering processes to specialized aspects of component design, manufacturing, testing and operations. Systems engineering education transcends the normal engineering education by requiring a deep understanding of key technical processes and their supporting methodologies and tools. The processes are most effectively understood through repeated application and the resulting lessons learned, with knowledge often captured through substantial team projects and hands-on experience. The capstone of the AFIT systems engineering program is the Graduate Warfighter Project. The students typically form a systems engineering team and perform a group design study, which is defended orally. However, in certain situations for part-time or out-of-cycle single-students, an individual thesis may be performed. In any case, the team or individual works on a major project of DoD or Air Force interest allowing the students to apply the systems approach to a real problem in a controlled environment.
The group project for the ISE program will typically be 9 credit hours of SENG 798 spread over three quarters - one credit in the Fall, four credits in the Winter and four more in the Spring.

6. **Elective Coursework:** The Systems Engineering degree requirements are 48 credit hours of which 43-44 credit hours provide by the ISE program coursework and project. The remaining 4-5 credit hours of coursework may be used to meet any prerequisites, elective courses, or for additional technical depth.

7. **Air Force Requirements:** All full-time Air Force students are required to carry an average of twelve credits per quarter.

8. **ABET Requirements:** Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

### Program Content

#### Coursework 39 hours

A total of 39 hours of coursework is satisfied by four Systems Engineering Core courses, a mathematics course (typically Probability and Statistics), an analysis course (typically Decision Analysis, Risk Analysis or Modeling and Simulation) and an Engineering Depth sequence. Additional elective courses can be added to achieve a minimum of 48 total quarter hours.

#### IDE Research Project 9 hours

- SENG 798 - Group Design Project

### Systems Engineering (M.S.)

#### Program Description

Systems Engineering (SE) is the process by which a customer’s needs are satisfied through the conceptualization, design, modeling, testing, implementation, and operation of a working system. There are a range of levels of systems engineering, from product systems engineering used for a standalone product or vehicle platform, to design and integration of so-called “systems of systems” (such as an air operations center or missile defense system), to enterprise-wide systems engineering that span an entire organization (such as mobility forces or space command).

The focus on SE becomes especially important in the analysis and synthesis of large and complex systems, such as those that arise regularly in Department of Defense and Air Force problems. Such examples include: space systems, missile defense, Battle Management/Command and Control, network-centric systems, and generally most business and combat support Information systems. Over the last few decades, Systems Engineering has matured into its own discipline, with a foundation on system science using tools and
repeatable processes from product development and systems engineering management. Recently, with the pervasive deployment of complex interconnected networked systems, the use of architecture has taken a central role in communicating the system of systems and enterprise-wide solutions.

The Graduate Systems Engineering (GSE) program is an ABET accredited program leading to a Master of Science (MS) degree in Systems Engineering. This program is provided to both resident students and part-time students via distance-learning (DL) modality. In full time residence, it is nominally a six quarter (18 month) program, with students normally entering in September and graduating in March. For distance learning, it is nominally a 24 month to 36 month program, depending on class availability and part-time course load. For more information about distance learning or about this specific program, and to apply, go to AFIT’s Extension Services website (http://www.afit.edu/en/dl).

Program Educational Objectives (PEOs)

The SE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. Specific Program Educational Objectives (PEOs) are as follows:

1. Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director.

2. Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk management, requirements management, architecture definition/evaluation and capability assessment.

Program Outcomes (POs)

The Systems Engineering program provides a substantial technical foundation in system ms architecture, analysis and design as well as opportunity for specialization within a traditional engineering discipline. The program culminates with an individual thesis or group design project typical of a defense system project. In the design study, the student will apply their individual technical expertise, exercise their system design skills, and experience the group dynamics of a team design effort while solving a realistic defense system problem. Finally, the program provides the necessary education to qualify full-time quota students for the academic degree code assigned to them on entry into the program. Program Outcomes (POs), those competencies that students are expected to achieve by the completion of the program, are as follows:

1. AFIT SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.

2. AFIT SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.

3. AFIT SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning.

160
4. SE graduates will be able to identify deficiencies and/or gaps in the current SE body of knowledge, and will be capable of proposing new approaches to bridge these gaps.

5. SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.

6. SE graduates will develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, human systems and cyber-warfare, among others.

Focus Areas

In order to best meet the needs of our customers, discussions with warfighter integration, capability planning, acquisition, product and logistics centers and MAJCOM requirements organizations have focused our Systems Engineering program. For example, Systems Engineers working within the space community, should know the physics of space surveillance and/or the space environment, be knowledgeable in the wealth of unclassified and classified space technologies and systems and apply lessons learned through a sponsored space-related Capstone project. We achieve this requested focus with a set of specified electives and technical specialty courses.

Students will usually satisfy the AFIT SE degree requirements by choosing a focus area. Based on the current needs of the DoD and the Air Force, our primary focus areas are as follows:

- **Airborne Systems**: Performance and design analysis of manned and unmanned aircraft will be examined, as well as major subsystems on our aeronautical systems. These include guidance, navigation, C4, radar, propulsion and structures, and include munitions and their effects.

- **Space Systems**: Military space vehicles or satellites are not “contained” systems, because their functionally is part of a networked constellation of satellites and ground stations synergistically performing a needed mission, providing warfighter capability and creating desired effects. The extreme environments in which these systems operate necessitate unique design and development processes.

- **Cyber Warfare**: The Cyber Warfare sequence is designed to study, analyze and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Students develop technical expertise and a technical foundation to better understand and analyze communications/networks, policy, operations, systems and technologies.

- **Logistics (supply chain) Systems**: The Logistics systems sequence is designed to provide students with graduate level education in the fundamentals of Supply Chain Management (SCM), with particular emphasis on Department of Defense (DoD) and Air Force specific applications. Statistical data analysis and basic quantitative modeling, to include linear programming, simulation analysis, and heuristics, are included. Students will be able to apply state of the art analytical and problem solving techniques to Air Force and DoD supply chain management problems.

- **Human Systems**: The Human Systems sequence is designed to provide students with graduate level education in the fundamentals of Human Factors Engineering with an understanding of Human Systems Integration, and particular emphasis on Department of Defense (DoD) applications. Courses in integration of human systems, human factors, human performance measurement, design of human computer interfaces and display/control systems, are included. This focus area will prepare students to apply state of the art analytical and problem solving techniques to design of systems having a significant human component.
- **Information Systems**: The IS focus area is designed to provide students with the perspective, knowledge and skills needed to develop, manage, and integrate enterprise-wide information systems for the Air Force, DoD, and allied military organizations in future assignments as middle and upper-level managers and leaders. Focus on IS will improve students understanding of DoD information systems, cyber-computer networks, organizational and enterprise systems-related issues, including strategy formulation and application, architecture analysis and design, cyber security issues and practices, technological systems design/development/acquisition and related business process support.

**School and Program Admission Criteria**

The general requirements for admission to the Master of Science in Systems Engineering program are as follows:

**DEGREE REQUIRED**: Any engineering degree (Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. A degree in science (e.g. physics), math or computer science will be considered for admission to a non-ABET Master of Science program on a case-by-case basis. Courses in calculus-based physics and dynamical systems (circuits or engineering dynamics) are required.

**MATHEMATICS REQUIRED**: Ordinary Differential Equations

**TEST REQUIRED**: GRE - 500V/600Q

**GPA REQUIRED**: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Students in the Wright-Patterson area who do not meet these criteria may register for individual courses as a part-time student (space available) but are expected to meet the above criteria prior to being granted candidacy for the degree. Waivers to the criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management.

**Degree Requirements**

The GSE program requires a minimum of 48 credit hours covering the following program elements: core courses, mathematics or math science requirement, a distribution course requirement, engineering depth to include an applicable education code sequence, an individual thesis or group project, and any additional Air Force and/or ABET requirements. The program elements are discussed below.

1. **Core Courses**: There are four Systems Engineering core courses. These are:
   - SENG 520  Systems Engineering Design
   - CSCE 593  Introduction to Software Engineering
   - SENG 610  Systems Engineering Management
   - SENG 640  System Architecture

   These courses provide a common breadth of knowledge and the basic building blocks for all Air Force and DoD Systems Engineers. All core courses are 4 credit hours.

2. **Mathematic Requirements**: Students must complete at least one course in graduate mathematics or math science (3-4 credit hours). Students without a background course in probability and statistics must take a course in this area. Appropriate probability and statistics courses include:
   - STAT 583  Introduction to Probability and Statistics
Additional math science courses include:

- MATH 509 Mathematical Methods in the Physical Sciences
- MATH 633 Graph Theory

3. **Distribution Requirement:** The distribution requirement includes a course in decision analysis, risk, simulation, project management, risk, leadership, cost analysis, financial management, economics, information/knowledge management and/or human factors. Primary candidate courses (3-4 credit hours) include:

- OPER 543 Decision Analysis (3 credit hours)
- QMG 680 Project Risk Analysis (3 credit hours)
- LOGM 590 Computer Simulation (4 credit hours)
- Additional distribution courses could include:
  - IMGT 669 Business Process Improvement (3 credit hours)
  - IMGT 680 Knowledge Management (4 credit hours)
  - IMGT 684 Strategic Information Management (3 credit hours)
  - SENG 560 Human Systems Integration (4 credit hours)
  - SENG 570 Lean for Scientists and Engineers (3 credit hours)

4. **Engineering Depth:** Systems engineering students will also take appropriate engineering and/or applied science courses in the technology area of their thesis or group design project as recommended by their program and/or thesis advisor. While the number of courses in the engineering depth sequence may vary, it is typically three or more courses (technical electives) for 12 or more credit hours. Candidate technical (or specialty) sequences will be developed by the student and the academic advisor and approved by the curriculum chair. A candidate sequence should be a cohesive group of classes in a single discipline area with at least one 600-level (or above) course. Our focused technical sequences include, but are not limited to, the following:

<table>
<thead>
<tr>
<th>Airborne Systems</th>
<th>Decision Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Systems</td>
<td></td>
</tr>
<tr>
<td>Space Systems</td>
<td>Optimization</td>
</tr>
<tr>
<td>C4ISR Systems</td>
<td>Modeling and Simulation</td>
</tr>
<tr>
<td>Information Ops/Cyber Warfare</td>
<td>Reliability</td>
</tr>
<tr>
<td>Sensors</td>
<td>Software Engineering</td>
</tr>
<tr>
<td>MASINT</td>
<td>Logistics Systems</td>
</tr>
</tbody>
</table>
5. **Individual Thesis or Group Project:** The breadth of the systems engineer is generally captured through an understanding of processes, ranging from general systems engineering processes to specialized aspects of component design, manufacturing, testing and operations. Systems engineering education transcends the normal engineering education by requiring a deep understanding of key technical processes and their supporting methodologies and tools. The processes are most effectively understood through repeated application and the resulting lessons learned, with knowledge often captured through substantial team projects and hands-on experience.

The capstone of the AFIT systems engineering program is the group design project. The students typically form a systems engineering team and perform a group design study, which is defended orally. However, in certain situations for part-time or out-of-cycle single-students, an individual thesis may be performed. In any case, the team or individual works on a major project of DoD or Air Force interest allowing the students to apply the systems approach to a real problem in a controlled environment.

The individual thesis or group project for the GSE program will be minimum of 12 credit hours of SENG 799, typically spread over 3 or more quarters.

6. **Elective Coursework:** The Systems Engineering degree is 48 credit hours. Depending on the number of technical sequence and associated prerequisites, additional credit hours to achieve this 48 total may be necessary, which can be fulfilled by any elective courses.

All full-time Air Force students are required to carry an average of twelve credits per quarter, thus will complete a minimum of 72 total credit hours during the normal 6-quarter resident program. The additional 24 credit hours of coursework will be used by the student to meet any prerequisites and to take a second engineering depth sequence. Remaining coursework may be fulfilled by elective courses found from the AFIT catalogue.

7. **Air Force Requirements:** Some Air Force officers attending AFIT as full-time quota students are assigned an Advanced Academic Degree Code, or education code. The requirements for the education code are normally met by taking at least three classes as part of an engineering depth sequence (or in addition to optional sequences). Currently supported education codes and their corresponding requirements are listed below:

**4TFY: Human Systems**

- SENG 560 Human Systems Integration
- HFEN 560 Introduction to Human Factors
- HFEN 610 Human Performance Measurement
- HFEN 663 Human-Computer Interaction
- HFEN 670 Human Interaction Technologies

**4THY: Operations Research**

- OPER 543 Decision Analysis
- OPER 610 Linear Programming and Network Flows
- OPER 612 Nonlinear Programming
- OPER 621 Multiple Criteria Decision Making
- OPER 643 Advanced Decision Analysis
• OPER 647 Queuing System Analysis
• OPER 561 Discrete Event Simulation

4TIY: Optimization

• OPER 610 Linear Programming and Network Flows
• OPER 612 Nonlinear Programming
• OPER 613 Integer Programming
• OPER 615 Large-scale System Optimization

4TJY: Reliability

• SENG 585 Reliability in Systems Design
• SENG 685 Reliability Engineering
• SENG 687 Advanced Topics in Reliability

or Additional Probability and Statistics course

4TKY: Simulation

• OPER 660 Object Oriented Simulation
• OPER 661 Simulation Modeling & Analysis
• OPER 683 Response Surface Methodology

1AUY (Information Resource Management), 0IYY (Information Systems Management), and 1AME (Management Information Systems)

• SENG 520 Systems Engineering Design
• IMGT 561 Applications of Database Management Systems
• IMGT 657 Data Communications
• SENG 640 Systems Architecture

8. ABET Requirements: Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

Degree Requirements

Coursework 36 hours

A total of 36 hours of coursework is satisfied by four Systems Engineering Core courses, a mathematics course (typically Probability and Statistics), an analysis course (typically Decision Analysis, Risk Analysis or Modeling and Simulation) and an Engineering Depth sequence. Additional elective courses can be added to achieve a minimum of 48 total quarter hours.

Thesis 12 hours
Systems Engineering (Ph.D.)

Program Description

The Department of Systems and Engineering Management offers a doctoral program which leads to the award of a Ph.D. The Doctor of Philosophy degree is a research degree that recognizes mastery in the field of Systems Engineering, a demonstrated ability to conduct independent research and the dissemination of significant and original contributions to the Systems Engineering body of knowledge. The Graduate School of Engineering and Management specifies the degree requirements for the school’s doctoral program which are summarized below.

School and Program Admission Criteria

The general requirements for admission to the PhD program are as follows.

DEGREE REQUIRED: An engineering Masters degree (Aeronautical, Astronautics, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering). Other relevant Masters degrees, together with an engineering BS, may be considered on a case-by-case basis. TEST REQUIRED: – GRE – 550V/650Q GPA REQUIRED: OVERALL - 3.5

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria may apply.

Degree Requirements

The PhD degree program consists of two phases:

Coursework

Phase 1 includes course work and examination period of 4-6 academic quarters. All requirements for admission to candidacy (course work, examination, committee selection and approval of research prospectus) are met.

A minimum of 36 hours (post-MS) consisting of 28 hours of integrated coursework which supports the student’s area of research specialization and 8 hours of mathematics. This coursework will normally be at the 600-level or above.

Dissertation

Phase 2 is dedicated to research. This lasts 12-24 months and the PhD candidate devotes their full attention to a research problem described in their prospectus, under the direction of an approved advisor and committee. At least 48 hours must be taken (at least one year residency requirement) of SENG 999, Dissertation Research, leading to the successful defense of the Ph.D. dissertation.
Human Systems Certificate

Program Description

AFIT offers a Graduate Certificate in Human Systems (HS), consisting of a series of three core courses, an elective course and a capstone project. These courses are part of the engineering management and systems engineering degree programs and may also be used as a minor concentration in another AFIT degree program. If the certificate is earned as a minor concentration in another AFIT degree program, the requirement for the capstone project may be met by the student’s thesis (with SE curriculum chair approval).

Under certain circumstances, this program can be offered via distance learning for part-time remote students. These courses use prerecorded lectures, supplemented with live webinars. The target audience is active duty military, DOD civilians, and contractors with traditional science or engineering backgrounds, usually working in laboratories, test centers, product centers, or in a requirements/capability planning office. Each course is offered during an AFIT academic quarter. If taking one course per quarter, this program can be completed in 15 months.

Program Outcomes

The HS Certificate Program takes students with traditional science or engineering backgrounds and produces graduates who can effectively use the tools and knowledge of human factors and human factors engineering to approach and analyze the design of systems for human use.

1. The HS graduates will understand the systems engineering process and the role of the human factors engineer within the systems engineering process.

2. HS graduates will demonstrate application of HS evaluation, design, and experimental processes on contemporary problems of interest to the DOD.

3. HS graduates will understand many of the tools and activities of the human factors engineer and other human systems integration oriented disciplines in the design of complex human-machine systems.

4. HS graduates will be able to identify deficiencies and/or gaps in the current human factors body of knowledge, and will be capable of proposing new approaches to bridge these gaps.

5. HS graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.

School and Program Admission Criteria

DEGREE REQUIRED: Candidates must have completed a bachelor’s degree in engineering or scientific field. At least one course in engineering design is recommended.

MATHEMATICS REQUIRED: Basic calculus and probability and statistics.

TEST REQUIRED: None

GPA Required: Overall – 3.0;

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.
Degree Requirements

Core Courses:
- SENG 520 – Systems Engineering Design
- SENG 560 – Human Systems Integration
- HFEN 560 – Human Factors

Capstone Project:
- SENG 798 – SPECIAL STUDY – GROUP OR INDIVIDUAL CAPSTONE PROJECT

Elective Course (select 1 of the following):
- HFEN 610 – Human Performance Measurement
- HFEN 663 – Human-Computer Interaction
- HFEN 670 – Human Interaction Technologies

Operational Technology Certificate

Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Operational Technology (OpTech) certificate. The program provides students with an in-depth study of the unique challenges associated with developing new defense products and systems within the DoD and Air Force. The program is intended to provide exposure to the warfighter’s perspective regarding combat operations and to broaden/deepen technical background relevant to those operations. Students will learn the principles of project management and the associated organizational management necessary for effective defense product development.

OpTech studies are accomplished by a multi-disciplinary team of students (mechanical, electrical, aerospace, physics, chemical, etc.). Graduates should be well positioned to use their technical skills to analyze complex problems, design feasible solutions, and lead technical teams.

Program Educational Objectives (PEOs)

Graduates of the Operational Technology certificate program should be able to:

1. Understand and apply the concepts, methods, and tools related to research and development of new defense products including planning, directing, and controlling resources (people, material, equipment, and funds) in a systems management context.

2. Understand and apply concepts from a wide range of business disciplines within the specific context of DoD product development.

3. Understand the overall DoD and USAF product development and systems development environment.
4. Provide oversight support and make specific recommendations on appropriate strategies and administration techniques for each phase of a weapon system development effort.

5. Apply the best commercial practices to the DoD product development process.

Additional Information

The target audience for the OpTech program is young scientific and engineering (S&E) officers and civilians, as well as technically trained project managers who will become future leaders in the S&E fields. The OpTech certificate program is designed for part-time students.

Five courses are conducted over a 9-month period in which students are presented graduate-level material and are provided laboratory time to apply the academic principles they are learning. Because of the time commitment, strong support is required from students’ supervisors and leadership throughout the program.

School and Program Admissions Criteria

DEGREE REQUIRED: technical area (engineering, math, or science) or with significant technical content (e.g., USAFA core)  
MATHEMATICS REQUIRED: Differential and Integral Calculus  
TEST REQUIRED: None  
GPA REQUIRED: OVERALL - 3.0; MATH - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 18 hours

- RDMT 541 - Operational Technology and Innovation  
- SENG 520 - Systems Engineering Design

Systems Engineering Certificate

Program Description

AFIT offers a Graduate Certificate in Systems Engineering (SE), consisting of four core courses and a Capstone Project. These courses are part of the SE degree program and may also be used as minor concentration in another AFIT degree program. If the certificate is earned as minor concentration in another AFIT degree program, the requirement for the capstone project may be met by the student’s thesis (with SE curriculum chair approval).

Likewise, this program is also offered via distance learning for part-time remote students. These courses use prerecorded lectures, supplemented with live webinars. The target audience is active duty military, DoD civilians, and contractors with traditional engineering backgrounds, usually working in laboratories, test centers, product centers, air logistics centers, or in a requirements/ capability planning office (Air Staff, Joint
Staff or MAJCOM staff). Each course is offered during an AFIT academic quarter. If taking one course per quarter, this program can be completed in 15 months.

Program Outcomes (POs)

The SE Certificate Program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution.

1. SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.

2. SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.

3. SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning.

4. SE graduates will be able to identify deficiencies and/or gaps in the current SE body of knowledge, and will be capable of proposing new approaches to bridge these gaps.

5. SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.

School and Program Admission Criteria

DEGREE REQUIRED: Any engineering degree (Aeronautical, Astronautics, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. Calculus-based physics and a course in dynamical systems (circuits or engineering dynamics) are required.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED - None

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0; MAJOR - 3.0

Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Core Courses 16 hours

- SENG 520 - Systems Engineering Design
- CSCE 590 - Engineering Software-Intensive Systems
- SENG 610 - Project Management

Capstone Project 4 hours

- SENG 797 - Certificate Capstone Project
AERO 500 - Introduction to Aeronautical Engineering
Introduction to fluid mechanics, airfoil and wing aerodynamics, steady and accelerated aircraft performance, and stability and control.

Notes Not open to graduates of an Aeronautical Engineering Program.

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered Summer

AERO 517 - Fluid Measurements Lab
Introduction to instrumentation and procedures used in the calibration of measurement systems and measurement of the static and dynamic response of fluid and thermal systems.

Notes Instrumentation includes os sensors, schlieren flow visualization, and other measurement systems at the discretion of the instructor.

Credit Hours 4
Prerequisites/Corequisites AERO 533 or equivalent
Terms Offered Spring

AERO 520 - Viscous Flow Theory
Derivation of the Navier-Stokes equations. Exact solutions of the N-S equations, similarity variables. Boundary layer equation, Falkner-Skan solutions, momentum-integral methods. Factors affecting transition; turbulent boundary layers.

Credit Hours 4
Prerequisites/Corequisites AERO 533 or equivalent
Terms Offered Fall

AERO 533 - Incompressible Aerodynamics
Dynamics of incompressible, inviscid and viscous flow fields. Topics include kinematics and dynamics of flow fields, potential flow theory, circulation theory of lift, characteristics of airfoils, fixed wings and rotary wings, introduction to laminar and turbulent boundary layers.

Credit Hours 4
Prerequisites/Corequisites Undergraduate fluid mechanics; Permission of Instructor
Terms Offered Fall

AERO 536 - High Speed Aerodynamics
Theory of compressible aerodynamics including classical gas dynamics, wave motion, normal and oblique shocks, Prandtl-Meyer expansions, linear airfoil theory, similarity rules and method of characteristics.

Credit Hours 4
Prerequisites/Corequisites Undergraduate Thermodynamics; Permission of Instructor.
Terms Offered Winter, Summer
AERO 543 - Advanced Computational Modeling for Aerodynamics

Usage of commercial and government software packages for detailed modeling and analysis of internal and external aerodynamic flow fields to include incompressible viscous solutions with various turbulence models will be discussed. Topics will include techniques for mesh generation and adaptation, boundary condition definitions, flow solver options to include serial versus parallel processing, and scientific visualization of numerical results.

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered Fall

AERO 543 - Lab

Notes Taken in conjunction with AERO 543.

Credit Hours 0
Prerequisites/Corequisites Permission of Instructor
Terms Offered Spring

AERO 551 - Numerical Methods for Computational Fluid Dynamics

Application of numerical finite-difference methods to selected model equations from fluid mechanics and heat transfer: Classification of partial differential equations (PDEs); Development and analysis of finite difference representations of partial derivatives; Analysis of consistency, stability, and accuracy of explicit and implicit finite difference solution schemes; Implementation of selected finite difference schemes in FORTRAN or MATLAB.

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered Fall

AERO 579 - Theory of Gases for Aerodynamics and Propulsion

Introduction to the behavior of gases. Gases are treated as interacting particles and the collective behavior is studied as an ensemble of semi-random events. The evolution of gas properties from the molecular viewpoint to the continuum viewpoint will be examined. Applications of interest include chemical reactions important to hypersonic aircraft and scramjet engines as well as current and future high pressure ratio gas turbine engines.

Credit Hours 4
Prerequisites/Corequisites Undergraduate Thermodynamics
Terms Offered Winter

AERO 610 - Rotorcraft Aeromechanics

This course provides the student with an understanding of the basics of rotorcraft aeromechanics. Primary areas of study include rotorcraft aerodynamics, dynamics of rotor blades, and rotorcraft aeroelasticity. Topics in aerodynamics include momentum theory, blade element theory, and rotocraft performance. Dynamics of rotor blades includes topics in both rigid and elastic blade motion. Topics in aeroelasticity include vibration and stability of rotors and rotor-fuselage systems. While the primary emphasis in this course is on basic analytical techniques, the students are also introduced to more sophisticated methods commonly used in government and industry.

Credit Hours 4
Prerequisites/Corequisites Prerequisites: AERO 533 or equivalent
Terms Offered Winter
AERO 622 - Introductory Hypersonics

Character of hypersonic flow and assumptions underlying inviscid hypersonic flow theories. Similarity, small disturbance and surface inclination methods are covered. The equivalence principle, blast wave methods, low density aerodynamics, high temperature aerodynamics and re-entry trajectories are also discussed.

Credit Hours 4
Prerequisites/Corequisites AERO 536, AERO 579 or Permission of Instructor
Terms Offered Spring

AERO 627 - Turbulence

Order of magnitude estimates for diffusivity, dissipation, and velocity and fundamental length scales in turbulence. Reynolds time averaging and mass averaging of the Navier-Stokes equations, the closure problem, and turbulent energy and vorticity balances. Boundary-free shear flows and wall-bounded shear flows for internal and external flows. Turbulence modeling, Statistical description of turbulence, Orr-Sommerfeld analysis and the transition problem.

Credit Hours 4
Prerequisites/Corequisites AERO 520
Terms Offered Winter

AERO 652 - Computational Fluid Dynamics

Explicit and implicit algorithms for the solution of the compressible Euler equations in one and two dimensions: Development of finite difference and finite volume formulations of the governing equations; Transformation of PDEs to generalized curvilinear coordinates and the geometric conservation law; Flux and flux-difference splitting schemes; Total variation diminishing (TVD) schemes; Characteristic Variable Boundary Conditions; Implementation of selected 2-D solution schemes in Fortran.

Credit Hours 4
Prerequisites/Corequisites AERO 551 or Permission of Instructor (AERO 536 recommended)
Terms Offered Winter

AERO 685 - Aerospace System Design

Team design project of an aircraft in response to a Request-For-Proposal. Design methodology focuses on a military need and incorporates performance, cost supportability, deployment, manufacturing, product quality and environmental considerations. The project draws on all of the aeronautical disciplines and provides students experience in applications of such disciplines to military aircraft design.

Credit Hours 4
Prerequisites/Corequisites completion of aeronautical engineering core courses
Terms Offered Summer
AERO 698 - Graduate Seminar in Aeronautics and Astronautics

Current problems and solutions in the design of Air Force aeronautical and astronautical systems are presented by representatives of USAF agencies and the aerospace industry.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered Fall short

AERO 699 - Master's Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 1 - 12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

AERO 753 - Advanced Computational Fluid Dynamics

Explicit and implicit algorithms for the solution of the incompressible and compressible Navier-Stokes equations in two and three dimensions: Turbulence Modeling; Numerical grid generation; Introduction to unstructured solution techniques; Selected topics of current interest in CFD such as Preconditioning for low-speed flows, High-Order Methods, Convergence acceleration techniques, Parallelization; Implementation of selected viscous solution schemes in FORTRAN.

Credit Hours 4
Prerequisites/Corequisites AERO 652 or Permission of Instructor (AERO 520, AERO 627 recommended)
Terms Offered Spring

AERO 799 - Independent Studies

The topic for an independent study is selected from a wide variety of problems of current interest to the Air Force. The results of the study are reported in a thesis written under the supervision of a departmental faculty and are presented in a formal oral report.

Notes Ordinarily this study extends over four quarters and no credit is given until the end of the last quarter.

Credit Hours 1 - 12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

AERO 899 - Doctoral Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 1 – 12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

AERO 999 - Dissertation Research

The topic for dissertation research is selected from a wide variety of problems of current interest to the Air Force. The results of the study are reported in a dissertation written under the supervision of a departmental faculty and are defended in a formal oral defense.

Notes Ordinarily this study extends over six quarters.

Credit Hours 1 - 12
Prerequisites/Corequisites Approval of Research Advisor
Terms Offered All
ASYS 525 - Linear Systems Analysis

This course covers the underlying theory of linear time invariant and time varying dynamic systems. The modeling of engineering systems, including mechanical, electrical, fluid, and thermal systems is covered. Analysis techniques include classical analysis in the continuous time, discrete time, frequency domain, and modern state space techniques for linear systems.

Credit Hours: 4
Prerequisites/Corequisites: Permission of Instructor
Terms Offered: Fall

ASYS 530 - Introduction to Space Programs and Operations

This course examines the history and current status of military space operations. Topics include the history of space flight, the relationships between military and civil space programs, space law, US space policy, military space missions, US military space organizations, and non-US space programs. Introduction to standard space mission analysis software.

Credit Hours: 3
Prerequisites/Corequisites: Permission of Instructor
Terms Offered: Fall

ASYS 535 - Military Space Systems and Applications

This course is designed to provide the student with a picture of worldwide space activities, with an emphasis on military space operations. Seminars will include classified presentations by intelligence analysts. Subjects covered will include operational and technical aspects of US and foreign space systems and related topics of DoD interest.

Notes: Required: U.S. Citizenship and Top Secret Clearance with eligibility for SCI access

Credit Hours: 1
Prerequisites/Corequisites: Permission of Instructor
Terms Offered: Fall, Winter

ASYS 545 - Linear Systems Analysis for Control

This course covers the fundamentals of linear system analysis which is used as a basis for control theory design. Topics include transfer function development, response analysis and controllability & observability concepts. The interrelation between conventional and modern control approaches is emphasized. Control specific topics include classical feedback systems analysis, root locus, Bode and Nyquist analysis, state-space feedback systems analysis.

Credit Hours: 5
Prerequisites/Corequisites: Permission of Instructor
Terms Offered: Winter
ASYS 563 - Terminal Effects and Delivery of Conventional Weapons

This course provides the analytical basis for computing delivery trajectories and terminal effects of conventional weapons. It covers such topics as vacuum trajectories and atmospheric trajectories, powered trajectories, and projectile stability. Terminal effects are quantified and related to potential targets and their damage criteria. The following terminal effects topics are studied in some detail: chemical explosives and blast waves, guns and projectiles, fragmentation warheads, projectile impact, target hardness, armor penetration, and shaped charge weapons.

Notes Required: U.S. Citizenship and Secret Clearance

Credit Hours 4
Prerequisites/Corequisites AERO 536, AERO 533, Permission of Instructor
Terms Offered Fall

ASYS 565 - Control and State Space Concepts

This course covers topics in conventional and modern control theory. The interrelation between conventional and modern approaches is emphasized. Topics include: classical feedback systems analysis, root locus, Bode, and Nyquist analysis, state space feedback systems analysis, control system compensation design.

Credit Hours 4
Prerequisites/Corequisites ASYS 525 or equivalent
Terms Offered Winter

ASYS 590 - Aircraft Survivability

This course provides the student with an understanding of the essential elements in the study of survivability and system safety engineering of aerospace vehicles. Presented are technologies for increasing survivability and methodologies for assessing the probability of survival in hostile (non-nuclear) environments. Air defense threat technology, identification of mission threat characteristics and threat operations are presented. Primary areas of study include identification, assessment and reduction of susceptibility and vulnerability and survivability enhancement of aerospace vehicles.

Notes Required: U.S. Citizenship and Secret Clearance

Credit Hours 4
Prerequisites/Corequisites Undergraduate degree in engineering or science
Terms Offered Spring

ASYS 625 - Non-Linear Systems Analysis and Control

This course serves as an introduction to analysis and synthesis methods for control of nonlinear systems. The first half of the course will focus on analysis method such as phase plane analysis, Lyapunov stability theory, and the use of describing functions for approximating the behavior of non-linear systems. The second half of the course will introduce synthesis methods for non-linear control systems. Topics such as linearizing feedback, sliding mode control, and adaptive control schemes will be covered.

Notes This course will be offered as part of the control and optimization sequence or as a standalone technical elective.

Credit Hours 4
Prerequisites/Corequisites Linear systems and state space control (ASYS 525, ASYS 565 or equivalent)
Terms Offered Summer
ASYS 630 - Analysis and Design for Weapons Delivery

This course provides an in-depth analysis of the calculations required to accurately estimate and guide a conventional or nuclear weapon precisely to a static or mobile target. Ballistic and mobile platform launched trajectories are developed initially in a vacuum and then analyzed further in realistic atmospheres with advanced concepts such as: Coriolis Effect, Epicyclic Swerve, Lateral Throwoff, and Nonlinear Aeroballistics. Students design delivery profiles and investigate the profile impact on accuracy and dispersion. The crucible of precision guided munitions and low collateral damage warheads are used to design precision guided munitions controller models and to further analyze the impacts on delivery profiles, accuracy and dispersion. This course is numerical model intensive and should only be attempted if the student is confident in their programming ability.

Notes Required: U.S. Citizenship and Secret Clearance

Credit Hours 4
Prerequisites/Corequisites U.S. Citizenship and Secret Clearance, Undergraduate Degree in Engineering or Science
Terms Offered Fall

ASYS 631 - Spacecraft Systems Engineering

This course provides a detailed introduction to the design of complex space systems. The key elements and subsystems of several important classes of space systems are presented. The systematic approach necessary to effectively design space systems is illustrated through case studies.

Notes Individual or group design projects are conducted and presented.

Credit Hours 4
Prerequisites/Corequisites MECH 532 or Permission of Instructor
Terms Offered Spring

ASYS 632 - Satellite Design & Test

This course provides a detailed introduction to the design, manufacture, and testing of complex space systems. The key elements and subsystems components of several important classes of space systems are presented. The systematic approach necessary to effectively design, build, test, and qualify space systems is illustrated through hands-on labs using satellite hardware and space testing facilities. Individual or group projects are conducted and presented.

Notes Required: U.S. Citizenship

Credit Hours 4
Terms Offered Term offered: Summer
ASYS 632 - Satellite Design & Test

This course provides a detailed introduction to the design, manufacture, and testing of complex space systems. The key elements and subsystem components of several important classes of space systems are presented. The systematic approach necessary to effectively design, build, test, and qualify space systems is illustrated through hands-on labs using satellite hardware and space testing facilities. Individual or group projects are conducted and presented.

Credit Hours 4
Terms Offered Summer

ASYS 635 - Conventional Explosives & Effects

Introduction to conventional explosives engineering and the blast effects of conventional explosives. Chemical and thermodynamic theory of explosive compounds. Nonreactive and reactive shock waves. Shock wave and fragmentation effects in air, water, and solids.

Credit Hours 4
Prerequisites/Corequisites Undergraduate thermodynamics and fluid dynamics
Terms Offered Winter

ASYS 640 - Survivability Analysis and Design

This course provides the student with an in-depth understanding of the survivability discipline and analysis techniques and applied to combat aircraft. Topics covered include: History of Survivability, Susceptibility Assessment, Vulnerability Assessment, Survivability Enhancement, Set Theory, Kill Chain concepts, Weapon Threats to Aircraft, Aircraft Kill Modes, Aircraft Signatures, Radar Fundamentals, Electronic Warfare, Electro-Optical and Infrared Sensors, Advanced and Directed Countermeasures, Presented and Vulnerable Area analysis and Markov Chain propagation theory.

Notes Required: U.S. Citizenship and Secret Clearance

Credit Hours 4
Prerequisites/Corequisites U.S. Citizenship and Secret Clearance, Undergraduate Degree in Engineering or Science
Terms Offered Spring

ASYS 650 - Advanced Explosives and Warhead Design

An examination of basic warhead physics and advanced explosive phenomenon such as initiation and detonation. The course will also study the design of multiple warhead types such as fragmentation, blast, direct energy, and kinetic energy rod warheads.

Credit Hours 4
Prerequisites/Corequisites ASYS 635
Terms Offered Fall
ASYS 765 - Robust Control

This course covers robust control theory and applications. The emphasis is on a unified theory in which performance and robustness to plant uncertainties and/or input disturbances are handled directly. Modeling of uncertainty is covered, and signal and transfer function norms are used to quantify both the levels of uncertainty and the robustness to it. Lyapunov and Riccati theory is treated in detail, as well as the concepts of parameterizing all stabilizing compensators linear fractional transforms, linear matrix inequalities, and Hamiltonian matrices. The H-2, H-infinity, and mu-synthesis techniques are covered, and relevant examples from air and space systems will be used to demonstrate applications of these techniques.

Credit Hours 4
Prerequisites/Corequisites ASYS 565
Terms Offered Spring

CHEM 560 - Chemistry for Engineers

The course presents a quantitative treatment of selected topics from physical chemistry that are important to environmental and nuclear engineering. Topics presented will include thermodynamics principles, chemical equilibrium, kinetic theory of gases, liquids and solutions, acids and bases, electrochemistry, kinetics, chemical bonding, etc. Emphasis is on fundamental physical chemistry that plays an important role in engineering processes.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

CHEM 581 - Introduction to Nuclear Fuel Cycles

Introduction to nuclear fuel cycles with emphasis on engineering techniques important to produce materials for nuclear weapons. Topics relevant to nuclear nonproliferation will be introduced, including uranium and plutonium chemistry relevant to milling, mining, and refining; isotope enrichment; fuel element fabrication; reactor operation; fuel separation; and reprocessing. Nuclides possibly released during these processes will be considered.

