



AIR FORCE INSTITUTE OF TECHNOLOGY

# GRADUATE SCHOOL OF ENGINEERING & MANAGEMENT



2009-2010  
GRADUATE CATALOG

# 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.

## Commandant's Message



We are pleased to welcome you to the Air Force Institute of Technology. Whether you are a U.S. or international military member, government employee, or civilian, the Graduate School of Engineering and Management has a wide range of exciting education and cutting edge research opportunities for you.

Since 1919, AFIT has educated the air, space, and cyberspace leaders that have made history. WWII raider Jimmy Doolittle, space architect Gen Bernard Schriever, astronauts Bill Anders, Guion Bluford, and Steve Lindsey, and former Secretary of the Air Force Michael Wynne are just a few of AFIT's distinguished alumni.

AFIT provides rigorous, respected, and relevant graduate education, research, and consultation to push the frontiers of air, space, and cyberspace power. What makes AFIT different from other schools you might be considering? We are focused on the defense applications of technology. The thesis effort is a cornerstone of our degree programs, and our students are expected to explore critical problems of military technology and national defense.

You will find a unique environment here to support you in that effort. AFIT's campus contains over 68 state-of-the-art laboratories for aerospace, physics, environmental science, radar and electronics, and more. AFIT also has a strong partnership with the Air Force Research Laboratory, as well as synergies with the Aeronautical Systems Center, National Air and Space Intelligence Center, and the DoD Supercomputer Center, all co-located on Wright-Patterson Air Force Base.

AFIT exists to develop not only future technology, but also future leaders capable of applying that technology to solve challenging national defense problems of the United States and its allies. You will be asked, even required, to stretch yourself, expanding your capabilities in multiple directions. We invite you to embrace this challenge.

Paula G. Thornhill, Brig Gen, USAF

AFIT Commandant

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## 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 15,000 master's degrees and 300 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 questioning 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's 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 the 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 Leadership

**Brigadier General Paula G. Thornhill, PhD**

Commandant

**CAPTAIN Timothy J. Duening, USN**

Vice Commandant

**Dr. Marlin U. Thomas**

Dean

**Colonel David W. Cribb, PhD**

Associate Dean

**Colonel Lisa Harrington, PhD**

Dean of Students

**Dr. Heidi R. Ries**

Dean for Research

**Dr. Paul J. Wolf**

Associate Dean for Academic Affairs

## 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 fledging 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

The Air School of Application was established within the Engineering Division at McCook Field

McCook Field in Dayton, OH, the home of Orville and Wilbur Wright.	with seven officers enrolled and Colonel Bane as the Commandant.
<u>1920</u> School renamed.	Following the creation of the Air Service, the school was redesignated the Air Service Engineering School.
<u>1926</u> 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.
<u>1927</u> 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.
<u>1927</u> 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.
<u>December 1941</u> Attack on Pearl Harbor.	The attack on Pearl Harbor caused the Air Corps Engineering School to suspend classes.
<u>April 1944</u> 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.
<u>September 1946</u> 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.
<u>1947</u> Institute adopts present name: Air Force Inst 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.
<u>1950</u> 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.
<u>1951</u> Two AFIT colleges combined into Resident College.	The Institute's progress toward the "graduate school" was marked by the enrollment of eight officers in the first Advanced Engineering Management Class in January 1951.
<u>1954</u> 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.
<u>April 1955</u> Logistics program established.	The Institute designed a logistics education program in 1955, and The Ohio State University (OSU) conducted the first courses on a contract basis.
<u>1956</u> First bachelor's degrees conferred.	The first undergraduate engineering degrees were granted in 1956.
<u>1958</u> 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).
<u>1960</u> Business programs transferred.	The School of Business programs were transferred to civilian universities in 1960.
<u>1960</u> Graduate programs accredited	AFIT obtains its initial accreditation from the North Central Association of Colleges and Schools (NCA) to award graduate degrees.
<u>1961</u> 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.
<u>1963</u> 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.
<u>1970s</u> Technology growth.	The seventies saw a scientific expansion as technology accelerated further. AFIT graduates were closely involved in the Apollo space program.
<u>1972</u> 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.
<u>1977-1978</u> 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.
<u>1980s</u> AFIT programs embody high technology education.	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.

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 centers of excellence-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 noncommissioned officers.

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 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-ever 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.

### 2009

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

As AFIT completes its ninth decade of operation, 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.

## **Mission**

**Education and Research** The mission of the AFIT 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.

**Award Degrees** 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.

# Accreditation

The Air Force Institute of Technology is accredited by The Higher Learning Commission 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  
30 North LaSalle Street, Suite 2400  
Chicago, Illinois 60602-2504  
Phone: (800) 621-7400

In addition to institutional accreditation, the Accreditation Board for Engineering and Technology (ABET) accredits selected engineering programs within the Graduate School of Engineering and Management. These programs are Aeronautical Engineering, Astronautical Engineering, Computer Engineering, Electrical Engineering, Engineering Management, Environmental Engineering and Science, Nuclear Engineering, and Systems Engineering.

**ABET can be contacted at:**

Accreditation Board of Engineering and Technology Inc.  
111 Market Pl, Suite 1050  
Baltimore, MD 21202  
Phone: (410) 347-7700

# 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.

The Graduate School is responsible for:

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 Graduate School is administered by the Dean's Office, which is composed of the Dean, the Associate Dean, the Dean for Research, the Associate Dean for Academic Affairs, and the Dean of 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.

# Board of Visitors

The Air Force Institute of Technology (AFIT) Board of Visitors (BOV) is comprised of a select group of eminent educators from prominent US colleges and universities and senior executives from major industries. The Board 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 Board of Visitors 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**  
Vice President, Strategy and Executive Consulting Service  
Shiplely Associates

**Members**    **Dr. Kyle Terry Alfriend**  
TEES Distinguished Research Chair Professor  
Dept. of Aerospace Engineering  
Texas A&M University

**Dr. Michael Bragg**  
Professor and Head  
University of Illinois at Urbana-Champaign

**CMSgt Karl Meyers, USAF, Retired**  
Realtor, Realty Executives  
Simmons Group

**Major General Richard Paul, USAF, Retired**

**Vice Adm Daniel Oliver, USN, Retired**

**Maj Gen Ronald Segal, USAF, Retired**

**Dr. Eugene Spafford**  
Professor of Computer Science  
Executive Director of CERIAS  
Purdue University

# Academic Calendar 2009-2010

<b>Military Students arrive</b>	Aug 18, Tuesday	Military students arrive
<b>Fall Orientation / Review Session 2009</b>	Aug 19 -28, Wednesday-Friday	Student Orientation / In-Processing
	Sep 1, Monday	Labor Day - Offices closed
	Aug 31 - Sep 25, Monday-Friday	Technical Refresher courses
<b>Fall Quarter 2009</b>	Sep 28, Monday	Fall term courses begin - Winter course schedule available
	Oct 2, Friday	Last day to add a class
	Oct 5, Monday	Open registration for Winter begins today
	Oct 09, Friday	Last day to drop a course without a record
	Oct 12, Monday	Columbus Day - Offices closed
	Nov 11, Wednesday	Veterans Day - Offices closed
	Nov 05, Thursday	Wingman Day – No classes
	Nov 20, Friday	Last day to drop a course
	Nov 26, Thursday	Thanksgiving Day - Offices closed
	Nov 27, Friday	AETC Family Day - No classes
	Dec 09, Wednesday	Classes end
	Dec 11-15, Friday-Tuesday	Final exams
<b>Winter Quarter 2010</b>	Jan 4, Monday	Classes Begin - Spring schedule available
	Jan 08, Friday	Last day to add a class
	Jan 11, Monday	Open registration for Spring begins today
	Jan 15, Friday	Last day to drop a course without a record
	Jan 18, Monday	Martin Luther King Day - Offices closed
	Feb 15, Monday	President's Day - Offices closed
	Feb 27, Friday	Last Day to drop a course

	Mar 12, Friday	Classes end
	Mar 15-18, Monday-Thursday	Final exams
	Mar 25, Thursday	Commencement
<b>Spring Quarter 2010</b>	Mar 29, Monday	Classes Begin - Summer course schedule available
	Apr 2, Friday	Last day to add a class
	April 5, Monday	Open registration for Summer begins today
	Apr 09, Friday	Last day to drop a course without a record
	May 21, Friday	Last day to drop a course
	May 31, Monday	Memorial Day - Offices closed
	Jun 4, Friday	Classes end
	Jun 7-10, Monday-Thursday	Final exams
	Jun 17, Thursday	Commencement
	Jun 18, Friday	Air mobility graduation
<b>Military Students arrive</b>	May 21, Friday	Military students arrive
<b>Summer Orientation / Review Session 2010</b>	May 24-28, Monday-Friday	Student Orientation / In-Processing
	May 31, Monday	Memorial Day - Offices closed
	June 1-25, Tuesday- Friday	Technical refresher courses
<b>Summer Quarter 2010</b>	Jun 28, Monday	Classes Begin - Fall course schedule available
	July 2, Friday	Last day to add a course
	Jun 29, Monday	Open registration for Fall begins
	Jul 2, Thursday	Last day to drop a course without a record
	Jul 5, Monday	Independence Day Observed- Offices closed
	Jul 2, Friday	AETC Family Day - No classes
	Aug 20, Friday	Last day to drop a course
	Sep 3, Friday	Classes end

Sep 07- 10, Tuesday -  
Friday

Final exams

Sep 6, Monday

Labor Day - Offices closed

## Academic Programs and Degrees Offered

The degrees currently available through the faculty of the Graduate School of Engineering and Management are a Master of Science (M.S.), Master of Science in (Engineering Discipline) for ABET accredited programs, and Doctor of Philosophy (Ph.D.). Master's Degree programs accredited by the Accreditation Board for Engineering and Technology (ABET) are identified with an asterisk (\*).

<b>Program</b>	<b>Degree</b>	<b>Department</b>
Aeronautical Engineering*	M.S., Ph.D.	Aeronautical and Astronautical Engineering
Applied Mathematics	M.S., Ph.D.	Mathematics and Statistics
Applied Physics	M.S., Ph.D.	Engineering Physics
Astronautical Engineering*	M.S., Ph.D.	Aeronautical and Astronautical Engineering
Combating Weapons of Mass Destruction	M.S.	Engineering Physics
Computer Engineering*	M.S., Ph.D.	Electrical and Computer Engineering
Computer Science	MS, Ph.D.	Electrical and Computer Engineering
Cost Analysis	M.S.	Systems and Engineering Management
Cyber Operations	M.S.	Electrical and Computer Engineering
Electrical Engineering*	M.S., Ph.D.	Electrical and Computer Engineering
Optical Science and Engineering	M.S., Ph.D.	Engineering Physics
Engineering Management*	M.S.	Systems and Engineering Management
Environmental Engineering and Science	M.S.	Systems and Engineering Management
Financial Analysis	M.S.	Systems and Engineering Management
Industrial Hygiene	M.S.	Systems and Engineering Management
Information Resource Management	M.S.	Systems and Engineering Management
Logistics and Supply Chain Management	M.S.	Operational Sciences

Materials Science	M.S., Ph.D.	Aeronautical and Astronautical Engineering; Engineering Physics
Nuclear Engineering*	M.S., Ph.D.	Engineering Physics
Operations Research	M.S., Ph.D.	Operational Sciences
Research and Development Management	M.S.	Systems and Engineering Management
Space Systems#	M.S.	Aeronautical and Astronautical Engineering
Systems Engineering*	M.S., Ph.D.	Systems and Engineering Management

# A Ph.D. is available that allows the student 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. The student 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 2009-2010 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 department section.

<b>Program</b>	<b>Department</b>
Advanced Geospatial Intelligence, IR/SAR	Engineering Physics
Combating Weapons of Mass Destruction	Engineering Physics
Information Assurance	Electrical and Computer Engineering Systems and Engineering Management
Operational Technology	Systems and Engineering Management
Space Systems	Aeronautics and Astronautics
Supply Chain Management	Operational Sciences
Systems Engineering	Systems and Engineering Management
Test and Evaluation	Operational Sciences

# 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 x 7422 (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. Once admitted the only hardware requirements are a telephone, 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:

- visit the office's webpage at <http://www.afit.edu/en/dl>;
- send an email to [en.dl@afit.edu](mailto:en.dl@afit.edu); or
- contact the Extension Services office by phone at (937) 255-3636 x 7422 (DSN 785-)

Currently, the graduate school offers one master's (MS) degree program, and five graduate certificate programs via DL. These programs are listed below.

DL Certificate  
Programs (5)

Advanced Geospatial Intelligence Certificate Program (ACP)

Combating Weapons of Mass Destruction

Space Systems Certificate Program

Supply Chain Management Certificate Program

Systems Engineering Certificate Program

Test and Evaluation Certificate Program (TECP)

DL Degree  
Programs (1)

**Systems Engineering MS Degree Program**

Application and  
Enrollment  
Information

More information about these programs, including application and enrollment information, can be found at AFIT's Extension Services website: [www.afit.edu/en/dl](http://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, making the program 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

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 2009-2010 IDE programs.

Intermediate  
Development Education  
(IDE) for 2009-2010  
Academic Year

Program	Degree	Department
Systems Engineering	Master of Science Master of Science in Systems Engineering	Systems and Engineering Management
Cyber Warfare* (See note)	Master of Cyber Warfare	Electrical and Computer Engineering
Logistics	Master of Science in Logistics	Operational Sciences
Air Mobility (ASAM)	Master of Science in Logistics	Operational Sciences
Operations Analysis	Master of Science in Operations Analysis	Operational Sciences

\* The cyber Warfare degree program is only available to military personnel and DoD civilians 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).

## Scholarships / Academic Consortiums

[^ TOP](#)

AFIT has agreements with two academic consortiums that afford degree candidate MS students and PhD students the opportunity to enroll in courses at other academic institutions.

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). Tuition-only scholarships are 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](http://www.DAGSI.org).

Graduate students who have obtained candidacy in a master's degree program and Ph.D. students may apply for a non-competitive, **STUDENT PROGRAM 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 serve 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/FAQ.cfm> . Or call Dr. Richard Raines - (937)255-6565, x4278, Dr. Rusty Baldwin - (937)255-6565, x4445, Mrs. Stacey Johnston - (937)255-3636, x4602, or Ms. Jamie Jones (937)255-3636, x4634.

#### 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 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.*

# Research

**Dean for Research: Heidi R. Ries, PhD**

Phone: 937-255-3636x4544

**Director of Sponsored Programs: Michael J. Caylor, PhD**

937-255-3636x4729

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](mailto: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 sustaining the technological supremacy.

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/researchresources.cfm?a=report> 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](mailto:research@afit.edu). The primary points of contact are Dr. Michael J. Caylor, Director of Sponsored Programs, 937-255-3636x4729, and Dr. Heidi R. Ries, Dean for Research, 937-255-3636x4544.

## RESEARCH CENTERS

**The Advanced Navigation Technology Center (ANT)** The Advanced Navigation Technology Center is a forward-looking navigation research center seeking to identify and solve tomorrow's most challenging navigation problems. The ANT Center's goal is to develop navigation technology that ensures we can navigate anywhere at any time. Under Air Force Research Laboratory sponsorship, the ANT Center designed and built a GPS-based relative navigation system that determines cm-level relative positions between two flying aircraft. The Center also developed autonomous formation flight control algorithms and successfully flew the entire system at the USAF Test Pilot School, accomplishing the first fully autonomous precision formation flight appropriate for aerial refueling. <http://www.afit.edu/en/ant/>

**The Center for MASINT Studies and Research (CMSR)** The Center for MASINT Studies and Research (CMSR) is focused on Air Force and DoD GEOINT (Geospatial Intelligence) and MASINT (Measurement And Signature Intelligence) scientific, technical, and operational activities. Research-based graduate programs offered by the Department of Engineering Physics support our activities. In building the CMSR into a center of excellence, strategic partnerships with world-class intelligence and research organizations located at Wright-Patterson AFB allow CMSR to maintain relevancy to the requirements and needs of these two communities. These partnerships also extended to local GEOINT and MASINT contractors supporting on-base

functions. Consequently, CMSR has truly become a national resource for the technical intelligence community for educating a new generation of GEOINT and MASINT professionals to assure the preeminence of our air and space, ground, and naval forces. <http://www.afit.edu/en/cmsr/>

**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 CyberSpace Research (CCR)** The Center for Cyberspace Research is the Air Force Cyberspace Technical Center of Excellence (AF CyTCoE), a designated Center of Academic Excellence in Information Assurance Education & Research by the National Security Agency and Department of Homeland Security, as well as a National Science Foundation CyberCorp institution. 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 faculty teaches and performs research focusing on understanding and developing advanced cyber-related theories and technologies. These theory and technology advancements have included efforts in network intrusion detection and avoidance, insider threat mitigation, cyberspace situational awareness, network visualization, software protection, and anti-tamper technologies development. The CCR, under tasking as the AF CyTCoE, works with the Air Force Leadership to develop and maintain the cyberspace workforce via cutting-edge education and training curricula. <http://www.afit.edu/en/ccr/>

**The Center for Operational Analysis (COA)** The Center for Operational Analysis, expanding the mission of the former Center for Modeling, Simulation, and Analysis, is dedicated to research and education in operational analysis with an emphasis on enhancing warfighter efficiency and effectiveness at all levels. Research at the COA is defining and enhancing how we do operational analysis at home and in the AOR. Student projects focus on developing techniques and tools to transform data into decision quality information, and the Center is producing operator and warfighter analysts across career fields as future senior AF leaders. <http://www.afit.edu/en/coa/>

**The Center for Rapid Product Development (CRPD)** The Center for Rapid Product Development provides the infrastructure, in conjunction with educational programs offered through the Department of Systems and Engineering Management, necessary for students during the rapid development of promising technologies for urgent warfighter needs. As a joint center between AFRL and AFIT, the CRPD developed a tactical information distribution system that integrates a range of sensors to provide street level situational awareness and strategic level intelligence on enemy activities. The Center also developed a network-enabled small UAV sensor that provides high resolution digital imagery to the user. Prototype efforts have included increasing duration of small gas-powered UAVs and an automated battlefield triage system. The Center resides in facilities located at TecEdge (on Springfield Pike) and TecEdge Works (on Janney Rd in Dayton). Other prominent activities include execution of the yearly AFRL Commander's Challenge. <http://www.afit.edu/crpd/>

# Financial Assistance

## Director, Financial Management and Chief Financial Officer, Ann M. Marburger

AFIT/FM

2950 Hobson Way, Building 643, Room 203

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/>. Click on Costs, Financial Aid in the column on the left.

Please forward a copy of your Registration Form and Approved Funding Documentation (i.e. Unit Funding, DAGSI Scholarship, Tuition Assistance) to the AFIT Bursar before the beginning of classes.

AFIT/FM

ATTN: Carol Autry, Contractor, Bursar

Bldg 643, Room 203

2950 Hobson Way

Wright-Patterson AFB OH 45433-7765

937-255-8400, x3623 DSN 785-8400 x3623

carol.autry.ctr@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), students are paid \$11.70 - \$14.50/hour (undergraduate student), \$17.90/hour (master's student) and \$21.60/hour (PhD student). Civilian students must be US citizens. To request additional

information contact Ms. Marcia Hutcheson, (937)258- 8894 or e-mail [Marcia.Hutcheson@soche.org](mailto:Marcia.Hutcheson@soche.org).

Scholarships	<p>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).</p> <p>For further information, visit the DAGSI website: <a href="http://www.dagsi.org">http://www.dagsi.org</a>.</p> <p>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 <a href="http://www.afit.edu/en/Admissions/Docs/ScholarshipInfo2.pdf">http://www.afit.edu/en/Admissions/Docs/ScholarshipInfo2.pdf</a>.</p>
Tuition Assistance	<p>Tuition Assistance can be used for AFIT courses and must be approved by the Base Education Office prior to registration. Please contact your local Base Education Office for more information.</p>
How to Apply for VA Education Benefits	<p>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.</p>
Academic Standards for VA Education Benefits	<p>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.</p>

# Resources

## Library

**Director, The D'Azzo Research Library, Laurene E. Zaporozhetz, PHD, MSL**

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 library is to provide comprehensive standard library services in support of the core instructional, research, and consultation requirements of the Institute's faculty, students, and staff.

**Location and hours** 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. The library is open from 7:30 a.m. to 9:00 p.m., Monday through Thursday; 7:30 a.m. to 5:00 p.m., Friday, and 11:00 a.m. to 6:00 p.m. Saturday and Sunday. A faculty reserve reading room is available to all faculty members for setting aside select materials relating to their respective courses. The facility also features 12 student seminar rooms and two conference rooms. In addition, a computer classroom with 20 workstations, and 26 workstations in the public service area, are available to library patrons.

**Over a Million Documents in our Library** 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 management, engineering, physics, procurement, computer science, mathematics, operations research, aviation, and military science.
2. The library holds or has access to over 25,000 (paper and electronic) foreign and domestic journal subscription titles covering the social, basic, and applied sciences, and the collection is continuously being updated to add hundreds of additional journal titles in the electronic format.
3. A comprehensive collection of conference reports, proceedings, and transactions are available to library users. The Library receives select series of Air Force technical reports as well as reports from the Army, the Navy, the National Aeronautics and Space Administration, the Air Force National Guard, the Rand Corporation, and other agencies. These reports are available in paper, e-format and microform and represent the largest segment of library holdings.
4. The Library also holds a comprehensive collection of the Institute's resident graduate student's theses and dissertations.
5. A small, circulating collection of non-print media is also available to the library's patrons. This collection is made up of audiovisual materials, including 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. Finally, 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.

Literature-searching tools available.

AFIT maintains literature-searching tools that are critical to support all Institute research requirements. These tools include access to:

1. The Aerospace and High Technology Database, INSPEC, Compendex, FirstSearch, ABI/Inform, Defense Technical Information Center (DTIC) databases, IEEE/IEE Electronic Library, Environmental Universe, Science Direct, Science Citation Index Expanded, and MathSciNet which are all delivered on the Internet.
2. In addition to the above mentioned end-user services, the library provides excellent interlibrary loan services. Materials that are not owned by our local library can be borrowed from other libraries for AFIT patron use.

Library instructional classes provided.

Orientation programs and instructional classes are provided to students and faculty throughout the year, so that they can make more effective use of library resources. Library liaisons are appointed to each major school and graduate department to ensure that appropriate focus and attention is paid to specialized requirements.

The Library holds many memberships.

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

1. With valid identification, all registered AFIT faculty members and students may borrow directly from most SOCHE member's 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 direct borrowing privileges.
3. The D'Azzo 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.

# Computer

**Director, Communications and Information, Wayne R Loveless, 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](mailto:afit.sc@afit.edu)

Website: <http://www.afit.edu/sc>

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

## 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, reduced prices on Microsoft Software, 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 ( <a href="http://asa.afit.edu/">http://asa.afit.edu/</a> ) contains information on student events and a means to contact the current leadership with questions and/or ideas.

## 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](mailto:studentservices@afit.edu); [richard.gammon@afit.edu](mailto: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
- 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

## **INTERNATIONAL STUDENT DIVISION**

**Director and International Military Student Officer (IMSO), Annette Rowell Robb, MAED**

AFIT/ENES, Building 641, Room 106

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.rob主@afit.edu](mailto:annette.rob主@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

# Admissions / Registrar

**Director, L. Edward Hart, MS**

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**

Phone: (937) 255-6234 x3184 (DSN 785-6234 x3184) 800-211-5097 x3184

Fax: (937) 255-2791 (DSN 255-2791)

E-mail address: <http://www.afit.edu/en/Admissions/Default.cfm?l=em&n=ad>

Website: <http://www.afit.edu/en/admissions/>

### 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, U.S. Government civilian employees, non-Government U.S. citizens (including Government contractors), and military officers from select foreign countries. At this time non-military international students are not admitted to the Graduate School of Engineering and Management.

