



Graduate School
of
Engineering and Management
Catalog
2015 - 2017



Chancellor's Message



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

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

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

For 96 years – since 1919, AFIT has educated the air, space and cyberspace Airmen who have led the Air Force. Among our distinguished alumni are numerous Air Force pioneers, including Generals Kenney, Doolittle, Fairchild, Bradley, Chidlaw, and Schriever and former Secretary of the Air Force Wynne. Nearly 20 astronauts, including Aldrin, Borman, Grissom, White and McDivott, are AFIT graduates. It is very likely that some students starting their academic program this fall could join these ranks of distinguished alumni.

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

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

TODD I. STEWART, PhD, Major General (Ret.), USAF
Director and Chancellor

AFIT Leadership

Todd I. Stewart, PhD, Major General (Ret.), USAF
Director and Chancellor

Sivaguru S. Sritharan, PhD
Provost

Colonel Doral E. Sandlin, PhD
Commandant

Adedeji B. Badiru, PhD
Dean, Graduate School of Engineering and Management

Colonel Mark B. Skouson, PhD
Associate Dean, Graduate School of Engineering and Management

Colonel Michael "Larkin" Hastriter, PhD
Dean of Students

Heidi R. Ries, PhD
Dean for Research

Paul J. Wolf, PhD
Associate Dean for Academic Affairs

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, with distribution unlimited.

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Mission

Education and Research

The mission of the AFIT Graduate School of Engineering and Management is to produce outstanding technical leaders in the Department of Defense by providing superior graduate education built on defense-focused research. The vision of the AFIT Graduate School of Engineering and Management is to be internationally recognized as the school of choice in engineering and applied science for defense-focused and research-based graduate 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. The Graduate School and AFIT are recognized as a doctoral/research institution by the Carnegie Foundation for the Advancement of Teaching, the only DoD academic institution with such a designation.

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 also offers graduate certificate programs.

The Graduate School is responsible for:

- All academic and admission policies as developed and approved by the Faculty Council
- Delivering high quality, research-based, academic programs
- Maintaining the appropriate standards for graduate-level programs

Administration

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

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 Engineering and 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.

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 almost 20,000 Master's degrees and 550 doctorates. The Graduate School not only enhances the intellectual growth of its students by offering a broad range of high-quality graduate programs but also prepares them for successful careers in those areas. To that end, research at AFIT is an essential ingredient of academic life because it creates the inquisitive and creative background characteristic of graduate-level teaching and learning.

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

- Strategic alliance with the Air Force Research Laboratory clears the path for streamlined access and resource sharing between AFIT and AFRL 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 (DAGSI)--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 \$one million in state funds each year to encourage collaborative research in support of the Air Force Research Laboratory at Wright-Patterson Air Force Base.

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

- The Dayton Opera
- The Dayton Philharmonic Orchestra
- The Victoria Theatre
- The Schuster Performing Arts Center
- The Dayton Ballet
- The Dayton Contemporary Dance Theatre

Museums and Recreation:

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

Community activities:

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

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

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

History

On 10 November 1919, Colonel Thurman Bane received authorization to begin instruction at the Air School of Application. The following year, the first class of nine students graduated from the newly named Air Services Engineering School. Now, more than 95 years later, the Air Force Institute of Technology has awarded almost 20,000 degrees and more than 400,000 people have gone through our continuing education courses!

What started as a school for select officers has grown into a premier educational institution for both officer and enlisted students, international students, Department of Defense civilians, and members of all branches of the armed services. However, some things never change. We continue to stress excellence in education and research to move AFIT through the twenty-first century, retaining its flexibility and resourcefulness in accomplishing its mission; just as it has done since its inception..

For more information on the history of AFIT please visit <http://www.afit.edu/ABOUT/page.cfm?page=715>

Changing names for a growing Institute

1919-1920: Air School of Application
1920-1926: Air Service Engineering School
1926-1941: Air Corps Engineering School
1944-1945: Army Air Forces Engineering School
1945-1947: Army Air Forces Institute of Technology
1947-1948: Air Force Institute of Technology
1948-1955: United States Air Force Institute of Technology
1955-1956: Institute of Technology, USAF
1956-1959: Air Force Institute of Technology
1959-1962: Institute of Technology
1962-Present: Air Force Institute of Technology

Accreditation/Memberships

The Air Force Institute of Technology is regionally accredited by The Higher Learning Commission (HLC).

The HLC can be contacted at:

The Higher Learning Commission
230 South LaSalle Street, Suite 7-500
Chicago, Illinois 60604-1413
Phone: (800) 621-7440
www.hlcommission.org

In addition to institutional accreditation, the Engineering Accreditation Commission of ABET accredits the following Master's degree programs in the Graduate School of Engineering and Management: Aeronautical Engineering, Astronautical Engineering, Computer Engineering, Electrical Engineering, Engineering Management, Environmental Engineering and Science, Nuclear Engineering, and Systems Engineering. The Applied Science Accreditation Commission of ABET accredits the Industrial Hygiene program.

ABET can be contacted at:

ABET, Inc.
111 Market Pl, Suite 1050
Baltimore, MD 21202
Phone: (410) 347-7700
www.abet.org

AFIT holds general membership in the Council of Graduate Schools (CGS), the Midwestern Association of Graduate Schools (MAGS), and the American Society for Engineering Education (ASEE)

Air University Board of Visitors AFIT Sub-Committee

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

Maj Gen Ronald "Ron" Sega, USAF, Retired

Woodward Professor of Systems Engineering and Vice President for Energy, Environment and Applied Research, Colorado State University

Members:

VADM Ronald A. Route, USN, Retired

President, Naval Postgraduate School

Lt Gen Mark Shackelford, USAF, Retired

Col Rayford Vaughn, USA, Retired

Vice President for Research, University of Alabama

Dr. Stephen E Cross

Executive Vice President for Research, Georgia Institute of Technology

Academic Programs and Degrees Offered

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

Of the degree programs listed below, the ABET-accredited Master's degree programs are identified with an asterisk.

Program	Degree	Department
Aeronautical Engineering*	M.S., PhD.	Aeronautical and Astronautical Engineering
Applied Mathematics	M.S., PhD.	Mathematics and Statistics
Applied Physics	M.S., PhD.	Engineering Physics
Applied Systems Engineering	M.E.	Systems Engineering and Management
Astronautical Engineering*	M.S., PhD.	Aeronautical and Astronautical Engineering
Combating Weapons of Mass Destruction	M.S.	Engineering Physics
Computer Engineering*	M.S., PhD.	Electrical and Computer Engineering
Computer Science	M.S., PhD.	Electrical and Computer Engineering
Cost Analysis	M.S.	Systems Engineering and Management
Cyber Operations@	M.S.	Electrical and Computer Engineering
Electrical Engineering*	M.S., PhD.	Electrical and Computer Engineering
Engineering Management*	M.S.	Systems Engineering and Management
Environmental Engineering and Science*	M.S.	Systems Engineering and Management
Industrial Hygiene*	M.S.	Systems Engineering and Management
Logistics	PhD.	Operational Sciences
Logistics (Air Mobility)	M.S.	Operational Sciences
Logistics and Supply Chain Management	M.S.	Operational Sciences
Materials Science	M.S., PhD.	Aeronautical and Astronautical Engineering; Engineering Physics
Nuclear Engineering*	M.S., PhD.	Engineering Physics
Operations Management	M.S.	Operational Sciences
Operations Research	M.S., PhD.	Operational Sciences
Optical Science and Engineering	M.S., PhD.	Engineering Physics
Space Systems#	M.S., PhD.	Aeronautical and Astronautical Engineering
Systems Engineering*	M.S., PhD.	Systems Engineering and Management

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

* ABET-accredited Master's degree programs.

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

Graduate Certificate Programs

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

Program	Department
Combating Weapons of Mass Destruction	Engineering Physics
Human Systems	Systems Engineering and Management
Information Assurance (4011, 4012, and 4016)	Electrical and Computer Engineering
Nuclear Weapons Effects, Policy, and Proliferation	Engineering Physics
Space Systems	Aeronautics and Astronautics
Supply Chain Management	Operational Sciences
Systems Engineering	Systems Engineering and Management
Test and Evaluation	Operational Sciences

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 (IDE)

The AFIT Graduate School offers the Advanced Studies of Air Mobility (ASAM) program under the auspices of Intermediate Development Education (IDE). Applicants interested in applying for this program should apply for an academic assessment at <http://www.afit.edu/ADMISSIONS/>. Selected officers will earn the Master of Science (MS) degree in Logistics (Air Mobility). This is a non-thesis Masters degree program, taught by the Department of Operational Sciences that begins in June each year.

Office of Extension Services

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)
FAX: (937) 656-2791 DSN 986-7720

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

Distance Learning programs are administered by AFIT's Office of Extension Services. For more information about these educational opportunities, you may:

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

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

DL Certificate
Programs (5)

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

Generally speaking, students must be unit-sponsored (i.e., unit-funded) to enroll in most AFIT DL Programs. Admission to the NWEPP program requires approval from the Director, NWEPP Program, Department of Engineering Physics. See our website for more details:
<http://www.afit.edu/ENP/>

DL Degree Programs (2 Systems)

Logistics MS Degree Program (GLM)
MS Degree Program (GSE)

Application and Enrollment Information

More information about these programs, including application and enrollment information, can be found at AFIT's Extension Services website: <http://www.afit.edu/DL/>.

PROGRAMS

Advanced Geospatial Intelligence Infrared/Synthetic Aperture Radar Certificate

Program Description

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

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

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

Program Educational Objectives (PEOs)

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

Program Outcomes (POs)

- Understand the science, phenomenology, and technology involved in IR, OPIR, MSI/HIS, and SAR
- Apply advanced concepts to applications in the areas of IR, OPIR, MSI/HIS, and SAR
- Perform analysis on data, working independently and in groups, with a focus on applications in specific intelligence areas of interest.
- Be able to contribute and communicate their results and understanding in the form of journal articles, research proposals, and conference presentations

Program Prerequisites

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

Special Admission Requirements

Attendees will be nominated to the AGI IR/SAR Certificate Program by the military services and Government agencies. This program is open only to citizens from the United States, United Kingdom, Australia, and Canada who are sponsored by their respective governments or by an organization supporting United States national security matters. Attendees must send the following materials four weeks before the start of a session:

- AGI IR/SAR Certificate Program Enrollment Form. This can be found at <http://www.afit.edu/en/cmsr/acpprograms.cfm>
- Official transcripts for all post-secondary education.
- Collateral SECRET United States Government security clearance. This should be forwarded to the Air Force Institute of Technology Security Office (AFIT/XPQ).

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

Aeronautical Engineering (M.S.)

Program Description

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

<http://www.afit.edu/ENY/>

Program Educational Objectives (PEOs)

- Our graduates will make direct contributions as practicing engineers in the area of aeronautical engineering
- Our graduates will effectively communicate, evaluate, monitor and administer aeronautical research and development programs
- Our graduates will solve new technological challenges to meet the needs of the Air Force and other DoD organizations

Student Outcomes (SOs)

- GAE graduates will demonstrate the ability to perform independent research, resulting in substantial contributions to the field of aeronautical engineering
- GAE graduates will demonstrate the ability to effectively communicate complex ideas and concepts both orally and in writing
- GAE graduates will be able to perform research that provides substantial and tangible value to the DoD

Program Elements

- Core Aeronautical Engineering
- Mathematics (2)
- Specialty Sequences (2)
- Independent Investigation (i.e., Thesis Research)
- Electives
- 48 graduate quarter hours, minimum

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

School and Program Admission Criteria

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

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

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

Specialty Sequences

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

Mathematic Courses

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

Core Aeronautical Engineering

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

Thesis

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

AERO 799 - Independent Study

An in-depth study of a research topic selected from 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

TENY 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENY 799 for 12 non-billable credit hours is required for all Master's students whose research advisors are in the Department of Aeronautics and Astronautics. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All

ABET Core

The Accreditation Board for Engineering Technology (ABET) specifies general program outcomes and professional components for Aeronautical Engineering; and the American Institute of Aeronautics and Astronautics (AIAA), acting as the lead society for ABET, specifies required course topics. The general ABET criteria are usually satisfied by any ABET-accredited undergraduate engineering program, while specific topics are usually only satisfied by an aeronautics or aerospace engineering undergraduate program. In order for students to graduate with an ABET-accredited degree, each student's transcript is examined to identify any deficiencies in the general and/or specific core aeronautical engineering areas. Those deficiencies can then be remedied by taking specific courses offered by the department.

Aeronautical Engineering (PhD.)

Program Description

Students are admitted to a study leading toward the PhD degree in Aeronautical Engineering with a concentration in one of the three major divisions of the Department of Aeronautics and Astronautics. A pro-tem advisor will be appointed by the Department to assist each full-time student in program planning. Additionally, each fully-funded officer student has an

educational code, the requirements of which are to be met within the appropriate division. See Department Brochure for additional details:

<http://www.afit.edu/ENY/>.

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

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

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

School and Program Admission Criteria

DEGREE REQUIRED: Requires Master's degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering.

GRE REQUIRED: 156V/151Q

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

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

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

Degree Requirements

Major

24 hours

Mathematics

12 hours

Dissertation Research

48 hours

Admission to candidacy

One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

Applied Mathematics (M.S.)

Program Description

The aim of this Master's degree program is to provide a balanced foundational education in mathematical and statistical analysis, an understanding of appropriate applications of the theory, and some depth in an area of specialization. The program, which requires a thesis, usually takes 18 months to complete and is designed for students who have completed an undergraduate major in mathematics or statistics. However, students from other disciplines who have a strong record in mathematics will usually find their preparation to be adequate. For those with weaker mathematics backgrounds, completing the program will normally take longer than 18 months.

The core courses common to all Applied Mathematics master of science degree options are STAT 601 (Theory of Probability), STAT 602 (Mathematical Statistics), MATH 601 (Complex Analysis), and either MATH 600 (Mathematical Analysis) or MATH 602 (Modern Applied Mathematics I). The student will specialize in analysis, statistics, or numerical analysis by taking three courses within the specialty area.