Credit Hours 4
Prerequisites/Corequisites NENG 651
Terms Offered Winter

BIOL 597 - Biological Weapons Effects and Technology

The malicious use of microorganisms and threats of further acts of war or of terrorism drive this course. A review of fundamental microbial biology and organisms known to have biowarfare applications will be followed by coverage of current advances in biotechnology and the potential for offensive or defensive applications. Finally, current technologies for detection and response to microbial agents will be reviewed.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall
CHEM 597 - Chemical Weapons: Materials, Effects, and Technology

The potential use of chemical agents as weapons of war or as weapons of terror motivates this course. A brief survey of chemistry foundations will be followed by coverage of chemical weapons, materials, and effects. Chemical weapons technology will be discussed in terms of the potential for offensive or defensive applications. Technologies for detection, protection, and response to chemical agent attacks will be reviewed.

Notes U.S. citizens only

Credit Hours 4
Terms Offered Fall

CHEM 675 - Upper Atmospheric Chemistry

This course focuses on the physical and chemistry of the upper atmosphere of which the ionosphere is a vital and integral part of this region. The principle ionization sources are photoionization and energetic particle collisions with ambient atoms and molecules. A variety of processes that operate in the upper atmosphere will be identified and related to input and output parameters by detailed mathematical and physical descriptions of the processes. This course should bridge the gap between elementary studies in the fields of physics and research literature in upper atmosphere physics and chemistry.

Credit Hours 4
Prerequisites/Corequisites PHYS 519
Terms Offered As needed

CHEM 680 - Atmospheric Chemistry

This course is a study of atmospheric physics and atmospheric chemistry to understand natural atmospheric processes and the effects of human activities on the atmosphere. The course begins with a study of physical and chemical processes in the atmosphere, focusing largely on atmospheric water, carbon, and nitrogen in the oxidizing environment. The origin and nature of chemistry of atmospheric pollutions is framed for particulate pollutants, gaseous inorganic pollutants, and organic pollutants. The chemistry of these materials in the atmosphere is given emphasis. A particularly important focus is the photochemical induced radical, ion, and excited state chemistry of pollutants. Models of anthropomorphic changes in the atmosphere are considered. A quantitative, problem-solving approach is used throughout the course. This course will be useful to individuals involved in compliance issues associated with the Environmental Protection Agency (EPA) Clean Air Act, with atmospheric environmental assessment, and in the interpretation of environmental data obtained from air sampling (environmental engineers and managers involved with Resource Conservation and Recovery Act [RCRA] and Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] sites).

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
**CHEM 681 - Nuclear Chemical Engineering**

Chemical engineering aspects of the military nuclear fuel cycles are studied to characterize weapon sources. Topics include an overview of the nuclear fuel cycle, including uranium mining and milling; solvent extraction for fuel reprocessing; and U-235 enrichment. Chemical and physical properties of plutonium and the actinides are applied to understand sources of plutonium and the properties of irradiated fuel. A detailed treatment of stable isotope separation is included with particular emphasis on uranium enrichment techniques, tritium production, and use in nuclear weapons.

*Notes* SECRET (RESTRICTED DATA) clearance required.

**Credit Hours** 4  
**Prerequisites/Corequisites** NENG 651, NENG 605  
**Terms Offered** As needed

**CHEM 699 - Master's Level Special Study**

Course content determined by faculty member based on student need.

**Credit Hours** 1-12  
**Prerequisites/Corequisites** None  
**Terms Offered** All

**CHEM 720 - Kinetics of Fast Reactions**

Advanced level investigation of the rates and mechanisms of chemical reactions and energy transfer. Theoretical methods of Slater and RRKM are presented for the calculations of rate coefficients from fundamental properties. Current experimental methods used to study the kinetics of jet engines, rockets, lasers, plasmas, and the Earth's atmosphere are discussed.

**Credit Hours** 4  
**Prerequisites/Corequisites** AERO 729 or PHYS 655, PHYS 635  
**Terms Offered** Spring

**CHEM 750 - Computational Chemistry and Materials Science**

This computational laboratory will build on topics covered in MATL 662 through a series of four to five computational projects. Each project will explore a specific technique used in computational chemistry and materials science through the use of the computational facilities at the Major Shared Resource Center (MSRC).

**Credit Hours** 4  
**Prerequisites/Corequisites** CHEM 662, CSCE 656  
**Terms Offered** As needed
CHEM 780 - Radiation Chemistry

Advanced treatment of chemistry produced by ionizing radiation. Important radiation interactions and reaction mechanisms involved in irradiation of gas and condensed phases will be reviewed. The nature, properties and reactions of intermediate species, including solvated electron and important radicals, will be studied.

Credit Hours 4
Prerequisites/Corequisites CHEM 560, PHYS 665 or permission of instructor
Terms Offered As needed

CHEM 825 - Chemical Physics

An advanced study in the area of chemical physics. Topics covered include the approximate solutions of the time dependent Schroedinger equation for reacting systems and for systems interacting with an electromagnetic field. The foundations of infrared and ultraviolet spectroscopy, angular momentum considerations, symmetry studies, and electronic states are included.

Credit Hours 4
Prerequisites/Corequisites CHEM 720 or permission of instructor
Terms Offered As needed

CHEM 840 - Advanced Chemical Kinetics

A seminar course covering the theoretical aspects of chemical kinetics; calculation of rate constants from a consideration of the fundamental properties of atoms and molecules; analysis of classical methods, such as Slater or RRKM; and introduction to quantum and statistical solutions involving the Liouville equation.

Credit Hours 4
Prerequisites/Corequisites CHEM 720 or CHEM 825 or permission of instructor
Terms Offered As needed

CHEM 850 - Molecular Orbital Theory

A study of modern variational methods to calculate electronic structure and properties of molecules. Topics include molecular orbitals and molecular orbital symmetry, mathematical methods for solving the wave equation for molecules, HF-SCF, LCAO, MCSCF, CI, perturbation methods, and density functional methods.

Credit Hours 4
Prerequisites/Corequisites PHYS 655
Terms Offered As needed
COMM 680 - Technical Reports and Thesis

Prepares students to present scientific and technical information in complex written and oral reports, specifically the AFIT thesis and oral defense of the thesis. Topics covered in the course include formal organizational patterns; accurate language and effective style; analyzing information in published scientific and technical reports; formal documentation methods; formal report format, including visual aids; elements of effective oral reports; and other aspects of formal reports.

Credit Hours: 3
Prerequisites/Corequisites: None
Terms Offered: Summer

COST 668 - Cost Analysis Colloquium

This course exposes students to current, real-world issues, problems, and practices of the defense cost analysis community as viewed by senior individuals and practitioners in the field. The presentations focus on cost estimating management, processes, problems, and action taken to mitigate the problems.

Credit Hours: 0
Prerequisites/Corequisites: None
Terms Offered: All

COST 669 - Advanced Cost Analysis

This course introduces the student to the cost analysis profession. The course is designed to develop a realistic perspective on the part of the student concerning the tasks a cost analyst is expected to be able to perform the techniques and methodologies available to the analyst to accomplish the job, and the environment in which the cost analyst will operate. The course includes important information about the role of the cost analyst in the planning, programming, and budgeting system and DoD acquisition process, as well as an introduction to contracting. This course is a collection of topics, each of which addresses a particular element of the cost analyst's job or environment. The topics are designed to develop a framework of understanding that enables the students to relate the value of specialized material to be covered in subsequent courses to the overall requirements of the cost analysis profession.

Credit Hours: 4
Prerequisites/Corequisites: None
Terms Offered: Winter
COST 671 - Defense Cost Modeling

This course builds upon the fundamental topics of cost analysis and estimating and takes a holistic approach in modeling and developing comprehensive weapon systems cost estimates. Specific topics include developing the cost element structure (CES), applying appropriate cost estimating methodologies, incorporating learning curve concepts, and developing and applying cost estimating relationships (CERs). These topics are incorporated with the Automated Cost Estimating and Integrated Tools (ACEIT), the standardized DoD cost estimating and analysis software, to model weapon systems cost. Additional topics to be incorporated with the ACEIT software capability include cost engineering models, life cycle cost models, economic analysis, risk analysis, and time-phases budgeting.

Credit Hours 4
Prerequisites/Corequisites COST 669
Terms Offered Spring

COST 674 - Seminar in Cost Analysis

This seminar is the capstone in the Cost Analysis curriculum. Its purpose is to integrate the material covered in the curriculum and to introduce the students to current topics and issues of interest to the cost analysis community. The seminar explores current concepts and applications of cost analysis, the demands of life cycle cost management and analysis, and the role of economic analysis. Other current topics are included as appropriate.

Notes Students will perform a case study cost estimate, including documentation and presentation to the program manager.

Credit Hours 4
Prerequisites/Corequisites COST 669
Terms Offered Winter

CSCE 431 - Fundamentals of Discrete Mathematics

An introduction to discrete mathematics for computer scientists and engineers. Basic concepts and terminology are presented along with examples from the different computer science specializations. Topics include: logical reasoning, methods of proof, sets, relations, and functions, summation and recurrence relations, counting, and an overview of graph theory.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required

CSCE 486 - Fundamentals of Data Structures and Program Design

This course introduces the principles and methodologies used to design and implement small programs. The key principle of using hierarchical approaches to problem solving and program design is stressed, as well as the importance of disciplined programming styles and program analysis techniques. Two critical parts of program design and implementation are the selection of the data structures used in the design and the programming language used to implement the program design. This course covers several of the basic data structures and demonstrates how data structure selection impacts program efficiency and maintainability. Additionally, the key features of structured and object-oriented programming languages, such as data types, decision structures, and modularity will be covered. Several programming projects using a high-level programming language will be assigned to demonstrate the principles, methodologies, and data structures covered in this class.

Credit Hours 4
Prerequisites/Corequisites Programming experience in a high-level language
Terms Offered Fall, Summer, As Required
CSCE 489 - Operating Systems

This course is an introduction to the concepts and principles of computer operating systems with emphasis on memory management, processor management, I/O management, and system file structures. The objective is to give the student an understanding of operating systems and the necessary skills to evaluate and trade-off desirable features of operating systems, given specific user and resource requirements. The student will learn to develop and apply models in order to evaluate the performance of specific algorithms and the effect of algorithms on overall computer system performance. Case studies of current operating systems will be utilized to illustrate the application of the concepts and principles studied.

Credit Hours 4
Prerequisites/Corequisites CSCE 431 and CSCE 486
Terms Offered Fall, Summer, As Required

CSCE 492 - Computer Systems Architecture

The objective of this course is for students to understand the basic principles of Von Neumann computer architecture. Emphasis is placed on how a processor and its control unit, memory, and input/output devices are organized, and how they interact to form a computer system. Specific topics covered in the course include instruction set design, computer arithmetic, pipeline design, memory hierarchy, natural memory, and input/output.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall, Summer, As Required

CSCE 523 - Artificial Intelligence

This course presents the major principles and techniques of artificial intelligence. Specifically, in-depth studies of core issues, such as knowledge representation and problem identification, formulation, and solving are pursued. Topics include knowledge representation (models of logic, predicate calculus, production-rules, semantic networks, symbolic and sub-symbolic representations), problem solving (search theorem proving, reasoning), and knowledge-based systems (expert systems, natural language processing, vision, planning).

Credit Hours 4
Prerequisites/Corequisites CSCE 531 and CSCE 586
Terms Offered Winter

CSCE 525 - Introduction to Information Warfare

This course studies the nature of Information Warfare and its ramifications for information system security and survivability, and information assurance. It provides a foundational understanding of C4ISR (Command, Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance), the relationship of EW (Electronic Warfare) to C2W (Command and Control Warfare) and IW (Information Warfare), active and passive IW, information operations, information terrorism, military deception and PSYOPS. Simultaneously, it engenders a systems-oriented viewpoint, while examining national information infrastructures, their vulnerabilities, interdependencies, threats, and opportunities for exploitation.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall, Spring, Summer
CSCE 526 - Secure Software Design and Development

This course synthesizes elements from computer networking, operating systems computer architecture, and computer security. Topics addressed include software security principles, security analysis techniques, buffer overruns, access controls, race conditions, input validation, network software security and testing. Students taking this course will understand the threats to software security, how hackers exploit poorly written software, and will learn about countermeasures and their limitations. Laboratory experiments are infused to strengthen the underlying principles.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

CSCE 527 - Cyber Forensics

This course discusses Cyber Forensics and its effects on both Information Warfare and traditional forensic sciences. Students will gain insight into the computer’s role in crime and the digital evidence that is available in a computer related investigation. Topics include the legal ramifications of evidence gathering, chain-of-custody, and methods for evidence preservation, identification, extraction, documentation, interpretation, and the tools available.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites CSCE 525
Terms Offered Summer

CSCE 528 - Cyber Defense and Exploitation I

This course discusses the hardware/software tools and techniques associated with the protection and exploitation of computer systems and networks. Students will learn how to protect and exploit network resources in preparation for the annual Cyber Defense Exercise. Course topics include the DoD and USAF policy and doctrine associated with the protection of communication resources, intrusion detection systems, firewalls, Honeypots and Honeynets, span of control and accessibility, and use of various commercial and DoD tools for system protection and exploitation.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites CSCE 525 and Permission of Instructor
Terms Offered Winter

CSCE 528 - Lab

Lab to be taken in conjunction with CSCE 528

Notes Enrollment limited to US citizens only

Credit Hours 0
Prerequisites/Corequisites CSCE 525 and Permission of Instructor
Terms Offered Winter
### CSCE 531 - Discrete Mathematics

This course provides more in-depth coverage, analysis, and application of set theory, binary relations, functions, and first-order predicate calculus from CSCE 431. Specifically, more emphasis is placed on applying predicate calculus and practice doing proofs, both deductive and inductive formal proofs, and informal proofs. New top areas include: set countability and resolution-based theorem proving. This course also provides detailed and varied examples of how discrete mathematics is applied in other graduate courses in computer science and engineering.

**Credit Hours** 4  
**Prerequisites/Corequisites** CSCE 431  
**Terms Offered** Fall

### CSCE 532 - Automata and Formal Language Theory

The objective of this course is to prepare the student with a basic foundation in the concepts of automata and formal language theory. Topics covered will include Turing machines finite state automata, combinatorics, and formal language theory.

**Credit Hours** 4  
**Prerequisites/Corequisites** CSCE 431/CSCE 531  
**Terms Offered** Winter

### CSCE 544 - Data Security

This course presents the rudiments of data security. The emphasis is on cryptography, beginning with simple ciphers, and extending to public key cryptography, based on sophisticated number-theoretic considerations. Other topics include key management, access controls and inference controls. Remarks: Familiarize the student with standard cryptographic techniques. Introduces the student to the concept of public key cryptography, and the theoretical underpinnings of public key cryptography. Learn key management.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Spring

### CSCE 546 - Introduction to Database Systems

This course introduces the concept of a Database Management System (DBMS), types of database models, application of database systems, and various components of a DBMS. The objectives of the course are to develop an understanding of the uses, capabilities, advantages, and disadvantages of DBMSs, an understanding of the organization and manipulation of data in the types of DBMS available today, and an understanding of database design. A comprehensive set of laboratory exercises leads the student through the design and manipulation of a database using a commercially available DBMS.

**Credit Hours** 4  
**Prerequisites/Corequisites** CSCE 531 or Permission of Instructor  
**Terms Offered** As Required
CSCE 554 - Fundamental of Performance Analysis and Experimental Design

The purpose of this course is to present practical techniques for the measurement, simulation, and analysis of systems including computer systems, software, and communication networks. A systematic approach to performance evaluation is developed. This course also covers how to use measured data to compare systems using elementary statistics including, confidence intervals. Experimental designs, such as single and multiple-factor experiments, full-factorial, and fractional factorial designs are presented. Development of regression models from measured data and effective presentation of data and experimental results is discussed. Other topics include selection and characterization of workloads and practical simulation techniques. Time permitting, queuing theory and random-variate generation will be covered.

Credit Hours 4
Prerequisites/Corequisites STAT 583 or STAT 586 or Equivalent
Terms Offered Summer, Fall

CSCE 560 - Introduction to Computer Networking

This course provides an introduction to the fundamental concepts in the design and implementation of computer communication networks, their protocols, and applications. Students will understand and evaluate network protocols. The course discusses the basic performance and engineering trade-offs in the design and implementation of computer networks. Topics include overview of network architectures, network topology design applications network/programming interfaces (e.g., sockets), transport protocols, flow control, routing, network protocols, data link protocols, addressing, and local area networks. Examples are drawn primarily from the internet (e.g., TCP, UDP, and IP) protocol suite. Sockets programming and network simulations are used to emphasize topics.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall, Summer

CSCE 581 - Digital Avionics Systems

This is the first in a sequence of two courses on Digital Avionics. The course will provide introduction to embedded computer architecture and design with an emphasis on avionics applications. Topics include binary number systems, microprocessor architectures, field programmable logic arrays (FPGA), static and dynamic memory systems, and inter computer communications. A brief introduction to avionics building blocks (buses, displays etc.), definition of clear, correct, and complete requirements for avionics systems and salient architectural aspects of F-22 and B-777 architectures.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required
CSCE 586 - Design and Analysis of Algorithms

This course emphasizes the structure of data and the efficient and effective manipulation (algorithms) of such structures. Physical and logical organization of data is discussed along with data and algorithm abstraction using object-oriented design and abstract data types. Detailed procedures are developed for analyzing the time and space complexities of general algorithms, as well as an introduction to NP completeness. Specific data structures discussed include generalized lists, trees, graphs, B-trees, and AVL-trees, along with indexing, hashing, sorting, searching, and recursive algorithms on specific structures. Well founded algorithm design techniques like divide-and-conquer, local searching, and global searching are also introduced. Course projects emphasize the analysis, reuse, and extension of existing designs and implementations.

Credit Hours 4
Prerequisites/Corequisites CSCE 486
Terms Offered Fall, Winter

CSCE 587 - Microprocessor Design and Synthesis

Provides a theoretical and practical experience in state-of-the-art microprocessor designs and design methodologies. This course teaches how to design, synthesize, and simulate microprocessors using VHDL, the very high speed integrated circuit hardware description language. Students will make use of CAD tools and field programmable gate array hardware systems to microprocessors and related components.

Credit Hours 4
Prerequisites/Corequisites CSCE 093, CSCE 486, CSCE 492 or Permission of Instructor
Terms Offered Spring

CSCE 590 - Engineering Software-Intensive Systems

This course explores the unique challenges faced by teams engineering large-scale software-intensive systems (i.e., systems which have a large software component). Techniques in software requirements elicitation, object-oriented design, and quality assurance are presented in the context of an iterative software development process. Particular attention is paid to object-oriented modeling using the Unified Modeling Language (UML) and real-world case studies of software development within commercial and government organizations. Techniques to facilitate the engineering of reliable and secure software systems are introduced. This course is an introduction to software engineering for experienced engineers whose area of expertise is outside computer science. This course will enable them to more effectively communicate with software users and developers and make sound management decisions with respect to software-intensive systems development.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Summer, Fall, Winter (DL)

CSCE 593 - Introduction to Software Engineering

This course is concerned with the development of computer software. Techniques in software requirements elicitation, design, implementation, quality assurance, and project management are presented, along with discussion of the software development process. Emphasis is on object-oriented modeling using a subset of the Unified Modeling Language (UML). Hands-on experience is provided through individual homework problems and a group project.

Credit Hours 4
Prerequisites/Corequisites Object-Oriented Programming (CSCE 093 or equivalent)
Terms Offered Fall, Summer
CSCE 623 - Artificial Intelligence Systems Design

This course covers a selection of current state-of-the-art areas in artificial intelligence and intelligent systems design. In particular, emphasis is placed on the detailed development of complete systems. Areas include planning and scheduling, reasoning under uncertainty, vision, expert systems, natural language processing, machine learning, autonomous agents and distributed intelligence.

Notes Required course in the artificial intelligence sequence in the graduate electrical engineering, graduate computer engineering, and graduate computer science programs.

Credit Hours 4
Prerequisites/Corequisites CSCE 523
Terms Offered Spring

CSCE 625 - System Security Analysis

This course examines the security of computer systems and networks using the tools provided by propositional and predicate logic to discover underlying principles of security. Computer and network security is in a rapid state of change; principles of security, however, remain constant. This course takes the approach that the key to understanding the problems in computer security is recognition that the problems are not new. The course synthesizes elements from computer networking, operating systems security, and data security within an analytic framework. Topics addressed include: access control matrices, protection models, confidentiality, integrity, representing identity, flow and confinement, and malicious logic and intrusion detection. Students taking this course will understand the threats to information resources and will learn about countermeasures and their fundamental limitations.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered Winter

CSCE 628 - Cyber Defense and Exploitation II

This course exposes students to real-life experiences through the Cyber Defense Exercise (CDX). The students actively participate with other DoD Institutions in the defense of the AFIT Cyber Defense Network. Students will use the tools and techniques learned in CDE 1 during the conduct of the CDX.

Notes Following the CDX, students will perform after action analyses of the data to create lessons learned and improve defensive capabilities. Enrollment limited to US citizens only.

Credit Hours 4
Prerequisites/Corequisites CSCE 528 and Permission of Instructor
Terms Offered Spring

CSCE 628 - Lab

Lab to be taken in conjunction with CSCE 628

Notes Enrollment limited to US citizens only

Credit Hours 0
Prerequisites/Corequisites CSCE 528 and Permission of Instructor
Terms Offered Spring
CSCE 629 - Cyber Attack

This course provides an introduction to the use of cyber attack in order to attain national security objectives. Students will learn the legal limitations of cyber attacks, as well as how to attack and exploit network resources using hardware/software tools and techniques. Course topics include the DoD and USAF policy and doctrine associated with attack and exploitation, specifying military objectives, defining targets, exploiting targets, attacking targets, gathering intelligence, maintaining access/control of targets, and assessing attack success. Students will learn how to use various commercial and DoD tools and techniques for system attack and exploitation via hands-on exercises.

Notes Enrollment limited to US citizens only
Credit Hours 4
Prerequisites/Corequisites CSCE 560 or Permission of Instructor
Terms Offered Winter

CSCE 644 - Cryptanalysis

This course focuses on the art and science of breaking codes and ciphers. Students will learn both theoretical and real-world techniques for defeating cryptosystems. Course topics include theoretical and implementation-based attacks on classical and modern cryptographic systems and methods, to include attacks on stream and block ciphers, cryptographically strong hash functions, and public key systems. Additional topics include linear/differential cryptanalysis, modern factoring algorithms, side-channel attacks, time/memory tradeoffs, and attacks on randomness.

Notes Enrollment limited to US citizens only.
Credit Hours 4
Prerequisites/Corequisites CSCE544 or equivalent
Terms Offered As Required

CSCE 646 - Object-Oriented Data Management

The purpose of this course is to study advanced techniques in management of data used by object-oriented systems. The course examines object serialization techniques with hands-on projects that give practical experience in developing custom serialization methods and using existing language-provided mechanisms. Storage of object data using relational database management systems is covered by studying transforms of class diagrams to relations and by developing an object-relational layer in project work. A significant portion of the course is dedicated to the study of object-oriented databases in terms of their use in applications and their underlying implementations. Concepts are reinforced through project work involving the use of a commercial object-oriented database system.

Credit Hours 4
Prerequisites/Corequisites CSCE 546/CSCE 593
Terms Offered As Required
CSCE 654 - Computer Communication Networks

This is the intermediate course in networks and protocols. It examines the performance evaluation, design, and management of networks using analytical, simulation and experimental methods to evaluate design and manage networks and protocols. Topics include queuing theory, simulation methods, wireless networks, mobility issues, network security, performance of multiple access, TCP/IP, and Asynchronous Transfer Mode (ATM) technologies, protocols, design of backbone and access networks, and network management methods and protocols.

Credit Hours 4
Prerequisites/Corequisites CSCE 560 and STAT 583, STAT 586 or STAT 601
Terms Offered Spring

CSCE 656 - Parallel and Distributed Processing Algorithms

This course develops an understanding of classical results for parallel and distributed design and analysis of algorithms. It provides practical insights into efficient and effective implementation on contemporary parallel computational machines. Topics discussed include process communications, process synchronization, task scheduling, algorithm decomposition, real-time considerations and programming environments. Application areas emphasized include sorting, searching, vector/matrix operations, graph algorithms, simulation, differential equations, logic programming and knowledge-based systems. A variety of programming assignments on parallel and distributed computers are required using a selected concurrent language.

Credit Hours 4
Prerequisites/Corequisites CSCE 586
Terms Offered Spring

CSCE 681 - Digital Avionics Systems II

This is the second course on digital avionics. The architecture of modern avionics system such as F-22 and B-777. The evolution of the system design, including design specifications, modular system integration, bus-oriented systems design, integration and evaluation. Operation of the avionics in real world: Link 16, SPS guided weapons, Wide Area Augmentation Systems (WAAS) and scientific visualization and monitoring of air space, etc.

Notes Three hours of lecture each week. One, two-hour laboratory or a fourth, one-hour (the first few weeks) lecture each week.

Credit Hours 4
Prerequisites/Corequisites CSCE 581
Terms Offered As Required

CSCE 681 - Lab

Lab to be taken in conjunction with CSCE 681

Credit Hours 0
Prerequisites/Corequisites CSCE 581
Terms Offered As Required
CSCE 686 - Advanced Algorithm Design

This course provides a theoretical and practical foundation for understanding and analyzing the design, complexity and correctness of algorithms (control structure) along with data structure and implementation considerations. The emphasis on computational models relating to NP complete problems is extended. Use of search algorithms (tree/graph, linear programming, dynamic programming, probabilistic, etc.) to solve NP complete problems is related to the selection of various problem solving strategies including the incorporation of heuristics. Formal properties of the various approaches are studied using graph theory and computational models. Additional focus on logic programming, knowledge representation and automated reasoning in concert with the above topics provide a foundation in computational theory. In particular, applications in artificial intelligence, knowledge-based systems, software engineering, database management, signal processing, VLSI, and computer architecture are related through algorithm modeling and current literature.

Credit Hours 4
Prerequisites/Corequisites CSCE 431 and CSCE 586
Terms Offered Spring

CSCE 687 - Advanced Microprocessor Design Lab

This is a project-oriented course which emphasizes the application of microprocessor systems to practical problems. Students working in small groups will be expected to design and implement a microprocessor based project. This includes hardware and software design, implementation and testing.

Notes A final report is required. This course is required for all Graduate Computer Engineering and Digital sequence Graduate Computer Engineering students.

Credit Hours 4
Prerequisites/Corequisites CSCE 587
Terms Offered Summer

CSCE 689 - Distributed Software Systems

The objective of this course is to rigorously extend the fundamentals of computer operating systems into more advanced features. Topics include distributed operating systems, distributed file systems, distributed scheduling, fault tolerance, and multiprocessor operating systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties, as well as case study analysis of existing and proposed advanced operating systems. The objective of this course is to rigorously extend the fundamentals of computer operating systems into more advanced features. Topics include distributed operating systems, distributed file systems, distributed scheduling, fault tolerance, and multiprocessor operating systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties, as well as case study analysis of existing and proposed advanced operating systems.

Credit Hours 4
Prerequisites/Corequisites CSCE 431, CSCE 489, and CSCE 492
Terms Offered Winter

CSCE 692 - Design Principles of Computer Architecture

The objective of this course is for the student to understand and be able to apply the fundamental principles of computer architecture design. An emphasis is placed upon the use of quantitative metrics to evaluate cost/performance tradeoffs and upon the use of actual performance data to evaluate design alternatives. Specific topics include instruction set architecture design, pipelining, super scalar/VLIW processors, out-of-order execution, compiler optimization, memory system design, and input/output systems.

Credit Hours 4
Prerequisites/Corequisites CSCE 489 and CSCE 492
Terms Offered Winter
CSCE 693 - Lab

Lab to be taken in conjunction with CSCE 693

Credit Hours 0
Prerequisites/Corequisites CSCE 593
Terms Offered Winter

---

CSCE 693 - Software Evolution

This course is concerned with evolution of software from design to implementation and covers various topics in the software development lifecycle. Emphasis is on the enduring principles of good design, such as abstraction, modularity and specification, and their application through the use of well-established patterns. Course concepts are reinforced through hands-on exercises and a group project.

Credit Hours 4
Prerequisites/Corequisites CSCE 593
Terms Offered Winter

---

CSCE 694 - Advanced Software Engineering

This course covers advanced current topics in the area of software engineering. Topics range from program verification, concurrency, and formal models. Students will consider current software trends in light of Air Force interests, local research needs, and trends in software engineering research/practice.

Credit Hours 4
Prerequisites/Corequisites CSCE 531 and CSCE 793
Terms Offered As Needed

---

CSCE 698 - Research Seminar

This course provides a forum for students to gain an understanding of the graduate education process, department requirements and advice for preparing and writing the thesis, research milestones and deadlines, the scientific method, experiment design and analysis, and current DoD research interests in computer engineering, computer science, and computer systems.

Notes This information will be provided as needed during the student's program in accordance with all programs; therefore, students are required to attend this course for two quarters (1 Winter, 1 Spring). This is a required course. This course will be graded Satisfactory or Unsatisfactory.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Winter, Spring

---

CSCE 699 - Master's Level Special Studies

Directed study at the intermediate graduate level on a special topic which is not normally covered in a regularly scheduled course or as part of thesis research. Topic, format, and course requirements are determined by the faculty member directing the study.

Notes Requires submission of Registrar Form ENER-RDA-02 (Registration Drop/Add, Special Studies Request Form) and a written course description to the Department for registration

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All
CSCE 723 - Advanced Topics in Artificial Intelligence

This course treats topics selected to prepare students for research in artificial intelligence and for the application of artificial intelligence in the solution of commercial and military problems. Typical topics are knowledge-engineering, learning, constraint-satisfaction, neural networks, knowledge acquisition, model and case-based reasoning, nonmonotonic reasoning, blackboard systems, and theorem proving.

**Credit Hours** 4  
**Prerequisites/Corequisites** CSCE 623  
**Terms Offered** Summer

---

CSCE 725 - Reverse Code Engineering

This course is a continuation of CSCE 625, placing increased emphasis on offensive information warfare techniques (information attack, offensive counter information, and automated retaliatory strikes). Students will apply their IW knowledge in group design and analysis projects, explore several IW case studies, propose solutions and analyze their proposals.

**Notes** Enrollment limited to US citizens only

**Credit Hours** 4  
**Prerequisites/Corequisites** CSCE 625  
**Terms Offered** Spring

---

CSCE 729 - Cyber Operations Capstone

This course is the capstone for the AFIT cyber warfare program. Students will study, analyze, develop, and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Objectives are for students to understand and apply cyber warfare in its various forms; demonstrate systems-level understanding of information systems, vulnerabilities, and capabilities; understand organizational planning and decision processes; understand how cyber war integrates with other aspects of joint warfare; demonstrate ability to analyze and solve operational problems; and think strategically and operationally, applying the concepts of cyber warfare to the problem of achieving national and military objectives. Topics will include cyber policy and doctrine, tracing strategy to tasks to support military objectives, targeting, strategic and operational cyber intelligence, measuring effects, and legal/ethical issues. The course culminates in developing, integrating, and defending an operational cyber annex plan that supports a notional theater level operations plan.

**Notes** Enrollment limited to US citizens only

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Spring
CSCE 746 - Advanced Topics in Database Systems

This course covers advanced current topics in the area of object-oriented and distributed Multi-Database Systems (MDBS). Specific topics are oriented toward Air Force interest, local research emphases, student interest, and trends in the object-oriented and multi-database technologies illustrative projects and or point papers give the student opportunities to explore some areas of the appropriate fields in enough depth to engender an appreciation and working knowledge for the complexity of the domain.

Credit Hours 4  
Prerequisites/Corequisites CSCE 646  
Terms Offered As Required

CSCE 754 - Advanced Topics in Computer Networks

This is the advanced course in networks and protocols. The objective of this course is to extend the fundamentals of computer communication systems into more advanced topics actively being researched. The course surveys current design and implementation techniques for development of high performance computer networks as well as to prepare students for doing research projects in this area. Topics are drawn from current papers in the field. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties. These types of analyses are reinforced through simulation projects.

Credit Hours 4  
Prerequisites/Corequisites CSCE 654  
Terms Offered Summer

CSCE 790 - Advanced Parallel and Distributed Computation

The purpose of this course is to study the current literature and to investigate topics of current interest in parallel and distributed computation with emphasis on high performance scalable computing. Extended insight into the details of software data and control decomposition for contemporary scalable architectures. Possible parallel and distributed computation topics are: discrete-event simulations, solutions to linear and non-linear ODE and PDE equations (vector/ matrix algebraic operations), graph algorithms, logic programming, knowledge-based systems, probabilistic search, and cache memory performance. Depending upon student and instructor interest, applications are discussed from the following areas: imaging processing, signal processing, simulation, Computational Fluid Dynamics (CFD), Computational Electromagnetics (CEM), computational modern physics, artificial intelligence, and functional optimization. Contemporary scalable computational environments are evaluated as general parallel and distributed performance models.

Notes Requires the ability to design and analyze parallel algorithms and implement them on parallel computational machines

Credit Hours 4  
Prerequisites/Corequisites CSCE 656  
Terms Offered Summer
CSCE 793 - Advanced Topics in Software Engineering

This course serves as the capstone course for the software engineering sequence and explores the management and modification of large-scale software systems as they change over time. Relevant software engineering techniques and processes are discussed as they apply to software maintenance. Course concepts are reinforced through a group programming project and individual research projects.

Credit Hours 4
Prerequisites/Corequisites CSCE 693
Terms Offered Spring

CSCE 799 - Independent Study

The thesis topic is normally selected during CSCE 698, Research Seminar, from a wide variety of subjects of current interest to various Air Force and DoD organizations. The thesis is performed under the supervision of a faculty member who serves as the student's thesis advisor and chairman of his thesis committee. The results of the research are presented in a formal written thesis. An oral presentation and defense or the research is also required.

Notes A master's degree candidate must enroll in CSCE 799 for a total of 12 credit hours while working on the master's thesis. Ordinarily this course extends over the last four quarters of a student's program, with the student enrolling for 2 credit hours during the first two quarters of thesis work and for 4 credit hours the final two quarters. The letter grade for the entire 12 hours of thesis is awarded in the final thesis quarter. A grade of in-progress (IP) or unsatisfactory (U) is awarded for the other quarters.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

CSCE 823 - Introduction to Artificial Neural Networks

This course provides a review of major Artificial Neural Network paradigms to include the multi-layer perception, radial basis function, learning vector quantization, self-organizing maps, support vector machines, and associative memory models. Analytical coverage of supervised and unsupervised learning is provided. Emphasis on state-of-the-art Hebbian (biologically most plausible) learning paradigms and their relation to information theoretical methods is discussed. Material is emphasized through the application of these techniques to pattern recognition, clustering, classification, text processing, and robotics.

Credit Hours 4
Prerequisites/Corequisites CSCE 623
Terms Offered Summer

CSCE 886 - Evolutionary Algorithms

This course provides a theoretical and practical foundation for continuing the understanding and analysis associated with the design, complexity and correctness of evolutionary algorithms. Evolutionary algorithms using genetic algorithms, evolutionary strategies and classifiers are discussed as probabilistic search algorithms. Evolutionary data representation and fitness function selection along with associated operators and population dynamics are thoroughly developed. Formal properties of various evolutionary approaches are addressed using graph theory, predicate calculus and computational models. Evolutionary algorithm implementations are associated with proper data and control structure selection, implementation and visualization considerations for serial, parallel and distributed computation. Application problems in artificial intelligence, knowledge-based systems, software engineering, database management, signal processing, VLSI, simulation, scheduling, planning and computer architecture design are related through similarity of domain structures.

Credit Hours 4
Prerequisites/Corequisites CSCE 686
Terms Offered Summer
CSCE 899 - Doctoral Level Special Studies

Directed study for doctoral students on a special topic which is not normally covered in a regularly scheduled course or as part of dissertation research. Topic, format, and requirements of the course are determined by the faculty member directing the study.

Notes Requires submission of Registrar Form ENER-RDA-02 (Registration Drop/Add, Special Studies Request Form) and a written course description to the Department for registration

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

CSCE 999 - Dissertation Research

This course supports doctoral research under the direction of a faculty research advisor from the Department of Electrical and Computer Engineering.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

CWMD 596 - Physiologic Effects of CBRN

A general knowledge of physiology and toxicology is critical to understanding the myriad of health effects that can occur from exposure(s) to chemical, biological, radiological, and/or nuclear agents. This course will cover the physiological effects of each of the agent classes. Human anatomy and physiology are inherent topics in the instruction. The course provides a foundation in the human health effects of CBRN agents, which will ultimately result in better informed decision-making concerning CBRN threat assessments and response and recovery operations.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

CWMD 597 - Combating Weapons of Mass Destruction Engineering Practicum

This course is designed to provide students with supervised practical application of the material studied in the other courses of the certificate program. The practicum will consist of a series of laboratories, tabletop exercises, group analysis projects, guest lectures and seminars. The practicum will cover various aspects of chemical, nuclear and biological weapons of mass destruction.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
CWMD 699 - Master's Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

CWMD 791 - Combating Weapons of Mass Destruction

This course examines the problem of global proliferation through a multidisciplinary approach. This course provides an understanding of the technology necessary to produce weapons of mass destruction, as well as the means of delivering these weapons. The effects of chemical and biological weapons (with specific emphasis on the differences between them and nuclear weapons) are studied. Combating proliferation with an emphasis on U.S. Government legal obligations, treaty requirements, and DoD capabilities is considered. Detection of WMD and protection from their effects is examined. Finally, this knowledge is combined with a working knowledge of the current status of international proliferation to assess future trends.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered Winter

CWMD 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

ECON 520 - Managerial Economics

This course familiarizes students with selected concepts of managerial economics, enhancing their ability to analyze situations with microeconomic tools, generate and evaluate alternatives, analyze and solve complex problems, and make good economic decisions. The course incorporates critical thinking skills, creative problem solving techniques, and microeconomic theory, thereby enabling students to internalize fundamental economic principles and concepts and then apply them to real-world problems. The course considers the nature of economic incentives facing consumers, workers, and businesses. Topics include demand, supply, individual behavior theory, the time value of money, personal finance, production processes and costs, problem solving, decision making, organization of firms and industry, game theory, and international applications. Also, the role and impact of government is addressed from a microeconomic perspective. Where possible, classroom discussions and assignments include examples tailored to the Department of Defense (DoD).