Applicants seeking master's degrees, doctoral degrees, and certificate programs offered are all encouraged to apply for admission. On-line applications are available at:  
<http://www.afit.edu/en/admissions/Default.cfm?l=apps>

Additionally, individuals holding a bachelor's degree from a regionally accredited college or university may apply as a non-degree-seeking applicant and, upon admission, enroll in graduate-level courses without being admitted to a graduate degree program. 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 for a graduate degree program or certificate program.

### 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 preparation in their proposed field of study and possess a reasonable expectation of successfully completing a graduate program. Standards for admission to doctoral degree programs are frequently higher than those for admission to master's degree programs.

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 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 course work 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 or graduate certificates, 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 masters program 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.
3. Submit satisfactory scores on standardized examinations like the Graduate Record Examination (GRE) or the Graduate Management Admissions Test (GMAT). The recommended GRE scores are 500 verbal and 600 quantitative, and 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. GRE scores of at least 550 verbal and 650 quantitative. Applicants who do not meet these criteria can be conditionally admitted and the department can grant individuals waivers to the entrance requirements. Endorsements by the student's MS faculty and/or thesis advisor may be requested by the faculty.

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.

Academic Waivers

Waivers to the above criteria, doctoral and masters programs may be granted on an individual basis, at the discretion of our faculty. Therefore, individuals whose academic credentials fall below any of above entry criteria are encouraged to apply for a graduate program.

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 fail to meet the criteria 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 would be granted upon successful completion of the conditions set forth.

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.

Eligibility Criteria for Certificate Programs And Non-Degree Seeking Applicants	<p>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 may enroll in graduate level courses as their qualifications and performance permit, and they must contact the department(s) offering the courses to ensure that courses are available to non-degree students. A maximum of 12 quarter hours of graduate credit, earned in a non-degree status and/or transferred from another institution may be permitted for application toward an advanced degree, once the student obtains acceptance into a degree program.</p>
General Application Process	<p>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 Admissions. The application form and instructions are found online at <a href="http://www.afit.edu/en/Admissions">http://www.afit.edu/en/Admissions</a>, look for Application for Admission or Application for Distance Learning the appropriate application.</p> <p>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.</p> <p>General inquiries for admission should be addressed to:</p> <p>The Office of Admissions and the Registrar  Graduate School of Engineering and Management  AFIT/ENER, Bldg 641  2950 Hobson Way  Wright-Patterson Air Force Base OH, 45433-7765  1-800-211-5097 x3184;  <a href="http://www.afit.edu/en/Admissions/Default.cfm?l=em&amp;n=ad">http://www.afit.edu/en/Admissions/Default.cfm?l=em&amp;n=ad</a></p>
Required Documentation for Masters and Doctoral Degree Programs.	<p>Each applicant must submit the following items, constituting a complete application package, to the Admissions Office:</p> <ol style="list-style-type: none"> <li>1. A completed application form.</li> <li>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 and the seal of the granting institution and should include the years of attendance, courses taken, grades received, and the degree, certificate or diploma received, if applicable.</li> <li>3. For doctoral programs only, if you did not receive a master's degree from Graduate School of Engineering and Management in residence submit two (2) letters of academic recommendation, preferably from faculty involved in or aware of your thesis.</li> <li>4. Standardized Test Scores. <ul style="list-style-type: none"> <li>○ The Graduate School of Engineering and Management graduate degree programs require applicants to submit standardized test scores applicable to the program requested.</li> <li>○ The Graduate Record Examination (GRE) is acceptable for all master's level degree programs and is required for all doctoral degree programs.</li> <li>○ The Graduate Management Admission Test (GMAT) is an acceptable alternative for several graduate programs, yet not all programs. Please contact Admissions if you cannot which standardized test are accepted under the academic department's web pages.</li> <li>○ Examination scores should be sent directly to the Admissions Office. The Air Force Institute of Technology institutional code for the GRE and GMAT is 1827, and we are listed under the State of Ohio.</li> <li>○ For more information, you may visit the web sites ( <a href="http://www.gre.org">www.gre.org</a> or</li> </ul> </li> </ol>

www.gmat.org) or write to the following addresses:

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

Graduate Management Admissions Test  
Educational Testing Services  
P.O. Box 6103 Princeton, NJ 08541-6103  
USA  
(609) 921-9000

**Note:** Officers, enlisted personnel, and civilians who apply 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 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 web page, <http://www.afit.edu/en/Admissions>.

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

For certificate and non-degree-seeking applications some programs require specific prerequisite course(s) 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) at which they took the prerequisite course(s).

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

Civilian – Non-  
Military

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

International Students

Admission to the Graduate School of Engineering and Management is restricted to citizens of the United States. The exception to this policy is that foreign military officers sponsored by their governments may be admitted. The International Military Student Office at the Air Force Institute of Technology (AFIT) assists international military officers and international government civilian employees with the procedures of application for admission to the Graduate School of Engineering and Management professional continuing education offered by AFIT. Prospective international military students apply for Graduate School of Engineering and Management through the United States Security Assistance Office (SAO) at the United States (US) Embassy in their home country.

International Military  
Officers Application  
Process

Application packages for evaluation for eligibility should arrive at the International Military Office (IMSO) no later than 1 April of each year in preparation for entrance the following September. The prospective student needs to submit the following documents:

1. Official transcripts in English from every academic institution attended (or official transcripts accompanied by an English translation)
2. The Test of English as Foreign Language (TOEFL) is required except for those countries exempted by the Defense Security Assistance Agency (DSAA)
3. A Graduate Record Examination (GRE) Score Report or, if applicable to the particular program, a Graduate Management Aptitude Test (GMAT).
4. The World-wide web site for the degree granting institutions for which transcripts are

submitted.

5. The email address of the office of the registrar for the degree granting institutions for which transcripts were submitted.

To support the application process and help with the admission decision, we recommend submitting the following documents as well:

1. A copy of the college grading scale for each official transcript submitted.
2. The countries International Grade Conversion Guide, if available.
3. Degree plans (in English) for the applicant's undergraduate and /or graduate majors and course descriptions (in English), especially for mathematical coursework, are highly recommended.
4. A Foreign Transcript Evaluation is highly recommended, however these evaluations are not free, thus the applicant may bare the costs. Here are few to view; Educational Credential Evaluators, Inc ( [www.ece.org](http://www.ece.org)), Educational Records Evaluation Services at [www.eres.com](http://www.eres.com), or World Education Services at [www.wes.org](http://www.wes.org).

A satisfactory command of the English language is required for admission to the Graduate School of Engineering and Management. 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).

1. Under the new Internet Based Testing a minimum TOEFL score of 76 is required for admittance.
2. A score of 207 is required for the computer based TOEFL test for admittance.
3. The only countries exempted from TOEFL testing are those countries who are exempted from all ECL testing requirements as determined by the Defense Security Assistance Agency (DSAA) MSG 131158Z MAR 98 (Antigua, Australia, Bahamas, Barbados, Canada, Dominica, Grenada, Guyana, India, Ireland, Jamaica, Malta, New Zealand, Singapore, St. Kitts, St. Lucia, St. Vincent, Trinidad, and the United Kingdom).
4. When applying for a TOEFL exam, the AFIT identification code is 1827.

The Graduate Record Examination (GRE) Score Report or, if applicable to the particular program, a Graduate Management Aptitude Test (GMAT) is required and the nominal scores are:

1. GRE: 500 Verbal and 600 Quantitative. Special note: A satisfactory TOEFL will satisfy the minimal GRE verbal score required for admission for no-English speaking country applicants.
2. GMAT: Total Score 550 (GMAT is only accepted in certain programs and not all. Thus we recommend taking the GRE as it is accepted by all departments.

Send all score reports (GRE, GMAT, TOEFL) to this school identification code 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 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.

Applications for doctoral programs must include all of the above documents, GRE scores must be submitted and the nominal standard scores are 550 Verbal and 650 Quantitative. 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 GRE scores, however those scores are waiverable, and thus a score lower than 550 Verbal and/or 650 Quantitative will not automatically disqualify any applicant.

## ADMISSION STATUS CATEGORIES

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

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 institution and the specific program requirements of the department in which the student plans to pursue study.

**Conditional Admission** Students may be admitted to conditional status because:

1. The previous academic record is borderline (e.g. low cumulative GPA or low GRE/GMAT scores).
2. The prerequisite course work in the chosen field is insufficient.
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 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.

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 quarter of study. Otherwise, the student will not be allowed to register for courses in subsequent quarters.

## 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 form through the Admissions Office. Students requesting such a change must also meet the program 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 <https://www.afit.edu/en/ener/pdf/Application%20for%20Change%20of%20Enrollment%20Status.pdf>.

The academic department will determine the number of Graduate School course hours, or classes, of prior coursework they 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 <https://www.afit.edu/en/ener/pdf/Application%20for%20Change%20of%20Enrollment%20Status.pdf>. 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 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 Admissions prior to changing a degree program.

**Termination** Admission status will terminate for students who are admitted either conditionally or unconditionally, but who do not enroll in any course within one year from the term for which admission was requested, except for Air Force officers seeking degree program acceptance under full Air Force sponsorship.

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, Dewey R. Richmond, Jr.**

Phone: (937) 255-6234 x3122 (DSN 785-6234 x3122)

FAX: (937) 255-2791 or (DSN FAX 785-2791)

E-mail address: [registrar@afit.edu](mailto: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 is accurate, easily understood, and available in a timely fashion.
5. To supply concise information regarding academic policies, transfer credit acceptability, grades, and graduation certification.

**Current Academic Catalog** The catalog may be viewed on line at:  
[http://www.afit.edu/en/ener/prospective\\_students.cfm?a=afitcatalog](http://www.afit.edu/en/ener/prospective_students.cfm?a=afitcatalog)  
click on catalog in left column

AFIT Website	Website for AFIT, general and detailed information about the Graduate School, and its departments and programs - <a href="http://www.afit.edu">http://www.afit.edu</a>
Release of Student Information	<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p>
Transcripts 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, and 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	<p>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".</p> <p>There is no fee for transcript service.</p> <p>Bring photo identification to our office, or you may obtain a transcript request form (Form ENER-TRF-01) by using the link: <a href="http://www.afit.edu/en/Ener/">http://www.afit.edu/en/Ener/</a></p> <p>If you are unable to download the PDF and wish to send a letter please make sure it contains the following information:</p> <ol style="list-style-type: none"> <li>1. Your name, maiden name, and any other previous names (if applicable)</li> <li>2. Social Security number/AFIT Student Identification number</li> <li>3. Birth date</li> <li>4. Dates of attendance</li> <li>5. Complete address where you would like the transcript sent</li> <li>6. Your current address and phone number in case we have questions</li> <li>7. Your signature authorizing the release of the transcript</li> </ol>
Mail requests to:	<p>AFIT/ENER          BUILDING 641, 2950 HOBSON WAY          WRIGHT PATTERSON AFB OH 45433-7765          Or fax to: (937) 255-2791 or (DSN 785-2791)</p>

# 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 Offerings and Schedules	Projected course offerings 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 the AFIT web portal 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 course 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 <a href="http://www.afit.edu/en/ener/registrar.cfm?a=calendars">http://www.afit.edu/en/ener/registrar.cfm?a=calendars</a> Registration is not permitted until tuition and fees are paid, where applicable.
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 full policy is published in ENOI-36-104.
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 report the change in writing to the Registrar. Billing address changes should be reported to the Bursar.
Incompletes	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 points used in calculating the grade point averages:

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

Further Clarification

1. Does not count toward earned credit hours nor do they 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 awards 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.

**Student Advising** 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.

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	<p>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):</p> <p><i>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.</i></p> <p>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.</p>
General Degree Requirements	<p>The Doctor of Philosophy 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:</p> <ol style="list-style-type: none"><li>1. Complete an approved program of study,</li><li>2. Meet the residency requirement,</li><li>3. Pass qualifying examination,</li><li>4. Be admitted into candidacy,</li><li>5. Submit a dissertation, and</li><li>6. Successfully defend the dissertation.</li></ol> <p>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.</p>
Advising	<p>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.</p> <p>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.</p>

Course Requirements	<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p>
Academic Load	<p>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:</p> <ol style="list-style-type: none"> <li>1. The PhD courses are of such advanced nature that a student needs time to understand and assimilate the material contained therein.</li> <li>2. The limitation allows time to interact with other PhD students and with the faculty.</li> <li>3. It allows time to explore areas that may intrigue him or her in the pursuit of the course work.</li> </ol> <p>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.</p>
Standards of Work	<p>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.</p>
Qualifying Examination	<p>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.</p>
Prospectus Examination	<p>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</p>

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	<p>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:</p> <ol style="list-style-type: none"><li>1. Passing the qualifying examination,</li><li>2. An academic record of the student that meets the program and grade point average requirements, and</li><li>3. Approval of the student's prospectus for the dissertation project.</li><li>4. Completion of the residency requirement or approval of a specific plan for meeting it.</li></ol> <p>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.</p>
Dissertation Requirement	<p>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.</p> <p>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 <i>Style Guide for AFIT Theses and Dissertations</i>.</p>
Defense of the Dissertation	<p>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.</p>
Time Limit	<p>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.</p>

# Departments

## Aeronautics and Astronautics (ENY)

### Department Head: Bradley S. Liebst, PhD

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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 three different buildings. Building 640 has 13,000 square feet of general laboratory facilities, building 644 with 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.)

**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** structural mechanics

**William E. Wiesel** astrodynamics

**Associate Professor**

**Robert B. Greendyke** fluid dynamics, physical chemistry

**Donald L. Kunz** dynamics and control

**Marc D. Polanka** heat transfer and propulsion

**Mark F. Reeder** fluid dynamics

**Marina B. Ruggles-Wrenn** structures and materials

**Assistant Professor**

**Bradley J. Ayres** dynamics and control

**Jonathan Black** structural dynamics and control

**Richard D. Branam** fluid and molecular dynamics

**Michael J. Caylor** dynamics, systems and control

**Richard G. Cobb** structural dynamics and control

**Douglas Decker** dynamics and control

**Frederick Harmon** dynamics and control

**Carl R. Hartsfield** propulsion

**Kerry D. Hicks** dynamics and control

**Richard Huffman** fluid dynamics and air weapons

**Andrew Lofthouse** computational fluid dynamics

**Chris Shearer** dynamics and control

**Ronald J. Simmons** propulsion and dynamics

**Eric Swenson** structural mechanics

**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

# Electrical and Computer Engineering (ENG)

**Department Head: Nathaniel J. Davis IV, PhD**

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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:

- 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 Lab
- Center for Cyber Research (CCR)
- Cyber Defense Network
- Laboratory for Information Systems and Development (LISSARD)
- Communication/Radar Lab
- Cyber Adaptive Network in Mobile Applications
- Digital Logic and Microprocessor Lab
- Low Observables Radar and Electromagnetics (LORE) Laboratory
- LORE Radar Cross Section (RCS) Lab
- Microsystems Design and Simulation Laboratory
- Micro and Nano-Devices and Systems Cleanroom
- Microsystems Test and Characterization Laboratory
- Signal and Information Processing Lab

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

**Nathaniel J. Davis IV** advanced computer architectures, computer networks, computer security

**Gary B. Lamont** evolutionary computing, parallel computing

**Meir N. Pachter** flight dynamics and control, inertial and GPS navigation

**Henry B. Potoczny** computer and data security, cryptography

**Richard A. Raines** satellite communications and networks

**Michael A. Temple** communication systems, radar systems, electromagnetic propagation

### Associate Professor

**Rusty O. Baldwin** wireless networks, protocols, information assurance, computer architecture

**Stephen C. Cain** digital systems, image processing, optics

**Peter J. Collins** low observables, remote sensing, materials design, electromagnetic theory, computational electromagnetics, signature metrology

**Steven C. Gustafson** pattern recognition, optical and signal processing

**Michael J. Havrilla** electromagnetics, guided waves, scattering, material characterization

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

**John F. Raquet** global positioning system (GPS), inertial navigation system/GPS integration

**Andrew J. Terzuoli** antennas, electromagnetics, stealth technology

### Assistant Professor

**Todd R. Andel** networking, mobile ad hoc networks, secure routing protocols, network security, formal methods, simulation

**Brett J. Borghetti** artificial intelligence, machine learning, team planning and communication with multi-agent tasks

**Ronald A. Coutu** MEMS/MEOMS, micro/nanoelectronics, semiconductor device/material physics

**Kenneth A. Fisher** guidance, navigation, and control

**Kenneth M. Hopkinson** distributed computing, computer networks, simulation, fault tolerant, reliable systems

**Jeffrey W. Humphries** cryptography, data security, information security

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

**Yong C. Kim** VLSI design, test, design for testability, faulttolerant computing, anti-tamper hardware

**Stuart H. Kurkowski** computer networks, mobile ad hoc networks, information visualization, network visualization

**Richard K. Martin** communication systems, signal processing

**Jeffrey T. McDonald** information security, program protection, code obfuscation, software engineering, mobile agents

**Michael J. Mendenhall** joint compression and classification of extremely high-dimensional data sets, hyperspectral image exploitation, artificial neural networks

**Robert F. Mills** communications, radar, information security

**Barry E. Mullins** computer networks, robotics, information assurance

**Michael A. Saville** radar modeling, radar instrumentation methods, radar signal processing, synthetic aperture radar, electronic warfare, electromagnetic theory, computational electromagnetics

**Jason D. Schmidt** optical effects of atmospheric turbulence, adaptive optics, free-space optical communications, laser weapons

**Lavern A. Starman** MEMS/MEOMS, micro/nanoelectronics, semiconductor device/material physics

**Michael J. Stepaniak** global positioning system, navigation, navigation and control

**Ryan W. Thomas** networking, software defined radio, cognitive networks, wireless communications systems

**Gregory J. Toussaint** control theory, nonlinear systems, target recognition

**Eric D. Trias** database, network security, negative databases

**Michael J. Veth** fusion of imaging and inertial sensors for navigation, multiple hypothesis tracking, GPS anti-jam/anti-spoofing techniques via ultra-tight coupling

#### **Professor Emeritus**

**Constantine H. Houppis** guidance, navigation, control systems

**Matthew Kabrisky** pattern recognition, man-machine interface

**Peter S. Maybeck** guidance, navigation, control, stochastic processes

**Vittal P. Pyati** electromagnetics, radar, electronic warfare

#### **Associate Professor Emeritus**

**Thomas C. Hartrum** computer database systems, software engineering

#### **Instructor**

**Geoffrey A. Akers** radar, antenna design, electromagnetics

**Scott A. Goodman** low observables, lasers, electro-optic systems, radar cross section reduction

**Jeffrey M. Hemmes** cooperative computing, design of mobile distributed systems, software architecture, software engineering

**Timothy H. Lacey** software protection, reverse engineering techniques, and network security

**Mark D. Silvius** communication, signal processing

# Engineering Physics (ENP)

**Department Head: Nancy C. Giles, PhD**

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## Introduction

The Department of Engineering Physics provides graduate education and research at both the M.S. and Ph.D. levels through a variety of programs including directed energy weapons, nuclear weapon effects, counterproliferation, combating weapons of mass destruction, space weather and space physics, remote sensing, and electronic and photonic materials. The Department offers courses of study leading to the Master of Science degree in the areas of Applied Physics, Optical Science and Engineering, Nuclear Engineering, Combating Weapons of Mass Destruction, and Materials Science (in conjunction with the Department of Aeronautics and Astronautics). Courses of study for the Doctor of Philosophy degree are also available in all areas except combating weapons of mass destruction.

## Facilities

The Air Force Institute of Technology maintains a 29,914 gross square foot engineering research laboratory (Building 644) on the main campus. The single story building overlooks AFIT Park and is connected to the southeast corner of the Graduate School of Engineering and Management (Building 640). The Engineering Physics Department operates laboratories within this facility to support graduate instruction and research. 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. Research laboratories support faculty and student research at the M.S. and Ph.D. levels in laser spectroscopy, nonlinear optics, solid state physics, Mossbauer spectrometry, nuclear radiation detection, nuclear effects, space weather, and environmental engineering.

## Laser and Optoelectronic Devices Laboratories

This facility is dedicated to experimental research in aeronautical engineering, applied physics, electrical engineering and environmental science and houses four research suites: Aerospace Research Facilities, Applied Physics Laboratories, Environmental Science Suite, and a Microelectronics Clean Room.

The Clean Room Suite enables the fabrication of micro-electromechanical systems (MEMS), and micro and opto-electronic devices and integrated systems. The Clean Room also 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 metalization capabilities.

These diagnostic facilities include a sub-micron probe station and a scanning electron microscope.

In addition, a set of eighteen laboratories designed specifically for laser and optical physics research supports the development of novel laser devices and research in nonlinear optics, spectroscopy, photonics, solid state physics, semiconductor materials and chemical physics. These include the Optics, Spectroscopy, and Kinetics Laboratory, the Ultrafast Laser Spectroscopy Laboratory, the Nonlinear and Fiber Laser Laboratory, and the Semiconductor Optical and Electrical Characterization Laboratory.

Laboratories for laser and optics instruction are housed in Building 640 and include the Optics Laboratory, the Optical Diagnostics Laboratory, and the Optical Low Observables Laboratory.

In addition, Building 644 contains a suite of three environmental science labs which provide for 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.

## **Nuclear Engineering Laboratories**

Located in Building 470, these laboratories support research and instruction in the application of nuclear measurement techniques to a variety of fields.

These laboratories have state-of-the-art equipment for detecting and measuring all sources of alpha, beta, gamma and neutron radiation, and these capabilities are constantly updated. Areas of focus include neutron and gamma-ray spectroscopy, gamma imaging, detection of nuclear fuels in trace quantities, and radiation effects studies on materials and electronics.

Data acquisition and analysis is 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.

## **Space Weather Computational Laboratory**

Located in Building 640, this laboratory is a modeling and simulation facility devoted to research analysis of naturally occurring electrically charged gases (a.k.a. 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 DoD and scientific communities, along with supporting data and software necessary to pursue publishable research.

### **PROGRAMS**

#### **Master of Science**

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

#### **Doctor of Philosophy**

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

#### **Certificate Programs**

- Advanced Geospatial Intelligence IR/SAR
- Combating Weapons of Mass Destruction

## FACULTY

### Professor

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

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

**Larry W. Burggraf** physical, computational and materials chemistry, optical and nuclear spectroscopy

**Kirk A. Mathews** computational nuclear engineering, nuclear weapons

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

**David E. Weeks** computational chemical physics

**Yung K. Yeo** electrical and optical characterization of semiconductors

**Paul J. Wolf** atomic, molecular and optical physics

### Associate Professor

**William F. Bailey** plasma physics, space physics

**Michael A. Marciniak** electro-optics, semiconductor lasers

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

**Ronald F. Tuttle** measurement and signature intelligence

### Assistant Professor

**Ariel O. Acebal** space physics, space weather

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

**Steven T. Fiorino** atmospheric physics, microwave remote sensing

**Kevin C. Gross** molecular spectroscopy, remote sensing

**Gordon D. Hager** chemical physics

**Michael R. Hawks** optics, remote sensing

**Jeremy C. Holtgrave** molecular spectroscopy, measurement and signal intelligence

**Benjamin R. Kowash** experimental nuclear physics, radiation detector physics

**Alex G. Li** atomic force microscopy, spectroscopy, nanomaterials and nanopatterning

**Amy L. Magnus** electro-optics and image processing

**John W. McClory** nuclear engineering, radiation effects on electronics

**James C. Petrosky** nuclear engineering, radiation effects on materials

**Robb M. Randall** atmospheric physics, remote sensing

**Eugene V. Sheely** nuclear engineering, kinetics of muon-catalyzed fusion

### Professor Emeritus

**Charles J. Bridgman** nuclear weapons effects

**George John** mossbauer spectroscopy, nuclear radiation detection

### Adjunct Faculty

**David J. Bunker** advanced technical intelligence applications, experimental unsteady aerodynamics

**Howard E. Evans** measurement and signature intelligence

**James J. Lange** measurement and signature intelligence

# Mathematics and Statistics (ENC)

## Department Head: Alan V. Lair, PhD

2950 Hobson Way, Building 641, Room 302

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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

**Mark E. Oxley** partial differential equations, wavelets, classifier fusion

**Aihua W. Wood** partial differential equations, electromagnetics

### Associate Professor

**William P. Baker** asymptotic and perturbation methods

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

### Assistant Professor

**Dursun A. Bulutoglu**, design of experiments, linear algebra

**Brett A. Bush** optimization, simulation

**Shay R. Capehart**, design of experiment, optimization

**Karen E. Dillard**, numerical analysis, optimization

**Donald E. Duckro**, decision science

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

**Matthew C. Fickus**, applied harmonic analysis, wavelets, Fourier series

**David M. Kaziska**, distribution on shape manifolds, gait recognition

**Kyle A. Novak**, numerical analysis, multiscale methods

**Samuel A. Wright** statistics, model validation, metric development

### Professor Emeritus

**David R. Barr** stochastic process

**Dennis W. Quinn** partial differential equations

**Daniel E. Reynolds** environmental statistics

# Operational Sciences (ENS)

## Department Head: Dr. Jeffery K. Cochran

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](mailto: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 the Center for Operational Analysis (COA), a multidisciplinary research and education center focused on defense-related, operational modeling and analysis. The COA is an Air Force Institute of Technology Center of Excellence, 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 war fighter efficiency and effectiveness at all levels.