The department believes that the applied nature of the program is enhanced by interaction with at least one other department in the Graduate School of Engineering and Management. Therefore, an out-of-department sequence (minimum of eight hours) taken from another department is required, and serves to help the future applied mathematician gain an appreciation for communicating with other scientists and engineers. In addition, the thesis project is invariably linked to an Air Force or Defense Department organization, further enhancing the student's appreciation for and experience in working with the non-mathematician.

Program Educational Objectives (PEOs)

Graduates are well-prepared to use mathematical and statistical techniques to make significant progress toward solving problems of interest to the AF, DoD and DHS. They are equipped to collaborate with the science and technology community to address questions of national defense and security.

Program Outcomes (POs)

Graduates will be able to:

- Understand an applied problem well enough to give a mathematical formulation of it
- Analyze a new problem rigorously and propose credible solutions
- Communicate mathematical concepts effectively by written and oral means

School and Program Admission Criteria

DEGREE REQUIRED: Bachelor's in mathematics or statistics, or in science or engineering with a strong background in mathematics.

MATHEMATICS REQUIRED: A senior-level mathematical analysis course.

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

Core Courses

16 hours

Out-of-Department sequence

8 hours

Specialization

12 hours

Thesis

12 hours

Applied Mathematics (PhD.)

Program Description

The aim of the doctoral program is to provide comprehensive knowledge of existing theory and how it applies to problems in science and engineering along with the opportunity to extend the world's knowledge significantly beyond those bounds. A student seeking a Doctor of Philosophy degree should have a Master's degree in mathematics, statistics, science, or engineering. Being an applied program, particular emphasis is placed on educating students to recognize the relevance of analytical and numerical methods to the solution of specific problems and to enable them to develop new methods when they are needed. The education aims to produce an applied mathematician or applied statistician with the ability to develop new theoretical results and apply them as the need arises. Central to this goal is the research part of the program. Both the ability to conduct the research successfully and to report it in a coherent and fully documented dissertation is essential to the program. The program is kept sufficiently flexible, however, to permit students to develop their own specific interests.

Program Educational Objectives (PEOs)

Graduates are experts in their respective specialty area of mathematics and statistics and are able to develop new theory and solution methods for problems of interest to the AF, DoD, DOE, and DHS. They are equipped to lead joint research efforts with other scientists and engineers to address questions of national defense and security.

Program Outcomes (POs)

Graduates will be able to:

- Formulate mathematically an applied or theoretical problem
- Investigate mathematically a new problem and develop methods for solving it. Produce research results which are publishable in high-quality archival journals
- Communicate mathematical concepts and solutions effectively to diverse audiences in both oral and written presentations

School and Program Admissions Criteria

DEGREE REQUIRED: Master's in mathematics or statistics, or in science or engineering and a strong background in mathematics or statistics.

TEST REQUIRED: GRE -156V/151Q

GPA REQUIRED: 3.5 in Master's

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

Degree Requirements

Completion of at least 36 hours of coursework beyond the Master's degree to include:

Specialization

24 hours

Out-of-Department Requirements

8 hours

Dissertation Research

48 hours

Admission to candidacy

One year before graduation

In-residence study

Three (3) quarters of full-time study in residence during any contiguous four-quarter period

Present Dissertation at a Public Defense

Applied Physics (M.S.)

Program Description

The Applied Physics program is conducted by the Department of Engineering Physics and provides each student with a broad, graduate-level foundation in applied physics with a focus on one of three educational tracks: engineering physics, atmospheric and space sciences, or space physics. Core courses address the foundational aspects of physics (mechanics, quantum mechanics, statistical physics and electrodynamics), 8 credit hours in this area are required. Both analytic and discrete mathematics are important. There is a 4-credit hour requirement in this area. Curriculum content in the applications area requires 12 credit hours, designed to achieve an educational breadth (example: directed energy, solid state physics, and plasma physics). The research experience is the capstone of graduate education. All students are required to complete and defend a thesis (12 credit hours).

Laboratory techniques and computational methods are emphasized in all tracks, providing a balanced exposure to experimental and theoretical practices.

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

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

Concentration in the three tracks is as follows:

- **The engineering physics track:** A broad range of applied physics topics, including the areas of laser physics, infrared systems, remote sensing, 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.
- **Atmospheric and Space Sciences:** A study of the physical laws and atmospheric/space weather relationships in order to understand, analyze and predict the air and space environments. This knowledge is acquired by completing a comprehensive five course sequence in space sciences and a complementary six course sequence in the atmospheric sciences. This track bridges the knowledge gap between pure meteorologist and pure space weather physicists in order to gain a complete understanding of both the air and space environments and their effects on air and space systems
- **The space physics track** Encompasses the variations in the Earth's magnetosphere and ionosphere and the subsequent effects of the space environment on the propagation of electromagnetic waves, communications, space operations, and manned space flight. An understanding of solar effects on the near-earth environment and ramifications on military operation is achieved

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

Program Educational Objectives (PEOs)

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

- Direct or perform basic research; conduct and evaluate design and analysis; and communicate their work clearly, working independently and in groups, with a focus on applications of interest to the Commands for which they are assigned after graduation
- 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
- Apply their knowledge and skills to solve problems that arise in the technical work they conduct or supervise
- Study an issue, identify and evaluate alternative actions, propose appropriate courses of action, and identify optimal choices
- Develop and implement programs, working within their organizations, to implement the chosen solutions
- Write, edit, and/or supervise the preparation by contractors or subordinates of written reports, journal articles, military briefings, and professional presentations that clearly communicate their work and support the needs of decision makers; present their ideas effectively and defend them appropriately
- Develop and implement, or sustain and improve, programs that entail multidisciplinary research, simulation, modeling, engineering design, production, and/or fielding of engineered systems

Program Outcomes (POs)

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

- Apply advanced concepts in mathematics and physics, including analytic and computational methods, electrodynamics, quantum mechanics, and statistical physics, to applications in the areas of solid state physics, plasma physics, space physics, and laser/optics technology
- Perform research, design, and analysis, working independently and in groups, with a focus on applications of interest to the Commands for which they are assigned after graduation
- Understand and critically evaluate technical communications in the form of journal articles, research proposals, and conference presentations and contribute and communicate their results and understanding in these same forums

School and Program Admissions Criteria

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

Mathematics Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q

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, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

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

Applied Physics (PhD.)

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. The program is under the supervision of the Department of Engineering Physics with specializations available in lasers, optics and optical systems, optical processing, remote sensing and signature analysis, semiconductor physics and devices, photonics, plasma physics and processing, and chemical physics.

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

School and Program Admissions Criteria

Degree Required: A Master's degree in a physical science or engineering

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

Test Required: GRE - 156V/151Q

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

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

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

Degree Requirements

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

Applied Systems Engineering (M.E.)

Program Description

The Applied Graduate Systems Engineering (ASE) program is offered by the Graduate School of Engineering and Management, Department of Systems Engineering and Management. The ASE program confers a Master of Engineering (ME) in Applied Systems Engineering and is available to part-time distance learning (DL) students only. ASE is nominally a 36-month program, depending on class availability and student course load. Program requirements for ASE are essentially the same as the existing Graduate Systems Engineering (GSE) program with the key difference being the removal of the requirement for a research thesis. In lieu of a 12-credit thesis, ASE students must complete at least two engineering analysis toolset courses and one capstone project course. This program is not ABET-accredited.

For more information about DL SE programs, or about general DL opportunities and application procedures, please visit www.afit.edu/DL/.

Admission Criteria

The general requirements for admission to the ASE program are as follows:

- **Degree:** A degree in engineering (e.g., Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science is required, although a degree in science (e.g., physics), math, or computer science will be considered for admission as well.
- **Courses:** Calculus-based physics and dynamical systems (e.g., circuits or engineering dynamics) are required. In terms of mathematics, at least multivariate calculus and ordinary differential equations are required.
- **GRE:** Verbal ≥ 153 (500 if taken prior to August 2012); Quantitative ≥ 148 (600 if taken prior to 1 August 2012)
- **GPA:** Undergraduate GPA ≥ 3.0 (on a 4.0 scale) overall; ≥ 3.0 in mathematics (on a 4.0 scale); ≥ 3.0 in major (on a 4.0 scale)

Waivers to the above criteria may be granted (on an individual basis) by the Department of Systems Engineering and Management. Therefore, individuals whose academic credentials fall below any of the above criteria may apply. For more information on specific admission procedures to AFIT programs, please refer to the AFIT Office of Admissions web page at www.afit.edu/ADMISSIONS/.

Program Educational Objectives

The ASE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. The ASE program consists of two educational objectives:

- Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director.
- Graduates will continue to employ SE methods across the DoD acquisition life cycle. Examples of such SE methods include requirements analysis and management, architecture definition/evaluation, iterative (software) design, technical decision analysis, trade studies, risk management, modeling and simulation, and optimization and capability assessment.

Student Outcomes

The ASE program provides a substantial technical foundation in systems architecture, analysis, and design as well as opportunity for specialization within a traditional engineering discipline or domain of application. The program culminates with a capstone project allowing students to apply their technical expertise, exercise their system design skills, and/or solve a realistic defense system problem. The following student outcomes are those competencies that students are expected to achieve by the completion of the ASE program:

- ASE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.
- ASE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.
- ASE graduates will be proficient with various tools for implementing the SE principles and processes.

- ASE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in written format.
- ASE graduates will develop a detailed understanding in at least one DoD-relevant specialization, either a domain of application or SE analytical toolset.

Degree Requirements

A Master's of Engineering (ME) degree at AFIT requires a minimum of 48 credit hours and the student must obtain an average GPA of 3.0 for all courses taken. In the ASE program, these 48 credit hours consist of the following elements: Core Courses (16 credits), Mathematics Course (4 credits), a Domain Specialization Track (minimum of 12 credits), Analytical Toolset Courses (minimum of 8 credits), a Technical Management Course (minimum of 4 credits), and a Capstone Project (4 credits).

Below is a description of each ASE program element, along with the courses that comprise and/or apply to that element. All listed courses are 4 quarter credit hours. The quarter the class is offered is indicated in parentheses. Note that a single course may not count against more than one program element (i.e., no "double-counting"). For instance, SENG 560 may not be simultaneously used as both a course in the student's Domain Specialization Track (of Human Systems) and as the student's Technical Management Course.

- **Core Courses (4 courses, 16 credits):** These courses provide a common breadth of knowledge and the basic building blocks for DoD systems engineers.
 - SENG 520 Systems Engineering Design
 - SENG 593 System Software Engineering
 - SENG 610 Systems Engineering Management
 - SENG 640 System Architecture
- **Mathematics (1 course, 4 credits):** Students must complete at least one course in graduate mathematics or math science. The standard DL mathematics course is—
 - STAT 583 Introduction to Probability and Statistics (Fall)
- **Domain Specialization Track (3 courses, 12 credits):** This sequence of courses is intended to provide the student with technical depth in a DOD-related domain of application. Each ASE student is required to take at least twelve credits worth of courses in one of the two domains below, one of which must be at the 600-level (or above).
 - **Human Systems:** This domain specialization addresses the integration of human systems, human factors, human performance measurement, design of human computer interfaces and display/control systems with particular emphasis on DoD applications. This focus area will prepare students to apply state of the art analytical and problem solving techniques to design of systems having a significant human component.
 - **Space Systems:** This domain specialization prepares systems engineers for the space-related assignments, and covers not only spacecraft system design and technologies, but also orbital mechanics, the space environment, satellite communications, and the physics related to space-based surveillance.
- Below are the specific courses that comprise each Domain Specialization Track.
 - Human Systems (choose 3 of 4, one of which must be HFEN 560)
 - SENG 560 Human Systems Integration
 - HFEN 560 Introduction to Human Factors
 - HFEN 620 Human Performance Modeling
 - HFEN 663 Human-Computer Interaction
 - Space Systems
 - ASYS 631 Spacecraft Systems Engineering
 - MECH 532 Introductory Space Flight Dynamics
 - PHYS 519 The Space Environment
- **Analytical Toolset Courses (2 courses, 8 credits):** The intent of this program element is to provide the student with technical depth in multiple engineering analysis methodologies. There are three Analytical Toolset courses available as part of the ASE program; students must choose at least two.
 - **Modeling and Simulation (M&S):** This toolset uses various simplified representations of a system (e.g., emulators, prototypes) to determine how that system will perform or behave without actually testing it in a real-world situation.
 - HFEN 620 Human Systems Modeling (4)
 - **Quantitative Analysis (QA):** This toolset involves the detailed analysis of engineering-related problems using mathematical/statistical techniques to assist with various aspects of system development, particularly those related to system dynamics, decision-making, and value assessments.
 - SENG 620 Quantitative Analytical Methods (4)

Astronautical Engineering (M.S.)

Program Description

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

Program Educational Objectives (PEOs)

- Make direct contributions to the area of astronautical engineering as a practicing engineer
- Successfully evaluate, monitor, and administer astronautical research and development projects
- Use an AFIT education to approach and solve new technical challenges to meet the needs of the Department of Defense

Student Outcomes (SOs)

Graduates of the GA program will:

- Apply sound engineering principles to solve Air Force and DoD problems
- Communicate technical information, via oral presentations and written documents, to a wide range of audiences, including engineering professionals and senior military officers
- Understand the principles of orbital mechanics. Graduates will be able to describe Keplerian motion, major perturbations to Keplerian motion, and be able to plan orbital maneuvers
- Prepared to describe and discuss significant aspects of the space environment and their effect on Earth-orbiting spacecraft
- Model spacecraft attitude dynamics and synthesize control laws to control spacecraft attitude. Graduates will understand transformations due to coordinate frame translation and rotations
- Have a basic understanding of modern communication principles as they relate to satellite communications. Graduates will recognize methods of modulation, multiplexing, and encoding. Graduates will be able to perform simple link margin analyses needed to establish initial design requirements
- Prepared to describe essential features of rocket propulsion including: performance parameters, propellant types, rocket staging, and fluid mechanics as it pertains to rocket propulsion
- Conduct basic analyses of space structures including deformation from tension, torsion, shear, and bending
- Basic understanding of the remote sensing process, and be able to recognize key concepts relating to optical systems, imaging, spatial and spectral resolution, and atmospheric absorption and scattering

Additional Information

The Graduate Astronautical Engineering program provides the student with a broad education in the scientific and engineering disciplines associated with Astronautical Engineering, as well as in-depth study in selected specialty areas.