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall
ECON 530 - Engineering Economic Decision Analysis

This course studies the analytical techniques necessary to optimize the economic outcome of technical and managerial decisions. Traditional engineering economic concepts such as basic cost concepts and time value of money are reviewed before presenting more complex concepts including comparison of alternatives, economic analysis, capital budgeting, analysis of risk and uncertainty, and decision models.

Credit Hours 3
Prerequisites/Corequisites MATH 291 or Permission of Instructor
Terms Offered Summer

ECON 580 - Fundamental Methods of Mathematical Economics

This course focuses on mathematical methods. Applications of mathematical techniques to selected topics including: theories of choice, theories of the firm, consumer behavior, general equilibrium, optimization, constrained optimization, distribution, growth and stability.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EENG 501 - Electro-Optical Systems (EOSYS)

This course presents an overview of electro-optical components, systems, and applications. Topics include methods of optical systems modeling and analysis, description of primary components including transmitters, receivers, apertures, and processing, and applications to hyperspectral sensing, laser radar, and laser communications.

Notes Enrollment limited to US citizens only
Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required

EENG 502 - Radio Frequency Systems

This course will provide an overview of Radio Frequency (RF) sensing systems and their components, along with a theoretical and practical understanding of their applications. Emphasis is on the top-level parameters that describe the capabilities and performance of such systems. Topics include basic properties of radar theory and application, Electronic Warfare (EW) theory and application including Electronic Attack (EA), Electronic Protection (EP) and Electronic Support (ES), and RF hardware considerations in RF system design. Particular applications to air-to-air fire control radar, air-to-ground imaging radar, EW active jamming and passive sensing and supporting hardware will be emphasized. By the conclusion of this course, the student will be able to make systems-level design estimates of various RF sensors and to make estimates of the applicability of various RF sensing techniques to different missions. In addition, the student will have a fundamental understanding of the various components required in an RF system.

Notes Enrollment limited to US citizens only
Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required
EENG 503 - Automated Target Recognition (ATR) Systems

This course covers topics related to Automatic Target Recognition (ATR) system design and analysis. This course will survey the theoretical principles of pattern recognition needed to design ATR systems, as well as address the application specific issues seen when transitioning ATR systems into operation. Topics include an overview of ATR applications, methodologies for handling unknown targets, data collection design and data characterization, the use of synthetic data in ATR systems, evaluation of an ATR system in an undetermined space, and data fusion. The goal of this course is to provide the student the capability to understand the current state-of-the-art in ATR systems, as well as provide them with the tools necessary to develop new ATR technologies.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required

EENG 510 - Linear Systems

The objective of this course is to develop tools for the analysis and simulation of linear dynamic systems. Emphasis is placed on state space analysis for estimation and control theory applications. Topics covered include: linearization of a nonlinear system, derivation of linear time-invariant and time varying state equations, and the continuous time solution; relations between the state equations and the system transfer functions eigenvalue/eigenvector and singular value analysis of the state equations; transformations to canonical forms; and controllability and observability properties.

Notes (Equivalent to SENG 525)

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

EENG 509 - Fundamentals of Electronic Warfare

This course studies theory and employment of Electronic Warfare (EW) as applied across the electromagnetic spectrum. It provides a foundational understanding of radar, electro-optical sensors, directed energy, communications techniques, and navigation systems in the context of electronic warfare. EW doctrine, systems, and countermeasures are also explored. Examples may be drawn from current, historical, and emerging capabilities and scenarios.

Notes Enrollment limited to US citizens only at the SECRET level

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered As Required

EENG 524 - Introduction to Electromagnetic Waves

This course focuses on the study of Maxwell's equations in the time and frequency domain. Faraday's and Ampere's laws are studied to illustrate the coupling of time-varying electric and magnetic fields. The dynamics and properties of electromagnetic wave propagation and polarization are explored for a variety of both lossless and lossy media. This naturally leads to an intensive study of transmission lines using both analytical (circuit models) and graphical (Smith Chart) methods. Then, field boundary conditions and the interactions at media interfaces are introduced in order to study the phenomena of reflection, refraction, and diffraction. Finally, a variety of waveguides including optical fibers are studied to introduce wave theoretic models for transmission lines or guided waves.

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered As Required
EENG 527 - Introduction to Fourier Optics

This course presents a systems approach to the analysis and design of both coherent and incoherent optical systems, with emphasis on application. Topics covered include: methods of analysis of two dimensional linear systems, scalar diffraction theory, Fourier transform properties of lenses, frequency analysis of imaging systems, spatial filtering concepts with selected applications, and holography. Important applications of Fourier optics to Air Force systems are stressed throughout the course.

Credit Hours 4
Prerequisites/Corequisites Permission of Instructor
Terms Offered Fall

EENG 530 - Analog Communication Theory

Analysis of analog communications systems in the presence of noise. Topics include: statistical models of modulated carrier signals; antenna parameters; channel models; noise sources and system noise calculations; link budget calculations; nonlinear detectors; performance analysis of AM, FM, PM, and FDM receivers; introduction to digital communication systems, including analysis of quantization error and matched filter receiver for baseband binary signals; design considerations and examples.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

EENG 532 - Introduction to Radar and Synthetic Aperture Systems

Provides the basis for understanding radar systems, including conventional range-azimuth, Moving Target Indicator, Doppler, synthetic aperture, phased-array, biostatic, and over-the horizon radars. Emphasizes the MASINT by signature exploitation of radar cross-sections and wideband signal interpretations.

Notes Examples may be drawn from current National Technical Sensors. Restricted to US, UK, Canada, and Australia at the SECRET level. Part of MASINT certificate series.

Credit Hours 3
Prerequisites/Corequisites OENG 530 (for MASINT certificate series)
Terms Offered As Required

EENG 533 - Navigation Using the Global Positioning System

This course provides a theoretical and practical foundation for understanding the Global Positioning System (GPS). Emphasis is on the use of GPS for determining navigational information such as user position and velocity. Topics include GPS satellite orbits, the three segments of GPS (control, space, and user segments). GPS signal structure, GPS measurements, least-squares solution of position and clock errors, GPS error courses, dilution of precision, GPS availability, differential GPS (DGPS), DGPS errors, GPS modernization, and other Global Navigation Satellite Systems (GNSS). Students will gain a thorough understanding of how GPS works, what errors exist, and how those errors can be mitigated. A number of hands-on laboratory experiments will familiarize students with a variety of GPS receivers and processing software.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter
EENG 534 - Fundamentals of Aerospace Instruments and Navigation System

Basic references frames are defined and coordinate transforms are derived. The applicable laws of mechanics are used along with basic control system theory to analyze the kinematic and dynamic behavior of inertial sensors used in attitude and tracking systems. Vector and matrix notation are used throughout. Topics covered are the earth model, two-degree-of-freedom and single-degree-of-freedom tuned and floated mechanical gyroscopes, laser gyroscopes linear accelerometers, inertial platforms, and unconventional inertial devices. Non-inertial navigation topics include radar, radio aids to navigation, optical trackers, and satellite navigation. The emphasis is on developing practical mathematical models useful to the guidance and control engineer.

Notes Examples are taken from current and planned Air Force systems.

Credit Hours 4
Prerequisites/Corequisites EENG 562
Terms Offered Fall

EENG 535 - Radar Systems Analysis

This course covers all aspects of radar from a systems point of view beginning with the definition and concluding with signal processing. After explaining the functions and characteristics of the transmitter, antenna, receiver, displays and the principles of microwave propagation and interaction with media, the Radar Range Equation is derived. Techniques of measurement and tracking of range, velocity, azimuth and bearing of a moving target are discussed. Recently introduced radars, such as the Over the Horizon, Synthetic Aperture, Terrain Following and Terrain Avoidance are briefly discussed.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EENG 538 - Synthetic Aperture Radar MASINT Lab

Calculation and demonstration of radar cross-sections for simple and composite targets, and synthetic aperture scene generation. Demonstrations and experience with X-patch and Case Executive radar data exploitation tools and techniques, including quality control and verification, digital elevation map gridding, orthorectification, and multi-color displays.

Notes Restricted to US, UK, Canada, and Australia at the SECRET level. Part of MASINT certificate series.

Credit Hours 1
Prerequisites/Corequisites None/EENG 532
Terms Offered As Required

EENG 562 - Feedback Systems

This course covers the fundamental characteristics and design of linear feedback control systems. The interrelation between conventional and modern approaches is emphasized. Topics include: feedback system analysis; root locus, Bode, and Nyquist analysis; state feedback control and observers; control system compensation design.

Notes Course is now combined with SENG 565.

Credit Hours 4
Prerequisites/Corequisites None/EENG 510
Terms Offered Fall
EENG 571 - Satellite Communications

The objective of this course is to provide a comprehensive introduction to modern communications principles with particular emphasis on applications to satellite and space communications systems. Topics include: modulation, signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware, earth-station hardware, and link analysis.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EENG 576 - Microwave Circuits

This course presents material on the application of electromagnetic theory to microwave propagation in wave guiding structures. Topics include Waveguides, Microwave Network Analysis, Impedance Matching and Tuning, Microwave Resonators, Power dividers, Directional Couplers, and Hybrids.

Credit Hours 4
Prerequisites/Corequisites EMAG Review
Terms Offered Fall

EENG 580 - Introduction to Signal Processing

This course presents an introduction to signal processing. Topics include I/O descriptions of discrete-time systems, Z-transforms, Discrete Fourier Transforms (DFT) and Fast Transforms (FFT), Finite Impulse Response (FIR) filter design, and Infinite Impulse Response (IIR) filter design.

Credit Hours 4
Prerequisites/Corequisites None/MATH 521
Terms Offered Fall

EENG 596 - Integrated Circuit Technology

This course presents the theoretical and physical principles involved in realizing devices from silicon and gallium arsenide. Implementation and fabrication of integrated circuits is stressed. The concepts of crystal structure, energy bands, carrier concentration, and carrier transport phenomena are explained. Discusses the basic fabrication processes relevant to integrated circuits. The following topics are developed: crystal growth, epitaxy, oxidation, dielectric and metallic film deposition, diffusion and ion implantation, lithography, and etching.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

EENG 622 - Advanced Electromagnetics I

Maxwell’s equations and governing boundary conditions in the time and frequency domains are explored for various media. The wave equation is developed for the rectangular and cylindrical coordinate systems. The propagation, polarization, reflection, and transmission of plane waves are investigated. Vector potentials and Green’s functions are studied. Fundamental theorems aiding in radiation and scattering applications are analyzed. The concept of radar cross section is introduced. Rectangular and cylindrical wave-guiding systems are examined. The course offers a balance of mathematical analysis, physical insight, and practical application.

Credit Hours 4
Prerequisites/Corequisites None/MATH 504
Terms Offered Fall
EENG 624 - Electromagnetic Characterization of Materials

The theory and measurement of the electromagnetic properties of materials are investigated. Fundamental properties of materials are studied, including complex permittivity and permeability, anisotropy, and dispersion along with their associated physical models. Low and high frequency calibration and measurement techniques in the frequency and time domains are explored. Students apply concepts to items of current Air Force interest.

Credit Hours 4
Prerequisites/Corequisites EENG 524
Terms Offered Winter

EENG 624 - Lab

Lab to be taken in conjunction with EENG 624

Credit Hours 0
Prerequisites/Corequisites EENG 524
Terms Offered Spring

EENG 625 - Antennas I

The basis of this course is the electromagnetic field produced by known source distributions, and fundamental antenna concepts such as gain, reciprocity, equivalence, duality, polarization and radiation pattern. The general behavior of dipoles, loops, and wire antennas is developed. An introduction to arrays of identical antennas is presented. Aperture antennas, including horns and reflectors, and their feed structures are studied.

Credit Hours 4
Prerequisites/Corequisites EENG 524
Terms Offered Winter

EENG 627 - RCS Analysis, Measurement, and Reduction

This is a fundamental course on Radar Cross Section (RCS) measurement and analysis. Characteristics of simple and complex shapes are explored and hip-pocket formulas are used extensively to compare predicted and measured RCS data. Methods of RCS reduction, Radar Absorbing Materials (RAM), design and performance of RCS measurement systems, frequency and time domain analysis, RCS imaging, and statistical processing of RCS data are discussed. Includes extensive laboratory RCS measurements.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites EENG 630
Terms Offered Summer

EENG 628 - Advanced Electromagnetics II

Rectangular, cylindrical, and spherical wave guiding and cavity systems are studied in detail. Electromagnetic scattering from rectangular, cylindrical and spherical structures (including plates, strips, cylinders, wedges, spheres and material-coated bodies) are investigated using modal analysis and two and three-dimensional Green’s function techniques. The formulation of integral equations is discussed and the subsequent Method-of-Moments (MoM) technique for solving these integral-equations is introduced. The radar cross section of various structures is explored. The course offers a balance of mathematical analysis, physical insight, and practical application.

Credit Hours 4
Prerequisites/Corequisites EENG 622
Terms Offered Winter
### EENG 630 - Asymptotic Techniques of Electromagnetic Theory

Analytical and numerical techniques to solve high frequency electromagnetic radiation and scattering problems are explored. The predominant high-frequency techniques investigated are Geometrical Optics (GO), Geometrical Theory of Diffraction (GTD), Uniform geometrical Theory of Diffraction (UTD), Equivalent Currents (EC), Physical Optics (PO), Physical Theory of Diffraction (PTD) and Incremental Length Diffraction Coefficients (ILDCs). The strengths and limitations of these methods as applied to complex practical problems are discussed. Computer programming of the methods is involved.

**Credit Hours** 4  
**Prerequisites/Corequisites** EENG 625 or EENG 628  
**Terms Offered** Spring

### EENG 631 - Advanced Antennas

Transform methods for analyzing antennas are explored. Broadband and frequency independent antennas are discussed, such as binconical, bow-tie, traveling wave, spiral, log-periodic, etc. In addition to frequency domain analysis, time domain techniques are explored including solving Maxwell’s Equations in the differential time domain form.

**Credit Hours** 4  
**Prerequisites/Corequisites** EENG 625 or Permission of Instructor  
**Terms Offered** Spring

### EENG 633 - Advanced GPS Theory and Applications

Advanced topics in GPS are presented, building on the foundation laid in EENG 533. A precise description of each of the GPS observables is presented, with an emphasis on differential positioning. Real world error sources are analyzed, including satellite position, ionospheric, tropospheric, multipath, and receiver measurement noise errors. A major portion of the course describes receiver design and signal processing methods used by GPS receivers. Current literature and laboratory projects provide enhanced insights into GPS receivers and systems.

**Credit Hours** 4  
**Prerequisites/Corequisites** EENG 533  
**Terms Offered** Spring

### EENG 634 - Computational Methods in Electromagnetics

This course develops numerical techniques commonly used to solve electromagnetic radiation and scattering problems. Focusing on the two major branches of the “First Principle Methods” (integral equation and differential equation); the primary subjects are the method of moments, finite element, and finite difference time domain formulations. The strengths and limitations of each method as applied to practical problems are discussed. Students learn the application and implementation of the methods through computer projects. While this course stands on its own, it is designed to be a companion course to EENG 630, Asymptotic Techniques of Electromagnetic Theory; together providing the student a firm grasp of all the major modeling and simulation tools used for electromagnetic analysis and design.

**Credit Hours** 4  
**Prerequisites/Corequisites** EENG 622  
**Terms Offered** Winter
EENG 635 - Inertial Navigation Subsystems

The Inertial Navigation System (INS) concept is defined and analyzed in the context of space stabilized, local level and strap down configurations. Perturbation techniques are applied in the derivation of unified INS error models. The earth’s gravitational field model is developed. Advantages and disadvantages of various configurations are presented within the context of the INS error dynamics. Methods of system alignment are examined. System response to inertial instrument errors, initial misalignments, and other sources are studied in frequency and time domains. System analysis tools, such as MATLAB are used throughout.

Credit Hours 4
Prerequisites/Corequisites EENG 534
Terms Offered Winter

EENG 636 - Micro Electro Mech Systems (MEMS)

This course covers the history, design, fabrication, and basic modeling of Micro- Electromechanical Systems (MEMS). The fabrication methods include surface micro mechining, and micro molding. A broad range of sensors, actuators, and transducers will be surveyed to include: electrostatic, electro-thermal, bi-layer, thermal bimorph, piezoelectric, and magnetic actuation schemes and various advanced sensor schemes. This course will include a weekly three hour laboratory wherein students will design classical MEMS devices, to include: electrostatic actuators, electro-thermal actuators, bi-layer actuator, and hinged structures. The MEMS devices will be designed with the aid of the computer aided drawing program 'LEDit', and submitted for fabrication in the silicon MUMPS process.

Notes The fabrication designs will be ready for testing in the follow-on course for this class, EENG 777, Advanced Micro Electro Mechanical Systems (MEMS)

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EENG 636 - Lab

Lab to be taken in conjunction with EENG 636.

Notes The fabrication designs will be ready for testing in the follow-on course for this class, EENG 777, Advanced Micro Electro Mechanical Systems (MEMS)

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Winter

207
EENG 651 - Command, Control, Communications, and Computer (C4) Systems

Examines the structure and dynamics of C4 support systems. In the context of this course, command and control is treated as a problem in generating, managing, transferring, and sharing information. This includes an overview of the Observe/Orient/Decide/Act (OODA) process and associated sensors, data feeds, communications, and processing subsystems required to support the operational commander’s decision making process. The course presents the main components of a generalized communication system in sufficient detail so the student can understand technical discussions of actual C4 support systems and architectures. Topics include communications engineering; satellite, terrestrial, ionospheric, and optical communication systems; radar, infrared, electro-optical, and electronic combat systems. Issues in attacking and protecting such systems are also discussed. Current and planned Army, Air Force, Navy, Marine, and joint C4 support systems will be studied, using the combined air operations center as launching point for discussion.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Spring

EENG 653 - Introduction to VLSI Design

The purpose of this course is to equip the student with the fundamentals of VLSI design, including semiconductor physics at the introductory level and CMOS logic, technology, interconnections, design rules, layout, simulation, and verification. The focus is on each element of the design cycle. At each stage in the cycle, both the theoretical concepts and the appropriate computer-aided design (CAD) tools are presented together. Practical experience is gained through the design of circuits of relatively low complexity.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites Introduction to Logic Design or Equivalent
Terms Offered Fall

EENG 653 - Lab

Lab to be taken in conjunction with EENG 653.

Notes Enrollment limited to US citizens only

Credit Hours 0
Prerequisites/Corequisites Introduction to Logic Design or Equivalent
Terms Offered Fall
EENG 658 - LiDAR Systems

This course presents a systems approach to the analysis and design of both coherent and incoherent LiDAR systems. Topics covered include range equations and detection considerations, fundamentals of incoherent and coherent receivers, radar waveform types, imaging system fundamentals, effects of atmospheric propagation, methods for computing detection probabilities and false alarm rates, as well as an introduction to subsystems and components. Selected portions of the material will be implemented within discrete computer simulations.

Credit Hours 4
Prerequisites/Corequisites EENG 580/STAT 586
Terms Offered Spring

EENG 665 - Random Signal and Systems Analysis

An introduction to the theory of random signals as it applies to communication. The concepts developed include: random signals, moments, correlation functions, stationary, ergodicity, power spectral density, joint processes and their cross-correlation, random signals in linear systems, and specific types of random processes.

Credit Hours 4
Prerequisites/Corequisites STAT 586
Terms Offered Winter

EENG 663 - Signal Detection and Estimation

This course covers methods of extracting information from noisy observations of a signal. In particular, this includes random and non-random parameter estimation and methods of detection and classification. The estimation theory includes maximum likelihood, minimum mean squared error, and maximum posteriori estimators; and the Cramer-Rao lower bound. The detection theory includes Bayesian, minimax, and Neyman-Pearson detection; multiple hypotheses; composite detection, and receiver operating characteristics.

Credit Hours 4
Prerequisites/Corequisites EENG 665
Terms Offered Spring

EENG 668 - Advanced Radar System Analysis

This course investigates advanced radar waveforms, radar modeling and phenomenology, detection analysis, and prepares the student to conduct independent research. Topics include the following: detailed investigation of pulse compression waveforms; compressed waveform modeling, design and analysis using the ambiguity function; matched filter processing; range and Doppler resolution; introduction to statistical decision theory; modeling noise, clutter, and barrage noise jamming; and detection probability analysis.

Credit Hours 4
Prerequisites/Corequisites EENG 535/EENG 663 is Highly Recommended
Terms Offered Spring
EENG 669 - Digital Communications I

The objective of this course is to present the significant considerations necessary for the design and analysis of digital communication systems. The course develops a mathematical representation of baseband digital signals including signal space concepts. Signal detection in the presence of noise and matched filters are described. The use of source coding for efficient descriptions of information sources is motivated. Channel coding concepts are developed and shown to improve communication system performance. Block and convolution codes are described and their performance analyzed.

Credit Hours 4  
Prerequisites/Corequisites EENG 530 and STAT 586  
Terms Offered Winter

EENG 670 - Digital Communications II

The objective of this course is to present the significant considerations necessary for the design and analysis of band-pass digital communication systems. This course examines coherent and non-coherent detection of digital band-pass signals in Gaussian noise and the corresponding error performance for binary and M-ary signaling. Modulation and coding tradeoffs are discussed. Methods of synchronization at the carrier, symbol, and frame rates are examined. Multiplexing and multiple access networking techniques are also explored, and a brief introduction to spread spectrum systems is provided.

Credit Hours 4  
Prerequisites/Corequisites EENG 665 and EENG 669  
Terms Offered Spring

EENG 672 - Statistical Optics

This course presents a systems approach to the analysis and design of electro-optics systems with emphasis on the stochastic nature of the received optical fields. Topics to be covered include the temporal and spatial coherence properties of light, propagation of coherence properties of light, effects of partial coherence on imaging systems, and imaging in the presence of randomly inhomogeneous media. The end of the course will emphasize applications such as speckle imaging, imaging using adaptive optics, and interferometric imaging. The course is designed to give students the ability to analyze and design optical systems which require the consideration of the non-deterministic nature of the light itself as well as its interaction with the optical system.

Credit Hours 4  
Prerequisites/Corequisites EENG 527 and EENG 665  
Terms Offered Winter

EENG 673 - Spread Spectrum Communications

This course examines the design and analysis of spread spectrum communications systems. The various forms of spread spectrum modulation, such as direct sequence, frequency hopping, time hopping, and hybrid forms, are discussed. Coding techniques for ranging and multiple accesses are also developed. Methods of synchronization at the carrier, chip, and data symbol rates are also examined. A major portion of the course is dedicated to applications of spread spectrum techniques, such as code division multiple access, Global Positioning System, low probability of intercept, and anti-jam communications.

Credit Hours 4  
Prerequisites/Corequisites EENG 670 or Permission of Instructor  
Terms Offered Summer
EENG 675 - Semiconductor Devices

This course is the focal point of the microelectronics sequence. Semiconductor statistics, carrier concentrations, and current mechanisms are discussed. All major device building blocks are studies: p-n junctions, metal-semiconductor junctions, and heterojunctions. Major semiconductor devices are then analyzed in detail including: p-n junction diodes, Schottky diodes, bipolar junction transistors, metal-oxide-semiconductor devices field-effect transistors, and heterojunction devices.

Credit Hours 4
Prerequisites/Corequisites PHYS 570
Terms Offered Winter

EENG 676 - Microwave Electronic Devices

This course extends the fundamental device concepts of EENG 675 to operation at microwave and millimeter-wave frequencies. Two-port networks are reviewed and various microwave transistors (HBTs, MESFETs, HEMTs and RF CMOS) are discussed in detail including device materials, geometry, physics of operation and limitations. Characterization techniques, device modeling (equivalent circuits), and parameter extraction are covered, specifically in these four areas: DC, RF (small-signal and large-signal), noise, and thermal. Design of microwave transistor amplifiers are discussed with regard to stability, gain, and noise figure.

Credit Hours 4
Prerequisites/Corequisites EENG 576 and EENG 675
Terms Offered As Required

EENG 680 - Multidimensional Signal and Image Processing

This course covers multi-dimensional signal and image processing. Topics include multi-dimensional Fourier transforms, image filtering and restoration, image transforms and data compression, compressive sensing, and an introduction to image analysis and computer vision topics.

Credit Hours 4
Prerequisites/Corequisites EENG 580/EENG 665
Terms Offered Spring

EENG 695 - Lab

Lab to be taken in conjunction with EENG 695.

Notes Enrollment limited to US citizens only

Credit Hours 0
Prerequisites/Corequisites EENG 653/CSCE 492
Terms Offered Winter

EENG 695 - VLSI System Design

This course extends the fundamental concepts developed in EENG 653 to larger scale VLSI systems. A hierarchical design methodology is developed using VHDL. A variety of subsystem elements are presented including arithmetic circuits, memory structures, control structures, and data path components. Each student will complete a design project of moderate complexity including VHDL specification, layout, and design verification. The result design will be submitted for fabrication to be tested in conjunction with EENG 795.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites EENG 653/CSCE 492
Terms Offered Winter
EENG 699 - Master's Level Special Studies

Directed study at an intermediate graduate level on a special topic which is not normally covered in a regularly scheduled course or as part of thesis research. Topic, format, and course requirements are determined by the faculty member directing the study.

Notes Requires submission of Registrar Form ENER-RDA-02 (Registration Drop/Add, Special Studies Request Form) and a written course description to the Department for registration

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

EENG 700 - Seminar in Remote Sensing and Communications Systems

This course is a student-participation seminar for students studying in the areas of antennas, propagation, electromagnetics, microwaves, communications, information and coding theories as applied to the broad areas of remote sensing and communications systems. Students are required to present research progress reports, analyses pertinent to their research. Students will also be required to practice drafting conference papers/presentations and journal papers, that, when appropriate, may be submitted for possible publication. The goal of this course is to foster an awareness of the open literature and IEEE publication standards for papers and presentations.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered Fall, Winter, Spring

EENG 701 - Seminar in Guidance Navigation and Control

This course is a student-participation seminar for students studying in the areas of guidance navigation and control. Students are required to present research progress reports, analysis of pertinent archival journal papers and conference papers, and tutorials on guidance, navigation, and control research, and to improve the student’s ability to publicly present technical data.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered Fall

EENG 714 - Advanced Topics in Radar Applications

This capstone radar course provides the student theoretical and practical exposure to advanced radar applications of continuing and/or emerging interest within the radar community. Instructor-led lectures develop the core mathematical, signal and image processing, modeling and simulation, and measurement methods as applicable to various radar applications. In addition, students conduct laboratory experiments and measurements, and/or modeling and simulation according to methods and techniques in the current literature.

Credit Hours 4
Prerequisites/Corequisites EENG 535 and EENG 668
Terms Offered Summer
EENG 716 - Imaging Through Turbulence

In this course the student is introduced to adaptive, speckle and hybrid imaging in the presence of the atmosphere. A collection of over 20 seminal papers as well as extensive faculty notes are used to introduce topics ranging from basic effects of atmospheric turbulence on optical propagation and conventional imaging to advanced imaging applications such as adaptive optical, speckle, and hybrid imaging. These advanced imaging applications are all techniques used to mitigate the detrimental effects of the earth’s atmosphere on conventional imaging.

Credit Hours 4
Prerequisites/Corequisites EENG 672
Terms Offered Spring

EENG 717 - Advanced Topics in Microelectronic Devices

This is the keystone course in the microelectronics sequence. Instructor and student-led lectures address a wide variety of evolving device topics currently being researched, focusing on present and future Air Force requirements. The course includes a laboratory providing students with hands-on experience in device fabrication and characterization via clean room processing technology and modern characterization equipment. Devices fabricated include heterojunction transistors (HEMTs, and HBTs), lasers, (VCSELS), LEDs, as well as other transistors, diodes, and simple circuits.

Credit Hours 4
Prerequisites/Corequisites EENG 675
Terms Offered Spring

EENG 717 - Lab

Lab to be taken in conjunction with EENG 717

Credit Hours 0
Prerequisites/Corequisites EENG 675
Terms Offered Spring

EENG 728 - Advanced Computational Methods in Electromagnetics

This course covers advanced mathematical, physical, and programmatic theory and practice for solving real-world problems in Computational Electromagnetics (CEM). Applications of advanced CEM methods are studied in relation to current Air Force research projects and current literature. Students are required to develop computer codes to support ongoing research and write a research report.

Notes This course is NOT restricted to US citizens only.

Credit Hours 4
Prerequisites/Corequisites EENG 634, MATH 508, MATH 521
Terms Offered As Required

EENG 734 - Lab

Lab to be taken in conjunction with EENG 734

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered As Required
EENG 734 - Multi-Target Tracking

This course introduces the basic concepts related to multiple-target tracking along with detailed discussion of algorithms focused on this area of research. Various methods for filtering and prediction of both linear and non-linear systems are presented with an emphasis on Kalman filtering and particle filtering. Dynamic target models are presented and included airborne, seaborne, and ground targets. Multi-target multi-sensor issues such as data association, attribute data fusion, multiple sensor tracking, and multiple hypothesis tracking are discussed. The course is structured to include a lab session designed to allow students to implement the theory and explore the most recent developments in the open literature.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As Required

EENG 735 - Inertial Navigation System Analysis and Integration

Optimal filtering theory is introduced and applied to the design of integrated navigation systems. The powerful properties of the Kalman filter are used to optimally combine the INS outputs with a variety of external measurements to extract superior navigation system performance. The Global Positioning System (GPS) mathematical and error models are derived and analyzed. Strap down INS computational algorithms are derived. Emphasis is placed on computational algorithms and their error performance. A substantial class project focuses on the benefits of INS integration (aiding) with external measurements, such as from the GPS.

Credit Hours 4
Prerequisites/Corequisites EENG 635 and either EENG 712 or EENG 765
Terms Offered Spring

EENG 765 - Stochastic Estimation and Control I

Probability theory and stochastic process theory are investigated to develop practical system models in the form of linear dynamic systems driven by known inputs, disturbances, and uncertainty. Using this model, the optimal estimator (Kalman filter) is derived and studied. Design of practical on-line filters, including performance analyses and aspects of implementation on digital computers, is accomplished for various Air Force applications.

Credit Hours 4
Prerequisites/Corequisites EENG 510 and STAT 586 or STAT 601
Terms Offered Winter

EENG 766 - Stochastic Estimation and Control II

Topics in linear estimation beyond those in EENG 765 are considered: frequency domain methods, square root filtering, optimal smoothing, and the extended Kalman filter as a means of applying linear estimation theory to nonlinear problems. Nonlinear filtering is then developed in detail, followed by stochastic digital controller design and performance analysis. The need for, and practical application of, these concepts in Air Force weapon systems are fully developed.

Credit Hours 4
Prerequisites/Corequisites EENG 712 or EENG 765/SENG 562
Terms Offered Spring
EENG 768 - Stochastic Estimation and Control III

Selected topics in advanced design of filters and stochastic controllers for Air Force systems, including adaptive algorithms, system identification, computational and implementation enhancement, decentralized control and large scale systems. Based upon current technical literature and Air Force research and development programs.

Credit Hours 4  
Prerequisites/Corequisites EENG 765 and EENG 766  
Terms Offered As Required

EENG 777 - Advanced Micro Electro Mechanical Systems (MEMS)

This course will provide the student an in depth experience in design and modeling of classical and advanced MEMS and optical MEMS devices. Classical MEMS devices, designed and fabricated in the prerequisite companion course EENG 636, will be fabricated and tested in a three hour weekly lab. The experimental results will be compared to numerical results obtained from finite element models and analytical models. This class will also include a course project where an advanced MEMS design is optimized through finite element modeling and simulation.

Credit Hours 4  
Prerequisites/Corequisites EENG 636  
Terms Offered Summer

EENG 779 - Nanotechnology

This course provides a critical look at the engineering and properties of materials, nanoelectric devices, and systems on the nanometer scale. Topics include epitaxial crystal growth, self assembly, nanolithography, nano-sensing, the physics of quantum wires and dots, and nanometer-scale measurement techniques.

Credit Hours 4  
Prerequisites/Corequisites Permission of Instructor  
Terms Offered Summer

EENG 780 - Statistical Image Processing

Selected topics in advanced design of stochastic image processing algorithms for Air Force remote sensing systems, including blind deconvolution algorithms and hyperspectral image processing algorithms. Topics based upon current technical literature and Air Force research and development programs are examined.

Credit Hours 4  
Prerequisites/Corequisites EENG 663, EENG 672, OENG 644  
Terms Offered Spring

EENG 777 - Lab

Lab to be taken in conjunction with EENG 777

Credit Hours 0  
Prerequisites/Corequisites EENG 636  
Terms Offered Summer
EENG 795 - Advanced Topics in VLSI Systems

This course is a combination of a testing laboratory and advanced topics class. The design projects which the student completed in EENG 695 will be tested both functionally and parametrically. The student will gain experience in both probing the circuit directly and using automated test equipment. The student will also have the opportunity to explore advanced topics in VLSI system design in a seminar format. Such topics may include analog circuit design, gallium arsenide circuit design, computer-aided-design theory, and new VLSI architectural concepts.

Notes Enrollment limited to US citizens only

Credit Hours 4
Prerequisites/Corequisites EENG 695
Terms Offered Spring

EENG 795 - Lab

Lab to be taken in conjunction with EENG 795

Notes Enrollment limited to US citizens only

Credit Hours 0
Prerequisites/Corequisites EENG 695
Terms Offered Spring

EENG 799 - Independent Study

The thesis topic is normally selected during EENG 698, Research Seminar, from a wide variety of subjects of current interest to various Air Force and DoD organizations. The thesis is performed under the supervision of a faculty member who serves as the student's thesis advisor and chairman of his thesis committee. The results of the research are presented in a formal written thesis.

Notes An oral presentation and defense of the research is also required. A master's degree candidate must enroll in EENG 799 for a total of 12 credit hours while working on his master's thesis. Ordinarily this course extends over the last three quarters of a student's program, with the student enrolling for 4 credit hours each quarter. The letter grade for the entire 12 hours of thesis is awarded in the final thesis quarter. A grade of in-progress (IP) or unsatisfactory (U) is awarded for the other quarters.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All

EENG 899 - Doctoral Level Special Studies

Directed study for doctoral students on a special topic which is not normally covered in a regularly scheduled course or as part of dissertation research. Topic, format, and requirements of the course are determined by the faculty member directing the study.

Notes Requires submission of Registrar Form ENER-RDA-02 (Registration Drop/Add, Special Studies Request Form) and a written course description to the Department for registration

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All
EENG 999 - Dissertation Research

This course supports doctoral research under the direction of a faculty research advisor from the Department of Electrical and Computer Engineering.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

EMGT 501 - Engineering Management curriculum and research options

This seminar guides the students in selecting a focus sequence and a thesis advisor as part of the engineering management program. All focus sequences will be introduced and discussed, along with relevant electives. Faculty will speak on their research interests and provide ideas on how to choose a research project, milestones to establish, and expectations of the completed research. Selected students from the class matriculating one year earlier will present and discuss their research approaches. This seminar shall be scheduled during the first full academic quarter of the full-time quota students’ program.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Fall

EMGT 502 - Engineering Management Research Perspectives

This seminar presents the principles of organizing and conducting research. Students are introduced to scientific literature, the concept of research objectives within the scientific method, and alternative methodological approaches. Thesis construction, development, and timelines are discussed. The seminar serves to help students complete their thesis prospectus and prepare to conduct graduate level research.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 503 - Critical Review of Research Literature

This seminar introduces students to the fundamentals of literature reviews. Students are introduced to library resources and prepared to conduct in-depth reviews of research topics. Also included is an introduction to the human subjects review process.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Spring
EMGT 504 - Engineering Management Thesis Research Review

This seminar provides students with the opportunity to informally present their thesis research before their student peers and faculty, exercising their abilities to clearly articulate the background, literature, research questions, methodologies, and the various methods being employed. For large classes, the seminar is scheduled over two academic quarters and is designated as EMGT 505 in the second quarter.

Credit Hours  1  
Prerequisites/Corequisites  None  
Terms Offered  Summer

EMGT 505 - Engineering Management Thesis Research Review

This seminar provides students with the opportunity to informally present their thesis research before their student peers and faculty, exercising their abilities to clearly articulate the background, literature, research questions, methodologies, and the various methods being employed. For large classes, the seminar is scheduled over two academic quarters and is designated as EMGT 504 in the first quarter and EMGT 505 in the second quarter.