Visit the COA on line at <http://www.afit.edu/en/COA/index.cfm>.

In addition to the COA, 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
- Logistics (IDE)
- Logistics (IDE Air Mobility)
- Operations Analysis (IDE)

### Doctor of Philosophy

- 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, customer service levels, decision analysis, empirical modeling and analysis, heuristics and simulation, logistics and operations planning and strategy, queuing networks, queuing systems analysis, stochastic modeling and analysis

**William A. Cunningham** - balanced scorecard, consolidation analysis, costing, customer service operations, economics, facility location, logistics management and analysis, modal choices, theory of constraints, transportation

**Richard F. Deckro** - 4th generation operations, 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** - applied statistics, empirical modeling and analysis, experimental design, heuristic methods for optimization, integer programming, mathematical programming and optimization, simulation modeling and analysis

**James T. Moore** - heuristic methods for optimization, heuristics, integer programming, large-scale optimization, mobility modeling, optimization, scheduling, strategic mobility, vehicle routing

**Marlin U. Thomas** - stochastic modeling and reliability, modeling and evaluating military contingency logistics

### Associate Professors

**Stephen P. Chambal** - applied statistics, decision analysis, simulation modeling and analysis

**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

**Joe Kebir** - dynamic programming, queuing systems analysis, reliability modeling and analysis, stochastic modeling, stochastic modeling and reliability, stochastic systems analysis

**John O. Miller** - applied statistics, combat models, network centric warfare, simulation modeling and analysis

**Jeffery D. Weir** - decision analysis, experimental design, graph theory, integer programming, large-scale optimization, mathematical programming and optimization, response surface methods

### Assistant Professors

**Bradley E. Anderson** - energy security and alternative fuels, supply chain management, forecasting, inventory, machine scheduling, heuristics, deterministic math modeling

**Shane N. Hall** - dynamic programming, heuristic methods for optimization, heuristics, integer programming, mathematical programming and optimization, multicriteria analysis, optimization

**Daniel D. Mattioda** - acquisition logistics, logistics management, project management, simulation modeling and analysis, supply chain management

**Jeffrey A. Ogden** - logistics management, operations management, procurement, supply chain integration, supply chain management

**Timothy J. Pettit** - lean, risk and decision analysis, simulation modeling and analysis, supply chain management

**August G. Roesener** - complex optimization, experimental design, heuristics, integer programming, metaheuristics

**Joseph B. Skipper** - logistics information systems, logistics management, supply chain management, transportation

### Adjunct Faculty

**Barry L. Brewer** - supply chain management, outsourcing, purchasing, logistics, acquisition logistics, logistics information systems, new product development

**Mark A. Gallagher** - applied statistics, forecasting, decision analysis, linear programming

**Jonathan T. Hamill** - mathematical programming and optimization, social network analysis, decision analysis, behavioral modeling, information operations, multicriteria analysis, modeling and simulation analysis

# Systems and Engineering Management (ENV)

**Department Head: Adedeji B. Badiru, PhD, PE**

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The Department of Systems and Engineering Management provides graduate education and applied research designed to address the needs of various US Air Force career fields. Master of Science degrees are offered in six major multi-disciplinary areas: Systems Engineering, Cost Analysis, Engineering Management, Environmental Engineering and Science, Industrial Hygiene, Information Resource Management, and Research and Development Management. The department also offers a certificate in Operational Technology (OpTech).

## FACILITIES

The department, in cooperation with the Air Force Research Laboratory, operates a joint rapid product development center (CRPD) that supports portions of the Research and Development Management master's degree program and the Operational Technology (OpTech) certificate program. This center, along with a mobile support lab and access to various aircraft, provides the necessary space, equipment, and tools to develop and rapidly prototype new products.

- Systems Integration Laboratories
- Collaborative Design Center
- 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

## PROGRAMS

### Master of Science

- Cost Analysis (M.S.)
- Engineering Management (M.S.)
- Environmental Engineering & Science (M.S.)
- Financial Analysis (M.S.)
- Industrial Hygiene (M.S.)
- Information Resource Management (M.S.)
- Research and Development Management (M.S.)
- Systems Engineering (IDE) (M.S.)
- Systems Engineering (M.S.)

### Doctoral Programs

- Systems Engineering

### Certificates

- Operational Technology Certificate
- Systems Engineering Certificate

# FACULTY

## Professor

**Adedeji B. Badiru** project management, economic analysis, simulation, mathematical modeling

**Charles A. Bleckmann** environmental remediation, environmental microbiology

**Mark N. Goltz** environmental remediation, pollution control and modeling, environmental technology transfer

**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** information assurance, information security, systems integration, modeling and simulation, computer design, VLSI design and test

**Som Soni** systems engineering approach to structural health monitoring, mechanics of composite materials and structures, analytical and experimental structural analysis, prototype and software development, and technology transfer, structural reliability

## Assistant Professor

**Alexander J. Barelka** leadership, team effectiveness, virtual teams, e-learning

**John M. Colombi** systems engineering, architecture (DoDAF), interoperability, complex systems, human-systems integration (HSI)

**David Fass** strategic alliances, strategic management, organizational development and change, government acquisition and contracting

**Peter Feng** engineering management, lean construction, construction rework, project management, production systems, decision making, simulation

**Daniel T. Holt** organizational change and development, human resource management, organizational behavior and measurement

**David R. Jacques** systems engineering, DoDAF, interoperability, human systems integration (HSI)

**Gregory Schechtman** human-computer interaction, computer-mediated communication, information security and privacy

**Jeremy M. Slagley** industrial hygiene, hearing conservation

**David A. Smith** CBRN emergency response and recovery, ionizing radiation

**Dennis D. Strouble** information resource management, law, ethics, systems engineering management, information assurance

**Alfred E. Thal, Jr** environmental policy/management, facility/infrastructure management, engineering management, product development and technology transition/ transfer, emergency response

**Jason M. Turner** organizational and managerial aspects of information and communication technology, collaborative technologies, human factors, reliability

**Christopher J. West** engineering management, system dynamics and analysis, crisis project management

**Eric J. Unger** operation and support costs, policy analysis, statistical analysis

## Instructor

**John 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

**Bryan K. Hasty** knowledge management, systems analysis, data communications, IT/IM/KM strategy

**David S. Long** unmanned aircraft systems, aircraft, C4ISR system acquisition, system acquisition, system architecture, modularity and commonality, product platforms, open architecture, human machine interfaces and automation

**J. Robb Wirthlin** DoD acquisition (including space systems), new product development, product development, systems engineering, risk management, lean six sigma, research development management, engineering management, product portfolio management, program management, social science research methods

## Professor Emeritus

**David K. Vaughn** technical communication

## **Certificate Programs**

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

## **Program Description**

Within the Air Force and the Department of Defense, there are many applied technology areas that are highly developed and satisfy the technical requirements of military weapon systems and operations. The graduate degree programs within the Department of Engineering Physics are tailored to satisfy these technical requirements which are codified in the form of an advanced degree education code. These specific graduate degree programs not only develop the applications to military weapons and operations, but also provide the fundamental understanding of the basic science and engineering required for an in-depth understanding of these application areas. In many cases, a subset of these applications courses can be grouped to provide a student with the applied technology needed for a person to work in a specific applied field but short of that required to meet graduate degree requirements.

Students satisfactorily completing such a subset of courses, either offered solely within one department or possibly between several departments, are then awarded a certificate. Such certificates thus represent knowledge of a body of coursework that has useful applications to a variety of military technologies or missions and, for the student, the certificate demonstrates proficiency in this subset of skills or knowledge.

The Department of Engineering Physics currently offers a graduate certificate program in the area of Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar (AGI IR/SAR).

## **Program Educational Objective (PEO)**

The Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar (AGI IR/SAR) Certificate Program is a ten-week educational series in the technical aspects of collecting, processing and exploiting non-literal, remotely sensed infrared (IR) and synthetic aperture radar (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 four, 3-credit hour academic courses focused on the technical basis of AGI IR/SAR; four, 1-credit hour labs introducing current data processing and exploitation algorithms and techniques; and a 1-credit hour seminar.

All students successfully completing the four courses, four labs, seminar (17 credit hours) and the comprehensive exit examination will receive a Certificate in AGI IR/SAR technologies and have this fact recorded on their transcript.

## **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 US 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 only open to citizens from the US, United Kingdom, Australia, and Canada who are sponsored by their respective governments, or by an organization supporting US national security matters. Attendees must send the following materials four weeks prior to the start of a session:

1. AGI IR/SAR Certificate Program Enrollment Form. This can be found at [http://www.afit.edu/en/cmsr/Apply\\_acp.cfm](http://www.afit.edu/en/cmsr/Apply_acp.cfm).
2. Official transcripts for all post-secondary education.
3. Collateral SECRET US Government security clearance. This should be forwarded to the AFIT Security Office (AFIT/XPQ).

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

### Degree Requirements

- MATH 699 - Special Studies
- EENG 532 - Introduction to Radar and Synthetic Aperture Systems
- EENG 538 - Synthetic Aperture Radar Masint Lab
- OENG 530 - Fundamentals of IR and MASINT Technology
- OENG 531 - Nonimaging IR and MASINT Collection Systems
- OENG 533 - Multispectral and Hyperspectral MASINT Exploration
- OENG 535 - MASINT for the Warfighter Seminar
- OENG 536 - IR and MASINT Fundamentals Lab
- OENG 537 - IR MASINT Collection System Lab
- OENG 539 - Multispectral and Hyperspectral MASINT Lab

## Combating Weapons of Mass Destruction Certificate

### Program Description

DoD organizations such as the Defense Threat Reduction Agency, Defense Intelligence Agency, Air Staff XOS (and its field operating agency, AF Nuclear Weapons Counterproliferation Agency), Air Force Technical Applications Center, Army Chemical Corps, Army Staff G-3/5/7 (and its field operating agency U.S. Army Nuclear and Chemical Agency), Army 20th Support Command (CBRNE) and other organizations outside of DoD (CIA, FBI, DOE, DHS) have indicated a need and desire for a short-term educational program to provide a technical grounding in aspects of WMD. Many of these organizations have the need for technical expertise in WMD, but also have limits on the resource commitment to send students to full-length graduate programs. The Combating Weapons of Mass Destruction Certificate Program is designed to fill this need.

The Combating Weapons of Mass Destruction Certificate program is a ten-week educational program targeting the technical aspects of combating WMD. The program provides the fundamental biology, chemistry and physics necessary for the follow-on study of the production, utilization, effects and mitigation of WMD. It consists of four academic courses, one each in biological weapon technology, chemical weapon technology and nuclear weapon technology and a fourth course which is a Practicum involving guest lecturers, laboratories, and group exercises and projects. The Practicum will present a unifying approach to the broader category of combating WMD. For example, topics such as risk analysis and mass casualty medical care, can apply to any type of WMD analysis.

Students satisfactorily completing such a subset of courses are then awarded a certificate. Such certificates thus represent knowledge of a body of coursework that has useful applications to a variety of military technologies or missions and, for the student, the certificate demonstrates proficiency in this subset of skills or knowledge.

The Department of Engineering Physics currently offers a graduate certificate program in the area of combating weapons of mass destruction.

## Program Educational Objective (PEO)

The goal of this certificate program is to provide the student with the knowledge, comprehension and application levels of cognitive learning in combating WMD through four academic courses, one each in biological weapon technology, chemical weapon technology and nuclear weapon technology, and a Practicum involving guest lecturers, laboratories, and group exercises and projects. All students successfully completing the four course sequence (16 credit hours) will receive a Certificate in Combating WMD technologies and have this fact recorded on their transcript.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** An undergraduate degree in an appropriate engineering or science discipline (mathematics, physical or biological science, engineering or computer sciences are highly desirable.) Note: In addition to the academic criteria, this program is only open to US citizens.

**GPA Required:** 3.0

**Test:** No admissions test is required.

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 16 hours of courses to include:

- BIOL 597 - Biological Weapons Effects and Technology
- CWMD 597 - Combating Weapons of Mass Destruction Engineering Practicum
- NENG 597 - Nuclear Weapons Effects, Technology and Non-Proliferation

## Information Assurance Certification

### Program Description

The Information Assurance (IA) Certificate Program provides students the opportunity to earn one or more National Information Assurance Training Standard Certificates. The NSA certified the courses required for these certificates as meeting the training standards for information security professionals in the federal government. 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 NSTISSI Number 4011 National Training Standard for Information Systems Security (INFOSEC) Professionals

Core Courses (14 hours)

- CSCE 544 - Data Security
- CSCE 625 - Information Systems Security, Assurance, and Analysis I
- CSCE 689 - Distributed Software Systems
- CSCE 725 - Information Systems Security, Assurance, and Analysis II

Choose one of the following:

- CSCE 654 - Computer Communication Networks
- CSCE 689 - Distributed Software Systems
- CSCE 725 - Information Systems Security, Assurance, and Analysis II
- IMGT 657 - Data Communications for Managers

Degree Requirements

Certificate Elements for CNSSI Number 4012 National Information Assurance Training Standard for Senior System Managers

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)

Choose one from the following:

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

Degree Requirements

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

Core Courses (14 hours)

- IMGT 684 - Strategic Information Management
- QMGT 680 - Project Risk Analysis

Choose one of the following

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

Choose one of the following

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

# 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
- RDMT 642 - Systems Development I-Concept Development
- RDMT 643 - Systems Development II - Systems Design and Implementation
- SENG 520 - Systems Engineering Design
- SMGT 543 - Systems Acquisition Management

## 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
- OENG 530 - Fundamentals of IR and MASINT Technology

## 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 21<sup>st</sup> 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 Logistics Readiness Officers (LROs) 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 Educational Objectives (PEOs)

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. Improve 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.

Core Courses (20 hours)

- LOGM 568 - Logistics Management
- STAT 521 - Applied Statistical Data Analysis
- STAT 521 - Lab
- LOGM 567 - Lean Operations Management
- LOGM 593 - Quantitative Modeling
- LOGM 565 - Strategic Sourcing

# 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
- SENG 610 - Systems Engineering Process and Management
- SENG 640 - Systems Architecture
- CSCE 590 - Engineering Software-Intensive Systems

### Capstone Project (4 hours)

SENG 797 - Certificate Capstone Project

# 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 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 Educational Objectives (PEOs)

1. The ability to identify and apply basic concepts required for supporting 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 will also be realized as a specialty area in the distance learning and in-residence Systems Engineering master's degree program.

## 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

# Doctor of Philosophy

## Aeronautical Engineering (Ph.D.)

### Program Description

Students are admitted to a study leading toward the PhD degree in Aeronautical Engineering, Astronautical Engineering, Materials Science or Space Systems with concentration in one of the three major divisions of the Department of Aeronautics and Astronautics.

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. Typical selections are: Fluid Mechanics, Solid Mechanics, or Dynamics Systems & Control.

### Program Educational Objectives (PEOs)

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 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:** 550V/650Q

**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

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

# Applied Math (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 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.

## 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 (3 successive quarters)

Present Dissertation at a Public Defense

# Applied Physics (Ph.D.)

## Program Description

The PhD 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. Specialization is 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.

Program content and length are largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research required in his or her chosen specialty. These program requirements are embodied in the student's "approved program" and reflect certain departmental requirements as well as the School's doctoral degree requirements. These degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management.

## Program Educational Objectives (PEOs)

1. The doctoral program in applied physics is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing and evaluating applied physics 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:** Requires a master's degree in a physical science or engineering

**GPA REQUIRED:** BS GPA 3.0 or higher; MS GPA 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; 8HHY, Engineering Physics; 8HKY, Nuclear Effects Physics; 8HLY, Nuclear Physics; 8HMY, Optics; 8HMJ, 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, 8HNJ, Plasma Physics, 8FDA, Aeronomy, 8FDD, Ionospheric Environment, 8FDY, 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.

Degree Requirements

The PhD degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. 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, and successful completion of a dissertation.

In addition, the faculty of the Department of Engineering Physics has specified a set of core requirements to be met by candidates for the PhD degree in the various disciplines offered by the department. These core requirements are designed to insure that students who enter the program with varied backgrounds will develop sufficient knowledge in their chosen doctoral area to qualify for the Ph.D. degree in that area. A typical specialty or major sequence of courses will usually consist of these core courses plus an in-depth sequence of courses at the 7XX or 8XX level that lays the groundwork for the dissertation research.

# Astronautical Engineering (Ph.D.)

## Program Description

Students are admitted to a study leading toward the PhD degree in Aeronautical Engineering, Astronautical Engineering, Materials Science or Space Systems with concentration in one of the three major divisions of the Department of Aeronautics and Astronautics.

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. Typical selections are: Fluid Mechanics, Solid Mechanics, or Dynamics Systems & Control.

## Program Educational Objectives (PEOs)

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 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)

**GPA REQUIRED:** 3.50

**GRE REQUIRED:** 550V/650Q

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

# 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

**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.

## 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

**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

# 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

**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

# Materials Science (Ph.D.) - Structural

## Program Description

Students are admitted to study leading toward the PhD degree in Aeronautical Engineering, Astronautical Engineering, Materials Science or Space Systems with concentration in one of the three major divisions of the Department of Aeronautics and Astronautics.

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. Typical selections are: Fluid Mechanics, Solid Mechanics, or Dynamics Systems & Control.

## Program Educational Objectives (PEOs)

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 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)

**GPA REQUIRED:** 3.50

**GRE REQUIRED:** 550V/650Q

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.)- Electronic/Photonic

## Program Description

The PhD program in Material Science (Electronic and Photonic Materials) is typically 36 months in length (beyond the M.S. degree), with a total of 48 to 60 credit hours plus dissertation. The program is under the supervision of the Department of Engineering Physics with specialization available in various aspects of electronic and optical materials or in the chemistry of materials.

Program content and length are largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research required in his or her chosen specialty. These program requirements are embodied in the student's "approved program" and reflect certain departmental requirements as well as the School's doctoral degree requirements. These degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. These basic requirements include completion of a 24 credit hour specialty area, an 8 credit hour math requirement, successful completion of exams in the specialty and the minor areas, as well as successful completion of a dissertation.

In addition, the faculty of the Department of Engineering Physics has specified a set of core requirements to be met by candidates for the Ph.D. degree in material science. These requirements are designed to insure that students who enter the program with varied backgrounds will develop sufficient knowledge in material science to qualify for the Ph.D. degree in that area.

## Program Educational Objectives (PEOs)

1. The doctoral program in material science 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:** MS in appropriate area

**GPA REQUIRED:** 3.50 or higher on MS degree

**TEST REQUIRED:** GRE 550V/650Q or higher

**USAF EDUCATIONAL 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.

### Degree Requirements

The PhD degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. These basic requirements include completion of at least 36 credit hours of courses including:

Specialty area (24 credit hours)

Mathematics (8 credit hours)

Successful completion of an exam in the specialty area

Successful completion of a dissertation.

In addition, the faculty of the Department of Engineering Physics has specified a set of core requirements to be met by candidates for the PhD degree in the various disciplines offered by the department. These core requirements are designed to insure that students who enter the program with varied backgrounds will develop sufficient knowledge in their chosen doctoral area to qualify for the Ph.D. degree in that area. A typical specialty or major sequence of courses will usually consist of these core courses plus an in-depth sequence of courses at the 7XX or 8XX level that lays the groundwork for the dissertation research.

## 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 48 to 60 credit hours plus dissertation. Specialization available includes nuclear weapons effects, counterproliferation, radiation detection, radiation effects on electronics, and neutral particle transport.

Program content and length are largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research required in his or her chosen specialty. These program requirements are embodied in the student's "approved program" and reflect certain departmental requirements as well as the School's doctoral degree requirements. These degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. These basic requirements include completion of a 24 credit hour specialty area, an 8 credit hour math requirement, successful completion of exams in the specialty and the minor areas, as well as successful completion of a dissertation.

### Program Educational Objectives (PEOs)

1. The doctoral program in nuclear engineering 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:** MS in Nuclear, Mechanical, or Chemical Engineering. 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 Engineering Physics Department for details.

**REQUIRED GPA:** BS GPA 3.0 or higher and MS GPA 3.5 or higher

**GRE REQUIRED:** 550V/650Q or higher

**USAF EDUCATIONAL 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.

#### Degree Requirements

The PhD degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. These basic requirements include completion of at least 36 credit hours of courses including:

Specialty area (24 credit hours)

Mathematics (8 credit hours)

Successful completion of an exam in the specialty area  
Successful completion of a dissertation

In addition, the faculty of the Department of Engineering Physics has specified a set of core requirements to be met by candidates for the PhD degree in the various disciplines offered by the department. These core requirements are designed to insure that students who enter the program with varied backgrounds will develop sufficient knowledge in their chosen doctoral area to qualify for the Ph.D. degree in that area. A typical specialty or major sequence of courses will usually consist of these core courses plus an in-depth sequence of courses at the 7XX or 8XX level that lays the groundwork for the dissertation research.

## 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.

### School and Program Admissions Criteria

**DEGREE REQUIRED:** MS in Operations Research, Systems Analysis, Operations Analysis, Mathematics, or other highly quantitative field of study.

**TEST REQUIRED:** GRE – 550V/650Q

**GPA REQUIRED:** OVERALL - 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

Residency requirement

Four consecutive quarters

Specialization Courses (24 hours)

Mathematics (8 hours)

Minor Courses (9 hours)

Successfully pass the Specialty Examination

Dissertation Research (48 hours)

Admission to candidacy (One year prior to graduation)

Oral defense of doctoral dissertation

# Optical Science and Engineering (Ph.D.)

## Program Description

The AFIT PhD program, initiated in 1965, is typically 36 months in length (beyond the M.S. degree), with a total of 48 to 60 credit hours plus dissertation. Specialization in the area of optical science and engineering, formally known as electro-optics, was added in the mid-1970's 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. Program content and length are largely determined by the areas and depth of knowledge required by the student in order to adequately carry out the research required in his or her chosen specialty. These program requirements are embodied in the student's "approved program" and reflect certain departmental requirements as well as the doctoral degree requirements. These degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management.

## Program Educational Objectives (PEOs)

1. The doctoral program in optical science and engineering 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:** MS in appropriate area

**GPA REQUIRED:** MS GPA 3.50 or higher

**TEST REQUIRED:** GRE 550V/650Q or higher

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

The PhD degree requirements adhere to standards defined by the faculty of the Graduate School of Engineering and Management. These basic requirements include completion of at least 36 credit hours of courses including:

Specialty area (24 credit hours)

Mathematics (8 credit hours)

Successful completion of an exam in the specialty area

Successful completion of a dissertation.

In addition, the faculty of the Department of Engineering Physics has specified a set of core requirements to be met by candidates for the PhD degree in the various disciplines offered by the department. These core requirements are designed to insure that students who enter the program with varied backgrounds will develop sufficient knowledge in their chosen doctoral area to qualify for the Ph.D. degree in that area. A typical specialty or major sequence of courses will usually consist of these core courses plus an in-depth sequence of courses at the 7XX or 8XX level that lays the groundwork for the dissertation research.