The program's core courses are designed to ensure graduates have a solid foundation in the areas of orbital mechanics, space environment, attitude determination and control, telecommunications, remote sensing, space structures, and rocket propulsion. Specialty sequences are available in, but not limited to, these important aspects of astronautical engineering.

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

School and Program Admission Criteria

DEGREE REQUIRED: Aeronautical, Astronautical, Aerospace, Mechanical, Systems Engineering or Engineering Mechanics from USAFA.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

Core Courses

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

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

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

Mathematics

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

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

Specialty Sequences

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

Thesis

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

Astronautical Engineering (PhD.)

Program Description

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

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

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

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

School and Program Admission Criteria

DEGREE REQUIRED: Requires Master's degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering.

GRE REQUIRED: 156V/151Q

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

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

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

Degree Requirements

Major

24 hours

Mathematics

12 hours

Dissertation Research

48 hours

Admission to candidacy

One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

Combating Weapons of Mass Destruction (M.S.)

Program Description

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

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

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

Program Educational Objectives (PEOs)

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

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

Program Outcomes (POs)

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

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

School and Program Admissions Criteria

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

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

Test Required: GRE – 153V/148Q

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

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

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

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

Combating Weapons of Mass Destruction Certificate

Program Description

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

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

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

Program Educational Objectives (PEOs)

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

Program Outcomes (POs)

- Understand the science, phenomenology, and technology involved in combating WMD
- Apply advanced concepts to applications in the area of combating WMD
- Perform analysis on data, working independently and in groups, with a focus on applications to combating WMD
- Be able to contribute and communicate their results and understanding in the form of journal articles, research proposals, and conference presentations

Program Prerequisites

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

Special Admission Requirements

U.S. citizenship

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

Computer Engineering (M.S.)

Program Description

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

Program Educational Objectives (PEOs)

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

Student Outcomes (SOs)

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

School and Program Admissions Criteria

DEGREE REQUIRED: BS in Computer Engineering or Electrical Engineering (with concentration in computer engineering).

MATHEMATICS REQUIRED: Discrete mathematics, ordinary differential equations

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

Core Courses

16 hours

CSCE 586 - Design and Analysis of Algorithms 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 (For a detailed discussion of degree requirements, see the Department Student Guide)

Computer Engineering (PhD.)

Program Description

The Department of Electrical and Computer Engineering offers doctoral programs in Computer Engineering that lead to the award of a PhD. 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 PhD. program after completing a BS degree)

TEST REQUIRED: GRE - 156V/151Q

GPA REQUIRED: 3.50

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

Degree Requirements

Coursework

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

Dissertation

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

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)

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

Student Outcomes (SOs)

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

School and Program Admissions Criteria

DEGREE REQUIRED: BS in Computer Science, or a BS in an engineering, science or mathematical field with extensive course work (24 semester hours) in computer science

MATHEMATICS REQUIRED: Discrete mathematics, differential and integral calculus

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

Core Courses

16 hours

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

Plus one of the following:

CSCE 689 Distributed Software Systems

CSCE 692 Design Principles of Computer Architecture

Mathematics

4 hours

Theory

4 hours

Application Sequence

12 hours

Thesis

12 hours (For a detailed discussion of degree requirements, see the Department Student Guide)

Computer Science (PhD.)

Program Description

The Department of Electrical and Computer Engineering offers doctoral programs in Computer Science that lead to the award of a PhD. 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 PhD. program after completing a BS degree)

TEST REQUIRED: GRE - 156V/151Q

GPA REQUIRED: 3.50

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

Degree Requirements

Coursework

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

Dissertation

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

Cost Analysis (M.S.)

Program Description

The Graduate School of Engineering and Management, Department of Systems Engineering and Management offers the Master of Science in Cost Analysis (GCA). The GCA program is designed to advance the knowledge and creative problem solving skills needed to effectively estimate program resources within the global military, U.S. Department of Defense (DOD) and the United States Air Force (USAF) environments. The curriculum integrates a strong foundation in quantitative concepts and techniques with specific military cost-related topics to prepare students to contribute effectively in a variety of complex and challenging roles in the global military arena. Besides the weapon system cost sequence, the curriculum includes courses in mathematical methods, quantitative decision-making, economics, cost management, risk, systems engineering and maintenance and production management.

Program Educational Objectives (PEOs)

- Program graduates are well-prepared to use analytical techniques to make significant progress toward solving problems of interest to the Air Force, DoD and Homeland Security
- Graduates will be independent, trusted advisors in proposing, developing, and implementing policy as judged by their immediate supervisors in the areas of financial management, cost estimation, and cost analysis as a result of excellent and consistent application of decision making and research tools to real issues confronting the staff

Program Outcomes (POs)

- Effectively communicate using both oral and written communications
- Understand and apply concepts and techniques of descriptive and inferential statistics to analyze problems under conditions of risk and uncertainty
- Understand and apply concepts, methods, and tools related to cost estimating in a program acquisition context
- Understand and apply concepts from a wide range of business disciplines within the specific context of DoD resource estimation
- 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: Business, Economics, Finance or Math preferred

MATHEMATICS REQUIRED: Calculus (but not necessarily including) differential equations and at least one course in statistics.

TEST REQUIRED: GMAT- 550 (28 - Verbal, 37 - Quantitative, 4.5 - analytical writing); GRE - 153V/148Q

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

COST 510 - Principles of Cost Estimating

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

COST 520 - Advance Concepts in Cost Estimating

This course builds upon the foundational topics of cost analysis and estimating from COST 510. The techniques, methodologies, and concepts of acquisition estimating are incorporated through the standardized DoD cost estimating and analysis software suite, Automated Cost Estimating and Integrated Tools (ACEIT). Additional topics relevant to the cost estimator are explored. These topics include: cost management, activity based costing, labor rate derivation, earned value management, O&S estimating, aging system issues, software estimating and source selection processes.

Instructional Method Lecture

Min Hours 3

Prerequisites COST-510

Terms Offered Winter

COST 610 - 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.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-525

Terms Offered Spring

COST 630 - Defense Cost Economics

This course is divided into two parts. The first part of the course provides the economic foundation of defense as a public good and establishes the role institutions, bureaucracy, collective action, rent-seeking, and public policy play in the defense realm. This first part of the course establishes the framework in which the cost estimator operates. The second part of the course examines topics of interest to cost estimators and relates these to the economic foundations of the first half. These topics include: portfolio analysis, cost growth, acquisition reform, and commercial derivatives.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

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.

Instructional Method Lecture

Min Hours 4

Prerequisites COST-510

Terms Offered Winter

EMGT 550 - Engineering Economic Decision Analysis

This course studies the analytical techniques necessary to optimize the economic outcome of technical and managerial decisions. Traditional engineering economic concepts such as basic cost concepts and time value of money are reviewed before presenting more complex concepts including comparison of alternatives, economic analysis, capital budgeting, analysis of risk and uncertainty, and decision models.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

Statistics

STAT 525 - Applied Statistics for Managers I

This course covers descriptive statistics, probability theory and statistical inference. Descriptive statistics covers both numerical and graphical techniques to illustrate data. Probability theory covers theoretical underpinnings of both discrete and continuous random variables. Statistical inference includes topics such as the central limit theorem, confidence interval and hypothesis testing (one sample and two), and nonparametric techniques.

Instructional Method Lecture

Min Hours 4
Terms Offered Fall and Summer

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).

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites STAT-525

Corequisite STAT-535L

Terms Offered Winter

Other

ECON 520 - Managerial Economics

ECON 520 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 allowing 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).

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

SENG 520 - Systems Engineering Design

This course provides a broad introduction to a systematic approach for the conceptualization, design, analysis, operation, and sustainment of complex systems within the Department of Defense. While this course serves as a stand-alone introduction to Systems Engineering, it also provides the foundation for further study in Systems Architecture and Engineering Software Systems.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall (DL) and Summer

SENG 610 - Project Management

Provides knowledge and tools to manage projects or effectively contribute as a project member. Framed by the systems development cycle, course explains challenges specific to three major project types: systems engineering, software systems, and construction. Basic topics include project lifecycle, project planning selection, cost estimating, scheduling, and risk management. Advanced topics include critical chain analysis, adaptive project management, acquisition logistics and contracting. A one hour lab illustrates course principles using Microsoft Project software.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite SENG-610L

Terms Offered Spring and Summer

Thesis

12 hours

Cyber Operations (M.S.)

Program Description

Information Operations (IO) is the integrated employment, during military operations, of information-related capabilities in concert with other lines of operation to influence, disrupts, corrupt or usurp the decision making of adversaries and potential adversaries while protecting our own. Cyber Operations (CO) encompasses most of the technological aspects of IO. To support CO, professionals must be cognizant of the tools, techniques, and practices required to defend, attack, and exploit these resources. At the technical level, CO encompasses multiple scientific disciplines that ensure the security of critical infrastructures.

Program Educational Objectives (PEOs)

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

Student Outcomes (SOs)

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

School and Program Admissions Criteria

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

MATHEMATICS REQUIRED: Differential and Integral Calculus

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

Core Courses

24 hours

- CSCE 525 Introduction to Information Warfare
- CSCE 526 Secure Software Design and Development
- CSCE 528 Cyber Defense and Exploitation
- CSCE 629 Cyber Attack
- CSCE 660 Mobile, Wireless & SCADA Device Security
- CSCE 725 Reverse Engineering

Mathematics

4 hours

Cyber Operations Breadth

8 hours

Thesis

12 hours (For a detailed discussion of degree requirements, see the Department Student Guide)

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:

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

Student Outcomes (SOs)

Students will be able to:

- Demonstrate an in-depth understanding in their specialty area within electrical engineering
- Communicate technical information clearly by written and oral means
- Conduct independent research on topics related to electrical engineering, including identifying and scoping a problem, locating and synthesizing relevant published prior work, planning and executing valid research, documenting results, and publishing them
- Apply the scientific method and use reliable standards of evidence for conclusions reached

School and Program Admissions Requirements

DEGREE REQUIRED: BS degree in Electrical Engineering or Computer Engineering

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

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

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

Degree Requirements

36 hours

Coursework

28 hours

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

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

- Observables Reduction
- Signal Processing

Mathematics

8 hours

Thesis

12 hours (For a detailed discussion of degree requirements, see the Department Student Guide)

Electrical Engineering (PhD.)

Program Description

The Department of Electrical and Computer Engineering offers doctoral programs in Electrical Engineering that lead to the award of a PhD. 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 PhD. program after completing a BS degree)

TEST REQUIRED: GRE 156V/151Q

GPA REQUIRED: 3.50

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

Degree Requirements

Coursework

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

Dissertation

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

Engineering & Technology Management Thrust Area

The Graduate School of Engineering and Management, Department of Systems Engineering and Management offers two programs in the Engineering & Technology Management thrust area. The two programs, which offer Master of Science degrees in Engineering Management and Cost Analysis, are described below

Engineering Management Program (M.S.)

Program Description

The Graduate School of Engineering and Management, Department of Systems Engineering and Management, offers the Master of Science in Engineering Management. The degree enjoys full accreditation from the Accreditation Board for Engineering and Technology (ABET) for those students who hold prerequisite qualifications for the ABET designation. The non-ABET degree title is Master of Science (Engineering Management). The degree reflects the importance of enhancing the interface between technology and management in environments dominated by Science, Technology, Engineering, and Mathematics (STEM) fields. Upon completion of the degree, students will have a better appreciation of the broad field of engineering management and a better understanding of the integrative nature of processes and relationships inherent in most technology-driven organizations. This will prepare them to manage both existing and emerging technologies while guiding innovative solutions to the complex problems their organizations face.

In a complex world characterized by technology-driven advances, an organization's success depends not only on access to cutting-edge technology. It also depends on the ability to manage the technology and develop dynamic capabilities to address rapidly changing environments. Therefore, to enhance their success, organizations must have individuals who possess both technical and managerial expertise. In a 1991 survey though, there was a strong consensus among engineering deans that technical expertise and on-the-job development are not sufficient to meet management responsibilities in highly technical and dynamic environments.

This program is thus designed for individuals operating in a technical environment who want to be more prepared to integrate technical and managerial skills within a decision-making context. Students will learn to define problems, formulate approaches to investigate the problems, collect and analyze data with appropriate analytical tools, and interpret findings for managerial action. With coursework in management science, project management, decision and risk analysis, systems analysis, and behavioral science, students are able to develop their management proficiency within their area of technical specialization. The strength of the program is thus its multidisciplinary approach in which core management principles are integrated with graduate-level technical education.

Students will be able to apply the appropriate concepts, methods, and tools related to fundamental engineering management responsibilities (i.e., planning, organizing, leading, and controlling resources) in a technical environment. The curriculum includes a foundation based on effective and efficient organizational processes, related managerial decision-making skills, and the importance of an integrated systems perspective. Upon completion of the program, students will be well prepared to conduct and present methodical research to solve problems and support decisions. Since the program is designed to appeal to students from different disciplinary backgrounds and technical environments, the core tools taught in the program provide breadth in the area of principled management. To provide flexibility for meeting individual objectives of depth, the program includes a concentration sequence that allows students to develop expertise in a particular specialization area.

Program Educational Objectives (PEOs)

Graduates will be well positioned to lead in a technical environment, both independently and collaboratively, while applying decision-making and analytical tools to solve operational problems. They will be able to propose, develop, and implement effective policy through a holistic systems approach in their area of specialization as judged by their immediate supervisors.