Credit Hours  0  
Prerequisites/Corequisites  None  
Terms Offered  Fall

EMGT 550 - Engineering Economic Decision Analysis

This course studies the analytical techniques necessary to optimize the economic outcome of technical and managerial decisions. Traditional engineering economic concepts such as basic cost concepts and time value of money are reviewed before presenting more complex concepts including comparison of alternatives, economic analysis, capital budgeting, analysis of risk and uncertainty, and decision models.

Credit Hours  3  
Prerequisites/Corequisites  MATH 291 or Instructor permission  
Terms Offered  Summer

EMGT 611 - Topics in Crisis Management

The topics in crisis management course will provide the student with a broad background of this emergent area of research and theory. The course will focus on the frameworks and perspectives developed in the literature to aid practitioners in working in crisis environments. The student will come away from the course with a vocabulary and knowledge set ready to be applied to the specific environments they may encounter after they graduate.

Credit Hours  3  
Prerequisites/Corequisites  None  
Terms Offered  Fall
EMGT 612 - Crisis Management Systems

The Crisis Management Systems course will provide the student with examples of active systems within the larger national Emergency Management system. The knowledge baseline developed in EMGT 611 can be applied to analysis and application in real-world situations and aid the engineering management practitioner in functioning effectively in such situations. The course discussion and assignments will be case study driven and will focus on the challenge of operationally managing military resources and organizations in crisis environments.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 621 - Asset Management

This course covers a wide variety of topics related to infrastructure asset management. A background of infrastructure terms will be presented and discussed. This course will introduce the concepts of inventory, assessment, condition state, Levels of Service, program development, prioritization, and advocacy as the primary management methods. Furthermore, this course will develop the concept of using a centralized database as a tool for infrastructure asset management and performance modeling.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 622 - Introduction to Geographic Information Systems and Sciences

This course presents an overview of the operations and functions of Geographic Information Systems (GIS). Experiential learning is emphasized through a series of lectures and tutorials followed by application exercises. The course is designed to develop student expertise in spatial reasoning, problem definition, and skilled application of ESRI's ArcGIS software.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring

EMGT 631 - Construction Inspection

This course will study inspection methods utilized to oversee major projects in the construction industry. The course presents the material in three main thrusts to better understand the inspection field: specific criteria and methods, safety, and contingency construction. The topics to be covered during this study are as follows: Site work, Asphalt, Concrete, Steel, Masonry, Roofing, Underground piping, Electrical, HVAC and Mechanical Systems, and OHSA – Safety.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter
EMGT 632 - Advanced Topics in Construction Inspection, Engineering and Materials

Knowledge of construction inspection, engineering, and materials is a necessity for today’s AF civil engineers. This class provides information on how vertical and horizontal projects should be inspected to include OSHA regulations and ASTM requirements. Construction engineering analysis provides information on how to calculate structural, mechanical, electrical and hydraulic loadings of horizontal and vertical construction.

Credit Hours 3
Prerequisites/Corequisites EMGT 641
Terms Offered Spring

EMGT 641 - Construction Contracts and Law

This course provides an introduction to construction contracts and law. Topics include legal aspects of contract documents, drawings and specifications, owner-engineer-constructor relationship and responsibilities, bids and contract performance, labor laws, governmental administrative and regulatory agencies, torts, business organizations, ethics and professionalism, analysis of current topics and issues, and investigation of recent statute and case implications.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 642 - Systems Dynamic Modeling

This course describes the methodology used for portraying and analyzing the behavior of holistic systems. It introduces the concepts of “systems thinking” developing the tools for modeling complicated systems of multiple feedback loops typical of environmental interactions. Specialized modeling software is used to develop modeling concepts and to apply systems modeling. The examples within the course are chosen for applicability to current management issues.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 670 - Organizational Systems Analysis

This course will be a practical applications-based course instructing students in the systemic implementation of more focused academic principles (taught in IMGT 669 and ORSC 542) to real AF and DoD organizational issues and processes. Students will learn basic systems engineering/framing and methodological concepts as well as practical organizational measurements methods. Analyses of realistic organizational case studies are the foundation for instruction and assignments.

Credit Hours 3
Prerequisites/Corequisites ORSC 542, IMGT 669
Terms Offered Winter
EMGT 680 - Advanced Project Management with Risk Analysis

This course reviews basic and presents more advanced tools, techniques, and models for comprehensive project management with risk analysis. The course will present integration of risk identification, risk modeling, and risk analysis into project systems decision framework with an emphasis placed on the construction project management context. A major component of the course involves skill development for technical journal articles.

Notes Initially will be offered as EMGT 699 course during the 2010-2011 Academic year.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

EMGT 713 - Crisis Project Management

In addition to daily operations in crisis environments, engineers are likely to face the separate prospect of managing projects from start to finish in such settings. The crises project management course applies a complex systems perspective to the operation, analysis, and evaluation of project management and project focused organization uses. In turn, this approach will also be applied to the specific cases of crisis environments. Examination of project failure modes, project design alternatives, intervention of and modeling of project management systems, and strategic project program integration are other course themes. The course will be a combination of lecture, case study and field work.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring

EMGT 699 - Master's Level Special Studies

Credit Hours 1 - 12
Terms Offered As needed

EMGT 723 - Advanced Geographic Information Systems and Science

This course follows EMGT 622, emphasizing applications in Geographic Information Systems (GIS). Experiential learning is emphasized through online tutorials followed by application exercises. The course is designed to advance the student’s expertise in spatial reasoning, problem definition, and skilled application of ESRI's ArcGIS software. As an application based course the student is expected to apply the course material to their thesis or a major project determined by the instructor. Students develop proficiency in spatial analysis from both a problem formulation and a problem solution perspective using spatial statics and other spatial reasoning tools such as the application of elementary spatial analyses concepts (spatial queries, intersects, unions, spatial statistics, etc.)

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Summer
EMGT 799 - Thesis Research

An in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis written under the supervision of a departmental professor. An oral presentation and defense of the research is required.

Credit Hours 1 - 12

---

ENVR 501 - GES/GIH Seminar

This course presents the principles of organizing and conducting research and will assist students in completing their thesis prospectus. Other specific topics: ethics/plagiarism, thesis checklist process, and PA approval process. Students from the class matriculating one year earlier will present and discuss their research. Faculty and guests may also provide lectures detailing current research topics.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Fall

---

ENVR 502 - GES/GIH Seminar

This course emphasizes general thesis construction and development, in accordance with the AFIT Thesis Style Guide. Beyond this introduction, thesis advisors will guide their students on specific formatting preferences during preparation of the thesis. Senior students will present and discuss the final results of their research, ahead of their thesis defense. Faculty and guests may also provide lectures detailing current research topics.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Winter

---

ENVR 503 - GES/GIH Seminar

Students will utilize this time to meet with their thesis advisor and research group. Faculty and guests may also provide lectures detailing current research topics.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Summer

---

ENVR 504 - GES/GIH Seminar

This course includes discussion on applicable business, managerial, and leadership skills relevant to graduating students. Discussions will include techniques, skills, and tools necessary for managers/leaders. Guest speakers will provide their personal leadership philosophies and views on mentorship, especially when faced with diverse, multidisciplinary teams. Faculty and guests may also provide lectures detailing current research topics.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Winter

---

ENVR 505 - GES/GIH Seminar

This course provides students an opportunity to informally present their thesis research before their student peers and faculty, in order to demonstrate effective communication skills and articulate their research to a larger audience. Students will receive critical feedback from both fellow students and faculty. All students will be exposed to the thesis work of their peers and gain a broader perspective on current research issues and the various methods being employed. Faculty and guests may also provide lectures detailing current research topics.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Fall
ENVR 511 - Environmental Management and Policy

This course is designed to provide an intensive introduction to the field of environmental management and policy, including basic concepts and approaches, major elements of American environmental policy, political processes and institutions, public policy tools, and environmental policy analysis.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall

ENVR 528 - Environmental Physiology and Toxicology

A general knowledge of physiology and toxicology is critical to understanding the myriad of health effects that can occur from environmental exposures to toxicants and toxins. Protecting human health is the primary motivation behind industrial hygiene and many environmental related activities. This introductory level course will cover the physiology of each major organ system in the human body along with injury/disease that can occur from toxicant or toxin exposure. This course will enhance the student’s ability to analyze current medical, toxicological, and environmental literature as it relates to human health exposure and effects. The course provides a strong foundation in human health effects, which will ultimately result in well informed decision-making concerning environmental health related issues. This course is required for all GIH students.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

ENVR 532 - Air Resources Management

This course serves as an introduction to air pollution control. Initially, the course provides an overview of the sources, properties, effects, and regulations of both particulate and gaseous air pollutants from stationary and mobile sources. The course then introduces the philosophy of process design and economic analysis central to the effective control of air pollution. As a design-oriented course, we will then focus on developing a detailed understanding of the operating principles of different control technologies and the process design of air pollution control equipment. Specific topics to be covered include baghouses, electrostatic precipitators, carbon adsorbers, VOC vapor incinerators, biofilters, SO₂ scrubbers, gas and particle wet scrubbers, basic meteorology, and dispersion modeling. Emphasis will be placed on understanding pollutant properties and behaviors and the principles of different control technologies, to include the basic design parameters and the strengths and weaknesses of each type of control equipment.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall (Alternating)

ENVR 534 - Ecology, Limnology, and Natural Resources

This course is to familiarize the student with ecology, limnology, natural resources, and general life science principles. A broader understanding of the many interactions of earth’s living and non-living systems will facilitate better decision making and land development practices. This class will focus on a conceptual understanding of genetics, species, population and ecosystem ecology, global climate, and global issues. Also included will be the examination of current topics and ecosystems through an individual and extensive review of an ecosystem of choice.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring
ENVR 535 - Solid and Hazardous Waste Management

This course provides an understanding of the challenges associated with solid and hazardous waste management. The primary focus is on municipal solid waste (MSW) and an integrated approach towards waste management. As the preface to the text states, “The basic goal of Integrated Solid Waste Management is to manage society’s waste in a manner that meets public health and environmental concerns and the public’s desire to reuse and recycle waste materials.” After introducing the importance of planning and decision-making, the course provides a review of the sources, composition, and properties of MSW. With the MSW properly identified and characterized, the course then covers the various ways in which we “handle” the waste. In this context, “handling” is meant to include collection, separation, processing, and transportation. Finally, the course presents the transformation of waste, though either composting or combustion, and the disposal of waste in landfills.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Summer (as needed)

ENVR 541 - Industrial Hygiene Applications I

This course provides the anticipation/recognition portions of the "anticipate, recognize, evaluate, control" (AREC) paradigm of classical industrial hygiene. This course provides the student with a background of industrial hygiene history and development, and an overview of all hazard types (chemical, biological, and physical). Topics include: IH history and regulations; exposure limit basis, interpretation, and application; chemical hazards and indoor environmental quality; biological hazards; and physical hazards (noise, thermal stress, ergonomics). This course is required for all GIH students.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall

ENVR 543 - Industrial Hygiene Applications II

This course provides the evaluation piece of the “anticipate, recognize, evaluate, control” (AREC) paradigm of classical industrial hygiene. Lecture and laboratory sessions focus on evaluation techniques and instruments for chemical, biological, and physical hazards. Exposure assessment strategies are also developed to prepare the students for the course project of in-depth evaluation of a hazard at an industrial site. Topics include lab-based and direct-reading instrument sampling and analysis of gases, vapors, and aerosols; biological monitoring and evaluation; dermal exposure assessment; noise evaluation; exposure distributions; sampling strategies; and data interpretation. This course is required for all GIH students.

Credit Hours 4
Prerequisites/Corequisites ENVR 541
Terms Offered Spring

ENVR 543 - Lab

Lab to be taken in conjunction with ENVR-543

Credit Hours 0

ENVR 544 - Introduction to Epidemiology

This course provides students with an introduction to epidemiological concepts and principle measures of disease frequency and association. Design of descriptive and analytic studies (case series, cross-sectional, and cohort studies); application to public health; and communication of epidemiologic information are presented. Issues of bias, confounding, and causal inference are discussed. Data analysis using tabular methods is accomplished. This course is required for all GIH students.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Summer
ENVR 547 - Non-Ionizing and Ionizing Radiation

This course covers the health and safety problems involved with the use of ionizing and non-ionizing radiation with an emphasis on identification (detection), control, radiation types, and interactions with matter. Specific areas covered include lasers, microwave radiation, medical and dental x-ray equipment, industrial x-ray, and personnel dosimetry. Radiation safety elements are discussed in detail to include the legal requirements for conducting an effective radiation safety program and required surveys (routine and contamination). This course is required for all GIH students.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring

ENVR 548 - Lab

Lab to be taken in conjunction with ENVR-548

Credit Hours 0

ENVR 550 - Environmental Systems Engineering

This course provides the student with analytical and mathematical tools to quantitatively and qualitatively assess the effect of Air Force operations on the environment. The course helps the student understand the basic engineering controls that can be used to minimize the impact of mission operations on the environment. Topics include: basic environmental chemistry and physics; fate and transport of contaminants in the air, water, and soil; physical, chemical and biological treatment alternatives; and mitigation of air, water, and soil pollution.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

ENVR 548 - (LWL) - Industrial Hygiene III (Controls) and Laboratory

This course completes the “anticipate, recognize, evaluate, control” (AREC) paradigm of classical industrial hygiene by providing control mechanisms competency. Lecture and laboratory sessions acknowledge the control hierarchy (substitution, engineering controls, administrative controls, then personal protective equipment-PPE), but focus on engineering controls. Students will specifically learn industrial ventilation design through practical exercises, as well as hazardous noise controls. Confined spaces, occupational safety, and environmental/safety/occupational health (ESOH) management will also be addressed. This course is required for all GIH students.

Credit Hours 4
Prerequisites/Corequisites ENVR 543
Terms Offered Summer
ENVR 556 - Sustainable Life Cycle Design

One could argue that we have not, and are not, living in very sustainable ways. Over the past few decades, the case to live as more responsible environmental stewards has been increasingly made. Therefore, the primary objective of this course is to introduce students to the fundamental concepts of sustainability. To be more specific, the overarching goal for this course is to raise awareness levels such that the concept of sustainability is factored into every applicable management decision. As such, this course is designed as a survey course – sustainability is a rather broad concept and a wide variety of subject areas will be covered. This course will introduce the philosophy and practice of sustainability primarily within the context of the built environment and secondarily within industry. The principles of sustainability will be reviewed and then their application to energy, water, climate change will be considered. We will also review the conceptual frameworks promoted by various individuals, to include Natural Capitalism, Cradle-to-Cradle, The Natural Step, and The Triple Bottom Line.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

ENVR 575 - Applied Environmental Health

The class will include coverage of basic environmental health topics/concepts. The format will be periodic lectures from the instructor and presentation/discussion of student/team projects. Topics covered will include basics of public health, intelligence data gathering, toxic industrial chemicals, physical hazards, and global environmental health issues.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall

ENVR 615 - Industrial Hygiene Site Surveys

This course provides exposure to various industrial workplaces in the local area, in order to better understand the industrial hygiene “anticipate, recognize, evaluate, control” (AREC) paradigm. Students will go on several field trips and will write trip reports to summarize their occupational, environmental, and safety observations. This course is required for all GIH students.

Credit Hours 1
Prerequisites/Corequisites ENVR 541 or permission of instructor
Terms Offered Fall

ENVR 616 - Advanced Industrial Hygiene

This course provides students the opportunity to demonstrate the knowledge, skills, and attitudes to competently and ethically implement and practice applicable scientific, technical, and regulatory aspects of industrial hygiene. This course also serves as a capstone to the GIH program and provides an exhaustive review for those preparing to take the voluntary Certified Industrial Hygienist (CIH) exam, offered by the American Board of Industrial Hygiene.

Credit Hours 2
Prerequisites/Corequisites ENVR 548 or permission of instructor
Terms Offered Fall
ENVR 622 - Ecosystem Dynamics

This course looks at the integration of individual organisms and non-organic materials into ecological systems. The flow, cycling, and storage of materials and energy are studied as it relates to the maintenance of ecological balance. Nutrient cycling and nutrient limitation are emphasized as a control mechanism. The modeling of these systems in homeostasis as well as prediction of cascading disruption upon environmental insult is explored at length. Also included are alternative modeling approaches to ecological population dynamics as related to various conservation management strategies. The use of tools of system dynamics modeling is employed throughout.

Credit Hours 3
Prerequisites/Corequisites ENVR 642
Terms Offered Summer

ENVR 625 - Environmental Microbiology

This course describes the principles of biological sciences as they relate to and impact environmental systems. Microbial systems serve as models to demonstrate the complex interactions between living organisms and the physical/chemical environment. The role of microorganisms and microbial processes in environmental problems, both positive and negative, will be investigated. Specific topics include microbial physiology and genetics, aerobic and anaerobic systems, biochemical pathways, nutrient cycles, pathogens and waste-water, and bioremediation of soils and ground water.

Credit Hours 4
Prerequisites/Corequisites ENVR 640
Terms Offered Summer

ENVR 624 - Water Chemistry for Environmental Engineers

Application of the principles of equilibrium chemistry to aquatic systems. After a presentation of basic physical/chemical concepts such as conservation of mass and energy, the tendency of a system to change toward a more stable (less reactive) condition, and chemical thermodynamics, these basic concepts are applied to describe acid/base chemistry, liquid/gas and liquid/solid phase equilibria, redox reactions, and reactions of metals in aqueous systems. The course intent is to provide the student with the theoretical tools to analyze natural water systems and solve specific chemical problems related to water treatment and water pollution control technologies.

Credit Hours 4
Prerequisites/Corequisites ENVR 550, suggested
Terms Offered Spring

ENVR 640 - Groundwater Hydrology and Contaminant Transport

Groundwater is a major pathway that serves as a conduit to transport contaminants placed on the land (either intentionally or unintentionally) to environmental and human receptors. This course provides students with an understanding of the occurrence and movement of groundwater in a variety of geologic settings, as well as the fate and transport of contaminants in the groundwater. Also discussed are sampling and site characterization methods, water chemistry, computer modeling of flow and transport, and groundwater restoration technologies.

Credit Hours 3
Prerequisites/Corequisites ENVR 550, suggested
Terms Offered Spring
ENVR 643 - Environmental Transport Processes

Starting with the law of conservation of mass, this course introduces students to the processes that govern the fate and transport of contaminants in the environment. Examples of transport processes relevant to the three main environmental media—air, water, and soil, are presented. Processes such as diffusive mass transport, advection-dispersion, filtration, and adsorption are discussed, with examples showing how each process affects contaminant fate and transport in several environmental media. A section of the course is devoted to reaction kinetics and reactor modeling. Students completing this course will better understand how contaminants move about and change in the environment, as well as how transport processes can be engineered to control contamination.

Credit Hours 4  
Prerequisites/Corequisites ENVR 550 (suggested)  
Terms Offered Winter

ENVR 645 - Water and Wastewater Treatment Design

Basic course in fundamentals and design of systems for the treatment of drinking water and wastewater. Topics include: water quality analysis; principles and design of physical, chemical, and biological water and wastewater treatment processes; and residuals processing and disposal.

Credit Hours 4  
Prerequisites/Corequisites ENVR 550  
Terms Offered Summer

ENVR 651 - Environmental Risk Analysis

Risk analysis is one major component of the overall process of managing an environmental issue. Other components include economic analysis, technology assessment, law and policy analysis, and remedial action. Risk analysis involves the scientific-quantitative disciplines of risk assessment (identification and evaluation of the hazardous agent and its likelihood of exerting an effect based on an exposure assessment) coupled with the philosophical and socioeconomic considerations of what risk is acceptable and how to communicate that risk to various audiences.

This course will systematically develop the sequential processes of analyzing hazardous agent release, transport, and effect as they lead to a comprehensive assessment of risk. Standardized EPA approaches to conducting a risk assessment will also be introduced. Various approaches to the use of risk assessment information in light of social, cultural, economic, and legal constraints will be presented.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Fall

ENVR 661 - Environmental Sampling and Analysis

This course will cover the basics of environmental sampling and the statistical basis of sampling. Topics to be addressed include normal and lognormal distributions, t-tests, f-tests, random, composite, stratified and systematic sampling. Analytical procedures including solids analysis, drinking and wastewater analysis, biological oxygen demand, chemical oxygen demand, atomic absorption, gas chromatography, and ion chromatography, will be discussed and then demonstrated in the laboratory.

Credit Hours 4  
Prerequisites/Corequisites STAT 525  
Terms Offered Spring
ENVR 661 - Lab

Lab to be taken in conjunction with ENVR-661

Credit Hours 0
Prerequisites/Corequisites STAT 525
Terms Offered Spring

ENVR 699 - Master's Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 1 - 12
Prerequisites/Corequisites None
Terms Offered All

ENVR 772 - Remediation Design and Management

This upper-level class investigates the physical, chemical, and biological methods used in remediation of environmental contamination in soils, surface water, and ground waters. Processes to address contamination, including the no-action alternative, containment techniques, and pump-and-treat and in situ technologies, will be reviewed with emphasis on practical applications. Included will be a review of the regulatory requirements that often determine the remediation process. Mechanisms for selection of appropriate treatment technologies will be described.

Credit Hours 3
Prerequisites/Corequisites ENVR 640, ENVR 624, ENVR 625, ENVR 643 (suggested)
Terms Offered Fall

ENVR 799 - Independent Study

An in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis written under the supervision of a departmental professor. An oral presentation and defense of the research is required.

Credit Hours 1 - 12

EVSC 560 - Environmental Monitoring

This laboratory/lecture course is an integrated approach to sampling and analyses of pollutants or target molecules in various environmental media. The student will have a hands-on laboratory experience to illustrate statistical sampling, sampling methods, instrumental chemistry analysis, and data handling. Students will study and apply selected principles and techniques of environmental monitoring, including learning to develop sampling and analysis plans, implement sampling and analysis plans, and report results of a monitoring study.

Credit Hours 4
Prerequisites/Corequisites STAT 526 or permission of instructor
Terms Offered Spring
EVSC 650 - Environmental Measurement Techniques

This course treats the proper application of the various chemical, physical, and thermophysical analytical methods that are used to characterize environmental samples. Techniques include emission spectroscopy, atomic absorption spectroscopy, x-ray fluorescence analysis, neutron activation analysis, gamma-ray spectroscopy, wet analytical chemistry, gas chromatography, mass spectrometry, scanning electron microscopy, transmission electron microscopy, and x-ray diffractometry. Hands-on experience will be obtained in the associated laboratory.

Credit Hours 4
Prerequisites/Corequisites EVSC 560 or permission of instructor
Terms Offered As needed

EVSC 666 - Remote Sensing of the Environment

This course considers techniques for remote sensing of atmospheric and water pollution, which uses nearly the entire electromagnetic spectrum. For example, airborne and satellite visible and infrared measurements are used to map oil spills and monitor chemical effluents from facilities. Radiation source characterization and transport of that radiation through free space, along with principles of optical detection, are considered. Remote laser techniques for monitoring gaseous pollutants, including infrared absorption, laser back-scatter (lidar), laser-induced fluorescence, and Raman back-scatter, are also treated.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

FMGT 510 - Finance Theory I

This is the first of two theory courses that prepares students to analyze problems with up-to-date finance tools. The course utilizes finance theory to help students internalize the fundamental principles and concepts in finance and apply them to real-world problems. Topics covered begin with the fundamental concepts of financial management including the time value of money, financial statements, cash flow, taxes, risk and return, portfolio theory, and asset valuation. Knowledge of asset valuation is expanded by covering stocks, bonds, and options. Topics in project and corporate valuation include cost of capital, capital budgeting, cash flow estimation and evaluation, risk analysis, real options, financial statement analysis, financial planning, and corporate governance.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

HFEN 560 - Introduction to Human Factors

This course examines the study and application of humans and the system interface, including the knowledge of human cognitive/social/physical behavior, capabilities, and limitations. Topics include anthropometrics, sensation-perception, decision-making, situational awareness, display/control design, warnings/alerts, automation, human error, and accident investigation. Numerous case studies are used to highlight course topics.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter
HFEN 610 - Human Performance Measurement

Theories, concepts, and methods for measuring and evaluating human performance will be discussed with an emphasis on facilitating the design of systems having enhanced human performance and satisfaction. The student will gain practice in measuring human performance and applying the results to suggest and validate system design improvements. Influence of fatigue, environmental/task stressors, and social/team factors will be discussed.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

HFEN 663 - Human-Computer Interaction

This course examines various aspects of usability in terms of the interfaces between humans, computers, and the information upon which both depend. This course will give you a broad overview of many topics critical to understanding and evaluating usability of computer systems interfaces, and to topics critical to designing and developing interfaces that are usable by their intended audiences.

Credit Hours 3
Prerequisites/Corequisites HFEN 560
Terms Offered Summer

HFEN 670 - Human Interaction Technologies

Robust human-system interaction requires information flow between the system and human brain. This course will introduce technologies available to mediate this flow of information, discussing the important characteristics and considerations for input and output technologies. Emphasis will be provided on visual information processing and visual display design. Human auditory processing and various input device technologies and will also discussed.

Credit Hours 4
Prerequisites/Corequisites HFEN 560
Terms Offered Spring

IMGT 561 - Applications of Database Management Systems

With emphasis on data in information systems, and with the increasing complexity of data management, this course explores the applications of computer database systems to support organizational and administrative functions. More specifically, the course covers from both a user's and a designer's perspective: the concept of database management systems (DBMSs); DBMS security, integrity, recovery, and concurrency considerations; DBMS data models (the relational will be emphasized, but the hierarchical and network models will also be covered); data manipulation; and database design. Additional emphasis is placed on emerging techniques including, but not limited to, data warehousing, data marts, and data mining. Principles studied will be reinforced in the laboratory. Students will use a relational DBMS to build a management-oriented application. Further students will be introduced to a variety of databases and database related programs when opportunities arise.

Notes The four credit hours for this course consist of three lecture and two hours in the laboratory.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Winter
IMGT 561 - Lab

Lab to be taken in conjunction with IMGT-561

Credit Hours 0
Terms Offered Winter

IMGT 599 - Special Studies

Study at an advanced graduate level of a special topic that is not covered in a regularly scheduled graduate course.

Credit Hours 1 - 4
Prerequisites/Corequisites None
Terms Offered Infrequently

IMGT 657 - Data Communications for Managers

This course introduces the data communications topics in sufficient detail to prepare managers to participate in decision-making activities regarding data communication technologies for organizational information processing. The course overviews concepts of communication systems models, computer networking, and computer security. The course also reviews hardware and software requirements for controlling the flow of data using current telecommunication technology. It examines communication transmission media including twisted pair, coaxial cable, microwave, fiber optics, and satellite. It introduces methods for selecting among alternative communication systems and concludes with an exploration of the future impact of trends in the telecommunications industry on organizational information systems. Wherever possible, both peace time and war time in the military data communication systems are examined.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Spring

IMGT 669 - Business Process Improvement

This course introduces students to the concepts of business process improvement, including the most popular approach to this concept, Business Process Reengineering, by Hammer and Champy, and principles of lean thinking. This course will cover the historical reasons that organizations are structured the way they are. The students learn to re-conceptualize the organization in terms of business processes and learn how to use that knowledge to improve organizational effectiveness and efficiency. The students will learn to analyze an organization from this standpoint, and will learn to use these concepts to re-design the organization in ways that lead to doing more with less, and at the same time improving the services provided by the organizations' customers.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Summer, Fall
IMGT 680 - Knowledge Management

This seminar-based course is based on the central premise that knowledge, as opposed to the traditionally recognized resources such as land, labor, or capital, is now a primary source of competitive advantage for today's organizations. As the advantages of new products and efficiencies are more and more difficult to sustain, it is knowledge, and more specifically the creation of new knowledge, that can give organizations a competitive edge. Given that knowledge is a newly recognized key organizational resource, it must be managed as such. This course begins with an exploration of the concepts of data, information, and knowledge and their relationships in the context of managing organizational knowledge. The course also specifically addresses the people, process, and technology elements of managing knowledge and how they contribute to individual and organizational knowledge creation and innovation as well as improving the overall productivity of knowledge workers. Finally, the course helps students draw conclusions about the relationships between information management, knowledge management, systems theory organizational learning, and innovation.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Spring

IMGT 684 - Strategic Information Management

This course explores the strategic use of organizational information. This includes a top-down view of how such information is gathered, structured, organized, stored, and used. It addresses both technical and managerial issues of information and its use, with a focus on maximizing the value of information to the organization. It also covers laws and policies related to the strategic management of information.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Fall, Winter

IMGT 687 - Managerial Aspects of Information Warfare (IW)

This course explores conceptual, managerial, and technological aspects of modern information warfare (IW). Upon completion, each student will understand the dimensions of threats to an organization's mission in a globally networked environment and appreciate the implications of interconnectivity; examine the types and ranges of current vulnerabilities and threats to which an organization's information assets may be exposed; understand the interrelationships among mission, information assets, threats, and infrastructure vulnerabilities; understand and apply concepts and techniques of risk management to analyze problems under conditions of risk and uncertainty; understand and apply the concepts, methods, and tools related to planning, directing, and controlling security resources (people, material, information, and funds) in an information resource management context; develop an approach for staying current with trends and requisite skills in information assurance and security; learn to conduct strategic information planning to like the management of information and technology to the organization's strategic business plan and help build control mechanisms to implement a strategic information plan; and communicate IA information effectively through written and verbal means.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Fall
LOGM 520 - Managerial Economics

Basic microeconomic principles such as supply and demand, elasticity, short-run and long-run shifts in resources allocation, diminishing returns, economies of scale, and pricing are covered. There is a general introduction to economics and economic reasoning, including the application of economic theory to the firm. Also covered are various tools of analysis helpful to decision makers, including demand, production, and cost estimation using regression analysis, forecasting, capital budgeting, and risk analysis. The nature of economic incentives concerning consumers, workers, and business are studied.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

LOGM 525 - Statistics for Mobility Managers

This course is designed as an introductory statistics course for graduate students in the Masters of Mobility Operations program offered at the Air Mobility Warfare Center. As such, it is to be taught from a managerial, rather than a mathematical perspective. Basic statistical concepts will be taught, including probability, distributions, hypothesis testing, and problem solving. Statistical techniques to be covered include both descriptive and inferential statistics, such as frequency distributions, histograms, regression analysis, chi-square, ANOVA, and nonparametric analysis. Emphasis is on the selection and analysis of statistical output, rather than manual computation, through the utilization of the software that is integrated with the text material.

Notes REMARKS: This course is open only to students in the Ft. Dix Air Mobility program.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Summer-Ft. Dix Only

LOGM 565 - Strategic Sourcing

This course provides an introduction to and an overview of the strategic sourcing process including topics such as supplier selection, supplier evaluation, negotiation, contract management, supplier development, e-procurement, buyer-supplier relationships, strategic cost management, and purchasing law and ethics.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter-Distance Learning Only; Spring

LOGM 567 - Lean Operations Management

Creating, sustaining, and employing military capability is the purpose of military leadership and management. Operations management theory outlines how organizations perform the systematic direction and control of the processes that transform inputs into finished goods and services. In the past decades, the concept on leanness has emerged as a management philosophy that can facilitate increased productivity while simultaneously reducing costs and improving service to the customer/warfighter. This course presents basic operations management concepts as well as the lean principles with a focus on how lean changes traditional operations management.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Spring, Summer
LOGM 568 - Introduction to Supply Chain Management

This class provides an introduction to and overview of supply chain management concepts and practices with an emphasis on the areas related to logistics (a sub-area of supply chain management). Supply chain management and its supporting activities of strategic planning, purchasing, operations management, and logistics represent one of the cornerstones of competitive strategy for most organizations, including the Department of Defense. This course introduces the concepts and tools that will enhance the student's understanding of supply chain management and their ability to effectively manage various supply chain operations.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter-Distance Learning only; Summer-Ft. Dix Only

LOGM 569 - Maintenance and Production Management

This course explores operations management functions as applied to an Air Force environment. The course familiarizes the student with a variety of operations management techniques which are being applied in maintenance as well as a variety of other operations management settings. Course topics include productivity, facility layout, location, capacity planning, quality control, scheduling, project management, queuing theory, inventory management, forecasting, and current operations management innovations.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring

LOGM 570 - Principles of Inventory Management

This course develops a fundamental understanding of the design and operation of inventory management systems. Specifically, this course provides students with a broad survey of methods and issues concerning inventory systems such as (1) logistics pipeline with emphasis on the DoD, (2) demand data and forecasting methods, (3) consumable and reparable item inventory models, (4) information theory, and (5) management implications.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

LOGM 590 - Computer Simulation for Managers

The course concentrates on the concept of designing a model, and analyzing the results. The course's main emphasis is on the proper use of simulation techniques to model systems and answer logistics questions. Course work focuses on the use of the computer to enhance the decision-making capabilities of the logistics manager. This course provides the student with a working knowledge of discrete-event computer simulation as a decision-making tool.

Credit Hours 4
Prerequisites/Corequisites MATH 291, STAT 525, STAT 535
Terms Offered Winter, Spring
LOGM 590 - Lab

Lab to be taken in conjunction with LOGM 590

Credit Hours 0
Prerequisites/Corequisites LOGM 590
Terms Offered Winter, Spring

LOGM 601 - Principles and Methods of Research

The course provides information on how to conduct an appropriate review of literature to identify gaps and opportunities surrounding the problem area, and to identify and to evaluate approaches for data collection and analysis leading to valid inference about the topic into answerable research and investigation questions leading to a formal research proposal. The broadest scope of qualitative and quantitative research methods are discussed. Application of appropriate research designs and analysis tools are course outcomes.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall-Ft. Dix Only; Spring; Summer-IDE Only

LOGM 617 - Transportation Systems and Strategic Mobility

Examines each transportation mode for similarities and differences. Ownership of the modes is also detailed, along with cost and service characteristics. Each mode is then examined for its particular contribution to the defense transportation system. The mission, organization, resources and financing arrangements of the three transportation operation agencies of the defense transportation system are examined. Problems associated with strategic mobility are emphasized.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall-Ft. Dix Only; Winter

LOGM 619 - Transportation Policy and Strategic Mobility

Focuses on a study of the complex national and defense policy frameworks that guide the constant development of the Department of Defense. Examines how policy impacts and is, in turn, impacted by policies formulated to address other national issues. Particular emphasis is placed on the study of the effects of national policies on the Department of Defense. Policy analysis models are presented and discussed.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall; Spring-Ft. Dix Only

LOGM 620 - Activity Based Costing/Management

This course is designed to give the students knowledge of Activity Based Costing (ABC), why traditional accounting practices do not support managerial decision-making, and techniques to perform ABC. Activity Based Management will be introduced to enable the student to utilize the output from ABC. The development and application of non-financial metrics will be covered. Students will be introduced to the Theory of Constraints, and Balanced Scorecard will be covered. Examples from DoD and the commercial sector will be used to illustrate the application of ABC.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Summer
LOGM 621 - Air Transportation Management

This course focuses on the air operations/air management aspect of the transportation network. As such, the students are expected to develop an understanding of both civilian and military air cargo and air passenger network operations. Topics covered will include: Airline/Air Cargo forecasting and management, principles of air scheduling, and the interaction between the civilian and military air transportation systems. Similarities and differences between these two systems will be covered extensively. The reliance of the DoD on civilian air transportation will be emphasized.

Notes

Credit Hours 3
Prerequisites/Corequisites LOGM 617
Terms Offered Winter-Ft. Dix Only

LOGM 627 - Supply Chain Management

This course concentrates on the cross-functional integration of key business processes within the firm and across the network of firms that comprise the supply chain in both commercial and DoD organizations. Emphasis is on managing the complexity of the supply chain, developing supply chain strategies, selecting metrics, and mapping supply networks. The concept of business partnerships will also be explored. A capstone project provides students with hands-on experience in managing the integration of functional skills such as planning, forecasting, inventory management, and distribution.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter; Spring-Ft. Dix and In-Residence

LOGM 630 - Forecasting Management

Since the DoD community collects much of its data as a natural time series, this course is concerned with the application of time series analysis theory in describing and forecasting logistics performance. This course covers analysis of time series data patterns, introduction of major forecasting techniques, measuring the effectiveness of these techniques, and implementing time series analysis theory in describing and forecasting logistics performance. Statistical development will be brief with intent to survey a wide variety of concepts. Forecasting methods covered include: moving average, exponential smoothing, regression, econometric, and Box-Jenkins.

Credit Hours 3
Prerequisites/Corequisites STAT 525, STAT 535
Terms Offered Fall (Cross-listed with OPER 684)

LOGM 631 - Scheduling: Theory and Application

This course is an introduction to scheduling theory with applications in manufacturing and services. The course is of primary interest to officers in maintenance career field who often encounter production scheduling problems in an industrial setting as well as workforce scheduling problems. Manufacturing applications include machine scheduling, job shop scheduling, scheduling of flexible assembly systems, and planning and scheduling supply chains. Services applications include reservations and timetabling, tournament scheduling, planning and scheduling in transportation, and workforce scheduling. The course is quantitative in nature but will also address management.

Credit Hours 3
Prerequisites/Corequisites MATH 291, STAT 525, and STAT 535
Terms Offered Summer
LOGM 634 - Reliability, Maintainability, and Supportability

Creating and sustaining military capability is the purpose of military leadership and management. Reliability and maintainability (R&M) are component characteristics which define the ability of a product to perform its specified functions throughout its operational life. Component R&M of the military system are primary determinants of military capability. This course teaches fundamental R&M and product warranty concepts. Additionally, probability theory is discussed and employed as a tool to quantitatively define these concepts. Topics discussed include the measures which quantitatively define component R&M, the relationships between reliability, maintainability, and availability, and the prediction of R&M measures.