# Space Systems (Ph.D.)

## Program Description

Students are admitted to a study leading toward the PhD degree in Aeronautical Engineering, Astronautical Engineering, Materials Science or Space Systems with concentration in one of the three major divisions of the Department of Aeronautics and Astronautics.

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. Typical selections are: Fluid Mechanics, Solid Mechanics, or Dynamics Systems & Control.

## Program Educational Objectives (PEOs)

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 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)

**GPA REQUIRED:** 3.50

**GRE REQUIRED:** 550V/650Q

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

# 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.

## Master of Science

### Aeronautical Engineering (M.S.)

#### Program Description

The Graduate Aeronautical Engineering program is designed to provide aeronautical engineering specialists for the Air Force. Students normally enter as a class in September and are scheduled to graduate in March after 18 months. The program leads to a Master of Science in Aeronautical Engineering and is fully accredited.

#### Program Educational Objectives (PEOs)

1. Our graduates will be prepared to make direct contributions as a practicing engineer in the area of aeronautical engineering.
2. Our graduates will have the technical expertise to communicate, evaluate, monitor and administer aeronautical research and development programs.
3. Our graduates will understand how to approach and solve new technological challenges to meet the needs of the Air Force and other DoD organizations.

#### 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 - 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

Primary Sequence (11 hours)

Secondary Sequence (9 hours)

Two Math Courses (8 hours)

Core Aeronautics (9 hours)

Thesis (12 hours)

Additional courses to total 48 quarter hours

# Air Mobility (IDE) (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 Objective (PEO)

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 curriculum consists of 13 required courses in the areas of transportation, logistics, contracting, quantitative decision-making, statistics, management, maintenance, and production. In addition, a graduate research paper that examines a topic pertaining to mobility operations must be completed. Satisfactory completion of the curriculum and the graduate research paper leads to the award of a Master of Science in Logistics.

## Additional Information

1. 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. Class size is limited to 16 students. Students typically come from operational and support AFSCs in the Air Force.
2. 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.
3. 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 chaired by the Air Mobility Command Vice Commander. Employing a “whole person” concept, the selection board picks only the best persons for this rigorous program.
4. 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; GRE - 500V/600Q

**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.

## Degree Requirements

### Logistics (12 hours)

- LOGM 568 - Logistics 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 (10 hours)

- LOGM 525 - Statistics for Mobility Managers
- OPER 501 - Quantitative Decision Making
- LOGM 601 - Principles and Methods of Research

### Graduate Research Paper (7 hours)

- LOGM 791 - Research Project for Mobility Managers

## 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 537 (Introduction to Statistics), STAT 696 (Applied General Linear Models), 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 Objective (PEO)

Graduates are well-prepared to use mathematical and statistical techniques to solve important problems of interest to the Air Force, DoD and Homeland Security. They are equipped to collaborate with the science and technology community to address questions of national defense.

## 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 math analysis course such as Advanced Calculus.

**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)

- MATH 600 - Mathematical Analysis
- MATH 601 - Complex Analysis
- MATH 602 - Modern Applied Mathematics I
- STAT 537 - Introduction to Statistics
- STAT 696 - Applied General Linear Models

Out-of-Department sequence (8 hours)

Specialization (12 hours)

Thesis (12 hours)

## Applied Physics (M.S.)

This 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 both tracks providing a balanced exposure to experimental and theoretical practices.

The 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.

The research is conducted at AFIT or at the Air Force Research Laboratory under a cooperative research program. Each student must complete an independent study/thesis as well as 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 AF education code.

Concentration in the three tracks is as follows:

1. **The engineering physics track** concentrates on 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, 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)

As stated above, these programs provide each student with a broad, graduate level foundation in applied physics with a focus on one of three educational tracks: engineering physics, optical physics or space physics, providing a balanced exposure to experimental and theoretical practices.

The educational objectives of the Applied Physics program are to ensure that a graduate will be prepared to successfully perform the following tasks:

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 to which our students 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 that 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.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** Physics or a major with at least 24 semester hours of Physics. Academy grads with Engineering Mechanics or Engineering Science are eligible. Undergrad 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; 8HMJ,

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, 8HNJ, Plasma Physics, 8FDA, Aeronomy, 8FDD, Ionospheric Environment, 8FDY, Solar and Space Sciences

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

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

### **Program Description**

The Graduate Astronautical Engineering program is designed to provide astronautical engineering specialists for the Air Force. Students normally enter as a class in September and are scheduled to graduate in March after 18 months. The program leads to a Master of Science in Astronautical Engineering and is fully accredited.

### **Program Educational Objectives (PEOs)**

1. Make direct contributions to the area of astronautical engineering as a practicing engineer.
2. Evaluate, monitor, and administer astronautical research and development projects.
3. Understand how to approach and solve new technical challenges to meet the needs of the Department of Defense.

### **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. It is expected that our graduates will be prepared to:

1. Make direct contributions to the area of astronautical engineering as a practicing engineer.
2. Evaluate, monitor, and administer astronautical research, development, and acquisition programs in support of Air Force needs.

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 - 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 (8 hours)

Major Sequence (10 hours)

Minor Sequence (10 hours)

Two Math Courses (8 hours)

Thesis (12 hours)

Additional courses to total 48 quarter hours

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

### Program Description

A graduate of the program will have developed a broad-based technical knowledge in all aspects of weapons of mass destruction (WMD) and will have demonstrated the ability to conduct independent research in a specialized area of combating weapons of mass destruction (WMD).

This program is of a genre known as a “Professional Science Master’s (PSM) degree Program.” Such programs are recognized by the American Council of Graduate Schools and nearly 100 PSM degree programs are currently offered by institutions such as Stanford, Case Western, Rice, Michigan State and Boston Universities. There is a wide variation with curriculum and structure among PSM programs but some common themes applicable to such programs are: inter - or multidisciplinary allowing multiple areas of “focusing” or “specialization” with the last portion of the program emphasizing the use of case studies in courses and “teamwork” approaches to projects, often with written/oral presentations to industry clients: certificates, within or as an addition to the standard PSM, are emerging as a common theme and some programs are structured so no two students take the same courses. Finally, PSM programs expect to place their graduates in traditional industries as opposed to academics.

### Program Educational Objectives (PEOs)

The educational objectives of this program are two-fold. The first is to develop a graduate who has a basic knowledge and comprehension level (as in Bloom’s hierarchy of learning) understanding of each area of WMD, chemical, biological, and nuclear. The second is to develop a graduate who is an expert in a specific area of WMD technology. Graduates of the program will demonstrate the full spectrum of cognitive learning of application, analysis, synthesis and evaluation through their Master’s research project. These objectives are based on the premise that developing a student who is an expert at the postgraduate level in all three areas of chemical, biological and nuclear weapons is not feasible since no student will have the necessary prerequisites to successfully take sufficiently advanced courses in all three fundamental areas. Hence all areas will be developed broadly and one will be selected for in depth study.

### School and Program Admissions Criteria

**DEGREE REQUIRED:** An undergraduate degree in a technical area (engineering, math, science) or one with sufficient technical content (e.g., USAFA or USMA core).

**MATHEMATICS REQUIRED:** Mathematics courses in calculus up to (but not necessarily including) ordinary differential

equations

**TEST REQUIRED:** GRE – 500V/600Q

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

**USAF EDUCATION CODE:** 0WMD

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

Specialty Track Sequence (12 hours)

(Nuclear, Chemical or Biological) Must all be in same track.

Broadening Sequence (12 hours)

- BIOL 597 - Biological Weapons Effects and Technology
- CWMD 585 - Introduction to Modern Fortran Programming with Applications in Weapons of Mass Destruction
- NENG 597 - Nuclear Weapons Effects, Technology and Non-Proliferation

Math (4 hours)

Capstone (4 hours)

Thesis (12 hours)

## 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 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 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.
4. **Professionalism.** Professionally communicate technical solutions and results.
5. **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning as professional engineers and scientists.

### 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 - 500V/600Q

**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 587 - Microprocessor Design and Synthesis
- CSCE 687 - Advanced Microprocessor Design Lab
- CSCE 692 - Design Principles of Computer Architecture

##### Mathematics (4 hours)

##### Theory (4 hours)

##### Application Sequence (12 hours)

##### Thesis (12 hours)

## 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.
4. **Professionalism.** Professionally communicate technical solutions and results.
5. **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning as professional engineers and scientists.

### 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 - 500V/600Q

**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 689 - Distributed Software Systems
- CSCE 692 - Design Principles of Computer Architecture
- CSCE 587 - Microprocessor Design and Synthesis

Mathematics (4 hours)

Theory (4 hours)

Application Sequence (12 hours)

Thesis (12 hours)

## 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, econometrics, quantitative decision making, economics, forecasting, cost estimating, finance, and lifecycle-costing.

### Program Educational Objectives (PEOs)

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.

### School and Program Admissions Criteria

**DEGREE REQUIRED:** Business, Economics, Finance or Math preferred

**MATHEMATICS 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 - 500V/600Q

**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
- FMGT 520 - Strategic Cost Management
- QMGT 680 - Project Risk Analysis

#### Analytical Methods Core (12 hours)

- ECON 545 - Introductory Econometrics
- ECON 580 - Fundamental Methods of Mathematical Economics
- ECON 645 - Applied Econometric Analysis

#### Thesis (12 hours)

## Cyber Operations (M.S.)

### Program Description

Cyber Operations are defined as those actions taken to affect adversary information and information systems while defending one's own information and information systems. Cyber Operations (CO) encompasses most of the technological aspects of Information Operations (IO). To support CO, professionals must be cognizant of the tools, techniques, and practices required in protecting these resources. At the technical level, CO encompasses multiple scientific disciplines required to 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/analyses. 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)

The Cyber Operations program produces graduates who can effectively use the tools and techniques of both computer science as well as traditional engineering disciplines to approach and analyze complex problems, and design feasible solutions for these problems. This program provides a substantial technical foundation in information assurance including, 1) computer operating systems; 2) computer networks and data security; and 3) network design and analysis.

### 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 articulation 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.

**MATHEMATICS REQUIRED:** Differential and Integral Calculus

**TEST REQUIRED:** GRE - 500V/600Q

**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 (20 hours)

- CSCE 525 - Introduction to Information Warfare
- CSCE 544 - Data Security
- CSCE 560 - Introduction to Computer Networking
- CSCE 625 - Information Systems Security, Assurance, and Analysis I
- CSCE 725 - Information Systems Security, Assurance, and Analysis II

Mathematics (4 hours)

Cyber Operations Breadth (12 hours)

Thesis (12 hours)

Theory (4 hours)

## **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 Objective (PEO)**

The objective is to develop a broad background in cyber warfare theory/application, thereby providing graduates with a foundation to better understand, develop, acquire, manage, and employ cyber-based capabilities now and in the future. Students are then educated in cyber war applications, to include network defense, attack, and exploitation. Due to the length of the program and the nature of the target audience, emphasis is on breadth rather than technical depth.

### **Additional Information**

This degree program is only available to military personnel and DoD civilians 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 - 500V/600Q

**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 Sequence (12 hours)

- CSCE 525 - Introduction to Information Warfare
- CSCE 560 - Introduction to Computer Networking
- EENG 509 - Fundamentals of Electronic Warfare
- IMGT 687 - Managerial Aspects of Information Warfare (IW)

##### Application Sequence (19 hours)

##### Mathematics Requirements (4 hours)

##### Project (8 hours)

## 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.

## 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 - 500V/600Q

**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

Coursework (36 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

As part of the total coursework, students will complete 8 hours of mathematics courses and 4 hours of systems engineering courses.

Thesis (12 hours)

## Engineering Management (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 Engineering Management. The Engineering Management program provides Air Force career professionals with relevant graduate education in the management of base, infrastructure, and facility resources and processes consistent with future duties across the spectrum of the Civil Engineer's mission.

The curriculum expands typical engineering management programs to enable the student to incorporate environmental impact constraints into the decision-making process. Upon completion, students are granted a Master of Science degree and will be able to apply the concepts, methods, and tools related to planning, directing, and controlling resources (people, financial resources, property, environmental resources, and information) in an operations management context.

Students will also be able to conduct and present methodical research to solve problems and support decisions. The core curriculum includes courses in engineering and technical operations management, organizational management and behavior,

statistics, research methods, decision analysis, cost management, environmental policy, sustainable development and design, project management, information management, law for managers, and system dynamics.

In addition, students have the opportunity to concentrate in a specific area such as applied decision analysis, leadership and management, or information management. Program graduates are well grounded in course work related to follow-on assignments within the Civil Engineer career field as well as other duties in support of facilities, programs, and environmental management at the base, MAJCOM, and higher levels. The output academic degree code is 1AGE.

## Program Educational Objectives (PEOs)

The Engineering Management Educational Objectives are to provide graduates who can manage base, infrastructure, and facility resources (people, financial resources, property, environmental resources, and information) and processes (contracting, construction, design, strategic planning, risk management, organizational behavior, property management, environmental management, occupational safety, acquisition, community planning, privatization, and legal processes (human resource law, contract law, and business law)) consistent with future duties across the spectrum of the Civil Engineer's mission.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** An undergraduate degree in an appropriate area of engineering or science.

**MATHEMATICS REQUIRED:** One year college calculus

**TEST REQUIRED:** GMAT: 550; GRE: 500V/600Q (minimum combined score of 1100)

**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 (19 hours)

- EMGT 678 - Engineering Operations Management
- ENVR 511 - Environmental Management and Policy
- FMGT 520 - Strategic Cost Management
- OPER 501 - Quantitative Decision Making
- ORSC 542 - Management and Behavior in Organizations
- SMGT 546 - Project Management

#### Methods Requirements (8 hours)

- RSCH 630 - Research Methods
- STAT 525 - Applied Statistics for Managers I

#### Focus Sequence (9 hours)

#### Thesis (12 hours)

# Environmental Engineering and Science (M.S.)

## Program Description

The Graduate Materials Science program leads to the degree of Master of Science (Materials Science).

The educational objective of this program is to provide Air Force officers and civilian professionals with relevant graduate education in the discipline of environmental engineering and science (encompassing air, water, and soil media) consistent with future duties across the spectrum of Air Force environmental consulting and management duties.

The program was developed considering guidelines established by the Accreditation Board of Engineering and Technology and subject areas from the Professional Engineering Exam for Environmental Engineering. Students matriculating with an 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 ABET-accredited undergraduate degree will receive the degree Master of Science.

## Program Educational Objectives (PEOs)

Upon graduation, students will be able to:

- Conduct and present methodological research to solve problems and support decisions.
- Apply principles of design to environmental engineering applications.
- Demonstrate knowledge of basic concepts in the areas of environmental engineering and science, industrial hygiene, health risk assessment, and public health.
- Demonstrate environmental laboratory sampling and analytical skills.
- Understand environmental laws, policies, procedures and regulatory practices as they relate to Air Force base resources and processes.
- Demonstrate knowledge of basic descriptive statistical procedures and the ability to solve statistical problems.
- Critically analyze studies within the current literature.
- Acquire a more in-depth knowledge in my chosen environmental emphasis area.
- Apply basic mathematical models to solve environmental engineering problems.
- Understand and appreciate the role of the basic sciences in support of environmental engineering and science principles.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** 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.

**MATHEMATICS REQUIRED:** Ordinary Differential Equations

**TEST REQUIRED:** GRE – 500V/600Q (minimum combined score of 1100)

**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

Thesis (12 hours)

Focus Sequence (9 - 11 hours)

Math Requirement (4 hours)

- STAT 525 - Applied Statistics for Managers I

Core Courses (25 hours)

- ENVR 532 - Air Resources Management
- ENVR 550 - Environmental Systems Engineering
- ENVR 624 - Water Chemistry for Environmental Engineers
- ENVR 643 - Environmental Transport Processes
- ENVR 645 - Water and Wastewater Treatment Design
- ENVR 651 - Environmental Risk Analysis
- ENVR 661 - Environmental Sampling and Analysis

## Financial 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 Financial Analysis. The Financial Analysis program is designed to provide students with the knowledge and creative problem solving skills needed to effectively estimate program resources within the Department of Defense (DoD) and the United States Air Force (USAF). The curriculum integrates a strong foundation in quantitative concepts and techniques with specific DoD and USAF financial-related topics to prepare students to contribute effectively in a variety of complex and challenging roles within the military. The curriculum includes courses in statistics, quantitative decision-making, economics, financial management, finance, regression, time series forecasting, and simulation.

Program graduates are well grounded in course work related to follow-on assignments within the financial management field, including resource estimating at the base, MAJCOM, and higher levels.

### Program Educational Objectives (PEOs)

All graduates of the Financial Analysis program should be able to:

1. Effectively communicate decision support analysis using both oral and written communications.
2. Understand and apply concepts and techniques of descriptive and inferential statistics to analyze problems under conditions of risk and uncertainty.
3. Understand and apply the concepts, methods, and tools related to financial analysis in a DoD context.
4. Understand and apply concepts from a wide range of business disciplines within the specific context of DoD resource estimation.
5. Conduct and present methodical research to creatively solve complex and ambiguous problems and support resulting decisions with appropriate documentation.

### School and Program Admissions Criteria

**DEGREE REQUIRED:** Economics, Finance or Math Preferred

**MATHEMATICS 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 - 500V/600Q

**GPA REQUIRED:** Overall -3.0; Mathematics – 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 (12 hours)

- ECON 545 - Introductory Econometrics
- ECON 580 - Fundamental Methods of Mathematical Economics
- ECON 645 - Applied Econometric Analysis

##### Financial Analysis Specialty (21 hours)

- ECON 520 - Managerial Economics
- ECON 670 - Nonmarket Valuation
- FANL 520 - Strategic Financial Analysis
- FANL 620 - Defense Budgeting
- FMGT 510 - Finance Theory I
- FMGT 520 - Strategic Cost Management

##### Capstone (3 hours)

- FANL 674 - Seminar in Financial Analysis

##### Thesis (12 hours)

## Industrial Hygiene (M.S.)

### Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Master of Science in Industrial Hygiene. The Industrial Hygiene Program was designed to provide Air Force career professionals with relevant graduate education in the principles of industrial hygiene and engineering. This program was developed considering guidelines established by the American Board of Industrial Hygiene (ABIH) and the Accreditation Board for Engineering and Technology (ABET). The Industrial Hygiene program was developed in response to a request from the AF Bioenvironmental Engineer (BEE) career field. This new program was offered for the first time in the Fall of 2006 and capitalizes on existing coursework and research thrusts present in several AFIT departments. The core curriculum includes course offerings in statistics, chemistry, risk assessment, chemical fate and transport in the environment, and physiology, along with classic industrial hygiene classes such as epidemiology, industrial ventilation, and radiation.

### Program Educational Objectives (PEOs)

To produce knowledgeable and highly skilled environmental health professionals in support of the health and global mission of the uniformed services. At the end of the program the student should have:

1. The ability to apply knowledge of statistics, epidemiology, physiology, environmental health, chemistry, radiation, and risk analysis in daily professional activities.
2. The ability to formulate a hypothesis, design and conduct experiments, as well as to analyze and interpret data.
3. The ability to formulate and implement a system, process, or program to meet environmental and occupational health needs.
4. The ability to function independently and on multi-disciplinary teams.
5. The ability to identify and solve environmental and occupational health problems.
6. The understanding of professional and ethical responsibility.
7. The ability to communicate effectively both orally and in writing.
8. The knowledge of contemporary occupational health issues.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** 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.

**MATHEMATICS REQUIRED:** Ordinary Differential Equations

**TEST REQUIRED:** GRE - 500V/600Q (minimum combined score of 1100)

**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 (11 hours)

- ENVR 528 - Environmental Physiology and Toxicology
- ENVR 643 - Environmental Transport Processes
- ENVR 651 - Environmental Risk Analysis

Mathematics Core (8 hours)

- STAT 525 - Applied Statistics for Managers I
- STAT 535 - Applied Statistics for Managers II

Industrial Hygiene Core (17 hours)

Thesis (12 hours)

## Information Resource Management (M.S.)

### Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Master of Science in Information Resource Management (IRM) with options for a concentration of study in strategic information management, information assurance, database systems, and/or computer networks.

This program is designed to provide students with the knowledge and skills needed to oversee both the information management and information systems needs of Air Force, DoD, and allied military organizations in future assignments as middle and upper-level managers. The program is designed primarily to reflect the needs of the officer and enlisted members of the Air Force communications and information officer career field; however, it is currently open to members of other career fields as well. In order to address the requirements associated with the growing importance of information as a critical resource for all career fields, the program continues to expand as necessary to serve a new customer base.

Overall, the Information Resource Management program provides students with a broad perspective of DoD information-related issues, including information strategy, information architectures, information security, information system design/development/acquisition and related business process support, information ethics, and the individual and organizational implications of rapidly evolving information technology.

During recent years, the program has also expanded to examine knowledge, in addition to information, as a critical organization resource. Knowledge, which is supported by information, is that which resides in the heads of the organizational decision-makers. Ultimately, the need to better support decision making is the impetus for capturing, storing, and disseminating organizational information in more efficient and effective ways.

The overall focus of the IRM program is to improve the student's understanding of and ability to manage information and knowledge in today's organizations in the context of a dynamic information technology and global environment.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** Any field

**MATHEMATICS REQUIRED:** College Algebra

**TEST REQUIRED:** GMAT – 550; GRE – 500 Verbal (minimum) and 500 Quantitative (minimum) with a required minimum total of 1100.

**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 (22 hours)

- IMGT 530 - Conceptual Foundations for Information Resource Management
- IMGT 561 - Applications of Database Management Systems
- IMGT 580 - Enterprise Information Architecture
- IMGT 651 - Systems Analysis and Design
- IMGT 657 - Data Communications for Managers
- IMGT 690 - Seminar in Information Resource Management

#### Management Core (4 hours)

- ORSC 542 - Management and Behavior in Organizations

#### Research Methods and Statistics (11 hours)

- RSCH 630 - Research Methods
- STAT 525 - Applied Statistics for Managers I
- STAT 535 - Applied Statistics for Managers II

#### Thesis (12 hours)

# Logistics (IDE) (M.S.)

## Program Description

The IDE Logistics 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. In addition, students have the opportunity to pursue a systems view of logistics management. For DoD-sponsored full-time students, the ILS program requires 12 months (4 academic quarters) of full-time study and begins in June of each year. Only those students selected for IDE in-residence may participate in this program. This program leads to a Master of Science in Logistics.

## Program Educational Objectives (PEOs)

All graduates of the Logistics Management program shall be equipped to:

1. Use effective oral and written communications.
2. Understand and apply the concepts, methods, and tools related to planning, directing, and controlling resources (people, material, equipment, and funds) in a logistics management context.
3. Analyze the impacts of changes in the defense transportation network on other functional areas within the total defense logistics system.
4. Understand and apply acquisition logistics and integrated logistics support concepts to affect weapon system life cycles.
5. Comprehend the role of the general logistician in the DoD and Air Force for planning, acquiring, distributing, supplying, and maintaining weapon systems.
6. Gain exposure to the research process to solve problems and support decision making.

## 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 ILM 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; GRE - 500V/600Q

**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 (27 hours)

- LOGM 520 - Managerial Economics
- LOGM 567 - Lean Operations Management
- LOGM 570 - Principles of Inventory Management
- LOGM 615 - Logistics Information Systems
- LOGM 617 - Transportation Systems and Strategic Mobility

- LOGM 620 - Activity Based Costing/Management
- LOGM 660 - Strategy for Logistics
- ORSC 542 - Management and Behavior in Organizations

Tools (10 hours)

- STAT 521 - Applied Statistical Data Analysis
- LOGM 593 - Quantitative Modeling

Capstone (3 hours)

- LOGM 627 - Supply Chain Management

Graduate Warfighter Project (9 hours)

- OPER 791 - Research Project for Operational Sciences
- LOGM 601 - Principles and Methods of Research

## **Logistics and Supply Chain Management (M.S.)**

### **Program Description**

The Graduate Logistics 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)**

All graduates of the Logistics Management program shall be equipped to:

1. Use effective oral and written communications.
2. Understand and apply the concepts, methods, and tools related to planning, directing, and controlling resources (people, material, equipment, and funds) in a logistics management context.
3. Analyze the impacts of changes in the defense transportation network on other functional areas within the total defense logistics system.
4. Understand and apply acquisition logistics and integrated logistics support concepts to affect weapon system life cycles.
5. Comprehend the role of the general logistician in the DoD and Air Force for planning, acquiring, distributing, supplying, and maintaining weapon systems.
6. Methodically conduct and present research to solve problems and support decisions.