Student Outcomes (SOs)

Upon graduation, students should be able to:

- Use effective oral and written communications
- Understand and describe the integrative nature of processes and relationships within the engineering management field and within their respective technical environments
- Understand and apply the concepts, methods, and tools related to planning, organizing, leading, and controlling resources and processes in a technology-focused organization
- Understand and apply principles of organizational behavior to manage people-centric processes in a technology-focused organization
- Understand and apply critical thinking skills and appropriate analytical techniques to support more informed decisions
- Conduct and present methodical research, using a systems thinking approach, to analyze problems and recommend solutions

Program graduates are well grounded in managerial concepts and technical coursework related to their particular specialization areas. For Air Force students, there are several advanced academic degree (AAD) codes associated with the program: OIYY (Information Systems Technology), 1AGE (Engineering and Environmental Management), 1AGY (Engineering Management),

1AME (Management Information Systems), 1APY (R&D Management), 1AUY (Information Management), and 4LCY (Human Factors Engineering). Additional AAD codes may be applicable for students from other engineering environments. A new set of codes is being implemented to reflect the integration and synergy within the program; the tentative codes are shown below.

- 4JM – General Engineering (Engineering Management)
- 4JME – Engineering and Environmental Management
- 4JMF – Facility and Infrastructure Management
- 4JMH – Human Factors
- 4JMI – Information & Technology Management
- 4JMS – Science & Technology Management

Program Admission Criteria

All students working in a STEM-related environment are welcome to apply, to include those from industry and the public sector. Although the core elements of the program do not require specific knowledge from any particular engineering discipline, students must be comfortable with technical concepts and topics. The general requirements for admission to the Master of Science program in Engineering Management are shown below.

DEGREE REQUIRED: An undergraduate degree in an appropriate area of engineering or science; an undergraduate degree from another STEM-related discipline will be acceptable provided it contains significant technical coursework or is accompanied by work experience in a technology-focused organization.

MATHEMATICS REQUIRED: Mathematics courses to include at least one year of college-level calculus and a course in probability and statistics. Applicants without a previous course in probability and statistics, and who otherwise have strong academic backgrounds, may be provisionally admitted and required to take a probability and statistics course in their initial quarter.

REQUIRED GPA: A cumulative undergraduate GPA of 3.0 (on a 4.0 scale); the GPA in mathematics-related courses should be at least 3.0.

REQUIRED TESTS: Either the Graduate Record Examination (GRE) or Graduate Management Admissions Test (GMAT) are required. For the GRE -153V/150Q is required. Weaknesses in one area may be offset by strengths in the other area, provided the combined score exceeds 305. For the GMAT, a score of at least 550 is required.

Deficiencies in any of these areas may be waived on a case-by-case basis, or corrected through additional coursework, as approved by the Curriculum Committee. Students in the Wright-Patterson area who do not meet these criteria may register for individual courses as a part-time student (space available) but are expected to meet the above criteria prior to being granted candidacy for the degree.

Curriculum Description

The program is conducted in six academic quarters and a short term (18 total months, beginning in September) for full-time students. The short term provides an orientation to curriculum options, a review of basic statistics, mathematics, and writing skills, and an overview of the engineering management program.

Because of its flexibility, the Graduate Engineering Management (GEM) program may be viewed either as a terminal degree program with a professional focus or as preparation for more advanced graduate work. The program is typically completed in six academic quarters and a short term (18 total months, beginning in September) for full-time students. The GEM program requires a minimum of 48 credit hours. The minimum curriculum satisfying the degree requirements consists of two methods courses (8 hrs), four engineering management core courses (14 hrs), an approved focus sequence comprising at least 14 hrs, and 12 hours of thesis research.

- The **methods** courses provide a strong background central to informed decision-making, which prepares students for follow-on coursework and research efforts. A foundation in probability helps students better understand and describe the nature of uncertainty in real-world decision-making, while statistics prepares the student for rigorous problem solving.
- The **engineering management core** provides both quantitative and qualitative concepts concerned with the many facets of engineering management. These concepts include courses in organizational behavior, systems approach to analyzing and solving problems, project management, engineering economics, business process improvement, and analytical tools. These core areas represent an interdisciplinary approach to the degree and establish a framework to help integrate courses and research streams within both the program and the department.
- The **focus sequence** may be based on disciplinary specialization providing technical depth or functional specialization providing breadth across multiple disciplines integrated in a technology-focused area. Both approaches are intended to prepare the student for future leadership roles in a technology-focused organization. Example sequences are provided in the next section. More information regarding the sequences is provided in the next section.
- The **thesis** must address a real-world problem involving engineering management. The principal purposes of the thesis are to demonstrate the student's ability to integrate concepts and techniques acquired through coursework and to

demonstrate scholarly pursuit of a focused research question, all of which leads to enhanced analytical and decision-making skills for graduates. In some cases, thesis topics may be provided by faculty working in one of the respective focus areas, often in concert with DoD and USAF agencies interested in sponsoring student research in areas of practical concern. Students are expected to participate in no-credit colloquiums throughout the year that will assist them in the identification, development, and execution of their research; these colloquiums also provide students a forum to share their research with their peers and engage in scholarly discussions.

- **Electives** are offered in addition to strict degree requirements and broaden the student's horizons and/or provide more in-depth knowledge in a specific area of interest. Electives may also be required by the thesis advisor in order to adequately complete the required thesis research.

In addition to degree requirements, and to demonstrate full-time status, all DoD-sponsored full-time students must complete an average of 12 credit hours per quarter (i.e., 72 total credit hours). The additional credit hour requirement may be achieved by taking additional courses of interest, participating in internships, engaging in directed readings courses, or conducting additional research. Sponsored students may also be required to take additional courses to satisfy the education needs of the sponsor, qualify for the award of an additional advanced degree code, or gain certifications. In no instance will more than 12 credit hours of graded thesis registration be allowed.

Example Focus Sequences

Described below are example focus sequences for specific concentration areas. Provisions are available to tailor sequences to meet specific student and research requirements.

Facility and Infrastructure Management

Intended primarily for the Air Force Civil Engineer (CE) community, this focus sequence provides students with an in-depth study of the unique challenges associated with the management of resources and processes dedicated to facility and infrastructure assets. Specifically, CE stakeholders expect civil engineers in the GEM program to achieve the program's desired outcome to address interdisciplinary challenges across the spectrum of the Civil Engineer's Mission, with particular emphasis on asset management and construction management.

Shown below are the courses included in this sequence, which fulfills the requirements for the IAGE and IAGY AAD codes.

Required for all students in this sequence

- EMGT 641 (Construction Law)
- EMGT 680 (Advanced Project Mgmt and Risk Analysis)

Concentration areas: Students may choose the initial course in each concentration area to develop breadth or take all three courses in a concentration area to develop depth. Quota students will be expected to complete one concentration area and take the initial course in each of the other concentration areas.

- EMGT 621/622/723 (Asset Mgmt Concentration)
- EMGT 631/632/733 (Construction Mgmt Concentration)

S&T Management

This sequence provides students with an in-depth study of the unique challenges associated with management and leadership responsibilities in the science and technology (S&T) community, particularly within the Department of Defense (DoD) and Air Force. The primary objective is for students to better understand the unique nature of the S&T community, build their technical and managerial skills, and prepare themselves to effectively lead S&T efforts. Shown below are the required courses included in this sequence, which fulfills the requirements for the IAPY AAD code.

- RDMT 554 (Mgmt in R&D Organizations)
- RDMT 654 (Capstone)
- RDMT 541 (Operational Technology and Innovation)
- COST 610 (Project Risk Analysis)
- SENG 520 (Systems Engineering)

Information Systems

The Information Systems (IS) sequence is designed to provide students with the perspective, knowledge and skills needed to develop, manage, and integrate enterprise-wide information systems for the Air Force, DoD, and allied military organizations in future assignments as middle and upper-level managers and leaders. Focus on IS will improve the student's understanding of

DoD information systems, cyber-computer networks, organizational and enterprise systems-related issues, including strategy formulation and application, architecture analysis and design, cyber security issues and practices, technological systems design/development/acquisition and related business process support. Shown below are the required courses included in this sequence, which fulfills the requirements for the OIYY, 1AU, and 1AME AAD codes.

- SENG 520 (Systems Engineering)
- IMGT 561 (Database Mgmt)
- IMGT 657 (Data Communications)
- SENG 640 (Systems Architecture)

Human Factors Engineering

The Human Factors Engineering sequence is designed to provide students with the knowledge and skills needed to lead the development of systems with a significant human interface component within the Air Force, DoD, and allied military organizations while providing skills to enable future assignments as middle and upper-level managers. The focus of the sequence is on providing graduate level education in the fundamentals of Human Factors Engineering with an understanding of Human Systems Integration. Shown below are the required courses included in this sequence, which fulfills the requirements for the 4LCY AAD code.

Required course: HFEN 560 (Human Factors Engineering) • Three of the following five courses:

- SENG 560 (Human Systems Integration)
- HFEN 610 (Human Performance Measurement)
- HFEN 620 (Human Performance Modeling)
- HFEN 663 (Human-Computer Interaction)
- HFEN 670 (Human Interaction Technologies)

Degree Requirements

Core Courses

14 Hours

Methods Requirements

8 Hours

Focus Sequence

14 hours

Thesis

12 hours

ENVIRONMENTAL ENGINEERING AND SCIENCE AND INDUSTRIAL HYGIENE THRUST AREA

The Graduate School of Engineering and Management, Department of Systems Engineering and Management offers two programs in the Environmental Engineering and Science and Industrial Hygiene thrust area. The two programs, which offer Master of Science degrees in Environmental Engineering and Science and Industrial Hygiene, are described below.

Environmental Engineering and Science Program

The Environmental Engineering and Science program offers two majors: Environmental Engineering and Science and Environmental Science and Management. While the two majors are similar, the Environmental Engineering and Science major places a bit more emphasis on science and engineering principles while the Environmental Science and Management major has more emphasis on environmental management and decision making.

Students who have an ABET-accredited undergraduate degree who successfully complete the Environmental Engineering and Science major receive the ABET-accredited MS in Environmental Engineering and Science. Students without an ABET-accredited undergraduate degree who complete the Environmental Engineering and Science major receive the MS (Environmental Engineering and Science) degree, while all students who complete the Environmental Science and Management major receive a degree titled MS (Environmental Science and Management).

Program Educational Objectives (PEOs)

The Environmental Engineering and Science Program is designed to provide DoD career professionals with relevant graduate education in the principles of environmental engineering and science. The educational objective of the environmental engineering and science program is that within a few years of program completion, graduates, who would be serving as DoD officers and career professionals, will demonstrate that they can apply the principles of environmental engineering and science (encompassing air, water, and soil media) to successfully accomplish their duties across the spectrum of DoD environmental consulting and management duties. These abilities may be validated through voluntary professional certification, as appropriate (e.g., PE, CEM, BCEEM, QEP).

Student Outcomes (SOs)

Upon graduation, students in the Environmental Engineering and Science major will be able to:

- Apply knowledge of mathematics through differential equations, probability and statistics, calculus-based physics, chemistry, earth science, biological science, and fluid mechanics
- Formulate material and energy balances
- Analyze the fate and transport of substances in and between air, water, and soil phases;
- Conduct laboratory experiments, and analyze and interpret the resulting data in more than one major environmental engineering focus area (e.g., air, water, land, environmental health)
- Design environmental engineering systems that include considerations of risk, uncertainty, sustainability, life-cycle principles, and environmental impacts
- Demonstrate understanding of concepts of professional practice, project management, and the roles and responsibilities of public institutions and private organizations pertaining to environmental policy and regulation
- Apply advanced principles and practice relevant to the program educational objectives.

Upon graduation, students in the Environmental Science and Management major will be able to

- Apply knowledge of mathematics, probability and statistics, physics, chemistry, and biology to solve environmental problems
- Formulate material and energy balances
- Analyze the fate and transport of substances in and between air, water, and soil phases
- Conduct laboratory experiments, and analyze and interpret the resulting data in more than one major environmental engineering focus area (e.g., air, water, land, environmental health)
- Consider risk, uncertainty, sustainability, life-cycle principles, and environmental impacts when making decisions
- Demonstrate understanding of concepts of professional practice, project management, and the roles and

- responsibilities of public institutions and private organizations pertaining to environmental policy and regulation
- Apply advanced principles and practice relevant to the program educational objectives.

Admission Standards and Procedures

The general requirements for admission to the Master of Science program in Environmental Engineering and Science are:

- A Bachelor's degree from an ABET accredited engineering program (for the ABET-accredited degree)
- or-
- A B.S. degree in a science related to environmental science, such as physics, biology, chemistry or industrial hygiene or an undergraduate degree in a management area, such as business, economics, or cost analysis. Applicants with undergraduate degrees in management should take the Environmental Science and Management major.
- An introductory statistics course*
- Two semesters of calculus (Calc I & Calc II)
- An introductory environmental engineering course*.
- A cumulative undergraduate GPA of 3.0 (on a 4.0 scale) and minimum GRE scores of 153 verbal and 148 quantitative (or 500 verbal and 600 quantitative for GREs taken prior to 1 Aug 2011). Applicants who are applying for the Environmental Science and Management major may substitute the GMAT (minimum score of 550) for the GRE.

*Courses can be taken in first quarter if not yet completed

NOTE: Deficiencies in the above areas may be waived or corrected through additional coursework on a case-by-case basis by the Department of Systems Engineering and Management.

Industrial Hygiene Program

Program Educational Objectives (PEOs)

- Our graduates have achieved positions of leadership as occupational/environmental health consultants, instructors, or similar positions of responsibility
- Our graduates have applied their education to address difficult technical problems for the Air Force, sister service, civilian, or foreign industrial and community environments
- Our graduates have attained voluntary professional board certification as Certified Industrial Hygienists

Student Outcomes (SOs)

Upon graduation the student will be able to:

- Anticipate and recognize agents, factors, and stressors
- Evaluate agents, factors, and stressors for hazard potential
- Control hazards presented by agents, factors, and stressors

This program was developed considering guidelines established by ABET and subject areas from the Certified Industrial Hygienist exam from the American Board of Industrial Hygiene. The Master's degree of this program is accredited by the Applied Science Accreditation Commission of ABET (<http://www.abet.org>). Students matriculating with an ABET accredited undergraduate degree will receive the degree Master of Science in Industrial Hygiene, 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.