Credit Hours 3  
Prerequisites/Corequisites  
Resident Students: STAT 525, STAT 535 or equivalents. Ft. Dix Students: LOGM 525  
Terms Offered Fall-Distance Learning, In-Residence, and Ft. Dix

LOGM 636 - Service Operations Management

The body of knowledge pertaining to the management of operations has evolved largely in the context of manufacturing. However, the majority of operations in both the commercial and defense sectors are more properly classified as services, whose outputs are less tangible. This course draws on production management techniques to enhance the effectiveness of managers of service operations. Topics covered include characteristics of services, establishing customer service levels, designing service delivery systems, measuring systems performance, the psychology of waiting lines, and scheduling personnel and capacity.

Credit Hours 3  
Prerequisites/Corequisites LOGM 568  
Terms Offered Winter-Ft. Dix Only

LOGM 644 - Current Topics in Logistics

This course is a seminar-based investigation into current and emerging topics which originate in, or affect, logistics thought or action. The purpose of this course is to provide knowledge depth to students on critical issues most likely to affect the logistics field in the coming years. The main source of these issues will be recent academic and trade publications. Following individual, in-depth critiques of these works, class members will discuss topics in an open discussion format. Students will be challenged to take and defend their positions on a variety of issues relevant to the field of logistics. A final project will allow each student to more deeply explore an area of special interest within the field of logistics.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Summer-Distance Learning and In-Residence

LOGM 650 - Seminar in Space Logistics

This course will address, in a seminar format, the activities associated with supporting all aspects of military and civilian space operations. Topics to be covered include: logistical support for spacecraft, satellites, stations, facilities, or other entities on earth orbits, or on orbits/ trajectories associated with or situated on other celestial bodies. Discussion will address planning for total life cycle support, continued support of operation and maintenance, and current issues in space logistics operations and support.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Fall (As needed)
LOGM 651 - Petroleum Management

This course provides an overview of the primary aspects of petroleum management within the Department of Defense. Major topics covered include product procurement, transportation modal selection, storage and inventory management, quality assurance, distribution, and joint operations. Additional areas include alternative fuels, environmental concerns, and interfaces with key Department of Defense organizations.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered As needed

LOGM 660 - Strategy for Logistics

This course focuses on the strategy process and its specific application to the logistics discipline. It covers the strategy formulation, implementation, and evaluation process at the enterprise level to include discussions of the top level decisions and their long-term impact on the organization. The course will apply those concepts to the major decision factors involving infrastructure and organizational issues in logistics enterprises and business units.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Fall

LOGM 675 - Logistic Management Colloquium

This course introduces students to current issues, concerns, and practices of logistics management through a series of presentations by key logistics personnel during the graduate program.

Credit Hours 0 credit hours
Prerequisites/Corequisites None
Terms Offered All

LOGM 678 - Advanced Topics in Logistics

This course is intended for students planning advanced study and research in the areas of logistics and supply chain management. A continuation of material covered in LOGM 627, the course covers in more detail the theoretical properties of product support and physical distribution systems found in defense and commercial sector contexts. Course topics are drawn from the current literature.

Credit Hours 3
Prerequisites/Corequisites LOGM 627
Terms Offered As needed

LOGM 6770 - Advanced Inventory Theory

This course develops advanced concepts in the design and operation of inventory management systems. Specifically, this course will examine various research methods to study advanced inventory theories. Students will investigate inventory theoretic issues such as demand data, forecasting of inventory requirements, dependent and independent inventory modeling, and select topics as determined by the professor. The emphasis is on both analytic development and data analysis.

Credit Hours 3
Prerequisites/Corequisites LOGM 570
Terms Offered As needed
LOGM 791 - Research Project for Mobility Managers

A research topic is selected from mobility problems of interest to USAF and DoD. This topic is thoroughly investigated by the student, and the findings, recommendations, and conclusions are presented as a graduate research paper under the supervision of an AFIT faculty member.

Credit Hours 1-7
Prerequisites/Corequisites None
Terms Offered Winter; Spring-Ft. Dix and In-Residence

MATH 291 - Calculus for Engineering Managers

Preparatory course in which the student reviews and studies mathematical prerequisites required for the core courses in the graduate management programs. This course establishes competence with standard material in differential and integral calculus, including multivariable calculus.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Fall

MATH 302 - Elementary Differential Equations

This course is an introduction to ordinary differential equations. Topics include linear first-order differential equations, linear second-order homogeneous differential equations with constant coefficients, the method of undetermined coefficients, the method of variation parameters, power series solutions, an introduction to eigenvalues and eigenvectors for matrices, systems of first-order linear equations, reduction of linear differential equations to a first-order system, and solution of linear differential equations using Laplace transforms.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Summer

MATH 504 - Differential Equations of Mathematical Physics

This course builds proficiency with series solutions for ordinary differential equations with variable coefficients in the complex plane. It provides specific information on Bessel, Legendre functions, Laguerre and Hermite polynomials. Other special functions of mathematics are introduced including gamma and beta functions. The course covers the needed topics in complex variables such as analytic function, singularities, power series expansions, contour integration and residue theory.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Fall
MATH 508 - Applied Numerical Methods


Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Winter, Spring

MATH 509 - Mathematical Methods in the Physical Sciences

This course covers basic topics in linear algebra and the calculus of several variables. Topics from linear algebra include matrix algebra, solutions of systems of linear equations, real vector spaces, and linear transformations between real vector spaces. Topics from several variable calculus include partial differentiation, directional derivatives, functional transformations and Jacobians, maxima and minima, and integration in two and three variables.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Winter, Spring, Summer, Fall

MATH 511 - Methods of Applied Mathematics I


Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Winter, Summer, Fall

MATH 513 - Methods of Applied Mathematics II


Credit Hours 4
Prerequisites/Corequisites MATH 511
Terms Offered Winter, Spring
MATH 521 - Applied Linear Algebra

Algebra of matrices, the theory of finite dimensional vector spaces, and basic results concerning eigenvalues and eigenvectors with particular attention given to topics that arise in applications.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Spring, Fall

MATH 523 - Numerical Analysis and Linear Algebra

This course presents the basic concepts necessary for the qualitative and quantitative analysis of mathematical systems. The goal is to understand the underlying mathematical concepts as well as be able to explain the numerical issues when faced with a computational technique. Topics include vector spaces, systems of linear equations, norms, eigenvalues, and numerical iterative methods.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Fall

MATH 600 - Mathematical Analysis

This course provides the transition from elementary calculus to advanced courses (6XX and above) that require mathematical analysis with rigor. Topics include basic notions of set theory, point set topology, limits and continuity, derivatives, functions of bounded variation, Riemann-Stieltjes Integration, uniform convergence of sequences and series of functions and their consequences, and Lebesque measure and integration theory.

Credit Hours 4
Prerequisites/Corequisites Permission of Department
Terms Offered Spring, Fall

MATH 601 - Complex Analysis

Introduction to the theory of complex variables, analytic functions, elementary functions and their geometry; integrals; power series, residues and poles; conformal mapping; applications.

Credit Hours 4
Prerequisites/Corequisites MATH 600 OR MATH 602
Terms Offered Summer

MATH 602 - Modern Applied Mathematics I

Introduction to the foundations and applications of modern applied mathematics for students of applied science. Topics include distribution theory and Green’s functions applied to one-dimensional boundary value problems, classical and weak solutions, alternative theorems, functions and transformations, Banach and Hilbert spaces, linear functionals, basic properties of linear and metric spaces including topology, continuity, differentiability, convergence of sequences and series of functions.

Credit Hours 4
Prerequisites/Corequisites Permission of Department
Terms Offered Fall

MATH 604 - Modern Applied Mathematics II

This is a course in applied functional analysis. Topics include linear operator theory and applications to (approximate) solutions of boundary value problems of applied science, closed operators, the inverse operator, adjoint and compact operators, spectrum, contraction mappings, Fredholm integral equations.

Credit Hours 4
Prerequisites/Corequisites MATH 602
Terms Offered Winter
MATH 605 - Nonlinear Differential Equations

Topics include linear systems with an introduction to phase space analysis, existence theory, stability of linear and almost linear systems. Lyapunov’s second method, applications to nonlinear problems and optimal control theory, bifurcation theory and chaos.

Credit Hours 4
Prerequisites/Corequisites MATH 600 OR MATH 602
Terms Offered Spring

MATH 607 - Calculus of Variations

Topics include a study of functionals, fixed and variable end point problems, canonical forms of the Euler equations and related topics, sufficient conditions for a weak extremum, fields, sufficient conditions for a strong extremum, variational problems involving multiple integrals, direct variational methods, and applications.

Credit Hours 4
Prerequisites/Corequisites MATH 600 OR MATH 602
Terms Offered Winter

MATH 611 - Introduction to Partial Differential Equations

Introduction to the fundamental concepts of partial differential equations and applications emphasizing the use of these basic concepts. Topics considered include classification, reduction to canonical form, existence of solutions, variational principles, methods of obtaining solutions of the basic types of equations using analytical methods. Some numerical methods are presented.

Credit Hours 4
Prerequisites/Corequisites MATH 600 OR MATH 602
Terms Offered Winter

MATH 621 - Linear Algebra

Basic algebraic properties of vector spaces and matrices, including dimension and bases, linear transformations, determinants, similarity and congruence, solutions of linear systems of equations, generalized inverses, singular value decompositions, Jordan normal form, norms and inner products.

Credit Hours 4
Prerequisites/Corequisites MATH 521
Terms Offered Spring, Fall

MATH 631 - Algebraic Structures

An introduction to the algebra of semigroups, monoids, groups, rings, integral domains, fields and categories. Emphasis is placed on gaining a fundamental understanding of these basic algebraic structures so that the successful student will be able to apply the material in familiar and unfamiliar settings.

Credit Hours 4
Prerequisites/Corequisites MATH 600 or Permission of the Department
Terms Offered Winter

MATH 633 - Graph Theory

An introduction to the theory and application of graphs. Topics include introductory concepts and definitions, digraphs, connected and disconnected graphs, graph traversals, connection problems, trees, planar and nonplanar graphs, Eulerian and Hamiltonian graphs, coloring problems, graph isomorphisms, multigraphs.

Credit Hours 4
Prerequisites/Corequisites Permission of the Department
Terms Offered Spring
MATH 672 - Numerical Linear Algebra


Credit Hours 4
Prerequisites/Corequisites MATH 521 or Permission of the Department, and Programming Experience
Terms Offered Winter

MATH 674 - Introduction to Numerical Analysis

Roots of nonlinear equations, interpolation and approximation of functions, techniques for numerical integration and differentiation, techniques for solving ordinary differential equations, error estimates and convergence analysis for each topic.

Credit Hours 4
Prerequisites/Corequisites MATH 521 and either MATH 600 or MATH 602
Terms Offered Spring

MATH 676 - Numerical Analysis for Partial Differential Equations


Credit Hours 4
Prerequisites/Corequisites MATH 674 or Permission of the Department
Terms Offered Fall

MATH 699 - Master's Level Special Studies

Study at a beginning graduate level of a special mathematics topic that is not covered in a regularly scheduled graduate course.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Department
Terms Offered Infrequent

MATH 705 - Linear Functional Analysis

Introduction to metric spaces and normed linear spaces, operators and functionals on a Banach space, dual space; concrete representations and applications in Hilbert space, Hahn-Banach theorem, Open Mapping theorem, Banach-Steinhaus theorem, Closed Graph theorem, and topics in spectral theory.

Credit Hours 4
Prerequisites/Corequisites MATH 600, AND MATH 621 OR MATH 672
Terms Offered Spring

MATH 799 - Independent Study

The topic for an independent study is selected from a wide variety of problems usually of current interest to the Air Force. The results of the study are reported in a thesis written under the supervision of a department faculty member and are presented in a formal oral report.

Notes Ordinarily this study extends over three quarters and no credit is given until the end of the last quarter.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Department
Terms Offered Winter, Spring, Summer, Fall
MATH 831 - Mathematical Optimization and Control

Modern Banach space formulation of optimization and control problems; calculus in Banach spaces; Gateaux and Frechet derivatives; optimization of functions. The geometric approach to optimal estimation in a Hilbert space; the global and local theory of constrained optimization in a Banach space; iterative methods of optimization.

Credit Hours 4  
Prerequisites/Corequisites MATH 705  
Terms Offered Fall

MATH 899 - Doctoral Level Special Studies

Study at an advanced graduate level of a special mathematics topic that is not covered in a regularly scheduled graduate course.

Credit Hours 1-12  
Prerequisites/Corequisites Permission of Department  
Terms Offered As needed

MATL 498 - Materials Selection Seminar

Definition of material properties as they relate to load bearing structural materials. General discussion of constitutive equations and how material properties are necessary both for stress strain relationships and for limit load analyses. Presentations on the material characteristics, strengths, weaknesses, applications, problems, and current research objectives for airframe metals, high temperature metals, organic composites, metal matrix composite, carbon-carbon, viscoelastic materials.

Credit Hours 1  
Prerequisites/Corequisites Undergraduate strength of material course  
Terms Offered As needed

MATL 525 - Thermodynamics and Kinetics of Materials

Applications of thermodynamics and kinetics relevant to materials science and engineering are presented. Concepts treated include free energy of phases, phase diagrams, metastability, and applications to problems in solids and thin films. Thermodynamics is applied to pure materials, solid solutions, phase equilibria, interfaces and defects. Kinetics topics include diffusion in solids, nucleation kinetics, composition-invariant solid/solid interface migration, and kinetics of surface deposition.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Spring

MATH 999 - Dissertation Research

Dissertation research conducted in mathematical analysis, including both the research itself and the preparation and defense of the prospectus and dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

Notes Remarks: This course is graded on a P (progress) or U (unsatisfactory) basis.

Credit Hours 1-12  
Prerequisites/Corequisites Approval of Research Advisor  
Terms Offered Winter, Spring, Summer, Fall

MATL 999 - Dissertation Research

Dissertation research conducted in mathematical analysis, including both the research itself and the preparation and defense of the prospectus and dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

Credit Hours 1-12  
Prerequisites/Corequisites Approval of Research Advisor  
Terms Offered Winter, Spring, Summer, Fall
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites/Corequisites</th>
<th>Terms Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATL 545</td>
<td>Mechanical Properties of Materials</td>
<td>Course is designed to provide a background for the understanding of the mechanical behavior of metals, ceramics, polymers, and composites in aerospace applications. Topics include behavior of materials under simple and combined stress systems, elastic and plastic behavior, introduction to dislocation theory, plastic deformation of single crystals and polycrystalline aggregates, strengthening mechanics, fatigue, creep, residual stress, fracture, and mechanical testing.</td>
<td>4</td>
<td>Permission of Instructor</td>
<td>Fall</td>
</tr>
<tr>
<td>MATL 560</td>
<td>Electronic, Magnetic and Optical Properties of Materials</td>
<td>Introduction to the theory and engineering applications of electronic, magnetic, and optical materials. Atomic bonding, crystal structure, crystal defects, lattice properties, diffusion, electrical properties of materials, metals, dielectrics, semiconductors, magnetic properties of materials, ferroelectrics, superconductors, polymers, ceramics and the growth and processing of materials are covered. Use of such materials in solid state devices, hard and soft magnets, superconductors, and optical devices are treated.</td>
<td>(4-0)4</td>
<td>Undergraduate Materials Science Course</td>
<td>Fall</td>
</tr>
<tr>
<td>MATL 598</td>
<td>Materials and Processes Seminar</td>
<td>Current technologies, applications, and research issues in the materials and processes are presented by experts from the Air Force, Industries and other universities.</td>
<td>4</td>
<td>None</td>
<td>As needed</td>
</tr>
</tbody>
</table>
MATL 620 - Chemistry of Materials

A study of the electrochemistry, inorganic chemistry, organic chemistry, polymer chemistry and solid-state chemistry relevant to synthesis processing of materials. Computational methods of predicting and correlating materials structure with properties of alternative materials will be introduced. This course introduces the student to chemistry of materials and chemical processes which use or produce significant quantities of toxic chemicals. Emphasis will be placed on chemistry of materials and processes important in current and future aerospace manufacture and maintenance. This course provides background for understanding pollution prevention.

Credit Hours 4
Prerequisites/Corequisites MATL 525 or permission of instructor
Terms Offered As needed

MATL 662 - Electronic Properties of Molecules and Solids

This course is an introduction to the electronic behavior of molecules and solid state materials with an emphasis on the symmetrization postulate, tight binding methods, band theory, Hartree Fock - self consistent field methods, configuration interaction methods, and density functional theory.

Credit Hours 4
Prerequisites/Corequisites MATL 620, PHYS 655
Terms Offered As needed

MATL 672 - Optical Properties of Materials

Study of the various optical phenomena in materials; topics will be selected from absorption, reflection and emission processes, luminescence, dispersion theory, optical materials, polymers, wave propagation in anisotropic media, and nonlinear properties of materials. Application will be made to the material requirements of optical devices such as lasers, detectors, etc.

Credit Hours 4
Prerequisites/Corequisites PHYS 670
Terms Offered Summer

MATL 672 - Optical Properties of Materials

Study of the various optical phenomena in materials; topics will be selected from absorption, reflection and emission processes, luminescence, dispersion theory, optical materials, polymers, wave propagation in anisotropic media, and nonlinear properties of materials. Application will be made to the material requirements of optical devices such as lasers, detectors, etc.

Credit Hours 4
Prerequisites/Corequisites PHYS 670
Terms Offered Summer
MATL 680 - Materials Characterization

The objective of this course is to provide an integrated view of characterization as a process requiring application of many methods to extract information about a material. Two classes of methods are considered, those using particles and those using waves. Particles are grouped into photons (visible, infrared, ultraviolet, x-ray), electrons, and atoms/ions/neutrons. Frequency ranges of waves include acoustic and microwave. The challenge in characterization is to understand the probe-material-sensor interactions, because these are the drivers to characterizing the material. Only a few specific methods are covered as representatives of the several hundred methods now used.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Winter

MATL 685 - Materials Selection and Processing

An introduction to methods for logical choice of materials processes for applications with emphasis on aerospace requirements. Includes methods for assessment of risk and cost with respect to requirements.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Spring

MATL 689 - Master's Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All
MATL 701 - Research Apprenticeship

Students will work on special problems related to an individual professor’s or laboratory scientist’s materials research program. These special problems will range from pedagogical problems intended to bring the student up to the state of knowledge to problems which represent immediate goals of a research program. The problems may be computational, experimental or theoretical and will vary depending upon the needs of the student and the individual research interests of the professor or laboratory scientist.

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered Summer

MATL 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

Credit Hours 1-12
Prerequisites/Corequisites Permission of instructor
Terms Offered All

MATL 899 - Doctoral Level Independent Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Research Advisor
Terms Offered Any

MATL 899 - Doctoral Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All
MECH 500 - Fundamentals of Solid Mechanics

Analysis of deformation, strain, and stress continuum. Introduction to elasticity, including definitions of stress, strain, compatibility, equilibrium, generalized Hooke’s law, and boundary conditions. Beams in tension, torsion, shear, and bending analyzed by applying St. Venant’s Semi-Inverse Principle and the Principle of Minimum Potential Energy.

Credit Hours 4  
Prerequisites/Corequisites Undergraduate Strength of Materials  
Terms Offered Fall

MECH 515 - Theory of Vibrations


Credit Hours 4  
Prerequisites/Corequisites MECH 521 or equivalent  
Terms Offered Winter

MECH 521 - Intermediate Dynamics

Three-dimensional kinematics using generalized vector notation, rotating and translating coordinate frames, particle and rigid body dynamics, equations of motion via direct and indirect methods, equations of motion via Lagrangian approach, aerospace vehicle applications.

Credit Hours 4  
Prerequisites/Corequisites Undergraduate Dynamics  
Terms Offered Fall

MECH 529 - Dynamics and Control of Flight Vehicles


Credit Hours 4  
Prerequisites/Corequisites MECH 521 or equivalent  
Terms Offered Winter

MECH 532 - Introductory Space Flight Dynamics

Formulation and solution of the two-body problem in three dimensions. Orbital elements, reference frames, coordinate transformations, orbit determination methods, basic orbital maneuvers. Formulation and description of basic attitude dynamics and control concepts, including spin, dual-spin, three-axis, and gravity gradient stabilization.

Credit Hours 4  
Prerequisites/Corequisites Undergraduate Dynamics or Permission of Instructor  
Terms Offered Winter, Fall

MECH 541 - MECH of Composite Materials

Introduction to the analysis of composite materials. The nature and scope of composite materials are discussed as well as mechanical behavior. Micromechanics, macromechanics, and characterization of composite materials are presented. Emphasis is placed on gaining a basic understanding of composite materials behavior from both the applied mechanics and materials science aspects.

Credit Hours 4  
Prerequisites/Corequisites MECH 500  
Terms Offered Winter
MECH 542 - Introduction to Finite Element Analysis and Computer-Aided Design

Introduce finite element analysis and computer-aided design tools for analyzing, pre-, and post-processing finite element models. Review historical development of finite element analysis and related computational tools. Demonstrate finite element process for truss elements. Program simple finite element code for trusses. Learn graphics software in AFIT computer environment to model one-, two-, and three-dimensional structures. Use pre-processor to create geometric models and associated finite element meshes. Use post-processor to generate deformed geometry, x-y plots, and contour plots. Present modeling guidelines and adaptive meshing techniques.

Credit Hours 4  
Prerequisites/Corequisites MECH 500 or MECH 545  
Terms Offered Winter

MECH 545 - Aerospace Structural Analysis

External loads on the aircraft, forces and load factors on space structures, spanwise airload distribution, shear and bending in symmetrical and unsymmetrical beams, analysis of typical semimonocoque structures, wing beam theory, deflections in aircraft structures, energy methods, introduction to structural stability and structure-aerodynamic interactions.

Credit Hours 4  
Prerequisites/Corequisites Undergraduate strength of materials  
Terms Offered Fall, Winter and Summer

MECH 600 - Elasticity

A review of linear, infinitesimal continuum theory. Introduction to nonlinear elasticity. Solutions in curve linear coordinate problems. Introduction to plate theory, buckling and instability.

Credit Hours 4  
Prerequisites/Corequisites MECH 500  
Terms Offered Winter

MECH 601 - Introduction to Time-Dependent Material Behavior

The objective is to provide a fundamental background in inelastic solid mechanics. Phenomenological aspects (observed experimentally) of inelastic behavior of real engineering materials are presented and inelastic constitutive models are introduced. Topics include Kelvin-Voigt, Maxwell and Standard Linear Solid models for materials with internal variables, creep and stress relaxation, linear and nonlinear viscoelasticity, correspondence principle, and time temperature equivalence of thermorheologically simple materials. In addition, rate-independent plasticity, viscoplasticity, yield criteria, yield surfaces, and isotropic and kinematic hardening rules are discussed.

Credit Hours 4  
Prerequisites/Corequisites MECH 500  
Terms Offered Summer
MECH 605 - Fracture Mechanics

The course is designed to acquaint students with analytical and experimental techniques used to solve current fracture problems. Specific course objectives are to develop the linear elastic fracture mechanics principles which allow one to predict the critical crack size for a given component (i.e., predict fatigue crack growth, stress corrosion cracking, etc.). The role fracture mechanics can play in assuring fracture prevention is discussed, with emphasis on current USAF requirements.

Credit Hours 4  
Prerequisites/Corequisites MECH 500, or MECH 545 or Permission of Instructor  
Terms Offered Spring

MECH 620 - Systems Optimization

This course covers theory and procedures for optimizing multivariable, non-linear objective functions that measure system performance. Topics include: formulation of classical and Kuhn- Tucker optimality conditions; numerical algorithms for solving classes of problems – linear programming, gradient and simulated annealing search techniques for nonlinear problems, multi objective optimization theory; and special topics illustrated with problems in aerospace design.

Credit Hours 4  
Prerequisites/Corequisites MATLAB Programming  
Terms Offered Winter

MECH 622 - Functional Optimization and Optimal Control

Variational techniques are applied to optimize linear and nonlinear dynamic systems with respect to prescribed inequality constraints. Optimization of functionals using the calculus of variations and Pontryagin’s Maximum Principle, leading to the derivation and solution of the optimal control problem. Special topics include: bang-bang control, dynamic programming, terminal controllers and regulators, perturbation techniques and singular solutions.

Credit Hours 4  
Prerequisites/Corequisites ASYS 565 or Permission of Instructor  
Terms Offered Spring

MECH 628 - Aircraft Control

Introduction to aircraft flight control systems. Response to control inputs. Use of classical control theory to analyze and design longitudinal and lateral autopilots. Digital computer techniques and response to random inputs.

Credit Hours 4  
Prerequisites/Corequisites MECH 529, ASYS 565 or equivalent  
Terms Offered Spring

MECH 629 - Aircraft Handling Qualities and Performance

This course presents an overview of aircraft performance and handling qualities. Topics covered in performance include climb, cruise, and turn performance. The flying qualities portion includes aircraft dynamics, classical aircraft handling qualities, parameters, pilot modeling, pilot ratings and their prediction.

Credit Hours 4  
Prerequisites/Corequisites MECH 529  
Terms Offered Summer
MECH 632 - Intermediate Space Flight Dynamics

Rigorous development of equations of motion of a rigid body in a gravitational field. Decoupling the translational and rotational equations of motion. Ballistic missile and interplanetary trajectories. The three-body problem and perturbation methods. Analysis of important problems in attitude dynamics and control, including reorientation, despin, control moment gyros, and reaction wheel systems. Introduction to attitude determination methods.

Credit Hours 4
Prerequisites/Corequisites MECH 532 and MECH 521
Terms Offered Spring

MECH 637 - Astrodynmic Re-Entry


Credit Hours 4
Prerequisites/Corequisites MECH 521
Corequisites: MECH 532 (if not previously taken) or permission of instructor
Terms Offered Summer

MECH 642 - Finite Element Methods for Structural Analysis I


Credit Hours 4
Prerequisites/Corequisites MECH 542
Terms Offered Spring

MECH 662 - Introduction to Aeroelasticity


Credit Hours 4
Prerequisites/Corequisites AERO 535 and MECH 515.
Terms Offered Spring

MECH 699 - Master's Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites Permission of Instructor
Terms Offered All
MECH 712 - Nonlinear Oscillations


Credit Hours 4
Prerequisites/Corequisites MECH 720 or Permission of Instructor
Terms Offered Spring

MECH 719 - Vibration Damping and Control

A survey course in vibration damping and control providing the necessary background to analyze structural vibrations and design effective and efficient vibration suppression using either passive or active means. Topics covered include modal analysis, viscoelastic damping treatments, vibration absorbers, vibration isolators, and active feedback control using both traditional and adaptive structures technology.

Notes Method of instruction will include both lecture and laboratory sessions.

Credit Hours 4
Prerequisites/Corequisites MECH 515 and ASYS 565 or Permission of Instructor
Terms Offered Fall

MECH 720 - Analytical Mechanics

Elements of calculus of variations, virtual work, D’Alembert’s principle, Lagrange and Hamilton’s equations of motion; applications of holonomic and nonholonomic systems with emphasis on rigid body motion and gyroscopic instruments.

Credit Hours 4
Prerequisites/Corequisites MECH 521
Terms Offered FALL

MECH 731 - Modern Methods of Orbit Determination

Introduction to probability theory. Statistical mission assessment. Derivation of the method of least squares in linear and nonlinear problems. Sequential estimation methods, including numerical instabilities and time weighting. Applications to the problem of determining and updating the orbital elements of satellites.

Credit Hours 4
Prerequisites/Corequisites MECH 532
Terms Offered Summer

MECH 732 - Advanced Astrodynamics

Introduction to canonical dynamics and applications to the two body problem. Classical and canonical variation of parameter equations of motion. Forces influencing earth satellite motion are surveyed. Applications to earth satellite motion. Additional topics from resonance, stability, periodic motion.

Credit Hours 4
Prerequisites/Corequisites MECH 521
Terms Offered Winter
MECH 899 - Doctoral Level Special Study

Course content determined by faculty member based on student need

Credit Hours 1 – 12
Prerequisites/Corequisites Permission of Research Advisor
Terms Offered All

MENG 501 - Aerospace Propulsion

This course provides the student with an understanding of the essential elements of air-breathing and non-air-breathing propulsion systems. Covered are basic principles of thermodynamics and fluid dynamics applied to the analysis of on-design and off-design performance of turbojet systems (turbojet, turbofan, turboprop), to performance parameters of ramjet and scramjet engines and to fundamentals of chemical and non-chemical rocket propulsion.

Notes Performance trade-offs are reviewed relative to military applications.

Credit Hours 4
Prerequisites/Corequisites Undergraduate thermodynamics
Terms Offered Fall

MENG 530 - Chemical Rocket Propulsion

Development of performance parameters, analysis of combustion, fluid mechanics, and heat transfer as they pertain to rocket engines and motors, comparison of propellants, and analysis of simple rocket flight and staging.

Credit Hours 4
Prerequisites/Corequisites Undergraduate thermodynamics
Terms Offered Winter

MENG 531 - Space Propulsion and Power Systems

Concept, theory and performance of chemical and non-chemical propulsion systems for use in space. Typical systems will include electrical, nuclear, liquid propellant, and exotic space propulsion systems. Concept, theory and performance of power generation methods in space. Systems studied will include low and high power systems intended for short term or long term applications. Chemical, solar, and nuclear devices and the energy conversion means for converting energy from these sources into useful electrical power will be studied. An overview of space mission requirements and how they impact propulsion and power system selection. Review of current and future trends in spacecraft propulsion and power generation.

Credit Hours 4
Prerequisites/Corequisites Undergraduate thermodynamics course
Terms Offered Summer
MENG 571 - Fundamentals of Heat Transfer

Fundamentals of conduction, convection and radiation heat transfer. Derivation and solution of the general heat conduction equation for one and two dimensional, steady and unsteady conduction problems. Both analytical and numerical solution techniques will be covered. Forced convection in laminar and turbulent flows on internal and external surfaces. Radiation heat transfer among surfaces. Application to thermal processes in a variety of systems.

Credit Hours 4  
Prerequisites/Corequisites Permission of Instructor  
Terms Offered Summer

MENG 633 - Fundamentals of Combustion

This course is designed to provide an understanding of the fundamentals of combustion aerodynamics. Topics include (1) Chemical thermodynamics: heats of reaction and flame temperature; (2) Chemical kinetics: rates of reaction, reaction order, chain reactions, and explosions; (3) Gas dynamics of reacting flows; (4) Deflagration and detonation of premixed gases; (5) Laminar flames; and (6) Turbulent flames. This course is designed to strengthen both the Air Breathing and Rocket propulsion sequences by providing a detailed analysis of combustion processes.

Credit Hours 4  
Prerequisites/Corequisites Thermodynamics, Chemistry, Differential and Integral Calculus  
Terms Offered Fall

MENG 699 - Master's Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 12  
Prerequisites/Corequisites Permission of Instructor  
Terms Offered All

MENG 732 - Advanced Turbomachinery

The principles of fluid mechanics, thermodynamics, heat transfer, and combustion are applied to gas turbine engines. Cycles and component performance are covered with emphasis on application in high performance aircraft propulsion systems.

Credit Hours 4  
Prerequisites/Corequisites Permission of Instructor  
Terms Offered Spring

MENG 733 - Airbreathing Engine Design

The laws of mechanics and thermodynamics are applied to determine the design point requirements for and the design of an aircraft gas turbine engine. Emphasis is placed on determining the engine type best suited to the requirements of a specified aircraft mission. Computer analysis is used extensively in mission analysis, on-design and off-design engine performance analysis, and in component design.

Credit Hours 4  
Prerequisites/Corequisites MENG 501 and MENG 732 or Permission of Instructor  
Terms Offered Summer
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites/Corequisites</th>
<th>Terms Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>MENG 899</td>
<td>Doctoral Level Special Studies</td>
<td>Course content determined by faculty member based on student need.</td>
<td>1-12</td>
<td>Permission of Research Advisor</td>
<td>All</td>
</tr>
<tr>
<td>METG 505</td>
<td>Atmospheric and Space Environmental Effects on Military Operational Systems and Plans</td>
<td>This course focuses on the advantageous exploitation of weather effects at the operational level of war. Historical cases are surveyed to highlight both successful and unsuccessful environmental adaptations. Future systems and plans are discussed in terms of weather exploitation and applicability within a Combined Air Operations Center (CAOC) structure.</td>
<td>4</td>
<td>None</td>
<td>As needed</td>
</tr>
<tr>
<td>METG 511</td>
<td>Atmospheric Physics for Engineers and Scientists</td>
<td>Applies physical, chemical, and thermodynamic fundamentals to atmospheric phenomena. Terrestrial radiative transfer and boundary layer effects are explored. Basic dynamic principles are introduced and applied to classical weather features, such as pressure systems, fronts, and air masses. Atmospheric applications of satellite and radar technologies are also covered.</td>
<td>4</td>
<td>Permission of instructor</td>
<td>Winter</td>
</tr>
<tr>
<td>METG 610</td>
<td>Radiative Transfer</td>
<td>This course covers topics in radiative transfer for visible, infrared, and acoustic energy including emission, absorption, scattering and atmospheric refraction. Application of the theory will be examined in operational models, such as Electro-optical Tactical Decision Aid, Integrated Refractive Effects Prediction System, Radio Physical Optics.</td>
<td></td>
<td>METG 511</td>
<td>As needed</td>
</tr>
<tr>
<td>METG 611</td>
<td>Atmospheric and Space Environmental Effects on Electromagnetic Propagation</td>
<td>Investigates the propagation properties of laser, radar, optical, and IR systems in the atmosphere and near-earth space environment. Weather and environmental effects on ground-based, airborne and spaceborne platforms are considered. Topics include signal processing to characterize both discrete and distributed targets, and inversion methods to retrieve atmospheric parameters. Focus is on the UV to microwave portion of the spectrum.</td>
<td>4</td>
<td>METG 511</td>
<td>Winter</td>
</tr>
<tr>
<td>METG 612</td>
<td>Cloud Physics</td>
<td>Covers the theories of cloud formation, precipitation, and atmospheric electricity. Particular emphasis will be placed on lightning formation, detection, and its effects. Convective clouds and mesoscale storm systems will be discussed in detail to include the general structure, scale, and vertical motions within these storms. A computer-based project will be included to help visualize the formation of clouds and the moisture in them.</td>
<td>4</td>
<td>Permission of instructor</td>
<td>Winter</td>
</tr>
</tbody>
</table>
METG 620 - Advanced Dynamic Meteorology

This course covers geophysical fluid dynamics including the development of the fundamental equations governing atmospheric motion, basic approximations, simplified flows, and physical interpretation of the corresponding theory. It also includes circulation theory, vorticity, planetary boundary layer, quasi-geostrophic, ageostrophic and linear theories and introductory numerical modeling concepts.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Spring

METG 644 - Satellite Meteorology

This course will provide students with a broad foundation on the history, theory, data, and application of meteorological satellites/sensors, so that they will be able to interpret and fully utilize these data for operational and/or research applications and understand their capabilities and limitations. It includes techniques, research, and operational applications related to satellite-based remote sensing of the atmosphere and their applications in numerical weather prediction.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Summer

METG 650 - Atmospheric Modeling for Engineers

Surveys major available dynamic and microphysical models that can, or have been adapted for environmental engineering applications. Specific applications include chemical/particulate trajectory, dispersion, and fallout studies and/or uses.

Credit Hours 4
Prerequisites/Corequisites METG 511
Terms Offered Summer

NENG 500 - Nuclear Weapons Strategy and Policy

This course covers the historical and current state of US nuclear policy and the implementation of that policy. First, we look at historical nuclear weapons policy, and current national and Air Force policy. Second, we provide an overview of how national and Air Force policy is implemented through current force structures, nuclear surety, and weapons employment.

Notes DL only
Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

NENG 560 - Electromagnetic Waves and Effects

Treats electrostatics, Maxwell’s equations, and electrodynamics. Course emphasis is on propagation of electromagnetic waves through the atmosphere and interaction of electromagnetic waves with matter, e.g., electronic systems. Fundamentals of interactions with systems are introduced, including external interaction, aperture penetration, and shielding.

Notes U.S. citizens only
Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
NENG 585 - Introduction to Modern Fortran with Applications in Computational Nuclear Engineering

Modern Fortran programming techniques are presented and practiced using example problems from the nuclear engineering curriculum. The objectives include developing knowledge of the structure and syntax of Fortran-95; developing skill in programming and effective use of the provided development environment; and practicing writing, debugging, and validating portable Fortran programs. Relevant ANSI/ANSI standards are presented. Programming exercises focus on numerical computations needed to solve problems encountered in the AFIT nuclear engineering curriculum. Modern programming approaches, including operator overloading, data abstraction, encapsulation, and objects, are introduced using Fortran-95 user-declared types and modules.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Fall

NENG 591 - Nuclear Proliferation

This course examines the elements and technology involved in building a nuclear weapons capability, including producing or obtaining nuclear fuel; assembling a weapon; fuzing and firing; testing, storage, surety, delivery; and how a proliferator might clandestinely complete the steps. The course covers elements of the United States nuclear weapon program, from fuel production to the maintenance of a nuclear arsenal.

Notes DL only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

NENG 596 - Nuclear Weapons Effects

This course emphasizes the unique effects of nuclear weapon detonations: blast, thermal, EMP, radiation, and fallout effects. Each effect is treated by examining its generation, transmission, and mechanisms of interaction with the environment. Survivability/vulnerability issues which apply to various weapons systems will be emphasized. US citizens only.