### **School and Program Admissions Criteria**

**DEGREE REQUIRED:** Any Field

**MATHEMATICS REQUIRED:** College Algebra

**TEST REQUIRED:** GMAT – 550; GRE - 500V/600Q

**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.

#### Management Core (12 hours)

- LOGM 590 - Computer Simulation for Managers
- LOGM 615 - Logistics Information Systems
- LOGM 620 - Activity Based Costing/Management
- OPER 501 - Quantitative Decision Making

#### Logistics and Supply Chain Management Core (15 hours)

LOGM 565 must be taken if pursuing one of the following specialty sequences: Operational Logistics, Operational Maintenance, or Petroleum Management. CMGT 523 must be taken if pursuing the Acquisition Logistics specialty sequence.

- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 570 - Principles of Inventory Management
- LOGM 569 - Maintenance and Production Management
- LOGM 627 - Supply Chain Management
- LOGM 565 - Strategic Sourcing
- CMGT 523 - Contracting and Acquisition Management

#### Specialty Sequence (6 hours)

Two courses from an approved specialty sequence are required. Specialty sequences are:

Acquisition Logistics (AL)

Operational Logistics (OL)

Operational Maintenance (OM)

Petroleum Management (PM)

#### Research Foundation (3 hours)

- LOGM 601 - Principles and Methods of Research

#### Thesis (12 hours)

- OPER 799 - Thesis Research

# Materials Science (M.S.)

## Program Description

The Graduate Materials Science program leads to the degree of Master of Science (Materials Science). Students normally enter as a class in September and are scheduled to graduate in March after 18 months.

The 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. The Materials Science program is normally six quarters in length; five quarters of study devoted to course work and one quarter of study 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. Also, each student is 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.

## Program Educational Objectives (PEOs)

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.

The specific goals of the Materials Science program are to produce graduates with:

1. 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. An in-depth knowledge in one specialty area.
3. Experience in conducting and documenting an independent investigation, a thesis, or a problem of Air Force interest.

## 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 - 500V/600Q

**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.

Degree Requirements

Core Courses (20 hours)

- MATL 525 - Thermodynamics and Kinetics of Materials
- MATL 545 - Mechanical Properties of Materials
- MATL 560 - Electronic, Magnetic and Optical Properties of Materials

- MATL 680 - Materials Characterization
- MATL 685 - Materials Selection and Processing

Mathematics (4 hours)

Sequence (12 hours)

Thesis (12 hours)

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

### **Program Description**

This program provides the student with a broad foundation in nuclear engineering at the graduate level 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.

The program is normally six quarters in length. Five quarters are devoted to coursework and one to thesis research:

1. The research is normally conducted at AFIT.
2. The first two quarters of work stress fundamentals: mathematics and physics.
3. The next two quarters provide advanced courses in nuclear applications areas and prepare the student for thesis research in one of these areas.
4. The fifth quarter is then 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.

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 AF education code.

### **Program Educational Objectives (PEOs)**

The Program Educational Objectives of the Nuclear Engineering program are that graduates will be able to accomplish the following tasks successfully:

1. Perform, direct, and coordinate technical work involving the military applications of nuclear technologies.
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, written reports, journal articles, military briefings, and professional presentations that clearly communicate their work and that 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.

### **School and Program Admissions Criteria**

**DEGREE REQUIRED:** Nuclear, Mechanical, Electrical, 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 Engineering Physics Department for details.

**MATHEMATICS REQUIRED:** Ordinary Differential Equations

**TEST REQUIRED:** GRE - 500V/600Q

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

**USAF EDUCATIONAL 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.

#### Degree Requirements

Nuclear Engineering Core (12 hours)

Nuclear Applications (12 hours)

- NENG 605 - Physics of Nuclear Explosives
- NENG 631 - Prompt Effects of Nuclear Weapons
- NENG 635 - Residual Effects of Nuclear Weapons
- NENG 681 - Nuclear Chemical Engineering

Mathematics (4 hours)

Capstone (8 hours)

Thesis (12 hours)

## 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 Objective (PEO)

Graduates will be well-prepared to fill a variety of key decision-making, and policy formulation positions at the Pentagon, MAJCOM headquarters, AFMC product centers, operational units, and other DoD agencies.

### 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 focuses 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 - 500V/600Q

**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

#### Operations Research Models (6 hours)

- OPER 503 - Deterministic Modeling
- OPER 504 - Probabilistic Modeling

#### Military Modeling (6 hours)

- OPER 595 - Issues in Defense Analysis
- OPER 671 - Combat Modeling I

#### Simulation (4 hours)

- OPER 561 - Discrete-Event Simulation

#### Cost Analysis (4 hours)

- FMGT 520 - Strategic Cost Management

#### Decision Analysis (3 hours)

- OPER 543 - Decision Analysis

#### Statistics (8 hours)

- STAT 583 - Introduction to Probability and Statistics
- STAT 696 - Applied General Linear Models

#### Mathematics (4 hours)

- MATH 509 - Mathematical Methods in the Physical Sciences

#### 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)

One general elective in the second quarter and one OPER elective in the fourth quarter

## Operations Research (M.S.)

### Program Description

Operations Research aims to provide 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, machines, and procedures.

Operations Research draws upon ideas from engineering, mathematics, management 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)

1. To educate military officers, Department of Defense civilians, and other civilians in the theory and practice of Operations Research (OR)
2. To emphasize the application of such techniques to rational decision making, particularly in a defense context.

### School and Program Admissions Criteria

**DEGREE REQUIRED:** BS in Operations Research, Mathematics (not math education), Engineering, Physics, Computer Science, or quantitative Economics, 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 - 500V/600Q

**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

Prerequisite courses exist to provide necessary background in fundamental operations research areas, as well as mathematics and statistics foundations. Specific prerequisite courses are MATH 523 Numerical Analysis and Linear Algebra, OPER 510 Deterministic Operations Research, and STAT 587 Applied probability and Statistical Analysis. Students who have previously taken comparable graduate courses may request action through their faculty advisor for transfer credit or waiver of specific courses. Under appropriate circumstances, course substitutions may be approved by the Department Head.

#### Core Courses (18 hours)

- OPER 540 - Stochastic Modeling and Analysis I
- OPER 543 - Decision Analysis
- OPER 561 - Discrete-Event Simulation
- OPER 610 - Linear Programming and Network Flows
- OPER 688 - Operational Experimentation

#### Specialty Sequence (9 hours minimum)

At least three courses from an approved specialty are required. Specialty sequences are:

Deterministic Operations Research

Probabilistic Operational Research

Simulation

Decision Analysis

Applied Statistics

Information Operations/Information Warfare (IO/IW)

Operational Modeling

#### Electives (9 hours minimum)

At least three additional graduate level elective courses are required. Students must coordinate their electives with their faculty advisor and independent study advisor (i.e. thesis advisor). Students who do not select Operational Modeling as their specialty must take at least one elective in the Operational Modeling emphasis. Students may wish to select elective courses which provide a specific emphasis. Emphasis study areas are: Logistics Analysis, Space System Analysis.

#### Thesis (12 hours)

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

### Program Description

Optical Science and Engineering 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 program is offered by the Department of Engineering Physics.

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

The program is normally six quarters in length for a full-time Air Force student. Research toward the Masters 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 in order to take full advantage of the varied backgrounds and abilities of individual students.

## Program Educational Objectives (PEOs)

A graduate of the Optical Science and Engineering Program will be able to:

1. Apply advanced concepts in mathematics, optical physics, and engineering, including analytic, experimental and computational methods, to applications in the optical science and engineering area.
2. Perform optical science and engineering research, design and analysis, and communicate the work effectively, working independently and in groups, with a focus on problems of interest to the commands to which they are assigned upon graduation.
3. Understand and critically evaluate technical communications in the form of journal articles, research proposals and conference presentations. Be able to 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 Department

**MATHEMATICS REQUIRED:** Ordinary Differential Equations

**TEST REQUIRED:** GRE - 500V/600Q

**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

Optical Engineering (16 hours)

Electrical Engineering (16 hours)

Mathematics (4 hours)

Thesis (12 hours)

## Research and Development Management (M.S.)

### Program Description

The Graduate School of Engineering and Management, Department of Systems and Engineering Management, offers the Master of Science with a major in Research and Development Management (GRD).

The GRD program provides students with an in-depth study of the unique challenges associated with the development of new defense products and systems within the DoD and Air Force. Students will learn the principles of product development, systems engineering, and the associated organizational management necessary for effectively and quickly fielding new products and systems.

The objective is for students to understand the research and development process in order to lead and effectively implement it in all phases of weapon system development. Overall, the program requires the building of technical and managerial skills in the areas required for effective product development to prepare the students for leadership roles in the research and development and systems acquisition communities. Program graduates are well grounded in course work related to follow-on assignments within the systems management environment at all levels of the DoD and USAF (e.g., unit, MAJCOM, SECDEF).

The output advanced academic degree (AAD) code is 1APY. (Some qualified students will have the opportunity to pursue a IASY AAD code by taking an additional 3-course sequence above the program degree requirements).

## Program Educational Objectives (PEOs)

Provide Air Force career professionals with relevant graduate education in the research and development process in order to lead and effectively implement it with particular focus on rapid technology transition and product development cycle time reduction.

At the end of the program, graduates should be able to:

1. Apply the business and organization management skills and the economic and decision making skills necessary for effective project analysis and decision support.
2. 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.
3. Provide oversight support and make specific recommendations on appropriate strategies and administration techniques for each phase of a weapon system development effort.
4. Apply the best commercial practices to the DoD product development process.
5. Conduct and present methodological research to solve problems and support decisions.

## School and Program Admissions Criteria

**DEGREE REQUIRED:** An undergraduate degree in a technical area (engineering, math, or science) or with significant technical content (e.g., USAFA core).

**MATHEMATICS REQUIRED:** One year College Calculus

**TEST REQUIRED:** GMAT – 550; GRE - 500V/600Q

**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)

- QMGT 680 - Project Risk Analysis
- RDMT 541 - Operational Technology and Innovation
- SENG 520 - Systems Engineering Design
- SENG 610 - Systems Engineering Process and Management
- SENG 640 - Systems Architecture
- SMGT 543 - Systems Acquisition Management
- SMGT 647 - Acquisition Strategy

#### Management Foundation (4 hours)

- ORSC 542 - Management and Behavior in Organizations

#### Methods Requirement (8 hours)

- RSCH 630 - Research Methods
- STAT 525 - Applied Statistics for Managers I

#### Thesis (12 hours)

# 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. Full-time quota students enter as a class in September and are scheduled to graduate in March, approximately 18 months later. 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.

## 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.

## 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 - 500V/600Q

**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 (22 hours)

Specialty Sequence (9 hours)

Mathematics (4 hours)

Thesis (12 hours)

Additional courses to total 48 quarter hours

# 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 stand-alone product or vehicle platform, to design and integration of so-called systems of systems (such as an air operations center), 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 capstone group project (9 credit hours). The ISE program is nominally a four quarter (12 month) program, with students entering in May and graduating the following June.

## 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. Specific objectives 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/Advisor, 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, and capability assessment.

## 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.

**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:** 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.

## 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 stand-alone product or vehicle platform, to design and integration of so-called systems of systems (such as an air operations center), 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 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. Specific objectives are as follows:

1. A graduate will understand the role of a Systems Engineer, both as it applies to the government organization as well as their counterparts in industry.
2. A graduate will have a thorough understanding of the systems engineering process, from mission area analysis through requirements definition and system development, sustainment and retirement.
3. A graduate will have the base knowledge to become proficient with tools for implementing the SE process, to include development of system architectures, tradeoff and decision analysis, risk management and test planning.
4. A graduate will have the skills to effectively participate in the evaluation of both competing designs as well as proposed processes from competing contractors.
5. A graduate will develop a detailed understanding in at least one technical specialty area, such as space systems, C4ISR, information operations / information warfare, capability based analysis, decision analysis, modeling and simulation, or sensors. Other technically specialty areas can be tailored to suit the student or the student's follow-on assignment.

### **School and Program Admission Criteria**

**DEGREE REQUIRED:** Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering or a degree in Engineering Science from a service academy. Calculus-based physics and a course in 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 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 (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)

# Courses

## **AERO 500 - Introduction to Aeronautical Engineering**

Introduction to fluid mechanics, airfoil and wing aerodynamics, steady and accelerated aircraft performance, and stability and control.

Credit Hours 4

**Prerequisites/Corequisites**

none

**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

### **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**

course in undergraduate thermodynamics

### **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**

Fall

## **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 rotorcraft 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, AERO 536 or Permission of Instructor

### **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**

Summer, Fall

## **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 520, AERO 652 or Permission of Instructor

### **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**

None

**Terms Offered**

Summer, 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. U.S. Citizenship and Top Secret Clearance with eligibility for SCI access.

This is a single 3 credit course divided over three quarters (students must enroll in all three quarters)

Credit Hours 1

**Prerequisites/Corequisites**

Permission of Instructor

**Terms Offered**

Fall, Winter, Spring

## **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.

This is a single 3 credit course divided over three quarters (students must enroll in all three quarters)

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**

US Citizens only

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 feed-back 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.

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 stand alone technical elective.

Credit Hours 4

### **Prerequisites/Corequisites**

Linear systems and state space control (ASYS 525, ASYS 565 or equivalent)

### **Terms Offered**

Summer

## **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**

Summer, 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.

Credit Hours 4

**Terms Offered**

Summer

## **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

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall

## **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**

College Chemistry

### **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**

Undergraduate general chemistry, NENG 597 or NENG 651

## **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**

This course is only open to U.S. citizens.

Credit Hours 4

### **Prerequisites/Corequisites**

None

## **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 photo ionization 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**

Spring

## **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 pollutants 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**

General college chemistry

### **Terms Offered**

As needed

## **CHEM 681 - Nuclear Chemical Engineering**

Chemical engineering of the military nuclear fuel cycles is 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**

Some secret (RD) material is included.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 651, NENG 605 Corequisites: NENG 650

### **Terms Offered**

Fall

## **CHEM 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

## **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**

General college chemistry and AERO 729 or permission of instructor

### **Terms Offered**

As needed

## **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 the instructor

## **CHEM 825 - Chemical Physics**

An advanced study in the area of chemical physics. Topics covered include the approximate solutions of the time dependent Schrodinger equation for reacting systems and for systems interacting with an electromagnetic field. The foundations of infrared and ultraviolet spectroscopy, angular momentum considerations, symmetry studies, electronic states are included.

Credit Hours 4

### **Prerequisites/Corequisites**

CHEM 720

### **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 AND CHEM 825

**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 756, CHEM 825 or Permission of Instructor

**Terms Offered:** As needed

## **CMGT 523 - Contracting and Acquisition Management**

This survey course introduces students to the DoD contracting and acquisition processes. Through classroom discussion and outside readings, the student is introduced to the overall weapon system acquisition environment, the acquisition process, the overall contracting process, and current ethical and reform issues. The objective of the course is to help students understand the role of contracting in the acquisition process as well as to assess their role and stake in these processes, whether it be as a user, developer, supporter, or manager of a weapon system.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered:** As needed

## **COMM 680 - Technical Reports and Thesis**

Prepares students to present scientific/technical material in oral and written reports. Topics covered include the communication situation; elements of precise, concise style; organizing information for oral and written presentation; methods of locating and evaluating published technical information; techniques of accurate documentation; and local and general conventions of briefings and reports.

**Notes**

Requires three papers and two briefings.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered:** As needed

## **COST 550 - Visual Basic Applications for Cost Analysis**

This course is a basic introduction to object oriented programming utilizing the Visual Basic programming language. Goals for this class include mastering basic programming concepts, learning the ability to conceptualize how to develop software using objects and events, and learning how to solve real, complex problems.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall

## **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 3

**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 3

### **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 3

### **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**

Fall, Summer

## **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**

None

### **Terms Offered**

Fall, Summer

## **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

## **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

## **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 thero-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.

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.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 525

### **Terms Offered**

Summer

## **CSCE 528 - Cyber Defense and Exploitation II**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Winter

## **CSCE 528 - Lab**

Lab to be taken in conjunction with CSCE 528

Credit Hours 0

### **Prerequisites/Corequisites**

None

**Terms Offered:** Winter

## **CSCE 529 - Biometrics For Security and Information Systems**

This course provides an introduction to biometrics and biometric systems. Course material focuses on how biometric systems are used for access security. Topics covered include the theory and design of various biometric systems to include fingerprinting, voice recognitions, Iris and retinal scanning, and gait recognition. Performance metrics such as the probabilities of false alarm and false acceptance are discussed, as well as receiver operating characteristic curves.

### **Notes**

Performance trade-offs are presented. Student laboratory exercises are conducted to reinforce concepts discussed in class.

Credit Hours 4

### **Prerequisites/Corequisites**

Permission of Instructor

**Terms Offered :** Summer

## **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, Winter, Summer

## **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

### **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. Introduce 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**

Winter, Summer

## **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**

Winter

## **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

## **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, Winter

## **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**

CSCE 582

### **Terms Offered**

Fall

## **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 486, CSCE 492, CSCE 093 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 (DL), Winter

## **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**

REMARKS: 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 - Information Systems Security, Assurance, and Analysis I**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

None

**Terms Offered:** Spring

## **CSCE 628 - Lab**

Lab to be taken in conjunction with CSCE 628

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.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 560 or Permission of Instructor

### **Terms Offered**

Winter

## **CSCE 631 - Machines, Languages, and Logics**

This course continues the theoretical development of computational machines, computational functions, and formal languages and their interrelationships. Topics include finite automata, regular expressions, pushdown automata, Turing machines, Post Machines, recursively enumerable sets, recursive sets, recursive functions, decidability and Godel numbering. Associated algorithms on these computational models can be proven correct by developing a proof system using predicate calculus. Topics include first and second order predicate calculus, resolution, and unification. Using these foundations, designs are discussed from a computation viewpoint with emphasis on general computer software and hardware architectures.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 531, CSCE 532, and CSCE 586

### **Terms Offered**

Winter

## **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 Needed

## **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:** Winter

## **CSCE 681 - Lab**

Lab to be taken in conjunction with CSCE 681

Credit Hours 0

**Prerequisites/Corequisites:** None

**Terms Offered:** Winter

## **CSCE 684 - Information Visualization**

The purpose of this course is to teach the student how to use computer graphics techniques, i.e., color, space, animation, highlighting, layout, etc., to convey the meaning of their data. Supporting the topics on graphics design are lectures on computer graphics fundamentals, user interface design, and graphic support languages and hardware. Classroom lectures are reinforced by selected laboratory projects in user interface or information display design.

Credit Hours 4

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Spring

## **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 0

### **Prerequisites/Corequisites**

None

### **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 construction 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:**None

**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**

Summer

## **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 the typical GCE/GCS programs; therefore, students are required to attend this course for six quarters (2 Summer, 2 Fall, 1 Winter, 1 Spring). The course will typically meet for only a few of the ten weeks in each quarter. This is a required course in the Graduate Computer Engineering and Graduate Computer Science Programs. This course will be graded Satisfactory or Unsatisfactory.

Credit Hours 0

**Prerequisites/Corequisites**

None

**Terms Offered** 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**

CSCE 200 or Equivalent High-Level Programming Language

**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 - Information Systems Security, Assurance, and Analysis II**

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.

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 Needed

## **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 783 - Advanced Topics in Graphics and Visualization**

This course examines, in detail, selected topics from current research areas in computer graphics and information visualization. Characteristic topics include virtual environments, human-computer interaction, visualization techniques and applications, and modeling of synthetic environments. This is a project-oriented course with topics varying from year-to-year.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 582 or CSCE 684

## **CSCE 788 - Advanced Topics in Computer Architecture**

The objective of this course is for each student to be able to apply the concepts of advanced computer architecture to the design and application of computers. A critique of current architectures and considerations for improved architectures are covered. This is a required course in the computer architecture sequence of the Graduate Computer Engineering and Computer Systems programs.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 692

### **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**

As Needed

## **CSCE 792 - Parallel Computer Architecture**

This course explores ways in which greater computing power can be achieved by exploiting parallelism. Architectures for exploiting parallelism at different granularities are examined. Superscalar and VLIW are examples of architectures which exploit instruction-level parallelism. For exploiting more coarse-grain parallelism, e.g., loop-level or procedure-level, architectures which employ multiple processors are examined. Both shared memory and distributed memory architectures are discussed. Advanced topics such as SIMD architectures, data flow architectures, and multi-threading are also covered.

Credit Hours 4

### **Prerequisites/Corequisites**

CSCE 692; CSCE 656 is highly recommended

### **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 of 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**

None

**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**

None

### **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 585 - Introduction to Modern Fortran Programming with Applications in Weapons of Mass Destruction**

Modern Fortran programming techniques are presented and practiced using example problems from the weapons of mass destruction (GNE and GCW) curricula. The objectives include: to develop knowledge of the structure and syntax of Fortran-95 and available additional features of Fortran-2003, to develop skill in programming and in effective use of the provided development environment, and to practice writing, debugging, and validating portable Fortran programs. Relevant ANS/ANSI standards are presented. Programming exercises focus on numerical computations needed to solve problems encountered in the AFIT weapons of mass destruction curricula. Modern programming approaches, including operator overloading, data abstraction, encapsulation, and objects, are introduced using user-declared types and modules.

Credit Hours 4

### **Prerequisites/Corequisites**

none

### **Terms Offered**

As needed

## **CWMD 597 - Combating Weapons of Mass Destruction Engineering Practicum**

This course is designed to provide students 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.

Credit Hours 4

### **Prerequisites/Corequisites**

BIOL 597, CHEM 597, NENG 597

**Terms Offered:** Fall

## **CWMD 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

## **CWMD 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.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 635

**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 written under the supervision of a department professor.

### **Notes**

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**

Winter, Spring

## **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 545 - Introductory Econometrics**

This course focuses on introductory concepts in probability and statistics which are needed to conduct research in economics and cost analysis. These concepts include probability theory, distribution theory, hypotheses testing and linear regression modeling. The course includes practical exercises in sampling, two-tailed and interval tests for means and variances, and linear regression. The course includes special emphasis on Bayesian modeling using the generalized linear model, with adjustments for violations of the assumptions of non-collinearity, non-serial correlation and homoscedastically distributed errors.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall

## **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:** Fall

## **ECON 620 - Macroeconomics and Public Policy**

This course focuses on the circular flow of activity in the industrial economy and on the policies invoked by central governments to influence national output, employment, income, and economic growth. National income accounting is discussed, and national income determination is investigated from various theoretical perspectives. The business cycle, international transactions, inflation, unemployment and the role of money are among subjects examined in detail.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 291 or Permission of Instructor

**Terms Offered:** Winter

## **ECON 645 - Applied Econometric Analysis**

This course is designed to present practical applications of econometric modeling employed in cost analysis, financial management, non-market valuation and a variety of other policy applications. The course begins with the classical linear model with extensions regarding the distribution of the error term, with a focus on limited dependent variable techniques. The course proceeds through the fundamentals of time series analysis for forecasting and culminates with an exercise in time series cross sectional analysis. Exercises will focus on research design, model construction and testing using data sets from published or ongoing research. The focus will be on the application of techniques to real problems such as cost analysis, non-market valuation, forecasting and spatial analysis.