In addition, the Industrial Hygiene program was developed in coordination with the Environmental Engineering and Science degree program. Both programs were motivated by a request from the AF Bioenvironmental Engineering (BE) career field. The Environmental Engineering and Science program was offered for the first time in the Fall of 2003, while the Industrial Hygiene program began later in the Fall of 2006. The curriculum includes department core course offerings in statistics, risk analysis, and sustainable design. The program curriculum includes course offerings in industrial hygiene anticipation/recognition/evaluation/control, radiation protection, environmental transport, epidemiology, physiology, and toxicology.

Admission Standards and Procedures

The general requirements for admission to the Master of Science program in Industrial Hygiene are:

- 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
- Math courses including an introductory statistics course, Calculus I and Calculus II
- An introductory environmental engineering course
- Courses in organic chemistry and biology
- A cumulative undergraduate GPA of 3.0 (on a 4.0 scale), GRE - 153V/148Q

NOTE: Deficiencies in the above areas may be waived or corrected through additional coursework on a case-by-case basis by the Department of Systems Engineering and Management.

Human Systems Certificate

Program Description

AFIT offers a Graduate Certificate in Human Systems (HS), consisting of a series of three core courses, an elective course and a capstone project. These courses are part of the engineering management and systems engineering degree programs and may also be used as a minor concentration in another AFIT degree program. If the certificate is earned as a minor concentration in another AFIT degree program, the requirement for the capstone project may be met by the student's thesis (with SE curriculum chair approval).

Under certain circumstances, this program can be offered via distance learning for part-time remote students. These courses use prerecorded lectures, supplemented with live webinars. The target audience is active duty military, DOD civilians, and contractors with traditional science or engineering backgrounds, usually working in laboratories, test centers, product centers, or in a requirements/capability planning office. Each course is offered during an AFIT academic quarter. If taking one course per quarter, this program can be completed in 15 months.

Program Outcomes

The HS Certificate Program takes students with traditional science or engineering backgrounds and produces graduates who can effectively use the tools and knowledge of human factors and human factors engineering to approach and analyze the design of systems for human use.

- The HS graduates will understand the systems engineering process and the role of the human factors engineer within the systems engineering process.
- HS graduates will demonstrate application of HS evaluation, design, and experimental processes on contemporary problems of interest to the DOD.
- HS graduates will understand many of the tools and activities of the human factors engineer and other human systems integration oriented disciplines in the design of complex human-machine systems.
- HS graduates will be able to identify deficiencies and/or gaps in the current human factors body of knowledge, and will be capable of proposing new approaches to bridge these gaps.
- HS graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.

School and Program Admission Criteria

DEGREE REQUIRED: Candidates must have completed a bachelor's degree in engineering or scientific field. At least one course in engineering design is recommended.

MATHEMATICS REQUIRED: Basic calculus and probability and statistics.

TEST REQUIRED: None

GPA Required: Overall – 3.0;

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

Degree Requirements

Core Courses:

- SENG 520 – Systems Engineering Design
- SENG 560 – Human Systems Integration
- HFEN 560 – Human Factors

Capstone Project:

- SENG 798 – SPECIAL STUDY – GROUP OR INDIVIDUAL CAPSTONE PROJECT

Elective Course (select 1 of the following):

- HFEN 610 – Human Performance Measurement
- HFEN 663 – Human-Computer Interaction
- HFEN 670 – Human Interaction Technologies

Information Assurance Certification

Program Description

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

Certificate Requirements

Certificate Elements for Information Systems Security Professionals under National Training Standard NSTISSI Number 4011.

Core Courses

- CSCE 544 - Data Security
- CSCE 625 – Formal Analysis of Security Systems
- CSCE 689 - Distributed Software Systems
- CSCE 725 - Reverse Engineering

Choose one of the following:

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

Certificate Requirements

Certificate Elements for Senior System Manager Certificate under National Training Standard CNSSI Number 4012.

Core Courses

- IMGT 684 - Strategic Information Management

Choose one of the following:

- CSCE 525 – Introduction to Cyber Warfare and Security
- IMGT 687 - Managerial Aspects of Information Warfare

Choose one of the following:

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

Certificate Requirements

Certificate Elements for Senior Risk Analyst Certificate under National Training Standard CNSSI Number 4016.

Core Courses

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

Choose one of the following:

- IMGT 687 - Managerial Aspects of Information Warfare
- CSCE 525 - Introduction to Cyber Warfare and Security

Choose one of the following:

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

Logistics (M.S.)

Program Description

The Logistics program (LOGSCI) provides students with the opportunity to learn and exercise state-of-the-art management knowledge and tools to solve defense acquisition and logistics problems. In addition, students have the opportunity to pursue a systems view of logistics management. For DoD-sponsored full-time or part-time students, the LOGSCI program requires 12 months (4 academic quarters) of full-time study and begins in June of each year, or 36 months (12 academic quarters) of part-time distance-learning-based study beginning in January of each year. Typically, only those DoD sponsored students selected for in-residence may participate in full-time program and only those DoD-sponsored students selected for the distance-learning track may participate in the part-time program. Other individuals, such as civilian DoD employees or defense contractor employees may participate in this program as space allows. This program leads to a Master of Science in Logistics.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

- **Breadth.** Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force and DoD logistics capabilities.
- **Depth.** Are well educated, highly-valued, and successful logisticians.
- **Professionalism.** Professionally communicate technical solutions and results.
- **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning.

Program Outcomes (POs)

Our Program Outcomes (student/knowledge/skills/abilities upon graduation) produce graduates who:

- **Critical thinking skills.** Can critically analyze situations, information, and data
- **Problem solving skills.** Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world
- **Communication skills.** Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing
- **Logistics specific knowledge.** Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area

Additional Information

All students are required to complete a research or design project under the direction of a faculty advisor. This study project requirement provides an introduction to the research process, strengthens the student's writing skills, and augments the AFIT/ENS research program. It is intended for students to apply the processes, methods, and tools, acquired throughout their academic program, to a relevant DoD war fighting problem. The project is documented in an advisor approved format and defended orally. Students will take 4 to 6 course hours (depending on track) of LOGM 791 and 4 hours of LOGM 601.

School and Program Admissions Criteria

DEGREE REQUIRED: Any Field

MATHEMATICS REQUIRED: College Algebra with grade of B or better

TEST REQUIRED: GMAT – 550; or GRE Scores of at least 153V/148Q

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0

Board selected for in-residence or distance-learning program

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

Degree Requirements

Detailed current information on this program, including degree requirements and suggested course sequence by term, is contained in the complete Program Guide at <http://www.afit.edu/ENS/>

Core Courses

- LOGM 520 - Managerial Economics
- LOGM 569 – Maintenance and Production Management
- LOGM 570 - Principles of Inventory Management
- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 620 - Activity Based Costing/Management
- LOGM 542 - Management of Logistics Organizations

Track Sequence

Resident

- LOGM 660 - Strategy for Logistics

Distance Learning

- LOGM 565 - Strategic Sourcing
- LOGM 568 - Introduction to Supply Chain Management

Tools

- STAT 521 - Applied Statistical Data Analysis
- OPER 501 - Quantitative Decision Making

Capstone

- LOGM 627 - Supply Chain Management

Graduate Warfighter Project

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

Logistics (PhD.)

Program Description

The Doctor of Philosophy (PhD.) degree entails completion of rigorous coursework requirements that prepare the student for advanced research and analysis in a chosen field of study. The doctoral degree is generally characterized as a research degree with substantial emphasis placed on the completion of the dissertation research. The PhD. program in Logistics is typically 36 months in length beyond the MS degree. It entails completion of rigorous coursework requirements that prepare the student for advanced research and analysis in a chosen field of study. The degree builds on an analytical core with a flexible program that can accommodate supply chain management, acquisition, inventory theory, transportation, and operations management thrust areas. The degree has strong interdisciplinary support, with typical technical methods options in reliability, optimization, applied statistics, or systems engineering areas.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduates who:

- Will be able to understand and evaluate critically the literature of the field
- Will be able to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge
- Will have acquired the knowledge, skills, ethics, and independence of thought and action expected of a scholar
- Will have extended and effectively communicated knowledge in his or her field

School and Program Admission Criteria

Degree Required: M.S. degree in logistics, supply chain management, operations research, operations management, industrial engineering, or other relevant field. Successful completion of a Master's thesis is very desirable.

Test Required: GRE scores of at least 156V/151Q.

GPA's Required: A quality bachelor's degree with grades averaging at least 3.0 on a 4.0 scale. A quality Master's degree with grades averaging at least 3.5 on a 4.0 scale.

Degree Requirements

Requirements for the PhD. degree include 36 quarter-hours of coursework beyond the Master's degree and a period of full-time research leading to successful completion of the doctoral dissertation . In addition to the Core courses (18 hours), the three required coursework areas are: technical methods (6 hrs), mathematics requirement (8 hrs), and an elective (4 hrs).

Detailed current information on this program, a complete Program Guide, and degree requirements are available at <http://www.afit.edu/ENS/>

Residency Requirement

The residency requirement for the PhD. program is three quarter hours of full-time study in residence during any contiguous four-quarter period.

Core Courses

18 hours

Technical Methods and Electives

6 hours minimum (technical methods)

4 hours (elective)

The technical methods and electives courses together foster interdisciplinary opportunities in areas such as operations research, statistics, and systems engineering. A particular choice of technical and elective courses constitute an area of specialty. Typical areas of specialty include: Reliability, Optimization, Applied Statistics, and Systems Architecture. A program of study would be tailored to the student's research thrust, and is established in consultation with the Advisor. Technical methods area courses may consist of courses from more than one department as long as these courses form an integrated program designed to make the student an expert in the chosen area of research. In some cases this may require more than 6 hours. These specialty courses normally build on the individual student's MS program and will include a minimum of first year graduate courses.

A list of courses supporting the technical methods requirement is available in the Program Guide at <http://www.afit.edu/NS/>

Mathematics Required

8 hours:

Dissertation Research

As with all doctoral programs, the AFIT resident PhD. program requires completion of a doctoral dissertation. The dissertation research consists of at least 48 quarter hours of supervised research and should result in a significant and original archival contribution to the literature of the field. The AFIT dissertation is also generally oriented toward a topic of relevance to the US Air Force.

Logistics Air Mobility (ASAM) (M.S.)

Program Description

The LOGAIR program is the formal graduate study portion of the Advanced Study in Air Mobility (ASAM) program sponsored by the US Air Expeditionary Center (AFEC) 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 logistics and air mobility operations to lead the Air Mobility Command (AMC) in the future. The ASAM program consists of the degree portion, plus additional AFEC 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, research methods and organizational management. Courses are taught individually in a compressed schedule, typically two weeks in length. The program also requires a graduate research paper that examines a topic pertaining to mobility operations. Satisfactory completion of the curriculum and the graduate research paper leads to the award of a Master of Science in Logistics.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

- **Breadth.** Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force and DoD air mobility capabilities
- **Depth.** Are well educated, highly-valued, and successful logisticians and air mobility officers
- **Professionalism.** Professionally communicate technical solutions and results
- **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

- **Critical thinking skills.** Can critically analyze situations, information, and data
- **Problem solving skills.** Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world
- **Communication skills.** Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing
- **Logistics specific knowledge.** Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area

Additional Information

The program is 13 months long (four academic quarters) and involves a Permanent Change of Station (PCS) to McGuire AFB, New Jersey. Classes begin each year in June, with class size limited to 16 students. Students typically come from operational and support AFSCs in the Air Force. Typical students in the ASAM program are rated or support officers with nine to thirteen years commissioned time in service (i.e., senior captains or junior majors) and have experience in mobility operations. Rated officers must be qualified in their assigned weapons systems. All applicants must possess or be eligible to obtain a top secret (TS-SSBI) clearance. Attendees are picked by a central selection board each year during the Air Force's Intermediate Developmental Education selection process. Employing a "whole person" concept, the selection board picks only the best persons for this rigorous program. All applicants must be proven leaders worthy of future consideration for command.

School and Program Admissions Criteria

DEGREE REQUIRED: Any Field

MATHEMATICS REQUIRED: College Algebra with a grade of B or higher

TEST REQUIRED: GMAT – 550; or GRE - 153V/148Q

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

Detailed current information on this program, including degree requirements and suggest course sequence by term, is contained in the complete Program Guide at <http://www.afit.edu/ENS/>

Core Courses

- LOGM 617 – Transportation Systems and Strategic Mobility
- LOGM 619 – Transportation Policy and Strategic Mobility
- LOGM 621 – Air Transportation Management
- LOGM 568 – Introduction to Supply Chain Management
- LOGM 636 – Service Operations Management
- LOGM 634 – Reliability, Maintainability and Supportability
- LOGM 542 – Management of Logistics Organizations
- LOGM 601 – Principles and Methods of Research
- LOGM 674 – Introduction to Numerical Analysis
- OPER 501 – Quantitative Decision Making
- IMGT 669 – Business Process Improvement

Tools:

- MATH 291 – Calculus for Engineering Managers
- LOGM 525 – Statistics for Mobility Managers

Capstone:

- LOGM 627 – Supply Chain Management

Graduate Research Paper:

- LOGM 791 – Research Project for Mobility Managers

Logistics and Supply Chain Management (M.S.)

Program Description

The Graduate Logistics and Supply Chain Management program provides students with the opportunity to learn and exercise state-of-the-art management knowledge and tools to solve defense acquisition and logistics problems. The curriculum includes courses in statistics, operations research, organization and management theory, inventory systems, transportation and strategic mobility, maintenance and production management, financial management, and economics. In addition, students have the opportunity to of either pursuing an Operational Logistics, Operational Maintenance, Petroleum Management, Life Cycle Logistics, or Nuclear Logistics Management track. Upon completion students are granted a Master of Science Degree.

Program Educational Objectives (PEOs)

Our Program Educational Objectives (expectations two or more years beyond graduation) are to produce graduates who:

- **Breadth.** Apply foundational logistics concepts and sound analytical principles to efficiently and effectively advance Air Force, DoD, and other employer logistics and supply chain management capabilities
- **Depth.** Are well educated, highly-valued, and successful logisticians and supply chain experts
- **Professionalism.** Professionally communicate technical solutions and results
- **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

- **Critical thinking skills.** Can critically analyze situations, information, and data
- **Problem solving skills.** Can formulate problem statements, ascertain and collect the relevant data, and utilize the correct methodology in order to both delineate and solve problems in the real world
- **Communication skills.** Can effectively communicate to peers, subordinates, and supervisors in a professional manner both orally and in writing
- **Logistics specific knowledge.** Have developed a thorough understanding of the logistics, mobility, and supply chain discipline as required to make strategic level managerial decisions in the logistics area

School and Program Admissions Criteria

DEGREE REQUIRED: Any Field

MATHEMATICS REQUIRED: College Algebra with a grade of C or higher

TEST REQUIRED: GMAT – 550; or GRE Scores of at least 153V/148Q.