Notes DL only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

NENG 597 - Nuclear Weapons Effects, Technology and Non-Proliferation

This course is designed to provide each student with an understanding of the effects of nuclear weapons (with specific emphasis on the differences between conventional and nuclear weapons); the technology necessary to produce nuclear weapons (emphasizing the nuclear fuel cycle); and the current status of international nuclear weapon proliferation. To accomplish this, the course investigates the energetics of nuclear weapons to develop an appreciation for the destructive forces inherent in nuclear weapons and lay a foundation for understanding their effects. Then, the specific effects of, and differences between, the various classifications of explosions (i.e., air, surface, subsurface, and high altitude bursts) are covered. This is followed by a look at the technology required to produce nuclear weapons, with specific emphasis on the nuclear fuel cycle (fuel enrichment processes). Finally, this knowledge is combined with a working knowledge of the current state of international nuclear proliferation to assess future trends.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
NENG 601 - Research Apprenticeship

Students will work on special problems related to individual professor’s research programs. These special problems will range from pedagogical problems intended to bring the student up to the state of knowledge to problems which are a part of the immediate goals of the program. The problems may be computational, experimental or theoretical. This will vary from professor to professor.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered As needed

NENG 605 - Physics of Nuclear Explosives

Elementary theory of fission and fusion explosive devices is taught. Diffusion theory is developed to examine the space-time variation of neutrons in fission devices. Criticality, yield and disassembly mechanisms are included. Methods of statistical physics including Maxwell-Boltzmann and Planck distributions are employed. In fusion systems, reaction rate production, radiation-loss balance and yield calculations are examined. Size, mass, density and temperature ranges for fusion burning are developed. Some Secret (RD) material is included.

Notes U.S. citizens only. SECRET (RESTRICTED DATA) clearance required.

Credit Hours 4
Prerequisites/Corequisites NENG 651
Terms Offered Winter

NENG 620 - Nuclear Reactor Theory and Engineering

This course presents nuclear reactor theory, building upon the coverage of nuclear physics (reactions, radiations, fission, etc.) from NENG 651 and the coverage of neutron diffusion, prompt fast criticality, and prompt kinetics from NENG 605. Delayed and thermal neutrons are incorporated into the treatment of criticality and kinetics. Reactor dynamics are examined, including aspects of reactor core and system design, which provide reactivity feedback for reactor control. Nuclear reactor engineering topics include thermal management, energy conversion, radiation shielding, and mechanical and structural aspects of reactor and system design. This course provides a broadened exposure to applications of nuclear science and provides the necessary foundation for the study of space nuclear power and the nuclear fuel cycle.

Credit Hours 4
Prerequisites/Corequisites MATH 508 or equivalent
Terms Offered Winter

NENG 625 - Electromagnetic Pulse Effects

Source, propagation, and interaction of the nuclear weapon generated electromagnetic pulse. Source generation is developed for high altitude burst, surface burst, and system generated situations. Propagation of the radiated signal is developed from classical electromagnetism (solution of Maxwell's equation) for free space and extended to the atmosphere. EMP interaction is examined using antenna theory. Energy coupling from the wave is developed. Methods of shielding are considered.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites PHYS 531, NENG 605
Terms Offered Summer
NENG 630 - Radiation Health Physics

This course in radiation health physics provides the foundation for understanding the biological effects of ionizing radiation and protecting individuals and population groups. The content depends in part on the student’s backgrounds and curricular goals. Topics may include physical measurements and properties of different types of radiation and radioactive materials; quantitative relationships between radiation exposure and biological damage; movement of radioactivity through the environment; and design of radiologically safe equipment, processes, and environments with the intent on assessing the radiological impact on humans. In some offerings of the course, the effects of non-ionizing radiation may be included. This course will be useful to bioenvironmental engineers, environmental managers, radiation safety officers, nuclear research officers, or medical personnel who will have responsibility for managing radiation safety programs and managing environmental activities of military installations that have nuclear sources (hospital, PMEL, or nuclear weapons) or who must interact in their environmental management jobs with the Department of Energy.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites NENG 651, NENG 650
Terms Offered Spring

NENG 631 - Prompt Effects of Nuclear Weapons

Topics include source, transmission, and mechanisms of interaction of x-ray, blast, thermal, neutron, and prompt gamma radiation. X-ray interactions include shock generation and propagation. The conservation equations of fluid dynamics are used to describe shocks. These same equations are applied to blasts in air and underwater shock. Shock “jump conditions” and scaling laws are derived and applied. Thermal transmission is examined. The heat transfer equation is used to study thermal interaction. Buildup factors and fits of transport calculations are employed to study neutron and gamma transmission. Various neutron and gamma interaction phenomena are studied. In the case of each effect, systems response is examined, hardening techniques are surveyed, and design trade-offs are discussed. Some secret (RD) material is discussed.

Notes U.S. citizens only. SECRET (RESTRICTED DATA) clearance required.

Credit Hours 4
Prerequisites/Corequisites NENG 605
Terms Offered Spring

NENG 635 - Residual Effects of Nuclear Weapons

Environmental radioactivity from natural, nuclear industry and weapon fallout is treated. The emphasis is on weapon fallout, both local and global. Methods of fallout modeling are included for both ground dose and airborne crew dose. Health physics fundamentals including mechanisms of biological response calculation of dose, body burdens and maximum permissible concentrations are also included. Seismic detection of nuclear explosions and worldwide detection systems are examined.

Notes U.S. citizens only

Credit Hours 4
Prerequisites/Corequisites NENG 605
Terms Offered Summer
NENG 650 - Nuclear Instrumentation Laboratory

Laboratory and lecture study of radiation detectors and detection systems; characteristics, applications, and principles of operation of gas-filled detectors, scintillation detectors, and semiconductor detectors; and applications and principles of electronic modules, such as single and multi-channel analyzers, pulse amplifiers, discriminators, time-to-amplitude converters, coincidence units, pulse shape analysis units, etc. Counting statistics, probability, and data reduction are applied to nuclear measurements.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites NENG 651
Terms Offered Winter

NENG 660 - Radiation Effects on Electronics

This course covers the fundamentals of damage mechanisms to electronic devices from gamma rays, neutrons, and charged particles. The course starts with a review of solid state physics and an introduction to the physics of bipolar and metal-oxide-semiconductor (MOS) technologies. The differences between ionization and displacement damage resulting from irradiation are pointed out and used as a foundation for understanding the effects of particular types of radiation. Neutron effects on bipolar devices are treated primarily as a result of carrier lifetime and mobility degradation. Annealing of neutron effects are discussed. Gamma ray effects on field-effect transistors (FETs), particularly the creation and effects of hole traps and interface states, are covered. The dependence of these effects on device parameters (e.g., oxide thickness) is explained. Transient radiation effects, such as latch up, upset, and single-event upset (SEU), are examined.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
NENG 664 - Radiation Effects on Electronics Laboratory

Experimental procedures used in radiation effects testing. Typical projects will include ionizing and non-ionizing radiation dosimetry, optical and electrical measurements, and irradiation of devices. The course will cover practical dosimetry, device modeling, characterization, development of a test plan, modeling device changes, irradiation of devices, and interpreting data. Special techniques include calibrating a PIN diode dosimeter, foil activation dosimetry, device irradiation, and development of test systems and controls. Students must establish test criteria, model effects, develop system controls and interpret data.

Notes U.S. citizens only. This is a lecture with laboratory course. Classes will meet for 1 hour, 3 days per week, for the lectures and for 3 hours, 1 day per week, for the laboratory. May require travel to off-site irradiation facilities.

Credit Hours 4  
Prerequisites/Corequisites NENG 650, NENG 660  
Terms Offered Summer

NENG 685 - Computational Nuclear Engineering

Develops numerical problem solving using case studies of problems encountered in nuclear engineering/weapons effects. Numerical methods employed may include differentiation and quadrature, root solving, linear algebra (particularly tridiagonal systems of equations), eigenvectors and Eigen values, initial and boundary value problems in ordinary differential equations, and partial differential equations. Examples of typical problems studied are temperature of a plasma given its energy density (iteration or root solving), radionuclide decay chains (initial value problem, system of ODEs), 1-d spatial dependence of radiation diffusion (boundary value ODE eigenvalue/eigenfunction problem), and transient heat diffusion (PDEs).

Notes U.S. citizens only.

Credit Hours 4  
Prerequisites/Corequisites MATH 508  
Terms Offered As needed

NENG 681 - Nuclear Chemical Engineering

Examines in depth the chemical engineering aspects of the nuclear energy power cycle. Students are introduced to the various types of nuclear reactor fuels, fuel-cycle operations, and fuel reprocessing and isotope separation. The decay chains of pertinent isotopes are reviewed in conjunction with the Bateman equation. Properties of irradiated fuel and other reactor materials are covered, leading into the objectives and methods of reprocessing. Finally, various methods of isotope separation are covered, including laser isotope technology.

Notes U.S. citizens only.

Credit Hours 4  
Prerequisites/Corequisites NENG 651  
Terms Offered As needed

NENG 699 - Master's Level Special Study

Course content determined by faculty member based on student need.

Notes U.S. citizens only.

Credit Hours 1-12  
Prerequisites/Corequisites None  
Terms Offered All
NENG 705 - Methods of Radiation Transport

The transport of x-rays, gamma rays and neutrons is examined by theoretical analysis and numerical methods. Diffusion theory is presumed from NENG 605; its relation to transport theory is considered. The Boltzmann transport equation is developed, including the multigroup energy formulation. The major numerical approaches (discrete ordinates and Monte Carlo) to its solution are developed. The methods are programmed and used to explore the behavior and relative advantages of the two approaches. Variance reduction, adjoint methods, anisotropic problems, time-dependent problems, and eigenvalue problems are introduced.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites MATH 508, NENG 605, NENG 685
Terms Offered As needed

NENG 720 - Nuclear Reactor Systems

A survey of current systems from a design point of view. An advanced course in that the prerequisites involve similar theory, both statics and kinetics, for explosive systems, some heat transfer, and a study of reactor effluents. The same theory and methods are applied to nuclear chain reactors in this course. Large civilian power production reactors, small military power reactors, and space nuclear systems are examined. Safety, cost, and performance are included.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites NENG 605, NENG 631, NENG 635
Terms Offered Winter

NENG 721 - Space Nuclear Power Systems

Current and future nuclear power systems such as radioisotope thermal generators, solid core, fluidized bed and gas core reactors are analyzed. Converter and heat rejection theory is studied and integrated with nuclear heat sources. One of the outstanding research issues for advanced nuclear space power systems is assigned as a group design project.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites NENG 631 or NENG 620
Terms Offered As needed

NENG 725 - Monte Carlo Methods of Radiation Transport

Monte Carlo calculational techniques are introduced and developed. The technique is applied to problems of X-ray, neutron, and gamma transport from and in nuclear explosions Monte Carlo techniques are contrasted with and compared to the Boltzmann equation solutions considered in NENG 705.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered As needed
### NENG 785 - Topics in Computational Nuclear Engineering

Advanced numerical problem solving techniques are examined in the context of problems encountered in nuclear engineering and/or nuclear weapons effects. State of the art numerical methods are adapted to the problems examined in the course. Numerical experiments are used to augment analysis in evaluating the stability, conditioning, accuracy, and efficiency of the resulting algorithms.

**Notes** U.S. citizens only.

**Credit Hours** 4

**Prerequisites/Corequisites** Permission of instructor

**Terms Offered** As needed

### NENG 790 - Nuclear Systems Design

Students are assigned to groups for the purpose of conducting a design study on an open-ended problem. Students must mathematically model the problem and propose solutions. Solutions are evaluated against established objectives and realistic constraints such as cost, reliability, survivability, safety, human factors, ethics, and social impact. The best solution is then optimized. Recent class problems have included future terrestrial and space-based Air Force systems.

**Notes** U.S. citizens only.

**Credit Hours** 4

**Prerequisites/Corequisites** NENG 631

**Terms Offered** As needed

### NENG 791 - Proliferation of Weapons of Mass Destruction

This course examines the problem of global proliferation through a multidisciplinary approach. This course provides an understanding of the technology necessary to produce weapons of mass destruction as well as the means of delivering these weapons. The effects of chemical and biological weapons (with specific emphasis on the differences between them and nuclear weapons) are studied. Combating proliferation with an emphasis on U.S. Government legal obligations, treaty requirements, and DoD capabilities is considered. Detection of WMD and protection from their effects is examined. Finally, this knowledge is combined with a working knowledge of the current status of international proliferation to assess future trends.

**Notes** U.S. citizens only.

**Credit Hours** 4

**Prerequisites/Corequisites** NENG 635, CHEM 581

**Terms Offered** Winter

### NENG 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

**Notes** U.S. citizens only.

**Credit Hours** 1-12

**Prerequisites/Corequisites** Approval of department

**Terms Offered** All
NENG 816 - Advanced Topics in Neutral Particle Transport

Problems in neutron, gamma ray and x-ray transport are formulated and solved. Emphasis is on numerical methods of solution of the Boltzmann equation. Topics introduced in NENG 705 are expanded and extended. Current topics from the literature are examined.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered As needed

NENG 830 - Advanced Nuclear Weapons Effects

Examines in depth selected problems in neutron, gamma, x-ray, thermal and electromagnetic radiation and in shock, debris, blackout and Argus effects. Treats problems both experimentally and theoretically on the basis of the most recent literature and information available.

Notes U.S. citizens only.

Credit Hours 4
Prerequisites/Corequisites Permission of instructor
Terms Offered As needed

NENG 899 - Doctoral Level Special Study

Course content determined by faculty member based on student need.

Notes U.S. citizens only.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

NENG 998 - Research Prospectus

This course is designed to provide direction to the doctoral student in the development of the research prospectus. The student will work with his research committee in carrying out a background study in the area chosen for dissertation research, scope the problem and finally present the problem to the committee in a formal document, the Research Prospectus. If necessary this course can be repeated in several quarters depending on the nature and scope of the dissertation research.

Notes U.S. citizens only.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

NENG 999 - Dissertation Research

This course consists of dissertation research conducted in nuclear engineering, including both the research itself and the preparation and defense of the dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

Notes U.S. citizens only.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

OENG 520 - Lasers for Engineers

A basic course in lasers for the non-specialist. The course covers systems engineering, the laser weapon, basic physics of a laser system, solid state, chemical free electron, semiconductor lasers, laser beam propagation and control, laser lethality and laser weapon design.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed
OENG 530 - Fundamentals of IR and MASINT Technology

This course lays the groundwork for solving MASINT/AGI remote sensing problems, with emphasis on IR technology. Both the signature and metric aspects of MASINT/AGI will be considered. Topics include source characteristics, radiometry, atmospheric and propagation effects, optics, detectors, and elementary signal/image processing. Students should have a strong background in basic mathematics and physics.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered All

OENG 531 - Nonimaging IR and MASINT Collection Systems

The principles developed in OENG 530 will be applied to explore the current technology for collecting, processing, and exploiting MASINT/AGI data for Missile Warning, Missile Defense, Battlespace Characterization, Support for Military Operation, Technical Intelligence, and Environmental Monitoring using National Technical Means. Classified information about the National Sensors will be discussed.

Credit Hours 3
Prerequisites/Corequisites OENG 530
Terms Offered All

OENG 533 - Multispectral and Hyperspectral MASINT Exploration

Examines the information that can be extracted from multispectral and hyperspectral data sets collected by MASINT/AGI sensors. Introduces the concepts of signature exploitation for materials identification and pattern recognition. Techniques covered include background suppression, principle components, Bayesian statistics, and neural network processing.

Credit Hours 3
Prerequisites/Corequisites OENG 530
Terms Offered All

OENG 535 - MASINT for the Warfighter Seminar

Seminars will present MASINT/AGI topics of interest to the Intelligence Community and take advantage of the knowledge and experience of users and practitioners of MASINT IR/SAR data products.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered All

OENG 536 - IR and MASINT Fundamentals Laboratory

Hands-on exercises in fundamentals of MASINT/AGI data processing and analysis including application of radiation source, propagation, and collection algorithms and techniques. Computing tools include spreadsheet and MODTRAN atmospheric transmission codes.

Credit Hours 1
Prerequisites/Corequisites OENG 530
Terms Offered All
OENG 537 - IR MASINT Collection Systems Laboratory

Experience and exercises in extracting and interpreting MASINT Formatted Event Data files using IR Workbench/NOAS/MATLAB tools and Principal Components background suppression. Mission planning with Satellite Tool Kit (STK).

Credit Hours 1
Prerequisites/Corequisites OENG 530
Terms Offered All

OENG 539 - Multispectral and Hyperspectral MASINT Laboratory

Exercises in multispectral/hyperspectral materials identification and target recognition using COSMEC/ENVI tools with LandSat and other data cubes. Applications to battlespace characterization and target detection.

Credit Hours 1
Prerequisites/Corequisites OENG 530
Terms Offered All

OENG 616 - Electro-Optical Systems Laboratory

A laboratory and lecture course that introduces laboratory techniques for the measurement of optical observables (emissions or reflections of optical radiation from aerospace vehicles). The weekly two-hour-long lecture period is used to discuss the design of experiments, safe and practical laboratory techniques, and the communication (in written and oral form) of experimental results. The experiments are in the areas of spectroradiometry, optical cross-section measurement, TV sensors, and IR sensors.

Credit Hours 4
Prerequisites/Corequisites OENG 650
Terms Offered Summer

OENG 620 - Laser Engineering

Treats the basic operation and components of the laser with emphasis on the knowledge required to use the laser as an optical system component. Covers laser media, resonator, pump, and waste heat removal, as well as types of lasers available. Both CW and pulsed lasers will be treated. Stress will be placed on the laser output beam and the device parameters that affect that beam.

Credit Hours 4
Prerequisites/Corequisites PHYS 556 or PHYS 655, PHYS 640
Terms Offered Spring

OENG 644 - Linear Systems and Fourier Optics

This course covers the linear systems approach to modeling optical wavefront propagation, diffraction, and imaging. Introductory material includes analysis tools and two-dimensional Fourier transforms. The majority of the course is devoted to using these tools to solve problems in optics imaging, and optical information processing.

Credit Hours 4
Prerequisites/Corequisites PHYS 640
Terms Offered As needed

OENG 645 - Wave Optics I

This course covers the first principles of wave optics modeling. Beginning with vacuum propagation of a single source of light, techniques will be examined to include the effects of extended sources, optical aberrations, and finally turbulent media. Particular attention will be paid to the assumptions and simplification necessary to model a continuous system in a discrete simulation and methodology to increase fidelity.

Credit Hours 2
Prerequisites/Corequisites OENG 644
Terms Offered Winter
OENG 646 - Wave Optics II

This course covers the principles of wave optics models with a focus on associated control systems. The course will begin with the ability to model a simple tracking system and then expand to higher-order/adaptive optics corrections, with a discussion of issues associated with modeling the effects with discrete samples. Modeling of imaging systems, both coherent and incoherent will be examined. Monte-Carlo methods of relevance to wave optics modeling will also be examined.

Credit Hours 2
Prerequisites/Corequisites OENG 645
Terms Offered Spring

OENG 647 - Hyperspectral Remote Sensing

This course provides a thorough treatment of the primary components of the field of hyperspectral remote sensing, including the underlying spectral signature characteristics of natural and man-made materials, the radiative transfer to remote sensors, the design of imaging spectrometers, and the data processing methods employed. The goal is to prepare the student to model the observed spectral radiance for several remote sensing scenarios, analyze the performance of hyperspectral imaging systems, and implement standard hyperspectral classification and detection algorithms.

Credit Hours 4
Prerequisites/Corequisites PHYS 640, OENG 650
Terms Offered Summer

OENG 650 - Optical Radiometry and Detection

Radiation source characterization and the transport of that radiation through free space is considered in the first half of this course. In the second half, the principles of optical detection are considered along with specific application of various types of detectors.

Credit Hours 4
Prerequisites/Corequisites PHYS 640
Terms Offered Winter

OENG 651 - Optical Diagnostics Laboratory

An advanced laboratory and lecture course in optical diagnostic techniques. The lecture phase of this course treats radiometry, optical sources, spectroscopic techniques, detector physics and performance, error analysis and laser safety. The laboratory experiments emphasize the design of optical systems for the purpose of analyzing physical phenomena. Typical experiments include: diagnostics of CW and pulsed laser systems, spectroscopic analysis of the luminescence from solids and plasmas, interferometric measurements, holography, and calorimetry.

Credit Hours 4
Prerequisites/Corequisites OENG 620, PHYS 542
Terms Offered Summer
### OENG 660 - Introduction to Non-Linear Optical Devices

This course is designed to develop those areas of electromagnetic wave interaction with matter necessary for an understanding of nonlinear optical devices. Plane wave propagation in anisotropic media, commonly called “crystal optics,” is stressed. Passive optical devices, such as wave plates, polarizers and compensators, are designed. Parametric processes are introduced, and applications, such as amplitude and frequency modulation, second harmonic generation, and parametric oscillation, are considered.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 640  
**Terms Offered** As needed

### OENG 681 - Digital Image Processing

The principle objectives of this course are to develop the concepts and techniques of digital image processing and lay a foundation that can be used as the basis for research in this field. Topics covered include the characteristics of digital images, image transforms, image enhancement, image restoration, image segmentation, and image representation and description.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 640  
**Terms Offered** As needed

### OENG 699 - Master's Level Special Study

Course content determined by faculty member based on student need.

**Credit Hours** 1-12  
**Prerequisites/Corequisites** None  
**Terms Offered** All

### OENG 720 - Laser Devices and Applications

Treats specific laser systems of importance to the commercial world and Air Force in particular. The course stresses current laser technology and engineering analysis of specific systems. Topics covered typically include operations characteristics, such as power and energy output, their scalability, spectral and temporal characteristics, and beam quality and the factors limiting the performance. Where appropriate, design issues associated with specific systems are also discussed. In addition to the laser systems commercially available, laser systems appropriate for the Air Force and other military applications, such as laser ranging, target designation, imaging, electro-optic countermeasures, and laser weapons, are discussed.

**Credit Hours** 4  
**Prerequisites/Corequisites** OENG 620  
**Terms Offered** Winter

### OENG 740 - Optical System Design

This course is designed to introduce the basic principles of computer-aided optical system design. Topics include basic principles of optical ray tracing (both geometric and analytic), chromatic aberrations, third-order Seidel aberrations, techniques for reducing these aberrations, current computer optical design programs, Gaussian beams, and modulation and scanning techniques. This course concludes with a design project of an optical system using a state-of-the-art computer optical design code.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 640  
**Terms Offered** As needed
OENG 775 - Introduction to Photonic Devices

Provides an introduction to photonic components and devices, focusing on their basic principles of operation and applications. This course covers the basic components that are used in photonic devices: dielectric waveguides; semiconductor lasers, including distributed feedback and quantum well lasers; semiconductor detectors; acousto-optic modulators; and fiber optics. Specific photonic devices are covered, including directional couplers, phase modulators, intensity modulators, photonic switches, bistable optical devices, and self-electro-optic-effect devices.

Credit Hours 4
Prerequisites/Corequisites PHYS 570 or PHYS 670, PHYS 640, OENG 620
Terms Offered Winter

OENG 780 - Infrared Technology

This course presents the principles and technology required for the design and analysis of electro-optic systems, with emphasis on those systems operating in the infrared. Topics include sources of radiation, targets and backgrounds, atmospheric propagation, optics, detectors, detector performance criteria, scanning and tracking techniques. The course concludes with the design of a representative IR system such as an imaging system (FLIR) or a tracking system.

Credit Hours 4
Prerequisites/Corequisites OENG 650
Terms Offered Spring

OENG 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

OENG 899 - Doctoral Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

OENG 998 - Research Prospectus

This course is designed to provide direction to the doctoral student in the development of the research prospectus. The student will work with his research committee in carrying out a background study in the area chosen for dissertation research, scope the problem, and finally present the problem to the committee in a formal document, the Research Prospectus. If necessary, this course can be repeated in several quarters, depending on the nature and scope of the dissertation research.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All
OENG 999 - Dissertation Research

This course consists of dissertation research conducted in optical engineering or electro-optics, including both the research itself and the preparation and defense of the dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

OPER 498 - Research Methods

This course is designed to provide the student with an understanding of the research process and department research expectations. Topics include problem definition, use of secondary sources, research design and communication of results. Students prepare and present a research proposal.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered Spring

OPER 500 - Operational Sciences Seminar

This seminar acquaints students with the application of operations research to Air Force and DoD issues and with faculty research interests. This course also provides a forum for lectures by distinguished visitors.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Fall, Winter, Summer
OPER 510 - Deterministic Operations Research

This course develops the theory of optimization, building on mathematical fundamentals introduced in the calculus. The emphasis of this course is on exposure to deterministic methods at an introductory graduate level. Topics include fundamentals of linear programming, application of the Kuhn-Tucker conditions, integer programming, nonlinear programming, and dynamic programming. The emphasis is on problem solving and examples.

Credit Hours 4
Prerequisites/Corequisites MATH 523 or Approval of Instructor
Terms Offered Winter

OPER 543 - Decision Analysis

This course is decision analysis theory and methodology. Decision analysis applies to complex problems involving sequential decisions, major uncertainties, single objectives, conflicting objectives, and multi-attribute value and utility functions. The course includes: decision structuring with influence diagrams, decision trees and value-focused thinking, modeling uncertainty with subjective probabilities, sensitivity analysis and the value of information, and modeling preferences with value and utility functions. Decision analysis applications for real world problems are discussed.

Credit Hours 4
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor
Terms Offered Fall, Winter

OPER 540 - Stochastic Modeling and Analysis I

This course applies the fundamental probability theory to develop standard approaches to stochastic modeling in operations research. Specific topics include conditional probability and exception, the Poisson process and exponential distribution, discrete-time Markov chains, and continuous-time Markov chains. The various models are discussed in the context of military applications.

Credit Hours 4
Prerequisites/Corequisites STAT 587 or Approval of Instructor
Terms Offered Winter

OPER 544 - Operational Decision Support Systems

This course blends techniques from the fields of operations research, management sciences, artificial intelligence, and information systems to create decision support systems primarily using Excel, including Excel VBA and specialized add-ins for analysis. This course will integrate the use of spreadsheets with operations research topics such as decision analysis, Monte-Carlo simulation, and optimization models.

Notes OPER 544 (lecture) is a 2 credit-hour course. OPER 544L (lab) is a 1 credit-hour course (three contact hours.) Students registering in OPER 544 will also automatically be registered in OPER 544L. Upon completion, two grades will be received, one for OPER 544 and one for OPER 544L.

Credit Hours 2 Lec, 1 Lab
Prerequisites OPER 543, OPER 561, and OPER 610 or Approval of Instructor.
Corequisite: OPER 544L
Terms Offered Spring
OPER 561 - Discrete-Event Simulation

This is an introductory course on the use of computer simulation modeling to analyze complex military systems. The focus of the course is on the development of discrete-event simulation models and the analysis of simulation model input and output. A modern simulation language is taught to provide a modeling framework and the means for implementing a computerized model. Basic concepts important to simulation studies such as random number and random variate generation, model verification and validation, and output analysis are discussed. Examples are oriented toward DoD operational systems.

Credit Hours 4  
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor  
Terms Offered Winter

OPER 595 - Issues in Defense Analysis

This course discusses the role of analysis in defense decisions and examines the historical contributions and limitations of analysis in the decision-making process. Specific topics include the origins of defense analysis, measures of merit, modeling, analytical pitfalls, contemporary topics, and issues of bias, advocacy, and ethics in defense analysis.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Winter

OPER 601 - Operations Research Seminar

This course is designed to provide students, primarily those enrolled in the doctoral program, with information relating to the state-of-the-art within the Operations Research field. Prominent speakers in the field will be invited and used whenever possible. This course may also be used by the faculty to present recent developments in their research and by doctoral candidates to present progress reports on their dissertation research.

Credit Hours 0  
Prerequisites/Corequisites None  
Terms Offered Fall, Winter, Spring, Summer

OPER 610 - Linear Programming and Network Flows

This course is an in-depth view of linear programming (LP) and network-flow problems. It includes model formulation, theoretical constructs, solution algorithms (simplex and interior-point methods), post optimality analysis, and large-scale considerations. Related areas, such as specialized LP, network models, and first-order approximations are presented. Software systems and models used to solve DoD problems are discussed.

Credit Hours 4  
Prerequisites/Corequisites OPER 510, MATH 523 or Approval of Instructor  
Terms Offered Spring
### OPER 612 - Nonlinear Programming

This course is a detailed study of nonlinear programming techniques. The differential calculus and Karush-Kuhn-Tucker results for constrained optimization are presented, including convexity, local and global optima, and saddle point conditions. A thorough treatment of duality theory and Lagrangian duality constitutes a major portion of the course, and serves to unify several key points. Various classes and types of techniques for solving nonlinear programs are presented, including geometric programming. Modern derivative-free optimization methods are also introduced.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 610 or Approval of Instructor  
**Terms Offered** Fall

### OPER 614 - Dynamic Programming

This course addresses the theory and practice of dynamic programming, i.e., optimal sequential decision making over time. The course will stress intuition, the mathematical foundations being for the most part elementary. Applications will be considered in capital investment, transportation, and production and inventory control.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 503 or OPER 510 and OPER 504 or OPER 540, or Approval of Instructor  
**Terms Offered** Winter

### OPER 613 - Integer Programming

Integer programming is the class of mathematical programming models that requires some or all of the variables to assume discrete or integer values. This course covers modeling, theoretical developments, and the principal solution procedures associated with the subject. At the completion of the course, the student should be able to recognize when integer programming is appropriate, set up a model for solution by an available algorithm, solve the model, interpret the solution, and understand the theoretical basis for the solution procedure.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 510 or Approval of Instructor  
**Terms Offered** Spring

### OPER 615 - Large Scale Systems Optimization

Large scale systems optimization takes advantage of the structure of large problems to develop efficient algorithms for their solution. Many large problems can only be solved by taking advantage of these special structures. The course examines the relationship between special structures and the algorithms which take advantage of them. Topics include interior point methods, Dantzig-Wolfe decomposition, column generation, Bender's decomposition, generalized upper bounding, and Lagrangian relaxation. Several examples of large problems will be examined, including scheduling a delivery fleet.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 610 or Approval of Instructor  
**Terms Offered** Winter
OPER 616 - Graph Theory

An introduction to the theory and application of graphs. Topics include introductory concepts and definitions, digraphs, connected and disconnected graphs, graph traversals, connection problems, trees, planar and non-planar graphs, Eulerian and Hamiltonian graphs, coloring problems, graph isomorphisms, and multigraphs. Applications of graph theory to problems in network flows and in combinatorial optimization are described.

Credit Hours 4
Prerequisites/Corequisites MATH 523 or Approval of Instructor
Terms Offered Spring (Cross-listed with MATH 633)

OPER 617 - Networks and Combinatorial Optimization

This course is an in-depth study of combinatorial programming and network flow optimization. The emphasis will be placed on discrete optimization and specialized solution techniques which are efficient ways to solve mixed-integer programming problems. These techniques include minimum cost flow, networks with gains, multi-commodity flow networks, networks with side constraints, and Lagrangian relaxation. Computational complexity is also discussed.

Credit Hours 3
Prerequisites/Corequisites OPER 610
Terms Offered Fall

OPER 621 - Multicriteria Decision Analysis

This course exposes students to a variety of approaches to the modeling and solution of multiple criteria decision making problems. Topics covered will include a discussion of preference structures, dominance, utility and value functions, analytic and interactive MCDM techniques, plus compromise programming and multi-objective optimization formulations.

Credit Hours 3
Prerequisites/Corequisites OPER 501, OPER 503, or OPER 510 (or equivalents), or Approval of Instructor
Terms Offered Fall

OPER 623 - Heuristic Search Methods

Introduction and application of modern search methods for solving complex optimization problems. Topics include genetic algorithms, simulated annealing, tabu search, hybrid combinations, and adaptive techniques.

Credit Hours 3
Prerequisites/Corequisites OPER 613 or Approval of Instructor
Terms Offered Spring

OPER 626 - Scheduling Theory

This course will cover the fundamentals of sequencing and scheduling. It will concentrate on the terminology, measures of effectiveness and basic problems found in the literature. Specific applications in vehicle scheduling will be introduced.

Credit Hours 3
Prerequisites/Corequisites OPER 503 or OPER 610 or Approval of Instructor
Terms Offered Summer
OPER 638 - Assessing Operational Cost and Risk

This course develops the theory of operational cost analysis, the evaluation of operational risk, and game theory. The effects of time on economic and monetary evaluation are studied, and risk and its impact on decision making is investigated. Specific topics covered include cost estimation, economic evaluation, risk assessment, value and utility functions, and multi-attribute utility theory. A systems analysis perspective is used in the presentation of course material.

Credit Hours 3
Prerequisites/Corequisites OPER 510, OPER 540, OPER 543, and STAT 587 or Approval of Instructor
Terms Offered Spring

OPER 641 - Stochastic Modeling and Analysis II

This course develops advanced concepts in the modeling and analysis of complex stochastic systems. Specific topics include generalizations of the Poisson process, renewal theory, regenerative processes, Markov-renewal theory, and Markov-regenerative processes. The course also introduces martingale, Brownian motion, and other diffusion processes.

Credit Hours 3
Prerequisites/Corequisites OPER 540 or Approval of Instructor
Terms Offered Summer

OPER 643 - Advanced Decision Analysis

This course presents advanced decision analysis concepts, theory, and methodology. The course covers value-focused thinking; hierarchal value structures; utility, value and scoring functions; multi-attribute utility and value problems; multi-attribute preferences under uncertainty; aggregation of individual preferences; and utilization of group preferences. Real world applications of the course material to DoD problems are emphasized.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Spring

OPER 645 - Risk Modeling and Analysis

This is a course on the theory and practice of risk analysis. Specific topics include quantitative risk assessment, multi-objective risk assessment, multi-objective risk analysis, Bayesian networks, game theory, actuarial risk, and fault tree analysis. Military and industrial applications are discussed.

Credit Hours 4
Prerequisites/Corequisites OPER 504 or OPER 540, or Approval of Instructor
Terms Offered Summer
**OPER 647 - Queuing System Analysis**

This course begins with an overview of stochastic modeling and transforms methods. These techniques are then employed in equilibrium analysis of simple Markov and embedded Markov queuing systems. Results are extended to address more advanced modeling concepts such as priority customers, bulk arrivals or service, generalized distributions of interarrival or service times, and networks of queues. Potential applications are discussed, including performance evaluation and optimization of communication systems, transportation networks, computer systems, and other resource-constrained operations.

**Credit Hours 3**  
**Prerequisites/Corequisites** OPER 504 or OPER 540, or Approval of Instructor  
**Terms Offered** Spring

**OPER 660 - Statistical Aspects of Simulation: Input Analysis**

This course provides an in-depth treatment of a number of important issues in the Statistical Aspects of Simulation. The emphasis in this course is on input modeling. Topics include random number generation, random variate modeling and generation, the structure of simulation programs, and model validation.

**Credit Hours 3**  
**Prerequisites/Corequisites** OPER 561 and STAT 587, or Approval of Instructor  
**Terms Offered** Summer

**OPER 671 - Combat Modeling I**

The purpose of this course is to present high resolution combat modeling. High resolution combat modeling provides detailed interactions of individual combatants or weapons systems. Topics include: simulating the battlefield environment, target search, acquisition and selection processes, single round accuracy and lethality models, and multiple round assessment models. Models currently for DoD analysis are used for class projects and examined in the context of support to major analytical simulation studies.

**Credit Hours 3**  
**Prerequisites/Corequisites** OPER 561 or Approval of Instructor  
**Terms Offered** Spring

**OPER 672 - Combat Modeling II**

The purpose of this course is to present modeling of large scale air/ground combat operations using aggregated force on force combat models. Topics include: aggregation and disaggregation, types of models used for large scale operations, firepower index and Lanchester equation approaches to attrition modeling, movement, rate of advance, air allocation, logistics, and C3I models. Models currently in use for DoD analysis are used as examples throughout the course.

**Credit Hours 3**  
**Prerequisites/Corequisites** OPER 671 or Approval of Instructor  
**Terms Offered** Summer
OPER 674 - Joint Mobility Modeling

The purpose of this course is to present mobility modeling from an application oriented large-scale point of view. Models currently in use for DoD analysis are examined. Particular attention will be given to the air mobility problem and its relation to land and sea mobility. Both strategic and theater mobility issues are explored.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter; Fall-Ft. Dix Only

OPER 676 - Information Operations Research

This course is designed to increase the awareness and integration of the relationship between Information Operations (IO) and Operations Research. The focus will be on the tools, techniques, theories, and models currently in use for IO analysis. Particular attention will be paid to current IO modeling issues.

Notes U.S. Military Only
Credit Hours 3
Terms Offered Summer

OPER 679 - Empirical Modeling

Analysis of experimental and observational data from engineering systems. Focus on empirical model building using observation data for characterization, estimation, inference, and prediction.

Credit Hours 3
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor
Terms Offered Spring - In-Residence and Distance Learning

OPER 681 - Statistical Process Control

This course provides an in-depth treatment of the fundamental concepts and methods of modern statistical process control. The primary focus will be on the use of control charts for monitoring the process mean and variance. Other topics include process capability analysis, the modern role of acceptance sampling, and the use of such statistical techniques within the context of total quality management.

Credit Hours 3
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor
Terms Offered Summer

OPER 683 - Response Surface Methodology

Emphasis in this course is directed towards understanding the basic concepts and uses of RSM to examine and quantify the effect of a large number of variables which influence a system's performance. Key topic areas are experimental design and exploration of response surfaces for determining an optimum conditions response model. Emphasis is on the application of RSM to simulation results.