Credit Hours 4

**Prerequisites/Corequisites**

ECON 545

**Terms Offered:** Winter

## **ECON 670 - Nonmarket Valuation**

This course focuses on the estimation of environmental and resource values. The introductory material of the course motivates the use of non-market valuation techniques as a tool for public policy and reviews basic welfare theory. The remainder of the course covers the main stated and revealed preference techniques, with emphasis on the underlying theory, data collection methods, and econometric analysis. In the context of each valuation method, we will discuss the current state of knowledge, as well as, hot research topics and unresolved issues.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 291 or Permission of Instructor

**Terms Offered:** Spring

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall

## **EENG 502 - RF Syst**

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.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Winter

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Spring

## **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

Credit Hours 4

### **Prerequisites/Corequisites**

Permission of Instructor

### **Terms Offered**

Fall

## **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 529 - Remote Surveillance**

This course presents the models and methods required for and used in remote surveillance systems, such as satellite-based systems that acquire and process ground imagery. Topics covered include the nature of remote sensing, optical radiation models, sensor models, data models, spectral transforms, correction and calibration, image registration and fusion, and thematic classification.

### **Notes**

Applications to Air Force Systems are emphasized throughout the course.

Credit Hours 4

### **Prerequisites/Corequisites**

Permission of Instructor

### **Terms Offered**

Summer

## **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, bistatic, 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.

Credit Hours 3

**Prerequisites/Corequisites**

EENG 530

**Terms Offered**

As Needed

## **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 reference 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**

EENG 530 and STAT 586

### **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.

Credit Hours 1

### **Prerequisites/Corequisites**

None/EENG 532

### **Terms Offered**

As Needed

## **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:** As Needed

## **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.

### **Notes**

This course will be taught at the level of Roberts and Mullis' Digital Signal Processing.

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 623

**Terms Offered**

Spring

## **EENG 624 - Lab**

Lab to be taken in conjunction with EENG 624

Credit Hours 0

**Prerequisites/Corequisites**

None

**Terms Offered:** Spring

## **EENG 625 - Antennas**

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 576 or EENG 623

**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 and EENG 623

**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 623

**Terms Offered**

Winter

## **EENG 630 - High Frequency Electromagnetic Scattering**

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:** Summer

## **EENG 634 - Comp Methods in Em**

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 - Lab**

Lab to be taken in conjunction with EENG 636.

Credit Hours 0

**Prerequisites/Corequisites**

None

**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 machining, 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 MEMS.

Credit Hours 4

**Prerequisites/Corequisites**

none

**Terms Offered**

Winter

## **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**

As Needed

## **EENG 653 - Introduction to VLSI Design**

The purpose of this course is to equip the student with the fundamentals of VLSI design, including design methodologies, circuit modeling and analysis, mask layout, simulation and design verification. The focus is on each element of the design cycle. At each stage in the cycle both the theoretical concepts and the appropriate CAD tools are presented together. Practical experience is gained through the design of circuits of relatively low complexity. The VHSIC Hardware Description Language is used throughout to specify and document circuit designs.

### **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.

Credit Hours 0

### **Prerequisites/Corequisites**

None

### **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:** Winter

## **EENG 663 - Signal Detection and Estimation**

A Study of techniques of extracting information of signals corrupted by noise. Maximum Likelihood, Neyman Pearson, Ideal Observer, Bayes, and Mini-decision criteria. Binary and multiple decisions under single and multiple observations. Detailed consideration of signals in Gaussian noise. Karhunen-Loeve expansion and detection of signals in colored noise. Composite hypothesis. Sequential and non-parametric decision theories. Maximum Likelihood, Least Squares, Minimum Variance, and Bayes estimators. Efficient estimators and Cramer-Rao bounds. Introduction to Kalman Filter.

Credit Hours 4

### **Prerequisites/Corequisites**

EENG 665

**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 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 527 and EENG 665

**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**

Spring

## **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 studied: 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 Elec 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:** Spring

## **EENG 679 - Info Theory and Inference**

This course provides theoretical and practical background in information theory and inference; topics which are central in signal processing, data mining, machine learning, pattern recognition, computational neuroscience, cryptography, and many other areas. In particular, it covers concepts such as entropy and channel capacity and techniques such as data compression and error-correcting codes that are key enablers for modern data acquisition, processing, storage, and transmission. This course is open to all U.S. and international students.

Credit Hours 4

**Prerequisites/Corequisites:** STAT 586 or Permission of Instructor

**Terms Offered:** Spring

## **EENG 680 - Multidimensional Signal and Image Processing**

This course covers multidimensional signal and image processing. Topics include multidimensional Fourier transform, discrete Fourier transform, multidimensional infinite impulse response filters, multidimensional finite impulse response filters, and an introduction to the basics of image processing, restoration, and coding. This course will be taught at the level of Jain's Fundamentals of Digital Image Processing.

Credit Hours 4

**Prerequisites/Corequisites**

EENG 580 and MATH 521

**Terms Offered:** Spring

## **EENG 695 - Lab**

Lab to be taken in conjunction with EENG 695.

Credit Hours 0

**Prerequisites/Corequisites:** None

**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:** None

**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**

All

## **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 - Adv Topics in Radar Appl**

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, 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**

Summer

## **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:** None

**Terms Offered:** Spring

## **EENG 734 - Lab**

Lab to be taken in conjunction with EENG 734

Credit Hours 0

**Prerequisites/Corequisites**

None

**Terms Offered**

Summer

## **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**

EENG 765

### **Terms Offered**

Summer

## **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, STAT 586

### **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, EENG 765

**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 766

**Terms Offered** Spring

## **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 777 - Lab**

Lab to be taken in conjunction with EENG 777

Credit Hours 0

**Prerequisites/Corequisites**

None

**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**

As Needed

## **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, OENG 644

### **Terms Offered**

Spring

## **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

Credit Hours 4

### **Prerequisites/Corequisites**

EENG 695

### **Terms Offered**

Spring

## **EENG 795 - Lab**

Lab to be taken in conjunction with EENG 795

Credit Hours 0

### **Prerequisites/Corequisites**

None

### **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 current status of the work in a concise manner. Each student will receive critical feedback from both 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.

### **Notes**

For large classes, this seminar is scheduled over 2 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 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 678 - Engineering Operations Management**

The purpose of this course is to introduce students to strategic analysis and operational decision making issues associated with managing a service operation to deliver a level of performance that consistently surpasses customer’s expectations. However, services are typically intangible, highly variable in nature, not storable or transportable, and often involve distributed operations with significant customer contact. Quite different from the manufacturing environment, service operations often require specialized analytical frameworks and tools. Common themes throughout the course are the importance of incorporating the service concept into an organization’s strategy; the review of tools to design, evaluate, and manage service processes; and the integration of new information technologies. Specific topics include service operations strategy, design and analysis of service processes, workforce planning and scheduling, demand and capacity management, response time (queuing) analysis, call center management, productivity evaluation, and support strategies and management systems. The course is tailored to operations and maintenance activities associated with facility and infrastructure management.

Credit Hours 3

### **Prerequisites/Corequisites**

STAT 525, OPER 501

### **Terms Offered**

Winter

## **EMGT 699 - Master's Level Special Studies**

Credit Hours 1 - 12

**Terms Offered**

As needed

## **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 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, toxicology and medical terminology is critical to understanding the many health effects that can occur from environmental exposures to chemicals. Human health is the primary motivation behind many environmental activities from spill clean up goals to pollution prevention. This introductory level course will cover the physiology of each major organ system in the human body along with the types of injury that can occur from chemical exposure. Specific areas covered are: cell physiology, cancer, respiratory system, cardiovascular system, nervous system, digestive system, kidney, liver, immune system, endocrine system and reproductive system. This course will enhance the students ability to comprehend medical health information. The course provides a strong foundation in human health effects, which will ultimately result in well informed decision-making concerning environmental health related issues.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Winter

## **ENVR 532 - Air Resources Management**

The course provides students with an overview of the science, engineering, and policy aspects of the management of the earth's air resources. The course begins with a discussion of the atmosphere, atmospheric pollutants and associated effects. Several special interest topics are included such as military applications, permitting/legal framework, global issues, natural resource economics, smog formation, health effects and global warming. Dispersion calculations and basic design of air pollution control technologies are covered.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered:** Fall

## **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 course establishes the legal and regulatory framework governing waste management in the United States – particular attention will be paid to an integrated approach towards waste management. Collection, storage, treatment, and disposal technologies and regulations will be discussed, with emphasis on sound engineering and economic solutions.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered:** Summer

## **ENVR 541 - Industrial Hygiene Applications I**

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) within the framework of the anticipate, recognize, evaluate, control (AREC) paradigm. The course will focus on anticipation and recognition of hazards with accompanying exposure limits. Topics include: IH history and regulations; exposure limit basis, interpretation, and application; chemical hazards and indoor environmental quality; biological hazards; physical hazards (noise, thermal stress, ergonomics).

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.

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 principles – measures of disease frequency and association. Design of descriptive and analytic studies (aggregate, case series, cross-sectional, and cohort studies); application to public health; and communication of epidemiologic information are presented. Issues of bias, confounding, effect modification, and causal inference are discussed. Data analysis using tabular methods is accomplished.

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Spring

## **ENVR 547 - Non-Ionizing and Ionizing Radiation**

This course covers the health and safety problems involved with the use of ionizing and nonionizing 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, transportation of radioactive material, and required surveys (routine and contamination).

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Spring

## **ENVR 548 - (LWL) - Industrial Hygiene III (Controls) and Laboratory**

This course completes the anticipate, recognize, evaluate, control (AREC) paradigm by providing control mechanisms competency to the students. The course will treat the control hierarchy (substitute, engineering controls, administrative controls, then last personal protective equipment-PPE), but focus on engineering controls. Students will specifically learn industrial ventilation design (airflow, local and dilution ventilation, hood design, fan selection, air cleaning devices, system evaluation, trouble-shooting) with practical exercises, as well as hazardous noise controls. The final piece of the course will treat industrial hygiene program management to tie in administrative and PPE controls.

Credit Hours 4

**Prerequisites/Corequisites:** none

**Terms Offered:** Summer

## **ENVR 548 - Lab**

Lab to be taken in conjunction with ENVR-548

Credit Hours 0

## **ENVR 550 - Environmental Systems Engineering**

This course is intended to provide the student with analytical and mathematical tools that can be used to quantitatively and qualitatively assess the effects of Air Force operations on the environment. In addition, the course provides the student with information regarding basic engineering controls that can be used to minimize the impact of mission operations on the environment. The course discusses the physical, chemical, and biological mechanisms which control the fate and transport of contaminants in the environment. These same mechanisms are discussed with regard to engineering controls which may be implemented to mitigate air, water, and land pollution. A student completing the course should: 1. Understand the basic physical, chemical, and biological processes which affect the fate and transport of contaminants in the environment, 2. Understand and apply simple mathematical models to describe environmental processes, and 3. Know what engineering controls may be used to mitigate air, water, and land pollution as well as understand the physical, chemical, and biological principles upon which these controls are based.

Credit Hours 4

**Prerequisites/Corequisites:** None

**Terms Offered:** Fall

## **ENVR 556 - Sustainable Life Cycle Design**

Sustainability has become a popular topic of discussion in various settings over the past decade and is often still associated strongly with "environmentalism." However, sustainable development is central to all aspects of engineering; after all, engineering can be generically described as a process of transforming natural resources for the benefit of society. Stated in another way, engineering can be regarded as the technology required to achieve societal, environmental, and economic goals. These four dimensions thus form the basis for sustainable development, which was defined by the Brundtland Commission as "the ability to meet our needs without compromising the ability of future generations to meet theirs." Although the emphasis of the course will be on generic sustainability issues, the intent is for students to begin thinking of various ways to apply the learned concepts to military operations.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered:** Winter

## **ENVR 575 - Applied Environmental Health**

The course will provide the student with an overview of historical (military & civilian) environmental health related issues. As well as contemporary issues pertinent to the deploying military member identification of toxic industrial chemicals/materials will be covered.

Credit Hours 3

**Prerequisites/Corequisites**

None

**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 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 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 628 - Physiologic Effect of NBC Agents**

A general knowledge of physiology and toxicology is critical to understanding the myriad health effects that can occur from exposure(s) to Nuclear, Biological and/or Chemical (NBC) agents. This course will cover the physiologic 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 NBC agents, which will ultimately result in better informed decision-making concerning military NBC threat assessments and response and recovery operations.

Credit Hours 3

### **Prerequisites/Corequisites**

ENVR 528

### **Terms Offered**

Winter

## **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**

The objective of this class is to familiarize the student with the concepts and principles involved with general and environmental risk analysis. This course will cover toxicology concepts, epidemiology, genetics, cancer, animal toxicology studies, exposure assessments, data collection, and computer tools used in risk analysis and risk communication to the public.

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; and random, composite, stratified, and systematic sampling. Analytical procedures including solids analysis, 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, data handling. Students will study and apply selected principles and techniques of environmental monitoring including learning to: (1) develop sampling and analysis plans (2) implement sampling and analysis plans (3) report results of a monitoring study

Credit Hours 4

### **Prerequisites/Corequisites**

CHEM 590 or CHEM 585 and STAT 526 or Permission of Instructor

### **Terms Offered**

Spring

## **EVSC 560 - Lab**

Lab to be taken in conjunction with EVSC-560

Credit Hours 0

## **EVSC 650 - Environmental Measurement Techniques**

This course treats the proper application of the various chemical, physical, and thermo physical 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 660

### **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. As examples, airborne and satellite visible and infrared measurements are used to map oil spills and to 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**

MATH 515, CHEM 590

### **Terms Offered**

As needed

## **FANL 520 - Strategic Financial Analysis**

This course is designed to present fundamental analytical skills required for budget officers at the base through DoD levels. The course begins with economic impact analysis with emphasis on regional impacts in an input-output model setting. The course continues with an extensive review of benefit/cost analysis with an emphasis on defining, quantifying and evaluating benefit streams to financial decisions. The course ends with a review of public finance issues, including a review of public goods, externalities and the microeconomics of revenues and expenditures. Practical exercises focus on estimating the regional economic impact of military and government facilities and benefit cost analysis of public goods provision

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Winter

## **FANL 620 - Defense Budgeting**

This course is a focused treatment of group dynamics and decision making, linked to capital budgeting. Instruction begins with an introduction to social networking, bargaining, negotiations, team building, reaching a consensus with special emphasis on communicating information and decision criterion. The focus then turns to major issues in capital budgeting with an emphasis on decision making. Capital budgeting issues include communicating project analysis under risk and uncertainty, developing sensitivity and break even analysis and the use of micro-simulations in a public good setting. Practical exercises include small group dynamics, bargaining, and case studies in capital budgeting under conditions of uncertainty and risk.

Credit Hours 3

### **Prerequisites/Corequisites**

FANL 520

### **Terms Offered**

Spring

## **FANL 674 - Seminar in Financial Analysis**

This seminar is the capstone in the Financial 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 Financial Analysis community. The seminar explores current concepts and applications of Financial Analysis, to include communication of information and decision criterion, with application of capital budgeting, economic and financial analysis and forecasting under conditions of risk and uncertainty. Students will perform a business case analysis within a small group setting which includes documentation, presentations, sensitivity analysis and communication of risk and uncertainty to the decision maker.

Credit Hours 3

### **Prerequisites/Corequisites**

FANL 520, FANL 620

### **Terms Offered**

Winter

## **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**

Fall

## **FMGT 520 - Strategic Cost Management**

This course familiarizes students with selected concepts of cost management and strategy to enhance their ability to develop plans, establish objectives, generate and evaluate alternatives, control operations, identify and analyze complex problems, and make good decisions. The course incorporates critical thinking skills, creative problem solving techniques, and strategic cost management theory to allow students to internalize fundamental principles and concepts and then apply them to real-world problems. Topics covered begin with fundamental strategy and cost concepts including the time value of money, personal finance, capital budgeting, just-in-time, activity based costing and management (ABC/M), theory of constraints, life cycle costing, quality, and continuous improvement. Knowledge is then expanded by covering cost estimation, master budget and strategy, strategic analysis, decision making, cost benefit analysis, earned value, cost allocation, and productivity. Where possible, classroom discussions and assignments include examples tailored to the Department of Defense (DoD).

Credit Hours 4

### **Prerequisites/Corequisites**

STAT 535, ECON 545, or Permission of Instructor

### **Terms Offered**

Winter

## **FMGT 610 - Finance Theory II**

This is the second 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 strategic and tactical financing decisions including capital structure, distributions, repurchases, investment banking, lease financing, and hybrid financing. Knowledge is expanded by covering special topics such as working capital management, risk management, reorganization, mergers, and acquisition, multinational finance, credit, cash management, pension planning and not-for-profit financial management.

Credit Hours 4

### **Prerequisites/Corequisites**

FMGT 510

### **Terms Offered**

Winter

## **FMGT 620 - Financial Analysis**

This is a real-world applications based course that builds on the theory learned in FGMT 510 and FGMT 610. The course utilizes finance theory to have students develop an investment portfolio that maximizes return for a given level of risk. Issues such as diversification, asset allocation, and portfolio maintenance will be highlighted.

Credit Hours 4

### **Prerequisites/Corequisites**

FMGT 610

**Terms Offered:** Spring

## **IMGT 530 - Conceptual Foundations for Information Resource Management**

Provides an overview of the broad range of concepts and theories on which academic study of information resource management is based. The course examines the role of information and control systems in supporting organizational functions from routine operational processes to strategic planning and decision making. It also surveys the primary directions that current information systems research is taking and identifies how a variety of research methodologies may be applied to information resource management research questions.

Credit Hours 3

### **Prerequisites/Corequisites**

None

**Terms Offered:** Fall

## **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:** Spring

## **IMGT 561 - Lab**

Lab to be taken in conjunction with IMGT-561

Credit Hours 0

## **IMGT 580 - Enterprise Information 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

## **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 651 - Systems Analysis and Design**

This course provides an in-depth study of the methodologies currently used in the analysis and design of information systems. Strategies for conducting system requirements analysis and methods for accomplishing the logical specifications of information systems are discussed at length. Techniques and tools used to complete the detailed logical and physical design are discussed in-depth.

Credit Hours 4

**Prerequisites/Corequisites:** None

**Terms Offered:** Winter

## **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, Fall

## **IMGT 663 - Human-Computer Interaction**

This course covers the principles of human-computer interaction in the design and evaluation of useful, usable interfaces as well as the social consequences of technological innovations. Topics include the joint performance of tasks by humans and machines; the structure of communication between human and machine; human capabilities to use machines; algorithms and programming of the interface itself; engineering concerns that arise in designing and building interfaces; the process of specification, design, and implementation of interfaces; and design trade-offs.

Credit Hours 4

**Prerequisites/Corequisites**

None

**Terms Offered**

Winter

## **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

## **IMGT 688 - Security and Ethics in the Information Age**

Over the past decade or so, rapid developments in the areas of networking and communications have vastly increased our ability to collect, send, store, and make use of digital information. The Air Force along with its sister services and the Department of Defense makes extensive use of these capabilities. As the technologies continue to develop, our use of them increases as well. However, in the rapid switch to storage, communication and use of digital information, there has often been a lag in our consideration of some of the security and ethical issues. This course will explore these issues from a management point of view, with emphasis on case studies, and real world applications. Issues covered in this course include: the impact of digital information storage, retrieval, communication and use on issues of military security; the evolution of thought about the proper safeguards of information in the digital age; the potential impact of digital information on our nation's security; ethical issues related to government collection, storage, and use of information; ethical implications stemming from the digital storage, communication, and use of information; the role of IRM in the management of information security; and the role of IRM in the ethical issues surrounding digital information.

Credit Hours 3

**Prerequisites/Corequisites**

none

**Terms Offered:** Spring

## **IMGT 690 - Seminar in Information Resource Management**

This is the capstone course for the GIR/GIS program that serves two purposes. First, the seminar is used to pull together the many concepts and issues covered in the program and it strives to put them into a context that will help the students prepare for using what they have learned to meet Air Force needs. Second, it provides a forum in which subjects of special interest can be addressed and explored in some depth. These subjects may change over time, as the field evolves, and as the needs of the Air Force change.

### **Notes**

With the seminar format, the students are expected to assume responsibility for developing and making classroom presentations on selected topics and to take an active part in classroom discussions.

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Winter

## **IMGT 695 - Information Resource Management Colloquium**

Provides a forum for discussion of Air Force, sister service, and DoD information resource management issues and topics with top leaders, academics, and practitioners. Information Resource Management (IRM) program-specific topics are also discussed.

### **Notes**

Enrollment encouraged for IRM program students only.

Credit Hours 0

### **Prerequisites/Corequisites**

None

### **Terms Offered**

All

## **IMGT 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**

None

### **Terms Offered**

All

## **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**

Spring; Summer-Distance Learning Only; Winter-Distance Learning Only

## **LOGM 567 - Lean Operations Management**

Topics to be covered include: Impacts of lean production on the overall logistics system, identification of wastes (muda) in lean logistics processes, the impact of JIT processes on logistics functions such as purchasing, transportation and inventory control, process capability identification and statistical process control, and achieving six sigma quality in lean processes.

Credit Hours 4

**Prerequisites/Corequisites:**

None

**Terms Offered**

Winter-Distance Learning Only; Spring; Summer-Distance Learning Only

## **LOGM 568 - Logistics Management**

This course examines physical distribution theory, concepts, and practices as applied in both commercial and DoD organizations. Elements of the physical distribution system (e.g., inventory, warehousing, materials handling, packaging, and transportation) are considered singly and interactively. Emphasis is on linkages which must be recognized in the design and management of physical distribution systems. The commercial and DoD environments are compared and contrasted; and, physical distribution issues impacting strategic mobility are analyzed.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered**

Winter-Distance Learning only; Summer-Distance Learning and 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 + TQM, forecasting, and current operations management innovations.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered:** Spring

## **LOGM 570 - Principles of Inventory Management**

This course is designed for students who seek a fundamental understanding of the design and operation of inventory management systems. Specifically, this course will provide students with a broad survey of issues concerning managing inventory systems such as (1) the logistics pipeline with emphasis on the DOD, (2) demand data and forecasting methodologies, (3) inventory models applicable to consumable items, (4) inventory models for repairable items, and (5) management issues for operating inventory systems. This is a survey course intended for students who are non-supply officers but wish a greater understanding of inventory systems. The course is intended to build upon the material presented in LOGM 568 Logistics Management, and LOGM 569 Maintenance and Production Management.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered:** Fall, Winter

## **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 593 - Quantitative Modeling**

This is an introductory course in operations research/management science. The course develops the fundamentals of building and using computer-based models to investigate the behavior of systems. Major topics covered include linear and integer programming, multiple objective optimization, and discrete event simulation. Emphasis is on understanding the mathematical concepts, their underlying assumptions, and associated terminology. Students will be expected to demonstrate their ability to identify applications, formulate appropriate models, and obtain and interpret analytical results. The focus is on managerial decision-making.

Credit Hours 5

**Prerequisites/Corequisites**

STAT 521

**Terms Offered**

Fall; Spring-Distance Learning Only

## **LOGM 601 - Principles and Methods of Research**

This course prepares the student to perform as Principle Investigator on independent research that leads to a significant contribution to a field of inquiry. Beginning with topic selection, the course provides information on how to conduct an appropriate review of the literature to identify gaps and opportunities surrounding the problem area, and identify and evaluate approaches for data collection and analysis leading to valid inference about the topic. Scoping and refining the topic, clearly identifying the problem and sub-problems, and converting the topic into answerable research and investigative questions leading to a formal research proposal is discussed. The broadest scope of qualitative and quantitative research methods, encompassing the stages of observation, categorization, correlation and causality are covered, and the data collection and analysis methods appropriate for a wide variety of problems are addressed in detail. Methods leading to both strong and weak inference are

presented, and the philosophy of the scientific method provides the overarching structure for the class. The material presents both a theoretical, why based approach as well as practical how to lessons.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall-Ft. Dix Only; Summer

## **LOGM 615 - Logistics Information Systems**

This course focuses on the application of information technologies to Logistics Management. As such, the students are expected to develop an understanding of the application of Information Systems to Logistics both in and outside military. Topics covered will include: Information Security Architecture, Warehouse Management Systems, and Transportation Management Systems. MRP/DRP, ERP systems, and E-logistics will be discussed. The application to USAF will be emphasized. The embedded OR/MS methodology in enterprise software will be discussed.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered**

Winter

## **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 transportation policy frameworks that guide the constant development of our transportation systems. Examines how transportation 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 defense transportation system. 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**

The course is designed to give the students a working knowledge of Activity Based Costing (ABC), including what it is, why traditional accounting practices do not support managerial decision making, and techniques to perform ABC. The necessity of accurate costing will be emphasized, with examples from current privatization initiatives within DoD, as well as commercial sector cases. Once the student is familiar with cost allocation under ABC, Activity Based Management (ABM) will be introduced to enable the student to utilize the output from ABC. In addition, the development and application of non-financial metrics, essential in ABM, will be covered.