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 (IAME) and The Association of Advance Collegiate Schools of Business (AACSB), consisting of: calculus, applied statistics (probability and distributions), managerial economics, and organization and management theory. If a student can demonstrate successful completion of a course in an undergraduate or previous graduate program, a waiver may be granted for those prerequisites. Otherwise, students identified with deficiencies are expected to fulfill this requirement by taking (as appropriate) MATH 291, STAT 525 , STAT 535, LOGM 520, and ORSC 542.

Detailed current information on this program, a complete Program Guide, sample curriculum, and degree requirements are available <http://www.afil.edu/ENS/>

Management Core Courses

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

Logistics and Supply Chain Management Core

- LOGM 565 - Strategic Sourcing

- LOGM 569 - Maintenance and Production Management
- LOGM 570 - Principles of Inventory Management
- LOGM 617 - Transportation Systems and Strategic Mobility
- LOGM 627 - Supply Chain Management

Specialty Sequence

Operational Logistics (OL)

- LOGM 619 - Transportation Policy and Strategic Mobility
- LOGM 630 - Forecasting Management

Operational Maintenance (OM)

- LOGM 631 - Scheduling: Theory and Application
- LOGM 634 - Reliability, Maintainability and Supportability

Petroleum Management (PM)

- LOGM 630 - Forecasting Management
- LOGM 651 - Seminar in Petroleum Management

Life Cycle Logistics (LC)

- LOGM 630 - Forecasting Management
- OPER 638 - Assessing Operational Cost and Risk

Nuclear Logistics Management (NL)

- LOGM 634 - Reliability, Maintainability and Supportability
- NENG 500 - Nuclear Weapons Strategy and Policy

Research Foundation

- LOGM 601 - Principles and Methods of Research

Thesis

- LOGM 799 - Thesis Research
- TENS 799 - Thesis Completion

Materials Science (M.S.)

Program Description

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

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

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

Program Educational Objectives (PEOs)

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

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

Program Outcomes (POs)

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

- Apply engineering principles to solve Air Force and DoD problems
- Communicate technical information, via oral presentations and written documents, to a wide range of audiences including engineering professionals and senior military officers
- Demonstrate knowledge of significant aspects of both structural and non-structural materials used in the current and future aerospace and defense systems

School and Program Admissions Criteria

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

Mathematics Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q

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

USAF Education Codes: 4FYF, Materials Science and Engineering, General, and 4FBY, Electronic and Optical Materials . Waivers to the above criteria may be granted on a case-by-case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

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

<http://www.afit.edu/ENY/>

Core Courses

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

Mathematics

Each student must complete at least one graduate level mathematics course. A second course is highly desirable. The particular courses each student takes are based upon background and area of specialization. Nearly all students take mathematics courses

that cover the following topics; advanced calculus, complex variables, Fourier series and boundary value problems, linear algebra, numerical methods, and probability/statistics. Two courses specifically designed to cover most of these topics are: MATH 511 - Methods of Applied Math I, and MATH 513 - Methods of Applied Math II. In addition, students should consider courses in Statistics or Numerical Methods such STAT 527 - Introduction to Probability; STAT 537 - Introduction to Statistics; and MATH 508 - Numerical Methods.

Specialty Sequence

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

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

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

Thesis

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

Materials Science (PhD.) - Structural

Program Description

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

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

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

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

School and Program Admission Criteria

DEGREE REQUIRED: Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering.

GRE REQUIRED: 156V/151Q

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

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

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

Degree Requirements

Major

24 hours

Mathematics

12 hours

Dissertation Research

48 hours

Admission to candidacy

One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

Materials Science (PhD.) - Electronic/Photonic

Program Description

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

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

Program Educational Objectives (PEOs)

- This program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating materials research at the frontiers of knowledge.
- The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.

School and Program Admissions Criteria

Degree Required: A Master's degree in a physical science or engineering

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

Test Required: GRE - 156V/151Q.

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

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

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

Degree Requirements

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

level and will establish a foundation of knowledge suitable for pursuing dissertation research and meeting general academic expectations for the major area of study.

Nuclear Engineering (M.S.)

Program Description

This program provides each student with a broad foundation in nuclear technology and engineering at the graduate level. The unique combination of coursework and laboratory practice provides the student with the background for work involving nuclear weapons, nuclear detection, nuclear weapon effects, the nuclear fuel cycle, and nuclear power.

This program is normally six quarters in length. Five quarters are devoted to coursework, and one quarter is devoted to thesis research. Research is normally conducted at the Air Force Institute of Technology (AFIT). The first two quarters of work stress fundamentals in mathematics and physics. The next two quarters provide advanced courses in nuclear applications areas and prepare the student for thesis research in one of these areas. The fifth quarter is devoted to independent research for the thesis. In the final quarter, the thesis is defended and revised, as necessary, while final courses cover additional application areas.

The Commission on Institutions of Higher Education of the North Central Association of Colleges and Schools accredits the Air Force Institute of Technology through the doctoral level. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) also accredits its engineering programs. The nuclear engineering program is ABET accredited and satisfies the Air Force education codes 4QYY (Nuclear Engineering) with subspecialties, as well as 8HKY (Nuclear Effects Physics) and 8HLY (Nuclear Physics). To meet ABET criteria, students must satisfy specific ABET requirements at the advanced level. This is usually possible only for a graduate of an ABET accredited undergraduate engineering program. Students satisfying the ABET criteria are awarded the degree of Master of Science in Nuclear Engineering, while those not satisfying the ABET criteria are awarded the Master of Science degree.

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

Program Educational Objectives (PEOs)

Our graduates, in their first (and subsequent) assignments within the military nuclear science and engineering career field, will be called upon to perform some or all the following tasks.

- **Develop Technical Skills:** apply their understanding of mathematics, computational modeling, science, and engineering to problems of interest to the Air Force and Department of Defense (DOD)
- **Perform Analysis:** conduct measurements and experiments and interpret results
- **Communicate:** communicate technical subjects orally and in writing with peers and to supervisors
- **Apply:** apply their education to meet the defense needs of their organization and the nation

Student Outcomes (SOs)

At graduation our students will have demonstrated:

- A high level of understanding of mathematics, science, and engineering as it applies to nuclear weapons and effects
- An ability to research, develop, and conduct nuclear science and engineering related research to meet a specified object or goal
- Their ability to measure, analyze, and report results of nuclear and radiation processes and measurements
- The ability to apply their education to research, and analyze a technical problem related to the needs of the defense of the nation

School and Program Admissions Criteria

Degree Required: Nuclear, Students entering this program will have an undergraduate degree in engineering, science, or mathematics. Note: In addition to the academic criteria, this program also requires a SECRET security clearance and appropriate certification to need to know. Interested students should contact the Department of Engineering Physics for details. **Mathematics**

Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q.

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

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

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

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

Nuclear Engineering (PhD.)

Program Description

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

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

Program Educational Objectives (PEOs)

- The program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating nuclear weapons and effects research at the frontiers of knowledge.
- The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.

School and Program Admissions Criteria

Degree Required: A Master's degree in Nuclear Engineering, Mechanical Engineering, Chemical Engineering, or Physics.

Note: In addition to the academic criteria, this program also requires a SECRET security clearance and appropriate certification to need to know. Interested students should contact the Department of Engineering Physics for details.

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

Test Required: GRE - 156V/151Q.

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

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

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

Degree Requirements

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

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

Program Description

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

The program consists of three, 4-credit hour courses. Focus topics included will be: the historical and current state of the US nuclear policy and the implementation of that policy, the elements and technology involved in building nuclear weapons capabilities, and the unique effects of nuclear weapon detonations. All students successfully completing and maintaining a GPA of at least 3.0 in the NWEPP program (12 credit hours) will receive a certificate and have the completed certificate noted on their Air Force Institute of Technology graduate transcript.

Program Educational Objectives (PEOs)

- Apply knowledge and skills to solve problems that arise in the technical work they conduct or supervise.
- Understand the science, phenomenology, and technology involved in nuclear weapons effects, nuclear weapons proliferation, and nuclear policy.
- Communicate technical subjects orally and in writing, perform analysis, and interpret results.
- Apply their knowledge to meet the defense needs of their organization and the nation.
- Understand the international political environment as it applies to the interplay among technology, national objectives, and adversary postures that shape nuclear policy.

Program Outcomes (POs)

- Understand the science, phenomenology, and technology involved in the areas of nuclear weapons effects, nuclear policy, and nuclear proliferation
- Apply advanced concepts in the areas of nuclear weapons effects, nuclear policy, and nuclear proliferation
- Perform analysis on data, working independently and in groups, with a focus on applications to nuclear weapons effects, nuclear policy, and nuclear proliferation
- Demonstrate the ability to quantify and estimate various nuclear effects in a scenario
- Demonstrate the ability to analyze nuclear policy decisions and ramifications
- Demonstrate the ability to identify and analyze nuclear proliferation areas of concern

Admissions

A Bachelors degree is required and candidates must have taken a course in college-level algebra. Certificate is available to US citizens only. A completed application form and submission of transcripts is required at least 6 weeks prior to start of entering quarter. Academic eligibility does not guarantee admission. Candidates will be nominated to the program by AETC/A10 in consultation with Air Force Global Strike Command (AFGSC) and AETC/A10.

Operational Technology Certificate

Program Description

The Graduate School of Engineering and Management, Department of Systems Engineering and 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:

- 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
- Understand and apply concepts from a wide range of business disciplines within the specific context of DoD product development
- Understand the overall DoD and USAF product development and systems development environment
- Provide oversight support and make specific recommendations on appropriate strategies and administration techniques for each phase of a weapon system development effort
- 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

Operations Management (M.S.)

Program Description

The OPSMGMT program is the formal graduate study portion for various Intermediate Developmental Education (IDE) programs in the US Air Force. The goal of the OPSMGMT program is to cultivate a core of officers with an in-depth education in operations management, quantitative decision making, and critical thinking skills to lead the Air Force in the future. The IDE programs consist of the degree granting portion, plus additional professional development courses combined with trips to joint and major commands around the globe. As such, this enhances the AFIT degree portion of the IDE program, providing the military with a professional, degree-granting program, similar to executive management degree programs in civilian institutions. The curriculum consists of eight core courses in the areas of operations management, process improvement, organizational management, quantitative decision making, and research methods. The remainder of the curriculum is tailored for each of the IDE programs using specialty tracks. Each specialty track has 15 hours of electives available to complete the degree requirements for the program. Courses are taught individually in a compressed schedule. The program also requires a graduate research paper that examines a topic pertaining to the operational Air Force. Each program will be 12 months long (four academic quarters) and will involve a Permanent Change of Station (PCS) to various locations, depending on the particular IDE program. Class size is limited to 16 students. Students typically come from operational and support AFSCs in the Air Force.

Program Educational Objectives (PEOs)

Our Program Education Objectives (expectations two or more years beyond graduation) are to produce graduates who:

- **Breadth.** Apply foundational managerial and leadership concepts and sound analytical principles to efficiently and effectively advance Air Force and DoD capabilities.
- **Depth.** Are well educated, highly-valued, and successful officers within their respective career field.
- **Professionalism.** Professionally communicate technical solutions and results.
- **Lifelong Learning:** Continue to pursue lifelong multidisciplinary learning and to become a well-informed and well-educated consumer of analysis.

Student Learning Outcomes (SLOs)

Upon completion of the program, the student:

- **Intellectual skills (analytic inquiry).** Disaggregates, adapts, reformulates, and employs in a paper or project principal ideas, techniques, or methods at the forefront of the field.
- **Intellectual skills (quantitative fluency).** Articulates and undertakes multiple appropriate applications of quantitative methods, concepts and theories.
- **Intellectual skills (communication fluency).** Creates sustained, coherent arguments or explanations and reflections on his/her work of that of collaborators (if applicable) in two or more media to both specialized and general audiences.
- **Specialized knowledge.** Initiates, assembles, arranges, and reformulates ideas, concepts, designs, and techniques in carrying out a project directed at a challenge in the field beyond conventional boundaries.

School and Program Admission Criteria

DEGREE REQUIRED: Any field

MATHEMATICS REQUIRED: College Algebra

TEST REQUIRED: GMAT score of at least 550; or GRE of at least 153 (verbal) and 148 (quantitative) on the Education Testing Service (ETS) 2012 GRE Concordance Table (which is based upon performance of all examinees who tested between 1 August 2011 and 30 April 2012); or at least 500 (verbal) and 600 (quantitative) for GRE tests taken/scored under the old scale ETS used prior to August 2011 test dates.

GPA REQUIRED: OVERALL – 3.0; MATH – 3.0

Waivers to the above requirements may be granted on an individual basis by the Department of Operational Sciences. Admission procedures are specified in the AFIT home page (www.afit.edu).

Degree Requirements

Detailed current information on this program, including degree requirements and suggested course sequence by term, is contained in the complete Program Guide.

Core Courses

15 hours

- LOGM 545 – Introduction to Management and Organizations
- LOGM 568 – Introduction to Supply Chain Management
- LOGM 619 – Transportation Policy and Strategic Mobility

- IMGT 669 – Business Process Improvement
- Choose one of the following
 - LOGM 569 – Production and Operations Management
 - LOGM 636 – Service Operations Management

Specialty Sequence

15 hours

Courses from an approved specialty sequence are required. Specialty sequences are listed below. Required courses for each specialty are listed in the Program Guide.

Logistics and Air Mobility (LOGAIR) and Nuclear Deterrence & Policy (NDP)

Research Foundation

11 hours

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

Graduate Research Paper

7 hours

- LOGM 791 – Research Project for Mobility Managers

Operations Research (M.S.)