Credit Hours 3
Prerequisites/Corequisites OPER 679 or STAT 696 or Approval of Instructor
Terms Offered Winter
OPER 684 - Quantitative Forecasting Techniques

This is a course in applied techniques to predict discrete time-series phenomena. The emphasis is on understanding and applying forecasting tools in analysis and management settings. Both classical smoothing methods and the Box-Jenkins methodology for model identification, estimation, and prediction are presented. Time series data are modeled and predictions made with interactive computer software.

Credit Hours 3
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor
Terms Offered Fall (Cross-listed with LOGM 630)

OPER 685 - Applied Multivariate Analysis I

This course is oriented toward the computer-assisted analysis of multidimensional data. The course will present statistical techniques such as multiple regression, principal components analysis, canonical correlation, factor analysis, cluster analysis, discriminate analysis, and neural networks. Emphasis will be on practical application to data sets using computerized statistical packages.

Credit Hours 3
Prerequisites/Corequisites STAT 587 or Approval of Instructor
Terms Offered Fall, Spring

OPER 688 - Operational Experimentation

Introduction to designing experiments for operational testing and evaluation. This is an applied course intended for operations analysts who perform experiments or serve as advisors to experimentation. A statistical approach to the design and analysis of experiments is provided as a means to efficiently study and comprehend the underlying process or system being evaluated. Insight gained leads to improved system performance and quality.

Notes Students must understand basic statistical concepts.

Credit Hours 3
Prerequisites/Corequisites STAT 583 or STAT 587, or Approval of Instructor
Terms Offered Fall; Summer -Distance Learning Only

OPER 699 - Master's Level Special Studies


Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All
OPER 710 - Advanced Linear Programming and Extensions

This course will explore the theoretical properties of the general linear program (LP), developing results concerning extreme points, the existence of extreme point solutions, interior point methods for LP, computational complexity, fractional programming, and current developments in LP.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 610  
**Terms Offered** As needed

OPER 712 - Advanced Math Programming

This course is intended for students planning advanced study and research in the areas of mathematical programming and optimization. A continuation of material covered in OPER 612, the course covers in more detail the theoretical and topological properties of the general nonlinear programming problem. Other topics are drawn from the current literature.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 612  
**Terms Offered** As needed

OPER 713 - Advanced Integer Programming

Integer programming is the class of mathematical programming models that requires some or all of the variables to assume discrete or integer values. This course covers advanced modeling and theoretical developments. The course will focus on polyhedral theory, computational complexity, integer lattices, valid inequalities, and Lagrangian relaxation.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 613  
**Terms Offered** As needed

OPER 741 - Advanced Stochastic Modeling

This course develops rudimentary concepts of measure-theoretic probability necessary for advanced stochastic modeling. The remainder of the course focuses on discrete and continuous-time martingale theory, followed by an introduction to Brownian motion and stochastic calculus in the context of Operations Research. The course is intended for doctoral or advanced M.S. students in Operations Research, mathematics, or related disciplines.

**Credit Hours** 3  
**Prerequisites/Corequisites** OPER 610 and MATH 600, or Approval of Instructor  
**Terms Offered** As needed

OPER 743 - Decision Analysis Practice

This course examines the professional practice of decision and risk analysis. The course provides new material on the selection of decision analysis topics, the interface with the decision makers and technical experts, the advanced use of decision analysis software, and the presentation of results to decision makers. Students have the opportunity to apply their knowledge and risk analysis to a real decision for a real decision maker.

**Credit Hours** 3  
**Prerequisites/Corequisites** At least two of the following courses: OPER 543, OPER 621, OPER 643, OPER 645, or Approval of Instructor  
**Terms Offered** Winter
OPER 746 - Advanced Topics in Reliability

This course develops advanced mathematical concepts for application in the reliability and maintainability areas. Topics include censored reliability data analysis, optimal preventive maintenance policies, warranty analysis, burn-in strategies, and other topics of current interest. The emphasis is on both analytic development as well as actual application to data analysis. The course will consider the implications of reliability during the system design phase as well as the system operational phase. Simulation software as well as "solver" software will be utilized in class exercises.

Credit Hours 3
Prerequisites/Corequisites OPER 540
Terms Offered As needed

OPER 747 - Queuing Networks

This course applies results from fundamental queuing theory to complex networks of queues. Specific topics of study include the modeling and analysis of product-form networks (open and closed), BCMP networks, and networks with multiple classes of customers. Approximation methods, including diffusion and decomposition, are explored. Applications in telecommunications, transportation, and manufacturing are also discussed.

Credit Hours 3
Prerequisites/Corequisites OPER 647
Terms Offered As needed

OPER 760 - Statistical Aspects of Simulation: Output Analysis

This course provides an in-depth treatment of a number of important issues in the Statistical Aspects of Simulation. The emphasis in this course is on output modeling. Topics include the analysis of terminating and steady state simulation output as well as variance reduction techniques. It is intended to provide a rigorous treatment of current issues within the simulation literature.

Credit Hours 3
Prerequisites/Corequisites OPER 561
Terms Offered Fall

OPER 785 - Applied Multivariate Analysis II: Pattern Recognition

This course is a survey course in pattern recognition. The course covers Bayesian Decision Theory, parameter estimation, linear discriminate functions, multilayer neural networks, and other topics. Real-world applications will be emphasized.

Credit Hours 3
Prerequisites/Corequisites OPER 685 or Approval of Instructor
Terms Offered Winter

OPER 786 - Multivariate Analysis III: Advanced Topics

This course examines a variety of topics in pattern recognition such as Bayesian networks, hidden Markov models, neural feature selection procedures and sensor fusion. Recent research in these areas is explored.

Credit Hours 3
Prerequisites/Corequisites OPER 785 or Approval of Instructor
Terms Offered Spring
OPER 791 - Research Project for Operational Sciences

A research topic or case study is selected from problems of interest to USAF and DoD. This topic is thoroughly investigated by the student, and the findings, recommendations, and conclusions are presented as a graduate research paper under the supervision of an AFIT faculty member.

Notes Available only for students enrolled in the Test and Evaluation Certificate Program or the Intermediate Developmental Education (IDE) Program. This course is offered as the 3 credit hour capstone course (distance learning) for Test and Evaluation Certificate students. It may be taken also be taken in residence for 1-7 credit hours by IDE students.

Credit Hours 1-7
Prerequisites/Corequisites None
Terms Offered As Needed.

OPER 799 - Thesis Research

A research topic is selected from those problems of interest to USAF and DoD. The topic is thoroughly investigated by the student and the findings, recommendations, and conclusions are presented as a formal thesis under the supervision of a departmental professor.

Notes On site research is conducted as required.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

OPER 899 - Doctoral Level Special Studies

Special topics of study for doctoral students in Operations Research under the direction of a member of the Operations Research faculty. Past Topics: Infrastructure Network Models; Social Network and Analysis Modeling, Modeling of Multi-agent Systems; Swarming: Mathematics and Applications; Fusion and Automated Target Recognition.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

OPER 999 - Dissertation Research

Dissertation research conducted in operations research, including both the research itself and the preparation and defense of the prospectus and dissertation. Selection of a research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with Doctoral Council policy letters.

Credit Hours 1-12
Prerequisites/Corequisites Approval of Research Advisor
Terms Offered All
**ORSC 542 - Management and Behavior in Organizations**

This course will give the student an in-depth understanding of organizational behavior, organization theory, and management theory. Topics include, but are not limited to, classical and neoclassical organization and management theory, study of organizations, organizational culture, individual behavior, motivation, rewards, organizational behavior, politics, leadership, organizational structure and design, job and organizational design, communication and information in the postmodernist era, decision-making process, and organizational change.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Fall, Winter

---

**PHYS 519 - The Space Environment**

The near-earth environment, from the surface to geosynchronous altitude, is that in which satellites and astronauts must operate. This course is concerned with the radiation, particles, and general conditions encountered in the Earth’s atmosphere, ionosphere, and magnetosphere. Specific effects that may be studied include spacecraft thermal equilibrium, orbit decay, spacecraft charging, spacecraft-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Fall/Summer

---

**PHYS 521 - Space Surveillance**

This course covers the fundamental physics necessary for an understanding of remote sensors with an emphasis on visible light and infrared systems. Beginning with the sources of electromagnetic radiation, the following aspects of the problem are treated phenomenologically; the interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors. Where appropriate, examples are chosen from current Air Force technology.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Winter

---

**PHYS 531 - Electromagnetism**

An intermediate level course stressing basic principles of electromagnetic field theory. Treats electrostatics, Maxwell’s equations, good conductor and good dielectric approximations, and wave propagation through interfaces. Paintin’s theorem and the flow of power are covered. Waveguides and simple radiating systems are introduced.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Summer

---

**PHYS 542 - Optics Laboratory**

A fundamental laboratory course with experiments on coherence, diffraction, lenses, interference, polarization and lasers. Lectures will introduce selected topics in laboratory practice such as error calculation, radiometry, spectrometry, coherence, and detectors.

**Credit Hours** 2  
**Prerequisites/Corequisites** PHYS 640  
**Terms Offered** Spring
### PHYS 556 - Introduction to Quantum Physics

Basic mathematical and conceptual principles of quantum physics. Includes black body radiation, photoelectric effect, Rutherford scattering, Bohr theory of the atom, wave-particle duality, Schrödinger wave equation and applications, one electron atom, atomic spectra, X-rays, periodic table, statistical physics, and statistical distribution functions.

**Credit Hours** 4  
**Prerequisites/Corequisites** None  
**Terms Offered** Summer

### PHYS 570 - Physics of Solid State Devices

Basic solid state physics for the non-physicist who needs an understanding of solid state devices. Topics include quantum theory, quantum statistics, crystal structure and binding, reciprocal lattice, crystal lattice dynamics, free electron theory, energy band theory, and semiconductors.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 556  
**Terms Offered** Fall

### PHYS 598 - Engineering Physics Seminar

This seminar, offered once a week, normally during the third quarter, is designed primarily to provide students with the information they need to carry out their thesis research and complete the thesis document. Topics covered include the student-advisor relationship, literature surveys, research prospectus, the thesis document, grading standards, and the thesis defense.

**Credit Hours** 1  
**Prerequisites/Corequisites** None  
**Terms Offered** Spring

### PHYS 600 - Dynamics

Treatment of theoretical mechanics at the advanced level. Develops Lagrangian and Hamiltonian formulations of dynamics from variational principles. Applications include central force problems, rigid body motion by matrix transformations, and coupled oscillators.

**Credit Hours** 4  
**Prerequisites/Corequisites** MATH 504  
**Terms Offered** As needed

### PHYS 601 - Electrodynamics I

A course in classical electromagnetic radiation. Treats wave propagation in space and in material media, reflection and refraction, and radiating systems.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 531  
**Terms Offered** Fall

### PHYS 624 - High Power Microwave Systems

A modular approach to the design and characterization of a high power microwave weapon system is adopted. The course objective is to provide an understanding of the system components and the attributes of the weapon system. The weapon system is viewed as consisting of five modules: prime power and power conditioning equipment, a microwave source, structures to couple the source to the propagation media, and the target. The physical principles associated with a module, module characteristics, and the influence and constraints of each module on total system requirements and effectiveness are identified and discussed.

**Credit Hours** 4  
**Prerequisites/Corequisites** PHYS 531 or PHYS 601  
**Terms Offered** As needed
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites/Corequisites</th>
<th>Terms Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 635</td>
<td>Thermal Physics</td>
<td>Treats statistical mechanics and thermodynamics. Topics include statistical methods, statistical thermodynamics with applications, ensemble theory, Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein statistics with applications.</td>
<td>4</td>
<td>PHYS 556 or PHYS 655</td>
<td>Winter</td>
</tr>
<tr>
<td>PHYS 640</td>
<td>Optics</td>
<td>Introduction to modern optics, with a treatment of both geometrical and physical optics. Geometrical topics include reflection and refraction, lenses, mirrors, stops, ray tracing, telescopes, and optical instruments. Wave phenomena treated will include interference, optical testing, polarization, and Fraunhofer and Fresnel diffraction.</td>
<td>4</td>
<td>None</td>
<td>Fall</td>
</tr>
<tr>
<td>PHYS 650</td>
<td>Kinetic Theory of Plasmas</td>
<td>Study of the basic concepts and definitions of plasma physics and the parameters that characterize plasma behavior. Includes applications of the Boltzmann equation and kinetic theory to such basic plasma phenomena as Debye shielding, plasma waves, magnetic confinement, and ionospheric physics.</td>
<td>4</td>
<td>PHYS 531 or PHYS 601</td>
<td>Spring</td>
</tr>
<tr>
<td>PHYS 655</td>
<td>Quantum Mechanics I</td>
<td>An introduction to the Schroedinger approach to quantum mechanics. Presentation and analysis of experimental background, postulatory basis, and perturbation methods. Application of theory to linear oscillator, free particle, hydrogen atom, hydrogen molecule, and tunnel effect is presented.</td>
<td>4</td>
<td>PHYS 556</td>
<td>Fall</td>
</tr>
<tr>
<td>PHYS 661</td>
<td>Atomic and Molecular Spectroscopy</td>
<td>Treats selected topics in atomic and molecular physics. Includes spectroscopy of atomic systems, diatomic and triatomic molecules, line shape, line broadening and interaction of radiation fields with matter, particularly in lasers. Approximation methods in quantum mechanics are applied to the spectroscopy of complex atoms and molecules. Analysis of electronic, vibrational and rotational experimental data is emphasized.</td>
<td>4</td>
<td>PHYS 655</td>
<td>Winter</td>
</tr>
<tr>
<td>PHYS 670</td>
<td>Introduction to Solid State Physics</td>
<td>Study of fundamental concepts in solid state physics. Topics include crystal structure and binding, X-ray diffraction and reciprocal lattice, lattice vibrations and phonons, free electron Fermi gas, transport properties of metals, quantum theory of electrons and energy bands, semiconductors and semiconductor devices.</td>
<td>4</td>
<td>PHYS 635, PHYS 655</td>
<td>Spring</td>
</tr>
</tbody>
</table>
PHYS 671 - Selected Topics in Solid State Physics

This course embodies the study of various phenomena in solids. Topics will be selected from semiconductors and semiconductor devices, optical and surface phenomena, transport properties, and superconductivity.

Credit Hours 4
Prerequisites/Corequisites PHYS 670
Terms Offered As needed

PHYS 686 - Computational Methods for Atmospheric and Space Sciences

Develops fundamental computational techniques, while emphasizing modern programming practices, with a focus on terrestrial and space weather applications. Topics include numerical integration, linear and nonlinear ODEs, finite difference discretization of PDEs and data assimilation.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered As needed

PHYS 699 - Master's Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All

PHYS 730 - Electrodynamics II

A continuation of PHYS 601 into areas appropriate for the study of charged particle beams and electromagnetic pulse effects. Treats relativistic particle dynamics, bremsstrahlung, and waves in a magneto-ionic medium.

Credit Hours 4
Prerequisites/Corequisites PHYS 601
Terms Offered Fall

PHYS 735 - Statistical Physics

Development of tools for the description of macroscopic systems based on microscopie insights. The physics of critical phenomena including superconductivity in the Landau-Ginzburg theory, mean field theories, renormalization group, cluster expansion and path integral approaches, and Monte Carlo techniques are developed. Elements of non-equilibrium statistical mechanics including Onsager’s theorem and the method of maximum entropy are also introduced.

Credit Hours 4
Prerequisites/Corequisites PHYS 635
Terms Offered As needed

PHYS 740 - Optics II

This course is designed to give a more rigorous mathematical treatment of optics principles. The properties of light propagation through practical optical components and systems, as well as free space, are described both in terms of geometric optics and physical optics languages. In particular, wave front aberrations and their implications on image quality and focal intensity are discussed in depth. Topics covered include matrix method in geometric optics and Gaussian beam optics, Jones matrix treatment of polarization, optics of solids (crystal optics), coherence theory, and diffraction theory of aberration.

Credit Hours 4
Prerequisites/Corequisites PHYS 640, PHYS 601
Terms Offered Winter
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Prerequisites/Corequisites</th>
<th>Terms Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 751</td>
<td>Plasma Dynamics</td>
<td>Expands the development of plasma physics beyond the basic phenomena discussed in PHYS 650 to include derivations of the Vlasov, Boltzmann, and Fokker-Planck equations. These equations are applied to plasma problems that illustrate the fluid equations and wave phenomena. Plasma oscillations, dispersion relations, Landau damping, and velocity space instabilities will be included in a study of plasma confinement and gas discharges.</td>
<td>4</td>
<td>PHYS 650</td>
<td>As needed</td>
</tr>
<tr>
<td>PHYS 755</td>
<td>Quantum Mechanics II</td>
<td>Intermediate quantum mechanics: develops the formal mathematical basis and postulates of quantum mechanics. Examines topics in measurement theory, two level systems, scattering, spin and quantum dynamics. Applications in atomic and nuclear physics are developed.</td>
<td>4</td>
<td>PHYS 655</td>
<td>As needed</td>
</tr>
<tr>
<td>PHYS 756</td>
<td>Quantum Mechanics III</td>
<td>Advanced quantum mechanics: examines topics of invariance and symmetries, systems of identical particles, time independent and dependent perturbation theory, and relativistic quantum theory of the Klein-Gordon and Dirac equations. Application topics in lasers, solid state and plasma physics are developed.</td>
<td>4</td>
<td>PHYS 755</td>
<td>As needed</td>
</tr>
<tr>
<td>PHYS 770</td>
<td>Solid State Physics I</td>
<td>First course in a sequence of courses covering topics in solid state physics at an advanced level. Topics include free electron theory, crystal structure, x-ray diffraction, reciprocal lattice, electron dynamics, energy band calculations, transport theory, Fermi surfaces, band structure of metals, electronic scattering and cohesive energy.</td>
<td>4</td>
<td>PHYS 670, PHYS 755</td>
<td>As needed</td>
</tr>
<tr>
<td>PHYS 771</td>
<td>Solid State Physics II</td>
<td>Second course in a sequence of courses covering solid state physics at an advanced level. Topics include lattice dynamics, phonons, anharmonic effects, dielectric properties, semiconductor properties, defects, magnetism, and superconductivity.</td>
<td>4</td>
<td>PHYS 770</td>
<td>As needed</td>
</tr>
<tr>
<td>PHYS 772</td>
<td>Solid State Physics III</td>
<td>An in-depth study of advanced topics in solid state physics. Special emphasis will be given to the topics covering the optical properties and optical processes in semiconductors, dealing with the interactions among photons, electrons, holes, and impurities in semiconductor crystals. Topics include energy states, radiative and non-radiative transitions, emissions, and absorptions in semiconductors, processes and p-n junctions, and photovoltaic effects on semiconductors.</td>
<td>4</td>
<td>PHYS 771</td>
<td>As needed</td>
</tr>
</tbody>
</table>
PHYS 775 - Ionospheric Physics and Chemistry

Formation and chemical properties of the ionosphere. Topics include ionization mechanisms, conductivity, energy loss mechanisms, and electromagnetic wave propagation.

Credit Hours 4
Prerequisites/Corequisites CHEM 675, PHYS 635, PHYS 650
Terms Offered Summer

PHYS 776 - Structure and Dynamics of the Magnetosphere

Physics of solar wind, formation of the magnetosphere, and properties of magnetosphere. Topics include solar wind flow, solar wind-earth magnetic field interaction, magnetosphere plasmawave interactions, Van Allen belts, and aurora phenomena.

Credit Hours 4
Prerequisites/Corequisites PHYS 650
Terms Offered Spring

PHYS 777 - The Solar Atmosphere

This course deals with the source of the Earth’s space weather, the sun. In particular, the student will study the outer solar regions, including the “quiet” photosphere, the chromosphere, the corona, and solar wind. The course heavily emphasizes both descriptions of instrumentation and data used to observe solar conditions and the “active” sun, which perturbs the Earth’s environment, and it is intended to provide the space environment student with a quantitative description of solar events that impact the forecaster’s mission. Class discussion will focus on sunspot activity, flares, prominence, coronal mass ejections, coronal holes, and other pertinent observables that indicate active conditions on the sun’s surface.

Credit Hours 4
Prerequisites/Corequisites PHYS 635, PHYS 650
Terms Offered As needed

PHYS 780 - Group Theory and Quantum Mechanics

Treats abstract theory of groups and the theory of group representations in sufficient detail to aid in understanding current theories of the structure of atoms, molecules, and solids.

Credit Hours 4
Prerequisites/Corequisites PHYS 755
Terms Offered As needed
PHYS 781 - Laser Spectroscopy

A first course in laser spectroscopy designed to provide the student with the fundamental principles underlying modern spectroscopic methods utilizing lasers. Topical coverage includes the discussion of elements of radiation physics relevant to laser spectroscopy, characteristics of lasers as a spectroscopic tool, and spectroscopic instrumentation including various detection techniques. These topics are followed by an overview of selected experimental techniques, such as laser induced fluorescence; laser Raman, and two-photon absorption spectroscopy.

Credit Hours 4
Prerequisites/Corequisites PHYS 661, OENG 620
Terms Offered Summer

PHYS 782 - Selected Topics in Nonlinear Optics

An advanced course in nonlinear optics designed to provide the student with the fundamental principles underlying nonlinear optical phenomena. Topical coverage includes the discussion of nonlinear interaction of light with matter in terms of nonlinear susceptibility. A semiclassical theory of nonlinear susceptibility is also included. These topics are followed by a discussion of applications in selected subject areas in nonlinear optics and/or laser spectroscopy, such as frequency conversion, phase conjugation, stimulated Raman and Brillouin scattering, and coherent anti-Stokes Raman spectroscopy.

Credit Hours 4
Prerequisites/Corequisites OENG 660, OENG 620, PHYS 755
Terms Offered As needed

PHYS 791 - Operational Assessments in the Space Environment

In the first part of this course, students will study the current operational aspects of USAF/NOAA space environment forecasting and observing. Students will then attempt to solve a current or future DoD operational space-environment-related problem through a class design study. Possible examples include improving satellite-anomaly analysis procedures; writing satellite-anomaly case studies; designing a space environment monitoring network to meet future DoD requirements; and developing a solar-event forecasting expert system.

Credit Hours 4
Prerequisites/Corequisites PHYS 775, PHYS 776
Terms Offered Winter

PHYS 792 - Space Weather Laboratory

This laboratory and lecture course introduces the student to the space weather computer codes used to provide operational space weather support to the DoD, including solar wind, magnetospheric, ionospheric, and thermospheric models. Students will learn about the required inputs for each model, gain experience running the codes, and evaluate the output. The course also discusses instrumentation used to assess space weather storm intensity, such as the fluxgate magnetometer. Finally, students will be exposed to real-time experiments that illustrate how space weather affects the accuracy of operational technologies such as the GPS receiver.

Credit Hours 4
Prerequisites/Corequisites CHEM 675, PHYS 650
Terms Offered Winter
PHYS 798 - Departmental Seminar

This seminar is offered once a week during the academic quarters for all students in Doctoral and Masters’ programs in the Department of Engineering Physics. This seminar is intended to provide the student with information on a wide range of topics from current scientific research to practical engineering design. Where possible, the focus is on specific Air Force needs and programs in areas related to their studies and the structure and organization of the R&D community within the Air Force.

Credit Hours 1
Prerequisites/Corequisites None
Terms Offered All

PHYS 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

PHYS 840 - Advanced Topics in Optics

Selections from a host of advanced topics such as the use of variational principles in geometrical optics, Fresnel-Kirchoff scalar diffraction theory, coherence, holography, imaging theory, interaction of light with materials and waves, dielectric waveguides and optical fibers.

Credit Hours 4
Prerequisites/Corequisites PHYS 740, OENG 644, OENG 620
Terms Offered As needed

PHYS 845 - Quantum Optics

A modern introduction to light and its interaction with quantum mechanical systems. Treats the photon concept and the fundamental physics that underlie modern optical phenomena, such as self-induced transparency, photon-echo, coherent pulse propagation, Lamb’s theory of the laser, and superradience.

Credit Hours 4
Prerequisites/Corequisites PHYS 640, PHYS 755, OENG 620
Terms Offered As needed

PHYS 880 - Positron Physics and Chemistry

Advanced treatment of physics and chemistry of positron and positronium. Topics include: 1) physical chemistry of positrons, 2) compounds and chemistry of positrons and positronium, 3) experimental techniques in positron spectroscopy, 4) positron poroimetry, materials applications, and 5) quantum computational methods to model positron chemistry.

Credit Hours 4
Prerequisites/Corequisites PHYS 655 or permission of instructor
Terms Offered Summer

PHYS 899 - Doctoral Level Special Study

Course content determined by faculty member based on student need.

Credit Hours 1-12
Prerequisites/Corequisites None
Terms Offered All
PHYS 998 - Research Prospectus

This course is designed to provide direction to the doctoral student in the development of the research prospectus. The student will work with his research committee in carrying out a background study in the area chosen for dissertation research, scope the problem, and finally present the problem to the committee in a formal document, the Research Prospectus. If necessary, this course can be repeated in several quarters, depending on the nature and scope of the dissertation research.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

PHYS 999 - Dissertation Research

This course consists of dissertation research conducted in applied or engineering physics, including both the research itself and the preparation and defense of the dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

Credit Hours 1-12
Prerequisites/Corequisites Approval of department
Terms Offered All

QMGT 680 - Project Risk Analysis

Whether in a laboratory or product center environment, risk analysis is a topic of great interest throughout the DoD acquisition community. Therefore, this course introduces students to a variety of approaches for evaluating risk and uncertainty in a dynamic decision-making environment. Topics include defining risk, risk identification, risk handling, and both qualitative and quantitative risk methods. Both analytical and simulation methods for quantifying risk will be discussed. In order to cover simulation methods, the general method of Monte Carlo simulation will be introduced. Finally, the problem of integrating risk analyses into a total measure of risk will be discussed.

Credit Hours 3
Prerequisites/Corequisites STAT 525
Terms Offered Fall (DL), Winter

RDMT 541 - Operational Technology and Innovation

Throughout history, technological changes and innovation have impacted the socio-political-economic systems in our society in a variety of ways. These changes often play a dual role - they disrupt the existing order and create new opportunities. Although most innovations and technological changes fail, companies that do not pursue innovation often fail too. Therefore, managing innovation is often considered one of the most difficult challenges a manager faces. The successful manager must understand the dynamics of how technologies are changing, who might be involved in potentially complementary (yet often competitive) work, and how to achieve and maintain a technological advantage. The focus of the course is on the management of product and process innovation, with special emphasis on economic, management, and technological influences on implementing product and manufacturing change. Both sustaining and disruptive innovations will be discussed.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter
RDMT 554 - Management in R&D Organizations

Throughout history, technological change and innovation have impacted the socio-political-economic systems in our society in a variety of ways. These changes often play a dual role – they disrupt the existing order and create new opportunities. Although most innovations and technological changes fail, companies that do not pursue innovation often fail too. Therefore, managing innovation is often considered one of the most difficult challenges a manager faces. The successful manager must understand the dynamics of how technologies are changing, who might be involved in potentially complementary (yet often competitive) work, and how to achieve and maintain a technological advantage. The focus of the course is on the management of product and process innovation; both sustaining and disruptive innovations will be discussed.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

RDMT 654 - Seminar in Research and Development Management

This class is the capstone course for the S&T management sequence in the GEM program. It is intended to prepare students to take leadership positions in the defense research and development community. Augmenting previously taught material, the course will integrate lessons learned and how they are/can be applied in the Air Force and other DoD organizations. Topics will be integrative in nature aimed at bringing together lessons from the entire curriculum. The class will consist of chapter analysis of the textbook, case studies, and additional material as required.

Notes This is a capstone class aimed at preparing students to take leadership positions in all aspects of the defense research and development community.

Credit Hours 3
Prerequisites/Corequisites None
Terms Offered Winter

RDMT 699 - Master's Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 1 - 12
Prerequisites/Corequisites None
Terms Offered As needed

RDMT 799 - Thesis Research

An in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis written under the supervision of a departmental professor. An oral presentation and defense of the research is required.

Credit Hours 1 - 12
RSCH 630 - Research Methods

Research Methods is one of the foundation courses in a management-related master of science degree program. It provides an understanding of the basic methods of conducting research and concepts related to scientific inquiry. This course is designed to advance students along the research process by introducing the basic tools needed to critically analyze claims made through the written body of knowledge and determine the degree to which these claims are valid. As such, the course should help students not only in conducting research, but also in judging the validity of any claims made verbally or in writing. An important part of the process is an understanding of the statistical procedure used to analyze the data (such as linear regression reliability of measure, correlation, and causality) to support drawing conclusions about the research question. Additionally, the course will provide a foundation for students in designing and conducting their own research projects and help them determine how close to the truth they have come in their own efforts.

Credit Hours 4
Prerequisites/Corequisites STAT 525
Terms Offered Winter, Spring, Summer

RSCH 631 - Advanced Qualitative Research Methods

This course has three primary goals: (a) to present the range of qualitative research methods which might support student thesis research projects, (b) to describe the logic behind and need for qualitative perspectives in management research, and (c) to present techniques for enhancing reliability and validity in qualitative research. Two group projects involving data collection and analysis as well as an individual research proposal are required.

Credit Hours 3
Prerequisites/Corequisites RSCH 630 or Permission of Instructor
Terms Offered As needed

RSCH 662 - Metrics, Surveys, and Instrument Development

This course provides students with the specific competencies needed to develop high quality metrics, surveys, and organizational measures to support decision making. It focuses on designing, pilot-testing, and interpreting measurement instruments used in management and the behavioral sciences. Topics in Psychometrics and methods for collecting descriptive and attitudinal data are drawn on to provide students with a solid base of knowledge. Applied projects are designed to stimulate procedural knowledge development. This course is very appropriate for students whose thesis research involves surveys, interviews, or other organizational measures.

Credit Hours 0
Prerequisites/Corequisites RSCH 630 or equivalent
Terms Offered As needed

SENG 520 - Systems Engineering Design

This course provides a broad introduction to the structured approach necessary for the design of complex systems. The formulation of systems problems and the approach to their solution will be emphasized. Basic mathematical techniques available to the systems engineer are presented. The design process will be illustrated through the review of past design efforts, and the application to a problem of current interest.

Credit Hours 4
Prerequisites/Corequisites none
Terms Offered Summer, Fall
SENG 560 - Introduction to Human Systems Integration

A human-centered design approach (i.e., "system" includes people within an organization that apply technology to accomplish a task) is explored through readings, discussion and a project. Included are discussions of the Human Systems Integration domains (manpower, personnel, training, human factors, system safety, environmental safety, occupational health and survivability) and a method for considering these domains within the Systems Engineering Lifecycle.

Credit Hours 4  
Prerequisites/Corequisites Prerequisites: none  
Terms Offered Terms offered: Fall

SENG 570 - Lean for Scientists and Engineers

Lean is a process improvement methodology often applied across manufacturing and logistics disciplines and has found application in several industry sectors ranging from aerospace to healthcare. However, translating the principles of Lean, Six Sigma, and other methodologies into the sciences and engineering has lagged. How does Lean apply to the work of scientists and engineers? This course will move beyond the introduction of lean concepts and methodologies to helping students answer this question. Topics include people, process, technology, and management dimensions across a Lean Enterprise focusing on applications for scientists and engineers. The course includes lectures, active learning exercises, a possible plant tour, talks by industry practitioners, and videos. Upon completion of the course, students will be well versed in these methodologies and prepared to help with any Continuous Improvement Process activity such as AFSO21.

Credit Hours 3  
Prerequisites/Corequisites None  
Terms Offered Fall, Spring

SENG 585 - Reliability in Systems Design

The purpose of this course is to introduce students to the probabilistic models and statistical methods used by reliability engineers. This first course gives basic definitions and terminology, investigates parametric lifetime models, non-parametric methods, coherent systems analysis. Markov analysis techniques and an introduction to repairable system analysis. Emphasis will be placed on using these mathematical tools to models RAM as a dynamic process, develop test plans, perform graphical and statistical inference, as well as model product improvement the development process.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Winter

SENG 610 - Project Management

Provides knowledge and tools to manage projects or effectively contribute as a project member. Framed by the systems development cycle, course explains challenges specific to three major project types: systems engineering, software systems, and construction. Basic topics include project lifecycle, project planning/selection, cost estimating, scheduling, and risk management. Advanced topics include critical chain analysis, adaptive project management, acquisition logistics, and contracting. A one hour lab illustrates course principles using Microsoft Project software.

Credit Hours 4  
Prerequisites/Corequisites SENG 520  
Terms Offered Spring, Summer
### SENG 620 - Topics in Systems Engineering

This course builds on the material presented in SENG 520, presenting additional depth and breadth in topics of use in systems engineering. Topics vary and have included system dynamics, chaos theory, general systems theory, and system architecting. Topics include, but are not limited to, multi-objective optimization, system design modeling languages, tradeoff and decision analysis, and design data management.

**Credit Hours** 3  
**Prerequisites/Corequisites** None  
**Terms Offered** Summer

### SENG 639 - Systems Design Project

This course provides a capstone system design experience for students who are not doing a systems design thesis. It will emphasize the practical details of applying systems engineering tools and techniques to a real multi-disciplinary design problem. Students will be assigned to small design teams and given a general problem statement. The team will be responsible for completing a thorough systems analysis of the problem, developing and evaluating alternative solutions, selecting the best alternative, proposing appropriate implementation of the selected solution, and documenting the entire experience.

**Notes** Student will also receive supplementary instruction covering details of the design process and new tools and techniques relevant to the selected projects.

**Credit Hours** 4  
**Prerequisites/Corequisites** SENG 520  
**Terms Offered** Summer

### SENG 640 - System Architecture

Examines enterprise information architecture (EIA) as a management tool to facilitate the implementation of strategic direction. This includes exploring the integration of EIA with strategic and resource planning, information assurance, and acquisition management. It introduces the use of EIA frameworks to improve the capability maturity level of the EIA to meet its intended purpose. Other topics include the role of the CIO in EIA management, the use of models and standards, implementation issues, and an overview of enterprise information assurance/security architecture. Strategies are also explored for using EIA to address enterprise problems such as interoperability and information sharing with the intent of improving enterprise performance of mission or business operations.

**Credit Hours** 4  
**Prerequisites/Corequisites** none  
**Terms Offered** Summer
**SENG 653 - Concept Definition and System Analysis**

This course provides students with theory and process to perform mission area analysis, definition of operational need, concept formulation, analysis of alternatives, program formulation, and risk management. A current DoD mission area will be chosen as the theme for the course in order to provide a relevant educational experience with defense systems. Topics for this course include the overall mission analysis and requirements development processes used to develop a weapon system and allocation of mission needs to system and subsystem functional requirements. In the latter half of the course, students transition from operational requirements to allocated functional performance requirements and synthesizing these into an affordable and operationally effective system design. The focus during this phase will be on risk identification/mitigation and cost affordability.

*Notes* US citizens only

**Credit Hours** 4  
**Prerequisites/Corequisites** SENG 520 and SENG 640  
**Terms Offered** Winter

---

**SENG 685 - Reliability Engineering**

This course introduces the students to some advanced reliability modeling and statistical analysis techniques. The student will be introduced to a variety of statistical inference procedures. Topics include sequential procedures, Bayesian procedures, and parameter estimation with covariates. Some of the specialized reliability models introduced in SENG 585 will be examined in more detail. In particular, competing risks, accelerated life, and proportional hazard models will be discussed. The final third of the course will focus on strategies currently being used to optimize the design of systems using the most cost effective combination of design parameters under uncertainty. Electrical circuits, mechanical structures, and manufacturing processes will be used as examples.

*Notes* This course is a continuation of SENG 585.

**Credit Hours** 4  
**Prerequisites/Corequisites** Prerequisites: STAT 601 and SENG 585  
**Terms Offered** Terms offered: Spring

---

**SENG 687 - Advanced Topics in Reliability**

The objective of this course is to introduce students to advanced topics in systems design in the area of reliability, maintainability, and availability applied to system design. Comparison of current Eastern/Western approaches to design is focus of course.

**Credit Hours** 4  
**Prerequisites/Corequisites** SENG 685, STAT 601 or Permission of Instructor  
**Terms Offered** Summer
SENG 699 - Master's Level Special Studies

Course content determined by faculty member based on student need

Credit Hours 1 - 12
Prerequisites/Corequisites None
Terms Offered All

SENG 740 - Advanced Topics in System Architecture

This course presents advanced analysis techniques using systems architecture, as defined in the Department of Defense Architecture framework (DODAF) and prescribed by DoD policy. Various topics will be selected based upon current state-of-the-art in systems engineering publications with topics including system of systems analysis, service orientated architecture, web-application design, network-centric operations and executable architectures. The student will bridge military concepts of network centric warfare with engineering tools from information systems modeling, architecture, and analysis.

Credit Hours 4
Prerequisites/Corequisites SENG 640
Terms Offered Winter

SENG 797 - Certificate Capstone Project

An investigation or preliminary design on a topic of current Air Force interest (which may be classified) is selected. The individual or team develops a proposal and conducts the investigation. A formal written report and oral presentation are prepared by the individual or group and provided to the sponsoring organization, as required. This class is for Systems Engineering Certificate students and is a single quarter in length. This course focuses on an appropriately scoped project to apply and demonstrate mastery of one or more aspects of the SE Certificate coursework.