Credit Hours 3

**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.

Credit Hours 3

**Prerequisites/Corequisites**

LOGM 617

**Terms Offered**

Fall-Ft. Dix Only; Spring

## **LOGM 627 - Supply Chain Management**

Intended as a capstone course for professional logisticians, LOGM 627 develops the major themes and strategies of Supply Chain Management. The focus is on the system design, structure, capacity, and management of an integrated supply chain. Subject matter includes cross functional analysis and treatment of sourcing/supply, distribution/transportation, maintenance/operations and related logistics support issues in a system-wide approach. Main themes developed are the necessity of an integrative approach to strategy, policy, and decision making; and the need to emphasize system commonality of sourcing, distribution, and operations to form an integrated supply chain in support of global military operations.

Credit Hours 3

**Prerequisites/Corequisites**

Must be taken in last quarter

**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

## **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**

The first part of the course will address reliability and maintainability (R&M) issues. This part of the course teaches fundamental R&M concepts, including R&M measures, component availability and R&M prediction. Additionally, probability theory is discussed and employed as a tool to quantitatively define these concepts. The second part of the course will address quality issues from a management perspective. The application of proven and innovative techniques with a quality focus for the management and control of programs in the defense environment is well documented. This course builds upon and applies basic statistical and systems management concepts. The materials for both parts of the course are presented in a lecture/discussion format with dialogue encouraged on the issues.

Credit Hours 3

### **Prerequisites/Corequisites**

Resident Students: STAT 525, STAT 535 or equivalents. Ft. Dix Students: LOGM 525

### **Terms Offered**

Fall-Distance Learning and In-Residence; Winter-Ft. Dix Only

## **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 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.

**Notes**

Open to International Students

Credit Hours 3

**Prerequisites/Corequisites**

LOGM 617

**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 15-month graduate program.

Credit Hours 0 credit hours

**Prerequisites/Corequisites**

None

**Terms Offered**

All

## **LOGM 791 - Research Project for Mobility Managers**

A research topic is selected from mobility problems of interest to USAF and DoD.

**Notes**

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 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 logistics 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**

Digital computer-oriented methods for determining roots of equations, solutions for systems of equations, approximation of functions, values of definite integrals, solutions of ordinary and partial differential equations, matrix eigenvalue problems.

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**

Introductory graduate level course in methods of applied mathematics. Differential and integral calculus of functions of several variables. Vector differential calculus, directional derivatives, gradient, divergence and curl. Line and surface integrals, Green's theorem, divergence theorem and Stokes's theorem. Fourier series expansions. Partial differential equations of applied science. Complex numbers, analytic functions of a complex variable.

Credit Hours 4

**Prerequisites/Corequisites**

none

**Terms Offered**

Winter, Fall

## **MATH 513 - Methods of Applied Mathematics II**

Introductory graduate level course in methods of applied mathematics. Complex integrals and Cauchy's integral formula. Orthogonal sets of functions. Laplace transforms and the solution of differential equations. Algebra of matrices, determinants, systems of linear algebraic equations, eigenvalues and eigenvectors, matrix methods for systems of linear differential equations. Power series, Taylor series and Laurent series. Integration by the method of residues and the evaluation of real integrals.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 511.

**Terms Offered:** Winter

## **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. Topics covered include vector spaces, linear transformations, inner products, vector and matrix norms, orthogonality, linear systems, eigenvalue problems, least squares problems, convex sets and functions, unconstrained optimization theory, numerical root finding, iterative methods, polynomial interpolation, and numerical differentiation and integration.

Credit Hours 5

**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 the consequences thereof, and Lebesgue 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**

Winter

## **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 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**

Summer

## **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 semi-groups, 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

### **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 Department

### **Terms Offered**

Spring

## **MATH 672 - Numerical Linear Algebra**

Vector and matrix norms, condition number, sensitivity analysis. Matrix decompositions including LU, QR and Cholesky. Direct and iterative methods for solving systems of linear equations. Iterative methods for the eigenvalue problem. Least squares, singular value decomposition, orthogonal projections, generalized eigenvalue problem.

Credit Hours 4

### **Prerequisites/Corequisites**

MATH 521 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**

Finite difference methods for partial differential equations. Consistency, stability and convergence of methods for hyperbolic, parabolic and elliptic problems. Finite element methods. Variation formulation, Ritz-Galerkin method, finite element spaces, approximation theory.

Credit Hours 4

### **Prerequisites/Corequisites**

MATH 674.

### **Terms Offered**

Summer

## **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

### **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**

Summer

## **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:** Infrequently

## **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 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**

Undergraduate material science course

### **Terms Offered**

Winter

## **MATL 545 - Mechanical Properties of Materials**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

Undergraduate material science course

### **Terms Offered**

Fall

## **MATL 560 - Electronic, Magnetic and Optical Properties of Materials**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

Undergraduate materials science course

**Terms Offered:** Fall

## **MATL 598 - Materials and Processes Seminar**

Current technologies, applications, and research issues in the materials and processes are presented by experts from the Air Force, Industries and other universities.

Credit Hours 4

### **Prerequisites/Corequisites**

Undergraduate materials science course

### **Terms Offered**

As needed

## **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**

CHEM 590 or equivalent

**Terms Offered**

Winter

## **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**

Spring

## **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**

Undergraduate materials science course

### **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**

Undergraduate materials science course

### **Terms Offered**

Winter

## **MATL 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

## **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**

The topic for an independent study in Materials Science and Engineering 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 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

## **MATL 899 - Doctoral Level Special Studies**

Course content determined by faculty member based on student need.

Credit Hours 1-12

### **Prerequisites/Corequisites**

Permission of Research Advisor

**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 505 - Introduction to Aircraft Structural Analysis and Mechanics**

This course covers fundamental aspects of structural analysis useful for understanding the response characteristics of aircraft/spacecraft components and materials. Topics include definitions and applications of stress, stiffness, strength, environmental aspects, failure analysis, impact response, fatigue and fracture, and relevant algorithms. Both metallic and nonmetallic materials and their composites are included. All these aspects are related to tools development for optimum design residual life evaluation, hazard detection, information evaluation and risk management.

Credit Hours 4

### **Prerequisites/Corequisites**

This class is open to ENV systems engineering students.

**Terms Offered:** Summer, Spring

## **MECH 515 - Theory of Vibrations**

Free and forced vibrations of damped and undamped systems with a finite number of degrees of freedom. Characteristics frequencies and mode shapes. Generalized coordinates and normal modes. Free and forced vibrations of simple continuous systems: transverse oscillations of strings, longitudinal and torsional oscillations of rods.

Credit Hours 4

### **Prerequisites/Corequisites**

MECH 521

### **Terms Offered**

Winter, Summer

## **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**

Aerodynamic consideration of lift, drag and moment, Aerodynamic stability derivatives. Derivation of the aircraft equations of motion. Trim conditions and stability analysis of the linearized equations of motion.

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 or 545

**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 mode 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**

Winter, 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 or MECH 545

**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 or MECH 545

**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 - Astrodynamic Re-Entry**

Introduction to planetary atmospheres and aerodynamic forces. Equations for flight over a spherical planet. Performance in extra-atmospheric flight. Return to atmosphere. Basic equations for planar entry trajectories. Analysis of first-order planetary entry solutions. Loh's Second-Order Theory. Yaroshevskii's Theory. Chapman's Theory. Entry corridors. Unified Theory of Re-Entry. Orbit contraction due to Atmospheric Drag.

Credit Hours 4

### **Prerequisites/Corequisites**

MECH 521 Corequisites: MECH 532 (if not previously taken) or permission of instructor

### **Terms Offered**

Summer, Spring

## **MECH 642 - Finite Element Methods for Structural Analysis I**

Energy principles. Stiffness analysis of structural members. Formulation of structural problems using finite element methods. Analysis of trusses, frames, plane stress and plane strain problems.

Credit Hours 4

### **Prerequisites/Corequisites**

MECH 542

### **Terms Offered**

Spring

## **MECH 662 - Intro to Aeroelasticity**

Mathematical foundations of Aeroelasticity. Static aeroelastic behavior of swept and straight wings, control surface effectiveness, coupled control surface/wing torsional divergence. Free vibration and dynamic response of continuous systems. Unsteady, quasi-steady aerodynamics in subsonic and supersonic regimes. Non-conservative dynamic instability, fluttering systems.

Credit Hours 4

### **Prerequisites/Corequisites**

AERO 535 and MECH 515.

### **Terms Offered**

Spring

## **MECH 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

## **MECH 712 - Nonlinear Oscillations**

Liapunov's direct method. Nonautonomous systems, linear systems with periodic coefficients, Floquet theory. Perturbation techniques, secular terms, Linstedt's methods, KBM method.

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 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 Studies**

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:** Spring

## **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**

Undergraduate thermodynamics

### **Terms Offered**

Winter

## **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. 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

## **MENG 899 - Doctoral Level Special Studies**

Course content determined by faculty member based on student need.

Credit Hours 1-12

**Prerequisites/Corequisites**

Permission of Research Advisor

**Terms Offered**

All

## **METG 505 - Env Effects on Military Ops Sy**

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.

Credit Hours 4

**Prerequisites/Corequisites**

None

## **METG 511 - Atmospheric Physics for Engineers and Scientists**

Applies physical, chemical, and thermodynamic fundamentals to atmospheric phenomena. Terrestrial radioactive 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.

Credit Hours 4

**Prerequisites/Corequisites**

none

**Terms Offered**

Winter

## **METG 611 - Atmospheric and Space Environmental Effects on Electromagnetic Propagation**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

METG 511, PHYS 640 (Desirable)

### **Terms Offered**

Spring

## **METG 612 - Cloud Physics**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

METG-510

## **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 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.

Credit Hours 4

### **Prerequisites/Corequisites**

Prerequisites: none

### **Terms Offered**

Summer

## **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: to develop knowledge of the structure and syntax of Fortran-95, to develop skill in programming and in effective use of the provided development environment, and to practice writing, debugging, and validating portable Fortran programs. Relevant ANS/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, objects, are introduced using Fortran-95 user-declared types and modules.

Credit Hours 4

**Prerequisites/Corequisites**

none

**Terms Offered**

Fall

## **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 structure forces inherent in nuclear weapons, and to lay a foundation for understanding their effects. Then the specific effects of, and differences between, the various classifications of explosions (i.e., Air, Surface, sub-surface and high altitude bursts) are covered.

Credit Hours 4

**Prerequisites/Corequisites**

none

**Terms Offered**

Summer

## **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.

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.

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 of the nuclear fuel cycle.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 605, NENG 651, and MATH 508 or equivalent.

## **NENG 625 - Electromagnetic Pulse Effects**

Source, propagation, and interaction of 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.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS-531 / NENG-605

### **Terms Offered**

As needed

## **NENG 630 - Radiation Health Physics**

This course in radiation health physics provides the foundation for understanding the biological effects of ionizing radiation and for 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, managing environmental activities of military installations which have nuclear sources (hospital, PMEL, or nuclear weapons) or who must interact in their environmental management jobs with the Department of Energy.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 651

**Terms Offered**

As needed

## **NENG 631 - Prompt Effects of Nuclear Weapons**

Topics include source, transmission and mechanisms of inter-action 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.

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.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 605

**Terms Offered**

Summer

## **NENG 650 - Lab**

Lab to be taken in conjunction with NENG-650

Credit Hours 0

## **NENG 650 - Nuclear Instrumentation**

Laboratory and lecture study of radiation detectors and detection systems; characteristics, applications, and principles of operation of gas-filled detectors, scintillation detectors, semiconductor detectors; 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.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 651

### **Terms Offered**

Winter

## **NENG 651 - Nuclear Physics**

A basic graduate level treatment of nuclear physics with emphasis on interaction of radiation with matter, nuclear reactions and radioactive decay processes. Essential ideas of nuclear structure, stability of nuclei and quantum characterization of nuclear energy levels are covered. A practical understanding and interpretation of nuclear data tabulations to serve the needs of the nuclear engineer are stressed.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 556

### **Terms Offered**

Fall

## **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 (FET's), 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.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 605

### **Terms Offered**

Spring

## **NENG 664 - Lab**

Lab to be taken in conjunction with NENG-664

Credit Hours 0

## **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 envelopment of systems and controls. Students must establish test criteria, model effects, develop system controls and interpret data.

### **Notes**

Remarks: This is a lecture with lab course. Classes will meet for 1 hour, 3 days per week, for the lectures and for 3 hours 1 day per week, for the lab. May require travel to off-site irradiation facilities.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 650, NENG 660

### **Terms Offered**

Summer

## **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.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 651 AND MATH 504

### **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 ODE's), 1-d spatial dependence of radiation diffusion (boundary value ODE eigenvalue/eigenfunction problem), transient heat diffusion (PDE's).

Credit Hours 4

### **Prerequisites/Corequisites**

MATH 504

### **Terms Offered**

As Needed

## **NENG 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

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 504, NENG 605 AND NENG 685

**Terms Offered**

Summer

## **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 (NENG 605), some heat transfer (NENG 631) 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.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 605, NENG 631 AND 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.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 631, NENG 635

**Terms Offered**

As required

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 705

## **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.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 674 OR NENG 685 OR 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.

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**

(Admission limited to US citizens only.)

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 635

### **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 written under the supervision of a departmental professor.

### **Notes**

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

## **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.

Credit Hours 4

### **Prerequisites/Corequisites**

NENG 705

### **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.

Credit Hours 4

**Prerequisites/Corequisites**

NENG 631 AND NENG 635

**Terms Offered**

As needed

## **NENG 899 - Doctoral Level Special Studies**

Course content determined by faculty member based on student need.

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.

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.

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**

Winter

## **OENG 530 - Fundamentals of IR and MASINT Technology**

This course lays the groundwork for solving MASINT remote sensing problems, with emphasis on IR technology. Both the signature and metric aspects of MASINT will be considered. Topics include source characteristics, radiometry, atmospheric and propagation effects, optics, detectors, and elementary signal/image processing.

**Notes**

Students should have a strong background in basic mathematics and physics.

Credit Hours 3

**Prerequisites/Corequisites**

none

**Terms Offered**

Fall

## **OENG 531 - Nonimaging IR and MASINT Collection Systems**

The principles developed in OENG 530 will be applied to explore the current technology for collecting, and exploiting MASINT 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:** Winter

## **OENG 533 - Multispectral and Hyperspectral MASINT Exploration**

Examines the information that can be extracted from multispectral data sets collected by MASINT 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 531

**Terms Offered:** Spring

## **OENG 535 - MASINT for the Warfighter Seminar**

Seminars will present MASINT topics of interest to the Intelligence Community, and will 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 Lab**

Hands-on exercises in fundamentals of MASINT data processing and analysis including application of radiation source, propagation, and collection algorithms and techniques. Computing tools include spreadsheet and PLEXUS/MODTRAN atmospheric transmission codes.

Credit Hours 1

**Prerequisites/Corequisites**

OENG 530

**Terms Offered**

Fall

## **OENG 537 - IR MASINT Collection System Lab**

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, OENG 531

**Terms Offered**

Winter

## **OENG 539 - Multispectral and Hyperspectral MASINT Lab**

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 531, OENG 533

**Terms Offered**

Spring

## **OENG 616 - Electro-Optical Systems Laboratory**

A laboratory and lecture course which introduces laboratory techniques for the measurement of optical observables (emissions or reflections of optical radiation from aerospace vehicles). The two hour long lecture period each week 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 which affect that beam.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 556, 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**

Winter

## **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**

Spring

## **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**

Summer

## **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**

Prerequisites: PHYS 640, OENG 650, EENG 580

### **Terms Offered**

As required

## **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**

Spring

## **OENG 651 - Optical Diagnostics Lab**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 640, PHYS 601

### **Terms Offered**

Winter

## **OENG 681 - Digital Image Processing**

The principle objectives of this course are to develop the concepts and techniques of digital image processing, and to 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**

Spring

## **OENG 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

## **OENG 720 - Laser Devices and Applications**

Treats specific laser systems of importance to the commercial world and to the Air Force in particular. The course stresses current laser technology and engineering analysis of specific systems. Topics typically covered 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 discussed as well. 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

## **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 which 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, bitable optical devices, and self-electro-optic-effect devices.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 570, PHYS 640, OENG 620

**Terms Offered**

Summer

## **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**

Winter

## **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 written under the supervision of a departmental professor.

**Notes**

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 Studies**

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 497 - Graduate Research Project Methods**

This course is designed to provide the student with an understanding of the research process and department research expectations for the Graduate Research Project (GRP). 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**

Fall

## **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**

Summer

## **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, Spring

## **OPER 501 - Lab**

This is a lab added to OPER 501-01 Quantitative Decision Making.

Credit Hours 0

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall

## **OPER 501 - Quantitative Decision Making**

This is an introductory course in management science applications for the logistics, systems, acquisition and transportation manager. Emphasis is on understanding and applying the techniques to managerial problem solving and decision making. Major topics include linear programming, decision theory, networks, and queuing theory.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered**

Fall; Summer-Ft. Dix Only

## **OPER 503 - Deterministic Modeling**

This course applies the basic theories of optimization to develop standard approaches to deterministic modeling. This course is designed to expose students to deterministic modeling in operational analysis. Topics include fundamentals of linear programming, network-flow problems, and integer programming. The emphasis of this course is on model formulation and model building.

Credit Hours 3

**Prerequisites/Corequisites**

None

**Terms Offered**

Summer

## **OPER 504 - Probabilistic Modeling**

This course introduces probabilistic models prevalent in the operational sciences. The tools employed include conditioning, elementary counting processes, and Markov chains. These tools shall be applied to analyze queuing, inventory, and reliability models.

Credit Hours 3

**Prerequisites/Corequisites**

STAT 583, OPER 503 or Approval of Instructor

**Terms Offered**

Fall

## **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 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 expectation, 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 543 - Decision Analysis**

This course is decision analysis theory and methodology. Decision analysis applies to hard problems involving sequential decisions, major uncertainties, significant outcomes, and complex values. The course includes: decision structuring with influence diagrams and decision trees; modeling uncertainty with subjective probabilities; sensitivity analysis and the value of information; and modeling preferences with utility functions. Decision analysis applications for USAF and DoD problems are considered.

Credit Hours 3

### **Prerequisites/Corequisites**

STAT 583, STAT 587, or Approval of Instructor

### **Terms Offered**

Fall, Winter

## **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 and applications are oriented toward operational systems within the DoD.

Credit Hours 4

### **Prerequisites/Corequisites**

STAT 583, STAT 587, or Approval of Instructor

### **Terms Offered**

Winter

## **OPER 561 - Lab**

Lab to be taken in conjunction with OPER-561

Credit Hours 0

### **Prerequisites/Corequisites**

OPER 561

### **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.

### **Notes**

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**

All

## **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**

MATN 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 Lagrangean 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 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 610 or Approval of Instructor

### **Terms Offered**

Summer

## **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 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**

Cross listed with MATH 633 or Approval of Instructor

### **Terms Offered:** Spring

## **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**

Summer

## **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 510 or Approval of Instructor

### **Terms Offered**

Summer

## **OPER 628 - Analysis of Algorithms with O.R. Applications**

This course is an introduction to the analysis of the computational complexity of algorithms. It will cover basic counting techniques,  $O(*)$  notation, and NP-Completeness. General algorithms will be studied in the areas of sorting and graph theory. Classic approaches to such problems as the traveling salesman problem and scheduling will also be covered.

Credit Hours 3

### **Prerequisites/Corequisites**

OPER 610 or Approval of Instructor

### **Terms Offered**

As needed

## **OPER 632 - Cost Analysis for Systems Design**

This course covers the principles of engineering economy, the development of cost estimating relationships, and the employment of the life cycle concept. Attention is paid to the measurement of tangible and intangible benefits. The goal of the course is to provide a complete treatment of cost analysis, originating with the identification of a need and ending with phase-out and disposal.

Credit Hours 3

### **Prerequisites/Corequisites**

STAT 699 or Approval of Instructor

### **Terms Offered**

As needed

## **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 Making**

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. Realworld 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 imbedded 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 or Approval of Instructor

### **Terms Offered**

Spring

## **OPER 662 - Advanced Topics in Simulation**

This is an advanced course focusing on several topics related to simulation. Areas of coverage include, but are not limited to input modeling, verification, and validation, distributed simulation, and simulation optimization.

### **Notes**

The course requires students to review the literature pertinent to these areas. Students will be given the opportunity to present selected papers from this literature search in the form of lectures. Guidance will be provided in terms of possible areas of topic concentration.

Credit Hours 3

### **Prerequisites/Corequisites**

OPER 561 or Approval of Instructor

### **Terms Offered**

As needed

## **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:** Fall

## **OPER 674 - Joint Mobility Modeling**

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.

Credit Hours 3

### **Prerequisites/Corequisites**

U.S. Military Only

**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.

Credit Hours 3

### **Prerequisites/Corequisites**

U.S. Military Only

**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 STAST 587, or Approval of Instructor

### **Terms Offered**

Fall; Spring-Distance Learning Only

## **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**

As needed

## **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

## **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, discriminant 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:** Spring

## **OPER 699 - Master's Level Special Studies**

Special topics of study for master students in Operations Research under the direction of a member of the Operations Research faculty. Future Topic: Stochastic Optimization (Winter). Past Topics: Social Network and Analysis Modeling; Independent Component Analysis.

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:** Summer

## **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:** Spring

## **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:** Fall

## **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.

### **Notes**

The course is intended for doctoral or advanced M.S. students in Operations Research, mathematics, or related disciplines.

Credit Hours 3

### **Prerequisites/Corequisites**

OPER 641, 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 646, OPER 643, OPER 645, or Approval of Instructor

**Terms Offered:** Fall

## **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 660

**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 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.

Credit Hours 1-6

### **Prerequisites/Corequisites**

None

### **Terms Offered**

All

## **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 501 - ORSC Research Colloquium**

The purpose of this course is to discuss potential topics of interest to management students for their graduate research project and help students get started in forming their ideas and groups, if necessary, to accomplish the GRP. This may be done through the use of guest speakers and AFIT faculty. In addition, students can present their own ideas for critique by the members of the class and the instructor.

Credit Hours 0

### **Prerequisites/Corequisites**

None

**Terms Offered:** All

## **ORSC 523 - Law for Senior Managers**

This course provides an overview of the current legal environment with specific emphasis on the knowledge needs of the Air Force Officer or engineer. Topics include: the legal system, torts, contracts, uniform commercial code, employment and labor relations, alternative dispute resolution, liability risk management, property law, privacy, freedom of information, environmental law, international law, and current topics to include privatization and construction.

Credit Hours 4

**Prerequisites/Corequisites:** None

**Terms Offered:** Summer

## **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

## **ORSC 572 - Organizational Behavior**

This course will provide students with an opportunity to study and articulate how fundamental management concepts at the macro and micro levels apply to daily experiences as members of the military. Example topics include scientific management, human relations, individual behaviors, attitudes and differences, as well as organizational level concepts such as effectiveness, structure environment technology, and culture of organizations. The underlying theme of this course is that management is a process which involves coordinating the efforts of people and designing and finding the most effective fit between key organizations variables to accomplish the organization's goals. To be successful, managers must understand how people behave in an organizational setting and what factors affect the functioning of organizations. Although the course will emphasize organizational science theories, a common goal throughout the course will be the applicability of these concepts to management within military organizations.