Program Description

Operations Research is the discipline of applying advanced analytical methods to help make better decisions. It provides rational bases for decision making by seeking to understand and structure complex problems and to use this understanding to predict system behavior and improve system performance. Much of this work is done using analytical and numerical techniques to develop and manipulate mathematical and computer models of organizational and operational systems composed of people, equipment, and procedures. Operations Research draws upon ideas from engineering, management, mathematics, and psychology to contribute to a wide variety of application domains; the field is closely related to several other fields in the “decision sciences” — applied mathematics, decision analysis, computer science, economics, industrial engineering, and systems engineering. Operations research is distinguished by its broad applicability and by the wide variety of career opportunities and work styles it embraces. Within the field, some OR professionals remain generalists while others specialize in particular tools or problem domains.

Program Educational Objectives (PEOs)

Our Program Education Objectives (expectations two or more years beyond graduation) are to produce graduates who:

- **Breadth.** Apply foundational operations research analysis techniques to efficiently and effectively advance Air Force, DoD, and other government inter-agency organizations, as well as other employer capabilities
- **Depth.** Are well educated, highly-valued, and successful operations research analysts
- **Professionalism.** Professionally communicate technical analytical assessments, solutions, and results
- **Lifelong Learning.** Continue to pursue lifelong multidisciplinary learning

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduates who:

- **Critical thinking and problem solving skills.** Have the ability to classify, formulate, and solve operations research problems
- **Operations research specific knowledge.** Have knowledge of operations research areas such as probabilistic modeling, applied statistics, mathematical programming, simulation, and decision analysis to directly support decision and policy making activities
- **Communication Skills.** Develop written and oral communications skills necessary to present complex problems to a decision-making audience: problem definition, modeling methodologies, including solution advocacy that utilizes rigorous analytical support

School and Program Admissions Criteria

DEGREE REQUIRED: Baccalaureate degree in operations research, mathematics (not math education), engineering, physics, computer science, or quantitative economics, or other quantitative discipline, provided in each case that curriculum includes sufficient mathematics as noted below.

MATHEMATICS REQUIRED: Calculus I & II (integral and differential calculus), and an advanced calculus course, (i.e. multivariable calculus).

TEST REQUIRED: GRE - 153V/148Q.

GPA REQUIRED: OVERALL - 3.0; MATH - 3.0

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

Degree Requirements

Detailed current information on this program, a complete Program Guide, sample curriculum, and degree requirements are available <http://www.afit.edu/ENS/>

Core Courses

- OPER 510 - Introduction to Mathematical Programming
- OPER 540 - Stochastic Modeling and Analysis I
- OPER 543 - Decision Analysis

- OPER 561 - Discrete-Event Simulation
- OPER 610 - Linear Programming
- OPER 679 – Empirical Modeling

Required for ALL U.S. Military Students

- OPER 544 – Operational Decision Support Systems
- OPER 544L – Operational Decision Support Systems Lab
- OPER 638 – Assessing Operational Cost and Risk

Mathematics or Statistics

- MATH 523 - Numerical Analysis and Linear Algebra
- STAT 587 - Applied Probability and Statistical Analysis

Elective

At minimum, 6 hours in elective courses must be taken.

Thesis

- OPER 799 - Thesis Research
- TENS 799 - Thesis Completion

Specialty Sequence (Optional)

In addition to the core and thesis requirements, all students are encouraged to develop in-depth knowledge in at least one specialty area. A specialty sequence consists of at least three courses selected from one of the following specialty areas:

Deterministic Operations Research, Probabilistic Operations Research, Simulation, Decision Analysis, Applied Statistics, Information Operations/Information Warfare (IO/IW), or Operational Modeling.

Operations Research (PhD.)

Program Description

The Doctor of Philosophy (PhD.) 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 PhD. program. Equally important is the discipline and dedication of the student, as independent study is a critical element for timely completion of the program.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities upon graduation) produce graduates who:

- Will be able to understand and evaluate critically the literature of the field
- Will be able to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge
- Will have acquired the knowledge, skills, ethics, and independence of thought and action expected of a scholar
- Will have extended and effectively communicated knowledge in his or her field

School and Program Admission Criteria

DEGREE REQUIRED: M.S. degree in operations research, mathematics, engineering, statistics, or other highly quantitative area of study. Successful completion of a Master's thesis is very desirable.

TEST REQUIRED: GRE - 156V/151Q.

GPA REQUIRED: A quality bachelor's degree with grades averaging at least 3.0 on a 4.0 scale. A quality Master's degree with grades averaging at least 3.5 on a 4.0 scale.

A baccalaureate-to-doctoral admission may also be granted in some circumstances to applicants who are entering directly from an undergraduate program without a Master's degree. In such case, the requirement to hold a Master's degree will be met during the student's PhD. program. All applications are referred to the Operations Research faculty of the Department of Operational Sciences for review and recommendation. Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

Degree Requirements

Requirements for the PhD. degree include 41 (for a well prepared student not needing to take the Core courses) to 53 quarter- hours of coursework beyond the Master's degree and a period of full-time research leading to successful completion of the doctoral dissertation . In addition to the Core courses, the three required coursework areas are: specialty area requirements (24 hrs), minor area requirements (9 hrs), and mathematics requirements (8 hrs).

Detailed current information on this program, a complete Program Guide, and degree requirements are available at <http://www.afit.edu/ENS/>

Residency requirement

The residency requirement for the PhD. program is three quarters of full-time study in residence during any contiguous four-quarter period.

Core Courses

Specialization Areas

24 hours

Typical choices for area of specialization are: optimization, stochastic operations research, simulation, applied statistics, or decision analysis. A list of courses supporting each specialization area is available in the Program Guide at

<http://www.afit.edu/ENS/>

Minor Courses

9 hours

This sequence is intended to broaden the student's exposure to graduate coursework. Successful completion of the minor area of study may also include completion of a minor examination requirement. Operations Research PhD. students have considerable flexibility when establishing a minor area of study. A student may choose an area within Operations Research other than his or her specialty area or the minor may also originate in another department (provided that the minor is acceptable to the other Department and that it is supported by that Department). Some examples of minor areas may include applied statistics, mathematics, or computer science. A list of Department of Operational Sciences minors and courses supporting those minors is available in the Program Guide at <http://www.afit.edu/ENS/>

Mathematics Required

8 hours

Dissertation Research

48 hours

As with all doctoral programs, the AFIT resident PhD. program requires completion of a doctoral dissertation. The dissertation research consists of at least 48 quarter hours of supervised research and should result in a significant and original archival contribution to the literature of the field. The AFIT dissertation is also generally oriented toward a topic of relevance to the US Air Force.

Optical Science and Engineering (M.S.)

Program Description

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

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

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

Program Educational Objectives (PEOs)

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

- Primarily within, but not limited to, the field of optical science and engineering, direct or perform basic or applied research, conduct and/or evaluate design and analyses, and work independently and in groups
- Communicate their work clearly, both orally and in writing (this includes writing, editing, and/or supervising the preparation of subordinates' or contractors' written reports, journal articles, briefings, and professional presentations to communicate their work clearly)
- Effectively interpret/translate between optical physicists and engineers who may not always understand each other's technologies and jargon
- Understand the details of technologies and programs in their area of responsibility
- Study an issue, identify and evaluate alternative actions, propose appropriate courses of action, and develop programs to implement optimal solutions
- Develop and implement, or sustain and improve, programs that entail multidisciplinary research, simulation, modeling, engineering design, production, and/or fielding of engineered optical systems

Program Outcomes (POs)

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

- Apply advanced concepts in mathematics and optical physics and engineering, including analytic, experimental, and computational methods, to a particular application in the field of optical science and engineering
- Perform optical science and engineering research, design, and analysis, working independently or in groups, limited to a particular problem or problems of interest with which they have experience
- Communicate optical science and engineering research, design, and analysis effectively, working independently or in groups, limited to a particular problem or problems of interest with which they have experience
- Understand and critically evaluate technical communications in the form of journal articles, research proposals, and conference presentations and contribute and communicate their results and understanding in these same forums

School and Program Admissions Criteria

Degree Required: Engineering or Physical Science with approval from the department

Mathematics Required: Ordinary Differential Equations

Test Required: GRE - 153V/148Q.

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

USAF Education Codes: TBD

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

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

Optical Science and Engineering (PhD.)

Program Description

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

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

Program Educational Objectives (PEOs)

The program is designed to produce graduates broadly educated at the highest level who are capable of actively identifying, conducting, directing, and evaluating research in electro-optics and photonics at the frontiers of knowledge. The successful student should be able to perform duties as a research scientist/engineer and scientific manager in order to develop the basic science and technology base required for new Air Force weapons systems.

School and Program Admissions Criteria

Degree Required: A Master's degree in a physical science or engineering

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

Test Required: GRE - 156V/151Q

USAF Education Codes: TBD

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

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

Degree Requirements

The PhD. degree requirements adhere to standards defined by the Graduate School of Engineering and Management faculty.

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

Space Systems (M.S.)

Program Description

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

Program Educational Objectives (PEOs)

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:

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

Program Outcomes (POs)

- Space Programs: Be knowledgeable about current and past US and international space programs. Understand the objectives of these programs and how they fit into military operations. Understand the basic technical means through which these objectives are achieved
- Spaceflight Dynamics: Understand the physics of orbital mechanics and what impact it has on orbital mission operations. Be able to calculate orbital maneuvers and understand the basics of orbit control in the presence of perturbations. Understand the basics of torque-free spacecraft attitude dynamics
- Satellite Communications: Understand modern communication principles with particular emphasis on applications to satellite and space communication systems including modulation, signals, multiplexing, demodulation, multiple access, coding, look angles, satellite hardware, earth station hardware, and link analysis
- Space Environment: Understand the physics of radiation, particles, and general conditions encountered in space. Understand spacecraft thermal equilibrium, orbit decay, spacecraft charging, space-to-ground communications, atmospheric chemistry, Van Allen belts, and solar phenomena
- Remote Sensing: Attain understanding of the remote sensing process with an emphasis on visible light and infrared systems. Understand the physics of interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors
- Spacecraft Engineering: Be knowledgeable of the design issues related to complex space systems. Understand the key elements and subsystems of important classes of space systems. Gain experience with the systematic approach necessary to effectively design space systems through a group design process

School and Program Admission Criteria

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

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

GPA REQUIRED: OVERALL - 3.0

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

Degree Requirements

Mathematics

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

Core Courses

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

Specialty Sequence

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

Thesis

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

Space Systems (PhD.)

Program Description

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

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

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

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

School and Program Admission Criteria

DEGREE REQUIRED: Requires masters degree in Astronautical, Aeronautical, Mechanical, or Systems Engineering.

GRE REQUIRED: 156V/151Q

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

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

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

Degree Requirements

Major

24 hours

Mathematics

12 hours

Dissertation Research

48 hours

Admission to candidacy

One year before graduation

In-residence study

3 successive quarters

Present Dissertation at a Public Defense

Space Systems Certificate

Program Description

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

Program Educational Objectives (PEOs)

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

Specific objectives are as follows:

- 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
- A graduate will have a thorough understanding of orbital mechanics and the space environment and how these might affect the spacecraft mission
- A graduate will have an understanding of a specific application of space vehicles

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: MECH 532, PHYS 519, ASYS 631, and one of the following: OENG 530 or EENG 571

Supply Chain Management Certificate (DL)

Program Description

The Graduate Certificate in Supply Chain Management was developed to provide the students with graduate level education in the fundamentals of Supply Chain Management (SCM), with particular emphasis on Department of Defense (DoD) and Air Force specific applications. In addition, lean operations related to Air Force Smart Operations for the 21st Century (AFSO21) will be covered. Finally, statistical data analysis and basic quantitative modeling, to include linear programming, simulation analysis, and heuristics, are included. The objectives of this program are to educate Air Force Logistics Readiness Officers (LRO's) in the above topics and to enable them to apply state of the art analytical and problem solving techniques to Air Force and DoD specific supply chain management problems, as well as enabling them to use the concepts of lean in similar situations.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduate certificate conferees who exhibit:

- The acquisition of a broad understanding of the principles and concepts of supply chain management and statistical concepts
- The ability to apply analytical techniques to SCM problems in the DoD environment
- Improved problem solving ability, critical thinking skills, and the ability to communicate

School and Program Admissions Criteria

DEGREE REQUIRED: Bachelors Degree or equivalent

MATHEMATICS REQUIRED: College Algebra

Test Required: None

GPA REQUIRED: OVERALL - 3.0

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

Related Program

The Supply Chain Certificate program includes courses that may be applied to Department of Operational Sciences logistics Master's degree programs, depending upon the specific course and program.

Certificate Completion Requirements

Successful completion of the Supply Chain Certificate program requires a cumulative grade point average on all course work of a 3.0 (based on a 4.0 scale). Time to completion is 5 quarters. There is no exit examinations required, and no final project. However, there are numerous projects and assignments required in the various courses that give an opportunity for the student to apply their knowledge to broad problems.

Detailed current information on this program is available <http://www.afit.edu/ENS/>

Core Courses

- LOGM 568 - Introduction to Supply Chain Management
- LOGM 569 - Maintenance and Production Management
- LOGM 565 - Strategic Sourcing
- OPER 501 - Quantitative Decision Making
- STAT 583 - Introduction to Probability and Statistics

Systems Engineering (IDE) (M.S.)

Program Description

Systems Engineering (SE) is the process by which a customer's needs are satisfied through the conceptualization, design, modeling, testing, implementation, and operation of a working system. There are a range of levels of systems engineering, from product systems engineering used for a standalone product or vehicle platform, to design and integration of so-called "systems of systems" (such as an air operations center or missile defense system), to enterprise wide systems engineering that span an entire organization (such as mobility forces or space command).

The focus on SE becomes especially important in the analysis and synthesis of large and complex systems, such as those that arise regularly in Department of Defense and Air Force problems. Such examples include space systems, missile defense, Battle Management/ Command and Control, network-centric systems, and generally most business and combat support Information systems. Over the last few decades, Systems Engineering has matured into its own discipline, with a foundation on system science using tools and repeatable processes from product development and systems engineering management. Recently, with the pervasive deployment of complex interconnected networked systems, the use of architecture has taken a central role in communicating the system of systems and enterprise-wide solutions.