Credit Hours 4
Prerequisites/Corequisites Must be enrolled in SE certificate program
Terms Offered All

SENG 798 - Group Design Project

A design study on a topic of current Air Force interest (which may be classified) is selected as a class project. The class develops its own organizational structure to suit the problem, develops a statement of work and conducts the study.

Notes Progress reports and final reports are given to the sponsoring organization, as required. A formal written report is prepared by the group. This class may be either one or two quarters in length. If it extends over two quarters, no credit is given until the end of the last quarter. This course is similar to SENG 799, but is for non-thesis students.

Credit Hours 4 - 8
Prerequisites/Corequisites Must be enrolled in ISE Program
Terms Offered Multiple
SENG 799 - Group Design Study

A design study on a topic of current Air Force interest (which may be classified) is selected as a class project. The class develops its own organizational structure to suit the problem, develops a statement of work and conducts the study.

Notes Progress reports and final reports are given to the sponsoring organization, as required. A formal written report is prepared by the group and accepted by the faculty in lieu of the Master's thesis. This course extends over four quarters and no credit is given until the end of the last quarter.

Credit Hours 1 - 12
Prerequisites/Corequisites Must be enrolled in Systems Engineering Program
Terms Offered All

SENG 899 - Doctoral Level Special Studies

Course content determined by faculty member based on student need.

Credit Hours 1 - 12
Prerequisites/Corequisites Approval of Research Advisor
Terms Offered All

STAT 521 - Applied Statistical Data Analysis

This course provides statistical tools for the analysis of data in the decision-making process. The course covers descriptive statistics, probability theory, and statistical inference. Concepts discussed include methods on how to specify what data is wanted, collect data, extract information from existing sources of data, test the validity of key concepts, estimate problem parameters, and relate one decision variable to another (ANOVA and regression).

Credit Hours 5
Prerequisites/Corequisites None
Terms Offered Summer

STAT 521 - Lab

Two-hour computer laboratory portion of STAT 521 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0
Prerequisites/Corequisites None
Terms Offered Summer

STAT 525 - Applied Statistics for Managers I

This course covers descriptive statistics, probability theory and statistical inference. Descriptive statistics covers both numerical and graphical techniques to illustrate data. Probability theory covers the theoretical underpinnings of both discrete and continuous random variables. Statistical inference includes topics such as central limit theorem, confidence interval and hypothesis testing (one sample and two), and nonparametric techniques.

Credit Hours 4
Prerequisites/Corequisites None
Terms Offered Summer, Fall
STAT 535 - Applied Statistics for Managers II

Statistical methods needed to gather, interpret and apply data in the decision-making process are presented. Concepts discussed include methods on how to: specify what data is wanted, collect data, extract information from existing sources of data, test the validity of key concepts, make intelligent estimates of major problem parameters, and relate one decision variable to another (ANOVA and regression).

Credit Hours 4  
Prerequisites/Corequisites STAT 525  
Terms Offered Winter, Fall

STAT 535 - Lab

Two-hour computer laboratory portion of STAT 535 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0  
Prerequisites/Corequisites STAT 525  
Terms Offered Winter, Fall

STAT 583 - Introduction to Probability and Statistics

Basic concepts of probability and statistics with applications are covered. Topics include permutations and combinations, random variables, probability distributions, estimation and confidence intervals, hypothesis testing.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Winter, Summer, Fall

STAT 586 - Probability Theory for Communication and Control

Selected topics from probability theory are introduced as a basis for applications in the analysis and design of modern communication and control systems. Topics include the concepts of sample spaces, random variables, random vectors, probability densities, probability distributions, discrete and continuous distributions, expectation and moments, characteristic functions, transformations of random variables and vectors, multivariate normal distribution.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Fall

STAT 587 - Applied Probability and Statistical Analysis

This course presents the basic concepts of probability and statistics. Emphasized topics are basic probability axioms and laws, discrete and continuous random variables, joint probability distributions, expectations, conditional probability, the central limit theorem, sampling theory, estimation, and hypothesis testing.

Credit Hours 4  
Prerequisites/Corequisites None  
Terms Offered Fall
STAT 601 - Theory of Probability

Topics include an introduction to probability theory, distributions and expectations of random variables, moment-generating functions, joint distribution of functions of several random variables, transformations of random variables, conditional expectation and conditional density functions, order statistics, and limit theorems.

Credit Hours 4
Prerequisites/Corequisites Permission of the Department
Terms Offered Fall

STAT 602 - Mathematical Statistics

This course provides the student with a solid foundation in the intermediate concepts of mathematical statistics. Topics include tests of hypotheses, point and interval estimation, sufficient statistics, uniform minimum variance unbiased estimates, Cramer-Rao Inequality, and convergence theorems.

Credit Hours 4
Prerequisites/Corequisites STAT 601
Terms Offered Winter

STAT 687 - Mathematics of Reliability Theory I

Reliability models, reliability estimation, exponential and Weibull models, sequential life testing, Bayesian reliability in testing and design, goodness-of-fit tests, accelerated testing, reliability growth models.

Credit Hours 4
Prerequisites/Corequisites STAT 602
Terms Offered Summer

STAT 694 - Design of Experiments

This course gives an introduction to the linear statistical model and its associated forms of inference with special emphasis on analysis of variance models. The classical experimental design models are analyzed with emphasis on fractional factorial designs and their application to engineering problems. The successful student will be able to pose a research question in statistical terms and design an experiment to answer that question including determination of Expected Mean Square (EMS) and F-tests.

Credit Hours 4
Prerequisites/Corequisites STAT 696
Terms Offered Summer

STAT 696 - Applied General Linear Models

Theory and application of the general linear statistical model. Population distribution and parameters are tested using regression and analysis of variance in the context of the general linear model. Topics covered include general regression and correlation analysis, basic analysis of variance, and multifactor analysis of variance.

Credit Hours 4
Prerequisites/Corequisites STAT 583 or STAT 602
Terms Offered Fall, Winter

STAT 696 - Lab

Two-hour computer laboratory portion of STAT 696 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0
Prerequisites/Corequisites STAT 583 or STAT 602
Terms Offered Fall, Winter
STAT 699 - Master's Level Special Studies

Study at a beginning graduate level of a special statistics topic that is not covered in a regularly scheduled graduate course.

**Credit Hours** 1-12  
**Prerequisites/Corequisites** Permission of the Department  
**Terms Offered** Infrequently

---

STAT 799 - Independent study

The topic for an independent study is selected from a wide variety of problems usually of current interest to the Air Force.

**Notes** The results of the study are reported in a thesis written under the supervision of a department faculty member and are presented in a formal oral report. Ordinarily this study extends over three quarters and no credit is given until the end of the last quarter.

**Credit Hours** 1-12  
**Prerequisites/Corequisites** Permission of the Department  
**Terms Offered** Winter, Spring, Summer, Fall

---

STAT 899 - Doctoral Level Special Studies

Study at an advanced graduate level of a special statistics topic that is not covered in a regularly scheduled graduate course.

**Credit Hours** 1-12  
**Prerequisites/Corequisites** Permission of the Department  
**Terms Offered** Infrequently

---

STAT 999 - Dissertation Research

Dissertation research conducted in probability and statistics, including both the research itself and the preparation and defense of the prospectus and dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters.

**Notes** Remarks: This course is graded on a P (progress) or U (unsatisfactory) basis.

**Credit Hours** 1 - 12  
**Prerequisites/Corequisites** Approval of Research Advisor  
**Terms Offered** Winter, Spring, Summer, Fall
AFIT Graduate Faculty

Graduate School of Engineering and Management

LIEUTENANT COLONEL ARIEL O. ACEBAL
Assistant Professor of Atmospheric Physics, Department of Engineering Physics, BS, MS, PhD (Utah State University)

LIEUTENANT COLONEL JEREMY S. AGTE
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Massachusetts Institute of Technology)

DARRYL K. AHNER
Assistant Professor of Operations Research, Director, Center for Operational Analysis, Director, DoD STAT in T&E Center of Excellence, Department of Operational Sciences, BS, MS, MS, PhD (Boston University)

BENJAMIN F. AKERS
Assistant Professor of Mathematics, Department of Mathematics and Statistics, BS, MA, PhD (University of Wisconsin-Madison)

LIEUTENANT COLONEL GEOFFREY A. AKERS
Electrical Engineering Division Chief and Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (University of Kansas)

LIEUTENANT COLONEL BRADLEY E. ANDERSON
Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, MBA, PhD (Indiana University - Bloomington)

HAROLD J. ARATA III
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, MS, MSCS, PhD (University of Tulsa)

BRADLEY J. AYRES
Visiting Professor, Department of Aeronautics and Astronautics, BS, MA, MS, PhD (Florida State University)

ADEDEJI B. BADIRU
Professor of Industrial Engineering and Head, Department of Systems and Engineering Management BS, MS, PhD (University of Central Florida)

WILLIAM F. BAILEY
Associate Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)
WILLIAM P. BAKER  
Associate Professor of Mathematics, Department of Mathematics and Statistics, BA, MA, PhD (Northwestern University)

RUSTY O. BALDWIN  
Professor of Computer Engineering, Department of Electrical and Computer Engineering, BSEE, MS, PhD (Virginia Polytechnic Institute and State University)

DAVID R. BARR  
Associate Professor Emeritus of Statistics, Department of Mathematics and Statistics BA, MA, MS, PhD (State University of Iowa)

MAJOR KEVIN S. BARTLETT  
Assistant Professor of Atmospheric Sciences, Department of Engineering Physics, BS, MS, PhD (SUNY-Albany)

KENNETH W. BAUER, JR.  
Professor of Operations Research, Department of Operational Sciences, BS, MEA, MS, PhD (Purdue University)

JONATHAN T. BLACK  
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Kentucky)

CHRISTOPH BOREL-DONOHUE  
Research Associate Professor of Engineering Physics, Department of Engineering Physics, Diploma, PhD (University of Massachusetts, Amherst)

LIEUTENANT COLONEL BRETT J. BORGHETTI  
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Minnesota)

DELMAR W. BREUER  
Professor Emeritus of Aerospace Engineering Department of Aeronautics and Astronautics BS, MS, PhD (The Ohio State University)

CHARLES J. BRIDGMAN  
Professor Emeritus of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (North Carolina State University)

DURSUN A. BULUTOGLU  
Associate Professor of Statistics, Department of Mathematics and Statistics, BS, MA, PhD (University of California, Berkeley)
DAVID J. BUNKER
Research Assistant Professor of Engineering Physics, Department of Engineering Physics, BS, MS, PhD (University of Colorado)

LARRY W. BURGGRAF
Professor of Chemical Physics and Engineering Physics, Department of Engineering Physics, BA, MS, MA, PhD (University of Denver)

COLONEL KEVIN E. BURNS
Associate Dean, Graduate School of Engineering and Management, Senior Military Professor, Graduate School of Engineering and Management, Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (University of Georgia)

MAJOR JONATHAN W. BUTTS
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Tulsa)

STEPHEN C. CAIN
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Tulsa)

ROBERT A. CALICO, JR.
Professor Emeritus of Aerospace Engineering Department of Aeronautics and Astronautics BS, MS, PhD (University of Cincinnati)

MICHAEL J. CAYLOR
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Notre Dame)

STEPHEN P. CHAMBAR
Adjunct Associate Professor of Operational Research, Department of Operational Sciences, BS, MS, PhD (Arizona State University)

CAPTAIN PATRICK S. CHAPIN
Assistant Professor of Statistics, Department of Mathematics and Statistics, BS, MS, PhD (Iowa State University)

JAMES W. CHRISSIS
Associate Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Virginia Polytechnic Institute and State University)

LIEUTENANT COLONEL JEFFREY D. CLARK
Assistant Professor Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Air Force Institute of Technology)
RICHARD G. COBB
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Air Force Institute of Technology)

JEFFERY K. COCHRAN
Professor of Operations Research, Department of Operational Sciences, BSE, MSNE, MSIE, PhD (Purdue University)

PETER J. COLLINS
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BA, BSEE, MSEE, PhD (Air Force Institute of Technology)

JOHN M. COLOMBI
Assistant Professor of Systems Engineering, Department of Systems and Engineering Management, BSEE, MSEE, PhD (Air Force Institute of Technology)

MARTHA C. COOPER
Adjunct Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, PhD (The Ohio State University)

MAJOR JAMES D. CORDEIRO, JR.
Assistant Professor of Statistics, Department of Mathematics and Statistics, BA, MS, MS, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL PAUL COTELLEO
Assistant Professor of Engineering Management, Department of Systems Engineering and Management, BS, MS, PhD (The Ohio State University)

RONALD A. COUTU, JR.
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (Air Force Institute of Technology)

WILLIAM A. CUNNINGHAM, III
Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BSBA, MS, PhD (University of Arkansas)

SALVATORE J. CUSUMANO
Assistant Professor of Optical Engineering, Department of Engineering Physics, BS, MS, PhD (University of Illinois)

ANTHONY P. D'ANGELO
Professor Emeritus of Logistics Management Department of Systems and Engineering Management BBA, MBA, DBA (Indiana University)
NATHANIEL J. DAVIS IV
Professor of Electrical and Computer Engineering and Head, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (Purdue University)

LIEUTENANT COLONEL JOHN R. DEA
Assistant Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, PhD (Naval Postgraduate School)

LIEUTENANT COLONEL DOUGLAS D. DECKER
Adjunct Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Air Force Institute of Technology)

RICHARD F. DECKRO
Professor of Operations Research, Department of Operational Sciences, BSIE, MBA, DBA (Kent State University)

MAJOR THOMAS E. DUBE
Assistant Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Air Force Institute of Technology)

MICHAEL T. EISMANN
Adjunct Assistant Professor of Optical Engineering, Department of Engineering Physics, BS, MS, PhD (University of Dayton)

WILLIAM C. ELROD
Professor Emeritus of Aerospace Engineering Department of Aeronautics and Astronautics BME, MME, PhD (University of Michigan)

LIEUTENANT COLONEL JOHN ELSHAW
Assistant Professor of Management Department of Systems and Engineering Management BS, MBA, PhD (Purdue University)

CAPTAIN ROGER A. ERICH
Instructor of Statistics, Department of Mathematics and Statistics, BS, MS, PhD candidate (The Ohio State University)

HOWARD E. EVANS, II
Adjunct Assistant Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Americus University)

MATTHEW C. FICKUS
Associate Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, PhD (University of Maryland, College Park)
STEVEN T. FIORINO  
Research Associate Professor of Atmospheric Physics, Director, Center of Directed Energy, Department of Engineering Physics, BS, BS, MS, PhD (Florida State University)

LIEUTENANT COLONEL KENNETH A. FISHER  
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MS, PhD (Air Force Institute of Technology)

STEVEN L. FORSYTHE  
Adjunct Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Air Force Institute of Technology)

MILTON E. FRANKE  
Professor Emeritus of Aerospace Engineering, Department of Aeronautics and Astronautics, BME, MSME, PhD (The Ohio State University)

LIEUTENANT COLONEL ANTHONY L. FRANZ  
Assistant Professor of Engineering Physics, Department of Engineering Physics, BS, MS, PhD (University of Maryland-College Park)

LIEUTENANT COLONEL MARK A. FRIEND  
Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Air Force Institute of Technology)

MARK A. GALLAGHER  
Adjunct Associate Professor of Operations Research, BS, MS, PhD (Air Force Institute of Technology)

CAPTAIN MATTHEW B. GARVIN  
Assistant Professor of Computational Chemical Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

NANCY C. GILES  
Professor of Physics and Head, Department of Engineering Physics, BS, PhD (North Carolina State University)

MARK N. GOLTZ  
Professor of Engineering and Environmental Management, Department of Systems and Engineering Management BS, MS, PhD (Stanford University)

ROBERT B. GREENDYKE  
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BBA, BS, MS, PhD (Texas A&M University)

MICHAEL R. GRIMAILA  
Associate Professor of Information Resource Management, Department of Systems Engineering and Management BSEE, MSEE, PhD (Texas A&M University)
KEVIN C. GROSS
Assistant Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

CAPTAIN MARSHALL E. HAKER
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL SHANE N. HALL
Adjunct Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (University of Illinois at Urbana-Champaign)

LIEUTENANT COLONEL FREDERICK G. HARMON
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of California-Davis)

LIEUTENANT COLONEL CARL R. HARTSFIELD
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Naval Postgraduate School)

WILLIE F. HARPER, JR.
Assistant Professor of Environmental Engineering and Sciences, Department of Systems Engineering and Management, BS, M.ENG, PhD (University of California)

MICHAEL J. HAVRILLA
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MSEE, PhD (Michigan State University)

LIEUTENANT COLONEL MICHAEL R. HAWKS
Assistant Professor of Optical Engineering, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL SHARON G. HEILMANN
Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MA, MS, MB, PhD (Indiana University)

ALAN R. HEMINGER
Associate Professor of Information Resource Management Department of Systems and Engineering Management BA, MS, PhD (University of Arizona)

ROBERT L. HENGEHOLD
Professor of Physics, Department of Engineering Physics, BA, MS, PhD (University of Cincinnati)
RAYMOND R. HILL, JR.
Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (The Ohio State University)

DOUGLAS D. HODSON
Assistant Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, MBA, PhD (Air Force Institute of Technology)

KENNETH M. HOPKINSON
Associate Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD (Cornell University)

LIEUTENANT COLONEL RICHARD E. HUFFMAN
Adjunct Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Illinois at Urbana-Champaign)

MAJOR MILO W. HYDE, IV
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MSEE, PhD (Air Force Institute of Technology)

JULIE A. JACKSON
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (The Ohio State University)

DAVID R. JACQUES
Associate Professor of Aerospace Engineering Department of Systems and Engineering Management BSME, MSAE, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL TAY W. JOHANNES
Assistant Professor in Engineering Management, Department of Systems and Engineering Management, BS, MS, PhD. (The George Washington University)

GEORGE JOHN
Professor Emeritus of Nuclear Engineering, Department of Engineering Physics, BSC, PhD (The Ohio State University)

ALAN W. JOHNSON
Associate Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, PhD (Virginia Polytechnic Institute and State University)

PAUL I. KING
Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Oxford University, England)
MAJOR BENJAMIN R. KOWASH
Assistant Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (University of Michigan)

DONALD L. KUNZ
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Georgia Institute of Technology)

TIMOTHY H. LACEY
Adjunct Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MSCE, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL DARIN A. LADD
Assistant Professor of Information Resources Management, Department of Systems and Engineering Management, BS, MS, PhD (Washington State University)

ALAN V. LAIR
Professor of Mathematics and Head, Department of Mathematics and Statistics BA, MS, PhD (Texas Tech University)

GARY B. LAMONT
Professor of Electrical and Computer Engineering, Department of Electrical and Computer Engineering, BA, MSEE, PhD (University of Minnesota)

JAMES J. LANGE
Adjunct Associate Professor of Physics, Department of Engineering Physics, BS, MS, PhD (University of Wisconsin)

LIEUTENANT COLONEL BRENT T. LANGHALS
Assistant Professor of Information Resources Management, Department of Systems and Engineering Management, BS, MS, PhD (University of Arizona)

CAPTAIN DERRICK LANGLEY
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Air Force Institute of Technology)

MARY Y. LANZEROTTI
Associate Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Cornell University)

LIEUTENANT COLONEL KEVIN J. LAROCHELLE
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Air Force Institute of Technology)
MAJOR KENNARD R. LAVIERS
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Central Florida)

COLONEL TIMOTHY J. LAWRENCE
Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Surrey, UK)

LIEUTENANT COLONEL DOUGLAS LEWIS, USA
Assistant Professor of Biodefense, BS, MS, PhD (George Mason University)

ALEX G. LI
Research Assistant Professor of Engineering Physics, Department of Engineering Physics, BS, MS, PhD (Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences)

BRADLEY S. LIEBST
Professor of Aerospace Engineering and Head, Department of Aeronautics and Astronautics, BS, MS, PhD (Massachusetts Institute of Technology)

CAPTAIN DAVID LIU
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Air Force Institute of Technology)

MAJOR ANDREW J. LOFTHOUSE
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Michigan)

LIEUTENANT COLONEL JAMES A. LOUTHAIN
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (Air Force Institute of Technology)

AMY L. MAGNUS
Research Assistant Professor of Engineering Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

SHANKAR MALL
Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Washington)

MICHAEL A. MARCINIAK
Associate Professor of Physics, Department of Engineering Physics, BS, BSEE, MSEE, PhD (Air Force Institute of Technology)

CAPTAIN CHRISTOPHER L. MARTIN
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Air Force Institute of Technology)
RICHARD K. MARTIN  
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, BS, MSEE, PhD (Cornell University)

KIRK A. MATHEWS  
Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

MAJOR DANIEL D. MATTIODA  
Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, PhD (The University of Oklahoma)

LIEUTENANT COLONEL BRIAN K. MCBEE, USAF  
Assistant Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, MS, MS, PhD (Virginia Polytechnic Institute and State University)

JOHN W. MCCLORY  
Assistant Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

LIEUTENANT COLONEL STEPHEN MCHALE, USA  
Assistant Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

MAJOR GARTH MCMURRAY  
Instructor of Systems Engineering, Department of Systems and Engineering Management, BS, MS, PhD Candidate (The Ohio State University)

LIEUTENANT COLONEL ROBERT J. MCTASNEY  
Assistant Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Colorado)

JOHN O. MILLER  
Associate Professor of Operations Research, Department of Operational Sciences, BS, MBA, MS, PhD (The Ohio State University)

MICHAEL E. MILLER  
Assistant Professor of Human Systems Integration, Department of Systems and Engineering Management, BS, MS, PhD (Virginia Polytechnic Institute and State University)

ROBERT F. MILLS  
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (University of Kansas)

BARRY E. MULLINS  
Associate Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Virginia Polytechnic Institute and State University)
JAN P. MUCZYK
Professor Emeritus of Management, Department of Systems and Engineering Management BS, MS, PhD (University of Maryland)

JEFFREY A. OGDEN
Associate Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MBA, PhD (Arizona State University)

MARK E. OXLEY
Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, PhD (North Carolina State University)

MEIR N. PACHTER
Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (Israel Institute of Technology)

ANTHONY N. PALAZOTTO
Distinguished Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (New York University)

GLEN P. PERRAM
Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

GILBERT L. PETERSON
Associate Professor of Computer Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Texas at Arlington)

JAMES C. PETROSKY
Associate Professor of Nuclear Engineering, Department of Engineering Physics, BA, MS, PhD, (Renssaler Polytechnic Institute)

LIEUTENANT COLONEL TIMOTHY J. PETTIT
Adjunct Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, PhD (The Ohio State University)

JOSEPH J. PIGNATIELLO
Professor of Operations Research and Head, Department of Operational Sciences, BS, MS, PhD (The Ohio State University)

MAJOR MICHAEL C.POCHET
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (University of New Mexico)

MARC D. POLANKA
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Texas)
CAPTAIN KEVIN R. POND  
Assistant Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, PhD (Virginia Polytechnic Institute and State University)

DENNIS W. QUINN  
Professor Emeritus of Mathematics, Department of Mathematics and Statistics BS, MS, PhD (University of Delaware)

MAJOR LEEANN RACZ  
Assistant Professor of Environmental Engineering, Department of Systems and Engineering Management, BS, MS, PhD (University of Utah)

LIEUTENANT COLONEL TIMOTHY C. RADSICK  
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of California, Santa Barbara)

RICHARD A. RAINES  
Director, Center for Cyberspace Research, DoD Force Transformation Chair, Professor of Electrical Engineering, Department of Electrical and Computer Engineering BSEE, MS, PhD (Virginia Polytechnic Institute and State University)

MAJOR CHRISTIAN E. RANDALL  
Instructor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS (Air Force Institute of Technology)

JOHN F. RAQUET  
Director, Advanced Navigation Technology Center, Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Calgary, Canada)

MARK F. REEDER  
Associate Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (The Ohio State University)

D. LANCE REVENAUGH  
Adjunct Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BBA, MBA, PhD (Arizona State University)

DANIEL E. REYNOLDS  
Assistant Professor Emeritus of Statistics, Department of Mathematics and Statistics BA, MS, MS (Wright State University)

HEIDI R. RIES  
Dean for Research, Graduate School of Engineering and Management and Associate Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Old Dominion University)
LIEUTENANT COLONEL DANIEL RITSCHEL  
Assistant Professor of Cost Analysis, Department of Systems and Engineering Management, BBA, MS, PhD  
(George Mason University)

MAJOR MATTHEW J. ROBBINS  
Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (University of Illinois at Urbana-Champaign)

LIEUTENANT COLONEL DAVID J. ROBINSON  
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD  
(Dartmouth)

MAJOR AUGUST G. ROESENER  
Adjunct Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD  
(University of Texas at Austin)

MARINA B. RUGGLES-WRENN  
Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD  
(Rensselaer Polytechnic Institute)

CAPTAIN JAMES L. RUTLEDGE  
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD  
(Air Force Institute of Technology)

LIEUTENANT COLONEL DORAL E. SANDLIN  
Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MBA, MLM, MA, PhD  
(The Ohio State University)

CHRISTINE M. SCHUBERT KABBAN  
Assistant Professor of Statistics, Department of Mathematics and Statistics, BS, MBA, MS, PhD  
(Air Force Institute of Technology)

KENNETH L. SCHULTZ  
Associate Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, PhD  
(Cornell University)

LIEUTENANT COLONEL CHRISTOPHER M. SHEARER  
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD  
(University of Michigan)

MICHAEL L. SHELLEY  
Professor of Engineering and Environmental Management Department of Systems and Engineering Management BCE, MS, PhD  
(University of North Carolina)
ANDREW J. SHINE
Professor Emeritus of Aerospace Engineering Department of Aeronautics and Astronautics BS, MS, PhD (The Ohio State University)

MAJOR MARK D. SILVIUS
Assistant Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSEE, MSEE, PhD (Virginia Polytechnic Institute and State University)

LIEUTENANT COLONEL RONALD J. SIMMONS
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (The Ohio State University)

JAMES R. SIMPSON
Adjunct Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Arizona State University)

LIEUTENANT COLONEL JOSEPH B. SKIPPER
Adjunct Assistant Professor of Logistics and Supply Chain Management, Department of Operational Sciences, BS, MS, PhD (Auburn University)

ERIC D. SWENSON
Assistant Professor of Aerospace Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Texas, Austin)

MICHAEL A. TEMPLE
Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BSE, MSE, PhD (Air Force Institute of Technology)

ANDREW J. TERZUOLI, JR.
Associate Professor of Electrical Engineering, Department of Electrical and Computer Engineering, BS, MS, PhD (The Ohio State University)

ALFRED E. THAL, JR.
Associate Professor of Engineering Management Department of Systems and Engineering Management BS, MS, PhD (University of Oklahoma)

MARLIN U. THOMAS
Dean, Graduate School of Engineering and Management, Professor of Operations Research, Department of Operational Sciences, BSE, MSE, PhD (University of Michigan)

PETER J. TORVIK
Professor Emeritus of Aerospace Engineering and Engineering Mechanics, Department of Aeronautics and Astronautics, BS, MS, PhD (University of Minnesota)
RONALD F. TUTTLE
Director, Center for Technical Intelligence Studies and Research and Associate Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (University of Missouri-Columbia)

DAVID K. VAUGHAN
Adjunct Faculty, Professor of Technical Communication, Department of Systems and Engineering Management BS, MA, PhD (University of Washington)

LIEUTENANT COLONEL ROOBERT S. WACKER
Assistant Professor of Atmospheric Physics, Department of Engineering Physics, BS, MS, PhD (University of Wisconsin-Madison)

LIEUTENANT COLONEL KARL C. WALLI
Assistant Professor of Engineering Physics and Deputy Head, Department of Engineering Physics, BS, MS, PhD (Rochester Institute of Technology)

MAJOR RICHARD L. WARR
Assistant Professor of Statistics and Deputy Head, Department of Mathematics and Statistics BS, MA, MS, PhD (University of New Mexico)

DAVID E. WEEKS
Professor of Physics, Department of Engineering Physics, BA, MS, PhD (University of Arkansas)

LIEUTENANT COLONEL JOHN WEIDNER, USA
Research Assistant Professor of Nuclear Engineering, Department of Engineering Physics, BS, MS, PhD (University of Wisconsin-Madison)

JEFFERY D. WEIR
Associate Professor of Operations Research, Department of Operational Sciences, BEE, MAS, MS, PhD (Georgia Institute of Technology)

EDWARD D. WHITE, III
Associate Professor of Statistics, Department of Mathematics and Statistics, BS, MAS, PhD (Texas A&M University)

WILLIAM E. WIESEL, JR.
Professor of Astronautical Engineering, Department of Aeronautics and Astronautics, BS, MS, PhD (Harvard University)

LIEUTENANT COLONEL J. ROBERT WIRTHLIN
Assistant Professor of Engineering Systems, Department of Systems and Engineering Management, BS, MS, Ph.D. (Massachusetts Institute of Technology)

JAMES W. WISNOWSKI
Adjunct Associate Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Arizona State University)
PAUL J. WOLF
Associate Dean for Academic Affairs, Graduate School of Engineering and Management and Professor of Physics, Department of Engineering Physics, BS, MS, PhD (Air Force Institute of Technology)

AIHUA W. WOOD
Professor of Mathematics, Department of Mathematics and Statistics, BS, MS, PhD (University of Connecticut)

CAPTAIN BRIAN G. WOOLLEY
Assistant Professor of Computer Science, Department of Electrical and Computer Engineering, BS, MS, PhD (University of Central Florida)

LIEUTENANT COLONEL DIRK P. YAMAMOTO
Assistant Professor of Industrial Hygiene, Department of Systems and Engineering Management BS, MS, MSPH, PhD (Air Force Institute of Technology)

ALAN T. YEATES
Adjunct Assistant Professor of Chemical Physics, Department of Engineering Physics, BS, PhD (University of Washington)

YUNG K. YEO
Professor of Physics, Department of Engineering Physics, BS, PhD (University of Southern California)

DANIEL J. ZALEWISKI
Adjunct Assistant Professor of Operations Research, Department of Operational Sciences, BS, MS, PhD (Air Force Institute of Technology)

CAPTAIN TIMOTHY W. ZENS
Assistant Professor of Materials Science, Department of Engineering Physics, BS, MS, PhD (Massachusetts Institute of Technology)
INDEX

A
Academic Advisor, 19
Academic Calendar, 32
Academic Departments, 4
Academic Departments, 56
Academic Honors, 23
Academic Integrity, 23
Academic Performance, 23
Academic Policies, 19
Academic Programs & Degrees Offered, 15
Academic Standards, 23
Academic Year, 19
Accreditation, 13
Administration, 4
Admission Statuses, 41
Admissions / Registrar Directorate, 35
Admissions Standards, 35
Advanced Geospatial Intelligence Infrared / Synthetic Aperture Radar Certificate, 110
Aeronautical Engineering (M.S.), 58
Aeronautical Engineering (Ph.D.), 68
Aeronautics and Astronautics (ENY), 56
AFIT Graduate Faculty, 303
AFIT Leadership, 2
AFIT Student Association, 55
Appeal of Grades, 21
Applied Mathematics (Ph.D.), 118
Applied Physics (M.S.), 96
Applied Physics (Ph.D.), 106
Astronautical Engineering (M.S.), 60
Astronautical Engineering (Ph.D.), 69
Attendance Policy, 23
Auditing, 19
B
Board of Visitors, 14
C
Chancellor's Message, 1
Change of Address, 21
Changes after Admission, 42
Classification of Students, 20
Combating Weapons of Mass Destruction (M.S.), 98
Combating Weapons of Mass Destruction Certificate, 112
Computer Engineering (M.S.), 78
Computer Engineering (Ph.D.), 87
Computer Science (M.S.), 80
Computer Science (Ph.D.), 88
Computer Support, 52
Confidentiality of Academic Records, 21
Cost Analysis (M.S.), 145
COURSE DESCRIPTIONS, 171
Cyber Operations (M.S.), 82
Cyber Warfare (IDE) (M.S.), 83
D
Dayton & AFIT, 5
Distance Learning Offerings, 17
Doctor of Philosophy Programs, 26
<table>
<thead>
<tr>
<th>E</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Plan, 20</td>
<td>Library Services, 48</td>
</tr>
<tr>
<td>Electrical and Computer</td>
<td>Logistics (IDE Air Mobility) (M.S.), 130</td>
</tr>
<tr>
<td>Engineering (ENG), 74</td>
<td>Logistics (IDE) (M.S.), 128</td>
</tr>
<tr>
<td>Electrical Engineering (M.S.), 85</td>
<td>Logistics (Ph.D.), 135</td>
</tr>
<tr>
<td>Electrical Engineering (Ph.D.), 89</td>
<td>Logistics and Supply Chain Management (M.S.), 123</td>
</tr>
<tr>
<td>Eligibility Criteria - Doctoral Degree, 36</td>
<td></td>
</tr>
<tr>
<td>Eligibility Criteria - Masters Degree, 36</td>
<td></td>
</tr>
<tr>
<td>Engineering Management Program (M.S.), 146</td>
<td></td>
</tr>
<tr>
<td>Engineering Physics (ENP), 92</td>
<td></td>
</tr>
<tr>
<td>Environment Engineering and</td>
<td></td>
</tr>
<tr>
<td>Science Program, 152</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Financial Assistance, 50</td>
<td>Master's Degree Programs, 24</td>
</tr>
<tr>
<td>G</td>
<td>Materials Science (M.S.), 63</td>
</tr>
<tr>
<td>Grading System, 22</td>
<td>Materials Science (M.S.), 100</td>
</tr>
<tr>
<td>Graduate Certificate Programs, 17</td>
<td>Materials Science (Ph.D.) – Electronic/Photonic, 107</td>
</tr>
<tr>
<td>H</td>
<td>Materials Science (Ph.D.) – Structural, 70</td>
</tr>
<tr>
<td>History, 5</td>
<td>Mathematics and Statistics (ENC), 115</td>
</tr>
<tr>
<td>Human Systems Certificate, 167</td>
<td>Mission, 4</td>
</tr>
<tr>
<td>I</td>
<td>N</td>
</tr>
<tr>
<td>Incompletes, 21</td>
<td>Nuclear Engineering (M.S.), 102</td>
</tr>
<tr>
<td>Industrial Hygiene Program, 153</td>
<td>Nuclear Engineering (Ph.D.), 108</td>
</tr>
<tr>
<td>Information Assurance Certification, 90</td>
<td>Nuclear Weapons Effects, Policy, and Proliferation Certificate (DL), 113</td>
</tr>
<tr>
<td>Intermediate Development Education, 18</td>
<td></td>
</tr>
<tr>
<td>International Student Division, 54</td>
<td>O</td>
</tr>
<tr>
<td>Internet Access, 53</td>
<td>Operational Sciences (ENS), 119</td>
</tr>
<tr>
<td></td>
<td>Operational Technology Certificate, 168</td>
</tr>
<tr>
<td></td>
<td>Operations Analysis (IDE) (M.S.), 132</td>
</tr>
<tr>
<td></td>
<td>Operations Research (M.S.), 126</td>
</tr>
<tr>
<td></td>
<td>Operations Research (Ph.D.), 137</td>
</tr>
<tr>
<td></td>
<td>Optical Science and Engineering (M.S.), 104</td>
</tr>
<tr>
<td></td>
<td>Optical Science and Engineering (Ph.D.), 109</td>
</tr>
<tr>
<td></td>
<td>Organization, 4</td>
</tr>
<tr>
<td>P</td>
<td>Probation and Dismissal, 24</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>R</td>
<td>Refund Policy, 50</td>
</tr>
<tr>
<td></td>
<td>Registrar Division, 43</td>
</tr>
<tr>
<td></td>
<td>Registration Changes, 20</td>
</tr>
<tr>
<td></td>
<td>Release of Student Information, 44</td>
</tr>
<tr>
<td></td>
<td>Repeated Courses, 21</td>
</tr>
<tr>
<td></td>
<td>Research, 45</td>
</tr>
<tr>
<td></td>
<td>Research Assistantships (RA), 51</td>
</tr>
<tr>
<td></td>
<td>Research Centers, 46</td>
</tr>
<tr>
<td>S</td>
<td>Scholarships, 51</td>
</tr>
<tr>
<td></td>
<td>Scholarships / Consortia, 30</td>
</tr>
<tr>
<td></td>
<td>Space Systems (M.S.), 66</td>
</tr>
<tr>
<td></td>
<td>Space Systems (Ph.D.), 72</td>
</tr>
<tr>
<td></td>
<td>Student Advising, 24</td>
</tr>
<tr>
<td></td>
<td>Student Services, 54</td>
</tr>
<tr>
<td></td>
<td>Student Support Division, 54</td>
</tr>
<tr>
<td></td>
<td>Supply Chain Management Certificate (DL), 139</td>
</tr>
<tr>
<td></td>
<td>Systems and Engineering Management (ENV), 142</td>
</tr>
<tr>
<td></td>
<td>Systems Engineering (IDE) (M.S.), 155</td>
</tr>
<tr>
<td></td>
<td>Systems Engineering (M.S.), 159</td>
</tr>
<tr>
<td></td>
<td>Systems Engineering (Ph.D.), 166</td>
</tr>
<tr>
<td></td>
<td>Systems Engineering Certificate, 169</td>
</tr>
<tr>
<td>T</td>
<td>Test and Evaluation Certificate (DL), 141</td>
</tr>
<tr>
<td></td>
<td>Transcript Release, 44</td>
</tr>
<tr>
<td></td>
<td>Transcript Request, 44</td>
</tr>
<tr>
<td></td>
<td>Transfer of Credits, 21</td>
</tr>
<tr>
<td>V</td>
<td>Transcripts, 22</td>
</tr>
<tr>
<td></td>
<td>Tuition Assistance, 51</td>
</tr>
<tr>
<td></td>
<td>VA Education Benefits, 51</td>
</tr>
</tbody>
</table>