Credit Hours 4

### **Prerequisites/Corequisites**

Admission to in-residence AFIT IDE program

### **Terms Offered**

Fall

## **ORSC 593 - Professional Military Ethics**

This course will provide situational analyses of current Air Force and military ethical dilemmas as a means of exploring the fundamental ethical issues they reveal. The course begins with a review of the fundamental aspects of ethics, including core aspects of individual and group value systems and an overview of the main ethical theories, especially those of Kant and Bentham. The primary course goal is to reinforce student understanding of the ethical aspects of situations they will encounter in their military and professional careers and to enable them to make the best ethical decisions possible.

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Spring, Summer

## **ORSC 638 - Seminar in Contemporary Leadership Theory and Application**

This course has the dual goals of providing in-depth instruction on approaches to leadership theory and facilitating the students' growth and development as leaders, particularly in the military environment. We will examine each of the major leadership theories as well as related areas such as the process of influence, bases of power, determinants of leader behavior, and leader facilitation of group problem solving. Leadership theories will be described, evaluated, and discussed in class; also, we will focus attention on military leadership articles through student led discussions.

Credit Hours 3

### **Prerequisites/Corequisites**

ORSC 542

### **Terms Offered**

Spring

## **ORSC 647 - Organizational Policy and Strategic Management**

This course serves as a basis for the understanding and use of the strategic process within organizations. Students are introduced to the history and current theory dealing with the development of strategies and policies which serve to help achieve organizational goals. Major sub-elements of the strategy process are detailed. In addition to theoretical work, students learn practical methods for implementing and maintaining a viable strategic process within Air Force and DoD organizations. Practical experience is gained through application of theory to specific cases of business problems encountered by actual firms. Through a simulation that resembles a real-world global market over a 5-year time period. This gives students hands-on experience in crafting business strategy, reasoning carefully about strategic options, using what-if analysis to evaluate action alternatives, and making strategic decisions.

Credit Hours 4

### **Prerequisites/Corequisites**

ORSC 542 or Permission of Instructor

### **Terms Offered**

Summer

## **ORSC 652 - Personnel Management**

This course provides an overview of topics important to the field of personnel management. Major emphasis is given to timely personnel theory and research, military and civil service personnel policy, and legislative and judicial decisions molding the field today. Subject areas in the course include job analysis, performance appraisal, wage and salary administration, training and development, benefits and services, personnel recruitment and selection, and equal opportunity issues.

Credit Hours 3

### **Prerequisites/Corequisites**

ORSC 542

### **Terms Offered**

Winter

## **ORSC 661 - Making Sense of Behavioral Research Data**

This course is designed to provide students with an opportunity to integrate and augment technical research skills learned in other courses. Furthermore, students are afforded an opportunity to practice designing research instruments, collecting data, and performing computer assisted statistical analyses in a laboratory environment prior to undertaking their own thesis research. Technical skills in research design, measurement theory, and statistical analyses are emphasized.

Credit Hours 4

### **Prerequisites/Corequisites**

STAT 525, RSCH 630 or permission of instructor

### **Terms Offered**

As needed

## **ORSC 672 - Management of Human Resources**

This course provides an overview of topics important to the field of human resource management in organizations. Major emphasis is given to timely personnel theory and research, military and civil service personnel policy, and legislative and judicial decisions molding the field today, especially as they apply to individuals who may occupy staff and command positions in the future. Subject areas in the course include job analysis, performance appraisal, wage and salary administration, training and development, benefits and services, personnel recruitment and selection, and equal employment opportunity issues.

### **Notes**

The course is intended for students with several years of experience, typically in the rank of major or above.

Credit Hours 4

### **Prerequisites/Corequisites**

ORSC 572 or Permission of Instructor

### **Terms Offered**

Winter

## **ORSC 675 - Corporate Strategy and Public Policy Analysis**

This course serves as a basis for the understanding and use of the strategic process within public, governmental, and private organizations. Students are introduced to the history and current theory dealing with the development, execution, and evaluation of strategies and policies to help achieve organizational goals. As part of the strategy process, students are introduced to the concepts of industry and competitor analysis, core competencies, and competitive advantage. In addition to theoretical work, students learn practical methods for implementing and maintaining a variable strategic process within Air Force and DoD organizations. Practical experience is gained through application of theory to specific cases of business problems encountered by actual firms and government organizations. While this course draws heavily on the core concepts and frameworks from strategic management and organizational behavior, we will also deal explicitly with the ways in which ideas based on the study of business organizations need to be adapted to deal with the unique aspects of the DoD/ government sector; thus, a blend of traditional private sector strategic management concepts as well as public policy concepts and applications are addressed in this course.

Credit Hours 4

### **Prerequisites/Corequisites**

Admission to in-residence AFIT IDE program

### **Terms Offered**

Summer

## **ORSC 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

## **ORSC 775 - Strategic Leadership**

This course has the dual goals of providing in-depth instruction on approaches to leadership theory and facilitating the student's growth and development as leaders, particularly in the military environment. We will examine each of the major leadership theories as well as related areas such as the process of influence, bases of power, determinants of leader behavior, and leader facilitation of group problem solving. Leadership theories will be described, evaluated, and discussed in class. We will also focus attention on military leadership articles through student led discussions. Emphasis will be placed on leadership application in command positions. Case studies or hands on projects may be used to allow students to apply their own leadership style to various situations.

Credit Hours 4

### **Prerequisites/Corequisites**

ORSC 572, ORSC 672, ORSC 675, and admission to in-residence AFIT IDE program

**Terms Offered:** Spring

## **ORSC 798 - Graduate Research Project**

A research topic is selected from either management problems of interest to the USAF or DoD, or topics of interest to ENV faculty, to be investigated by students either individually or in groups of up to four. The research is conducted under the supervision of an AFIT faculty member. Expected output is a research paper that can be presented to the project sponsor (if applicable) or a faculty committee for approval. Students should have topics, groups, and prospectus and faculty advisors by the end of the fall term.

### **Notes**

The prospectus is a 1-page outline of the research written for advisor approval.

Credit Hours 3

### **Prerequisites/Corequisites**

Admission to in-residence AFIT IDE program

**Terms Offered:** Spring

## **ORSC 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

## **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, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena.

Credit Hours 4

**Prerequisites/Corequisites:** none

**Terms Offered:** Fall

## **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 phenomenological; 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**

PHYS 519

**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. Poynting's theorem and the flow of power are covered. Waveguides and simple radiating systems are introduced.

Credit Hours 4

**Prerequisites/Corequisites**

MATH 504

**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 - Intro to Quantum Physics**

Basic mathematical and conceptual principles of quantum physics. Includes black body radiation, photo-electric 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, 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 under-standing 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 fourth quarter, is designed primarily to provide students in the applied physics and electro-optics programs 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**

Summer

## **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, 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

**Terms Offered:** Winter

## **PHYS 635 - Thermal Physics**

Treats statistical mechanics and thermodynamics. Topics include statistical methods, statistical thermodynamics with applications, ensemble theory, Maxwell-boltzman, Fermi-Dirac and Bose- Einstein statistics with applications.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 556

**Terms Offered:** Winter

## **PHYS 640 - Optics**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 531

**Terms Offered:** Fall

## **PHYS 650 - Kinetic Theory of Plasmas**

Study of the basic concepts and definitions of plasma physics and the parameters which characterize plasma behavior. Applications of the Boltzmann equation and kinetic theory to such basic plasma phenomena as Debye shielding, plasma waves, magnetic confinement, and ionospheric physics.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 531

**Terms Offered:** Spring

## **PHYS 655 - Quantum Mechanics I**

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, tunnel effect is presented.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 556

### **Terms Offered**

Fall

## **PHYS 661 - Atomic and Molecular Spectroscopy**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 655

### **Terms Offered**

Winter

## **PHYS 665 - Nuclear Physics**

Topics include static properties of nuclei including electric quadrupole and magnetic dipole moments, nuclear forces, quantum mechanical formulation of nuclear scattering and cross sections, nuclear shell model, the collective model, gamma decay and transition probabilities.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 651

### **Terms Offered**

As Needed

## **PHYS 670 - Intro to Solid State Physics**

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.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 635 and PHYS 655

### **Terms Offered**

Spring

## **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

## **PHYS 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

## **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 macro-scopic systems based on micro-scopic 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**

Winter

## 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

## PHYS 751 - Plasma Dynamics

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 which illustrate the fluid equations and wave phenomena. Plasma oscillations, dispersion relations, Landau damping, velocity space instabilities, will be included in a study of plasma confinement and gas discharges.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 650

**Terms Offered:** As needed

## PHYS 755 - Quantum Mechanics II

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.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 655

**Terms Offered:** Fall

## PHYS 756 - Quantum Mechanics III

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.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 755

**Terms Offered**

As needed

## **PHYS 770 - Solid State Physics I**

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.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 670 AND PHYS 755

**Terms Offered:** As needed

## **PHYS 771 - Solid State Physics II**

Second course in a sequence of courses covering solid state physics at an advanced level. Topics include lattice dynamics, phonons, an harmonic effects, dielectric properties, semiconductor properties, defects, magnetism, and superconductivity.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 770

**Terms Offered:** As needed

## **PHYS 772 - Solid State Physics III (Advanced Topics in SSP)**

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, radioactive and non-radioactive transitions, emissions, and absorptions in semiconductors, processes and p-n junctions, and photovoltaic effects on semiconductors.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 771

**Terms Offered:** As needed

## **PHYS 775 - Ionospheric Physics and Chemistry**

Formation and chemical properties of the ionosphere. Topics include ionization mechanisms, conductivity, energy loss mechanisms, electromagnetic wave propagation.

**Notes**

REMARKS: The Applied Physics Program is being expanded to include specialization in the space environment to serve Air Force needs in the area of Space Environment Support. This specialization is specifically directed at officers in the meteorology education code 8FDY. This new course supports this specialization.

Credit Hours 4

**Prerequisites/Corequisites**

CHEM 675, PHYS 635 and 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, aurora phenomena.

### **Notes**

REMARKS: The Applied Physics Program is being expanded to include specialization in the space environment to serve Air Force needs in the area of Space Environment Support. This specialization is specifically directed at officers in the meteorology education code 8FDY. This new course supports this specialization.

Credit Hours 4

**Prerequisites/Corequisites:** PHYS 531 and PHYS 650

**Terms Offered:** Summer

## **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 and 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.

Credit Hours 4

**Prerequisites/Corequisites**

PHYS 661 and OENG 620

**Terms Offered:** As needed

## **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 semi classical theory of nonlinear susceptibility is also included. These topics are followed by 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, and PHYS 755

### **Terms Offered**

As needed

## **PHYS 790 - Engineering Physics Design**

Treats the principles involved in the design of systems in the areas of optics, solid state physics, plasma physics and others. The student will participate in an engineering design study in one of these areas. Classified papers may be included.

Credit Hours 4

### **Prerequisites/Corequisites**

Permission of Instructor

### **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; developing a solar-event forecasting expert system.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 775 and PHYS 776

### **Terms Offered**

Winter

## **PHYS 792 - Lab**

Lab to be taken in conjunction with PHYS-792

Credit Hours 0

## **PHYS 792 - Space Weather Lab**

This laboratory course introduces the student to the space weather computer codes used to provide operational space weather support to 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 effects the accuracy of operational technologies such as the GPS receiver.

Credit Hours 4

### **Prerequisites/Corequisites**

CHEM 675, PHYS 650

### **Terms Offered**

Winter

## **PHYS 793 - Intermediate Developmental Education Research Project**

Individual or group research project pursuing specific problems of current Air Force interest.

### **Notes**

Enrollment is restricted to students enrolled in the 12-month intermediate development education program. Research activity extends over one or two quarters, with accumulated credit given at the end of the last quarter. An oral presentation and written report are required.

Credit Hours 1-9

### **Prerequisites/Corequisites**

Permission of Instructor

### **Terms Offered**

All

## **PHYS 798 - Departmental Seminar**

This seminar is offered once a week throughout the year 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 AF needs and programs in areas related to their studies and the structure and organization of the R&D community within the AF.

### **Notes**

This series is also used for faculty to present possible areas for student research and for students, particularly doctoral candidates, to present progress reports on their own dissertation research.

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 written under the supervision of a departmental professor.

### **Notes**

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 and 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 which underlie modern optical phenomena such as self-induced transparency, photon-echo, coherent pulse propagation, Lamb's theory of the laser and superradiance.

Credit Hours 4

### **Prerequisites/Corequisites**

PHYS 543, PHYS 755, PHYS 743

### **Terms Offered**

as required

## **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 porometry, materials applications, and 5) quantum computational methods to model positron chemistry.

Credit Hours 4

### **Prerequisites/Corequisites**

CHEM 780, CHEM 850, or PHYS 755, or Permission of the Instructor

## **PHYS 899 - Doctoral Level Special Studies**

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**

This course covers the concept of project risk with an emphasis on formal risk analysis methods. The course exposes students to a variety of approaches for evaluating risk and uncertainty as they apply to a dynamic decision-making environment. Topics include defining risk, DoD risk policy, risk identification, risk handling, qualitative and quantitative risk methods. Both analytical and simulation methods for quantifying cost risk will be discussed. In order to cover simulation methods, the general method of Monte Carlo simulation will be introduced. Methods of nominal ratings and scoring models will be introduced. The problem of integrating risk analyses into a total measure of risk will be discussed. Methods for documenting and presenting risk analysis will complete the course.

Credit Hours 3

**Prerequisites/Corequisites**

STAT 525

**Terms Offered:** Fall

## **RDMT 501 - R and D Curriculum and Research Options**

This seminar guides the students in selecting a focus sequence and a thesis advisor as part of the R&D 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

## **RDMT 502 - R and D 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

## **RDMT 503 - R and D Critical Review of Literature and Data Sources**

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

## **RDMT 504 - R and D Research Colloquium I**

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.

### **Notes**

For large classes, the seminar is scheduled over two academic quarters and is designated as RDMT 505 in the second quarter.

Credit Hours 0

**Prerequisites/Corequisites**

None

**Terms Offered:** Summer

## **RDMT 505 - R and D Research Colloquium II**

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 current status of the work in a concise manner. Each student will receive critical feedback from both 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.

### **Notes**

For large classes, this seminar is scheduled over 2 academic quarters and is designated as RDMT 504 in the first quarter and RDMT 505 in the second quarter.

Credit Hours 0

### **Prerequisites/Corequisites**

None

**Terms Offered:** 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.

### **Notes**

Some lectures will be held at the secret level.

Credit Hours 3

### **Prerequisites/Corequisites**

None

**Terms Offered:** Fall

## **RDMT 642 - Systems Development I-Concept Development**

This course focuses on the concept development and assessment stage of product development. Students will identify a range of potential concepts and undertake a systematic analysis of the potential concepts for defense and commercial application. Students will be instructed in many project identification and assessment tools and methods. These include opportunity identification, technology assessment and market analysis, project scoping and systems architecting, cost and schedule estimation techniques, and financial estimation and return on investment calculations. Students will apply these to their range of potential projects. Students will develop project proposals based on their findings and will apply project portfolio management practices as they select and narrow the range of potential projects.

Credit Hours 4

### **Prerequisites/Corequisites**

RDMT 541, SMT 543

**Terms Offered:** Winter

## **RDMT 643 - Systems Development II - Systems Design and Implementation**

This course focuses on the design and implementation phase of product development process. The class will take a project (or projects) identified through concept development and carry it through initial system design and development. This includes necessary system architecting and engineering, cost and schedule estimates, project planning, and acquisition and marketing strategy development. Depending on the system identified, students will conduct system design process leading to the development of a rapid prototype or demonstrate key concepts and technologies critical to the further development of the system. Students will refine a product concept and complete a formal project proposal complete with conops, requirements and market analysis, cost and schedule estimates, development and acquisition strategy, logistics and support concept, funding requirements, and proposed organizational structure. Students will work closely with AF users, program offices, MAJCOMS, and industry in the development of the project proposal to ensure applicability to the Air Force and enhance its potential implementation.

Credit Hours 4

### **Prerequisites/Corequisites**

RDMT 541, SMSGT 543, RDMT 642

### **Terms Offered**

Spring

## **RDMT 654 - Seminar in Research and Development Management**

This graduate level seminar will provide the opportunity for faculty, invited guests, and students to present issues of current interest to others in the research and development management area. The intention is to integrate the 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.

### **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**

This is an overview course on the principles and fundamentals of Human Factors and ergonomics. The objectives are to gain an understanding of how humans process sensory stimuli, how to design displays and systems to best match these capabilities and limitations, and how operators in military environments perform their tasks with various displays.

Credit Hours 4

**Prerequisites/Corequisites**

Prerequisites: None

**Terms Offered:** Fall

## **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**

Prerequisites: None

**Terms Offered:** Winter

## **SENG 610 - Systems Engineering Process and Management**

Designator change from SENG 510 to SENG 610. This is a graduate course primarily intended for the Master of Science program in Systems Engineering. It will provide an overview of the Systems Engineering process and selected topics from Systems Engineering Management. Topics include a model based-approach to key systems engineering design activities, process modeling, requirements analysis and functional allocation, trade-off analysis, and management of cost, schedule and risk. As part of the Systems Engineering core, it is complemented by SENG 520, Systems Engineering Design, SENG 540, Systems Architecture, and CSCE 593, Introduction to Software Engineering.

Credit Hours 4

**Prerequisites/Corequisites**

Prerequisites: SENG 520

**Terms Offered:** Winter, Spring

## **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**

Prerequisites: 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**

Prerequisites: SENG 520

### **Terms Offered**

Summer

## **SENG 640 - Systems Architecture**

This course provides the foundations for developing and evaluating architectures for systems of systems. The process for generating a functional, physical and operational architecture from a top level operations concept will be developed.

### **Notes**

Both structured

Credit Hours 4

### **Prerequisites/Corequisites**

Prerequisites: SENG 520, CSCE 593 or Permission of Instructor

### **Terms Offered**

Fall, Winter

## **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**

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**

Prerequisites: 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

## **SMGT 543 - Systems Acquisition Management**

This course provides the student with an understanding of the underlying concepts, fundamentals, and philosophies of the defense systems acquisition process and the practical application of program management methods within this process. It is designed to acquaint the student with the business, technical, and managerial aspects of managing a system acquisition program. The course examines management issues, control policies and techniques, and functional area concerns. Key topics include the system acquisition life cycle, acquisition management disciplines and activities, and the evolution and current state of systems acquisition management. Case studies are used to analyze various acquisition issues.

Credit Hours 3

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Fall

## **SMGT 546 - Project Management**

This course provides conceptual material on project management techniques appropriate in systems/subsystems management. The course introduces students to all areas of project management, from initiation to closing. Topics include project management functions; project management roles and responsibilities; effective teams; the project life cycle; conflict resolution; project planning, budgeting, scheduling, and control techniques; and cost estimating. Students get hands-on practice using the project management tool Microsoft Project. The goal of this course is to provide the student with the background knowledge and basic tools to handle a project or contribute effectively as a project team member.

Credit Hours 3

**Prerequisites/Corequisites:** None

**Terms Offered:** Spring

## **SMGT 647 - Acquisition Strategy**

The success of a defense acquisition program is frequently contingent on the development and execution of a viable acquisition strategy. This course addresses the policies governing the formulation and execution of acquisition strategies. Particular emphasis is placed on the evaluation of alternative strategies based on the advantages, disadvantages, and risks associated with each. Specifically, this course addresses alternative strategies associated with technology insertion, competition, contracting, supportability, production, and environmental protection.

### **Notes**

All students will participate in the development of a comprehensive acquisition strategy through an in-depth case study which is based on an actual acquisition program. Ultimately, this course prepares students to evaluate, formulate, and implement acquisition strategies for defense acquisition programs.

Credit Hours 3

**Prerequisites/Corequisites**

SMGT 543

**Terms Offered:** Summer

## **SMGT 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

## **STAT 521 - Applied Statistical Data Analysis**

This course provides statistical tools for the analysis of data in the decision-making process. Topics covered are 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.

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 credit hours

### **Prerequisites/Corequisites**

none

### **Terms Offered**

Summer

## **STAT 525 - Applied Statistics for Managers I**

Major subject areas in this first course in statistics include descriptive statistics, probability theory and statistical inference. This course has been tailored to provide the future military logistician with these essential tools in a framework to which he/she can relate.

Credit Hours 4

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Summer, Fall

## **STAT 525 - Lab**

Two-hour computer laboratory portion of STAT 525 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Summer, Fall

## **STAT 526 - Applied Statistics I**

This is the first course in the fundamentals of managerial statistics. The probability theory necessary to provide a foundation for statistics is developed. Topics include Bayes theorem, discrete and continuous random variables, cumulative distribution functions, joint probability distributions, expectation and functions of random variables, measures of central tendency and variation, sampling and sampling distributions, the Central Limit Theorem, and point/interval estimation.

Credit Hours 4

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Summer

## **STAT 526 - Lab**

Two-hour computer laboratory portion of STAT 526 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0

### **Prerequisites/Corequisites**

None

### **Terms Offered**

Summer

## **STAT 527 - Introduction to Probability**

This course presents the basic concepts of probability. Emphasized topics are basic probability, discrete and continuous random variables, joint probability distributions and expectations.

Credit Hours 4

### **Prerequisites/Corequisites**

None

### **Terms Offered**

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 536 - Applied Statistics II**

This is a second course in statistics stressing the point of view that statistics provides the tools for making decisions under conditions of uncertainty. Emphasis is on the processes by which the data are used to make decisions about the population of which the data are a part. Subjects include tests of hypotheses, regression, linear hypotheses, and analysis of variance.

Credit Hours 4

**Prerequisites/Corequisites**

STAT 526

**Terms Offered**

Fall

## **STAT 536 - Lab**

Two-hour computer laboratory portion of STAT 536 in which applications of statistical theory learned in the lecture are considered.

Credit Hours 0

**Prerequisites/Corequisites**

STAT 526

**Terms Offered**

Fall

## **STAT 537 - Introduction to Statistics**

This course presents the basic concepts of statistics. Emphasized topics are sampling theory, estimation, hypothesis testing, regression, and nonparametric statistics.

Credit Hours 4

**Prerequisites/Corequisites**

Prerequisites: STAT 527

**Terms Offered**

Winter

## **STAT 583 - Introduction to Probability and Statistics**

Basic concepts of probability and statistics with computer science 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**

Credit Hours 5

**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 and expectations, the central limit theorem, sampling theory, estimation, and hypothesis testing.

Credit Hours 5

**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**

STAT 527 AND MATH 600

**Terms Offered**

Winter

## **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 537 AND STAT 601

### **Terms Offered**

Spring

## **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 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/or 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 537 or STAT 602

### **Terms Offered**

Winter, Spring

## **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 537 OR STAT 602

**Terms Offered**

Winter, Spring

## **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 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 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 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

**LIEUTENANT COLONEL ARIEL O. ACEBAL**

Assistant Professor of Atmospheric Physics, Department of Engineering Physics, BS, MS, PhD (Utah State University)

**MAJOR GEOFFREY A. AKERS**

Instructor of Electrical Engineering Department of Electrical and Computer Engineering BSEE, MSEE, PhD (University of Kansas, In-Progress)

**MAJOR TODD R. ANDEL**

Assistant Professor of Electrical Engineering Department of Electrical and Computer Engineering BS, MS, PhD (Florida State University)

**LIEUTENANT COLONEL BRADLEY E. ANDERSON**

Assistant Professor of Logistics Management, Department of Operational Sciences, BS, MS, MBA, PhD (Indiana University - Bloomington)

**COLONEL HAROLD J. ARATA III**

Senior Military Professor Department of Electrical and Computer Engineering BS, MS, MS, MSCS, PhD (University of Tulsa)

**BRADLEY J. AYRES, NRO**

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**ADEDEJI B. BADIRU**

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**WILLIAM F. BAILEY**

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