The Intermediate Development Education (IDE) Graduate Systems Engineering (ISE) program is an ABET accredited resident program leading to a Master of Science (MS) degree in Systems Engineering. The ISE program requirements are identical to the Graduate Systems Engineering (GSE) program with the exception that a thesis is not required. In place of the thesis, the ISE program requires a group project (9 credit hours). The ISE program is nominally a four quarter (12 month) program, with students typically entering in May and graduating in the following June. The ISE program is only for in-residence IDE students.

Program Educational Objectives (PEOs)

The SE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD.

Specific Program Educational Objectives (PEOs) are as follows:

- Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director
- Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk management, requirements management, architecture definition/evaluation and capability assessment

Student Outcomes (SOs)

The Systems Engineering program provides a substantial technical foundation in systems architecture, analysis and design as well as opportunity for specialization within a traditional engineering discipline. The program culminates with an individual thesis or group design project typical of a defense system project. In the design study, the student will apply their individual technical expertise, exercise their system design skills, and experience the group dynamics of a team design effort while solving a realistic defense system problem. Finally, the program provides the necessary education to qualify full-time quota students for the academic degree code assigned to them on entry into the program. Student Outcomes (SOs), those competencies that students are expected to achieve by the completion of the program, are as follows:

- AFIT SE graduates will demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement
- AFIT SE graduates will demonstrate application of the SE process and methods on contemporary problems of interest to the DoD
- AFIT SE graduates will be proficient with many of the tools for implementing the SE process, including development of system architectures, tradeoff and decision analysis, risk management and test planning
- 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
- SE graduates will demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats
- SE graduates will develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, and cyber-warfare, among others

Focus Areas

In order to best meet the needs of our customers, discussions with warfighter integration, capability planning, acquisition, product and logistics centers and MAJCOM requirements organizations have focused our Systems Engineering program. For example, Systems Engineers working within the space community, should know the physics of space surveillance and/or the space environment, be knowledgeable in the wealth of unclassified and classified space technologies and systems and apply lessons learned through a sponsored space-related Capstone project. We achieve this requested focus with a set of specified electives and technical specialty courses.

Student will usually satisfy the AFIT SE degree requirements by choosing a focus area. Based on the current needs of the DoD and the Air Force, our primary focus areas are as follows:

- **Space Systems:** Military space vehicles or a satellite are not “contained” systems, because it is functionally part of a networked constellation of satellites and ground stations synergistically performing a needed mission, providing warfighter capability and creating desired effects. The extreme environments in which these systems operate necessitate unique design and development processes.
- **Airborne Systems:** Performance and design analysis of manned and unmanned aircraft will be examined, as well as major subsystems on our aeronautical systems. These include guidance, navigation, C4, radar, propulsion and structures, and include munitions and their effects.
- **Cyber Warfare:** The Cyber Warfare sequence is designed to study, analyze and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Students develop technical expertise and a technical foundation to better understand and analyze communications/ networks, policy, operations, systems and technologies.
- **Human Systems :** The Human Systems sequence is designed to provide students with graduate level education and the fundamentals of human factors engineering with an understanding of human systems integration and particular emphasis on the Department of Defense applications.

School and Program Admission Criteria

FOR IDE STUDENTS ONLY: This degree program is only available to military personnel and DoD civilians selected by their service component for the resident Intermediate Developmental Education (IDE) program. Waivers to the above criteria may be granted on a case by case basis. Therefore, individuals whose academic credentials fall below any of the above criteria are encouraged to apply.

The general requirements for admission to the Master of Science in Systems Engineering program are as follows:

DEGREE REQUIRED: Any engineering degree (Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. A degree in science (e.g. physics), math or computer science will be considered for admission to a non-ABET Master of Science program on a case-by-case basis. Courses in calculus-based physics and dynamical systems (circuits or engineering dynamics) are required.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q

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

Waivers to the criteria may be granted (on an individual basis) by the Department of Systems and Engineering Management.

Program Elements The ISE program requires a minimum of 48 credit hours covering the following program elements: core courses, mathematics or math science requirement, a distribution course requirement, engineering depth to include an applicable education code sequence, an individual thesis or group project, and any additional Air Force and/or ABET requirements. The program elements are discussed below.

Core Courses:

There are four Systems Engineering core courses. These are:

- SENG 520 Systems Engineering Design
- SENG 610 Systems Engineering Management
- SENG 640 System Architecture and either
- CSCE 593 Intro to Software Engineering or
- SENG 593 Software Systems Engineering

These courses provide a common breadth of knowledge and the basic building blocks for all Air Force and DoD Systems Engineers. All core courses are 4 credit hours.

Mathematic Requirements

Students must complete at least one course in graduate mathematics or math science (3-4 credit hours). Students without a background course in probability and statistics must take a course in this area. Appropriate probability and statistics course is:

- STAT 583 Introduction to Probability and Statistics

Distribution Requirement

The distribution requirement includes one analysis-related course. Appropriate courses (3-4 credit hours) include:

- OPER 543 Decision Analysis (3 credit hours)
- QMGT 680 Project Risk Analysis (3 credit hours)
- LOGM 590 Computer Simulation (4 credit hours)

Engineering Depth

Systems engineering students will also take appropriate engineering and/or applied science courses in the technology area of their thesis or group design project as recommended by their program and/or thesis advisor. While the number of courses in the engineering depth sequence may vary, it is typically three or more courses (technical electives) for 12 or more credit hours. Candidate technical (or specialty) sequences will be developed by the student and the academic advisor and approved by the curriculum chair. A candidate sequence should be a cohesive group of classes in a single discipline area with at least one 600-level (or above) course. Our focused program sequences include, but are not limited to, the following:

- Airborne Systems
- Space Systems
- Cyber Warfare
- Human Systems

Capstone Design Project / Graduate Warfighter Project (GWP)

The breadth of the systems engineer is generally captured through an understanding of processes, ranging from general systems engineering processes to specialized aspects of component design, manufacturing, testing and operations. Systems engineering education transcends the normal engineering education by requiring a deep understanding of key technical processes and their supporting methodologies and tools. The processes are most effectively understood through repeated application and the resulting lessons learned, with knowledge often captured through substantial team projects and hands-on experience. The capstone of the AFIT systems engineering program is the Graduate Warfighter Project. The students typically form a systems engineering team and perform a group design study, which is defended orally. However, in certain situations for part-time or out-of-cycle single-students, an individual thesis may be performed. In any case, the team or individual works on a major project of DoD or Air Force interest allowing the students to apply the systems approach to a real problem in a controlled environment.

The group project for the ISE program will typically be 9 credit hours of SENG 798 spread over three quarters - one credit in the Fall, four credits in the Winter and four more in the Spring.

Elective Coursework

The Systems Engineering degree requirements are 48 credit hours of which 43-44 credit hours provide by the ISE program coursework and project. The remaining 4-5 credit hours of coursework may be used to meet any prerequisites, elective courses, or for addition technical depth.

Air Force Requirements

All full-time Air Force students are required to carry an average of twelve credits per quarter.

ABET Requirements

Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

Program Content

Coursework

39 hours

A total of 39 hours of coursework is satisfied by four Systems Engineering Core courses, a mathematics course (typically Probability and Statistics), an analysis course (typically Decision Analysis, Risk Analysis or Modeling and Simulation) and an Engineering Depth sequence. Additional elective courses can be added to achieve a minimum of 48 total quarter hours.

IDE Research Project

9 hours

Systems Engineering (M.S.)

Program Description

Systems Engineering (SE) is the process by which a customer's needs are satisfied through the conceptualization, design, modeling, testing, implementation, and operation of a working system. There are a range of levels of systems engineering, from product systems engineering used for a standalone product or vehicle platform, to design and integration of so-called "systems of systems" (such as an air operations center or missile defense system), to enterprise wide systems engineering that span an entire organization (such as mobility forces or space command).

The focus on SE becomes especially important in the analysis and synthesis of large and complex systems, such as those that arise regularly in Department of Defense and Air Force problems. Such examples include: space systems, missile defense, Battle Management/ Command and Control, network-centric systems, and generally most business and combat support Information systems. Over the last few decades, Systems Engineering has matured into its own discipline, with a foundation on system science using tools and repeatable processes from product development and systems engineering management. Recently, with the pervasive deployment of complex interconnected networked systems, the use of architecture has taken a central role in communicating the system of systems and enterprise-wide solutions.

The Graduate Systems Engineering (GSE) program is an ABET accredited program leading to a Master of Science (MS) degree in Systems Engineering. This program is provided to both resident students and part-time students via distance-learning (DL) modality. In full time residence, it is nominally a six quarter (18 month) program, with students normally entering in September and graduating in March. For distance learning, it is nominally a 24 month to 36 month program, depending on class availability and part-time course load. For more information about distance learning or about this specific program, and to apply, go to AFIT's Extension Services website <http://www.afit.edu/DL/>

Program Educational Objectives (PEOs)

The SE program takes students with traditional engineering backgrounds (mechanical, electrical, aerospace, etc.) and produces graduates who can effectively use the tools and techniques of both systems science and traditional engineering disciplines to approach and analyze complex problems, design feasible solutions, and select an appropriate solution. It is expected that graduates possessing these skills will go on to make substantive contributions to capability development within the DoD. Specific Program Educational Objectives (PEOs) are as follows:

- Graduates will rise to positions of technical and/or programmatic leadership within capability planning, system acquisition and/or sustainment organizations. Examples of leadership positions include Technical Director, Division Chief, Chief Engineer, and System Program Manager/Director
- Graduates will employ SE methods and tools across the DoD acquisition life cycle. Examples of SE methods and tools include decision analysis, trade studies, risk management, requirements management, architecture definition/evaluation and capability assessment

Student Outcomes (SOs)

The Systems Engineering program provides a substantial technical foundation in system architecture, analysis and design as well as opportunity for specialization within a traditional engineering discipline. The program culminates with an individual thesis or group design project typical of a defense system project. In the design study, the student will apply their individual technical expertise, exercise their system design skills, and experience the group dynamics of a team design effort while solving a realistic defense system problem. Finally, the program provides the necessary education to qualify full-time quota students for the

academic degree code assigned to them on entry into the program. Student Outcomes (SOs), those competencies that students are expected to achieve by the completion of the program, are as follows:

AFIT SE graduates will:

- Demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement.
- Demonstrate application of the SE process and methods on contemporary problems of interest to the DoD.
- 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.
- 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.
- Demonstrate the ability to effectively communicate technically complex ideas and concepts in both spoken and written formats.
- Develop a detailed understanding in at least one technical specialty area such as airborne systems, space systems, human systems and cyber-warfare, among others.

Focus Areas

In order to best meet the needs of our customers, discussions with warfighter integration, capability planning, acquisition, product and logistics centers and MAJCOM requirements organizations have focused our Systems Engineering program. For example, Systems Engineers working within the space community, should know the physics of space surveillance and/or the space environment, be knowledgeable in the wealth of unclassified and classified space technologies and systems and apply lessons learned through a sponsored space-related Capstone project. We achieve this requested focus with a set of specified electives and technical specialty courses.

Students will usually satisfy the AFIT SE degree requirements by choosing a focus area. Based on the current needs of the DoD and the Air Force, our primary focus areas are as follows:

- **Airborne Systems:** Performance and design analysis of manned and unmanned aircraft will be examined, as well as major subsystems on our aeronautical systems. These include guidance, navigation, C4, radar, propulsion and structures, and include munitions and their effects.
- **Space Systems:** Military space vehicles or satellites are not “contained” systems, because their functionality is part of a networked constellation of satellites and ground stations synergistically performing a needed mission, providing warfighter capability and creating desired effects. The extreme environments in which these systems operate necessitate unique design and development processes.
- **Cyber Warfare:** The Cyber Warfare sequence is designed to study, analyze and challenge theories on the application of cyber power (offensive and defensive) to achieve strategic and operational military objectives. Students develop technical expertise and a technical foundation to better understand and analyze communications/ networks, policy, operations, systems and technologies.
- **Logistics (supply chain) Systems:** The Logistics systems sequence is designed to provide students with graduate level education in the fundamentals of Supply Chain Management (SCM), with particular emphasis on Department of Defense (DoD) and Air Force specific applications. Statistical data analysis and basic quantitative modeling, to include linear programming, simulation analysis, and heuristics, are included. Students will be able to apply state of the art analytical and problem solving techniques to Air Force and DoD supply chain management problems.
- **Human Systems :** The Human Systems sequence is designed to provide students with graduate level education in the fundamentals of Human Factors Engineering with an understanding of Human Systems Integration, and particular emphasis on Department of Defense (DoD) applications. Courses in integration of human systems, human factors, human performance measurement, design of human computer interfaces and display/control systems, are included. This focus area will prepare students to apply state of the art analytical and problem solving techniques to design of systems having a significant human component.
- **Information Systems :** The IS focus area is designed to provide students with the perspective, knowledge and skills needed to develop, manage, and integrate enterprise-wide information systems for the Air Force, DoD, and allied military organizations in future assignments as middle and upper-level managers and leaders. Focus on IS will improve students understanding of DoD information systems, cyber-computer networks, organizational and enterprise systems-related issues, including strategy formulation and application, architecture analysis and design, cyber security issues and practices, technological systems design/development/acquisition and related business process support.

School and Program Admission Criteria

The general requirements for admission to the Master of Science in Systems Engineering program are as follows:

DEGREE REQUIRED: Any engineering degree (Aeronautical, Astronautical, Aerospace, Chemical, Civil, Computer, Industrial, Mechanical, Electrical, or Systems Engineering) or a degree in Engineering Science. A degree in science (e.g. physics), math or computer science will be considered for admission to a non-ABET Master of Science program on a case-by-case basis. Courses in calculus-based physics and dynamical systems (circuits or engineering dynamics) are required.

MATHEMATICS REQUIRED: Ordinary Differential Equations

TEST REQUIRED: GRE - 153V/148Q.

GPA REQUIRED: OVERALL 00Q- 3.0; MATH - 3.0; MAJOR - 3.0

Students in the Wright-Patterson area who do not meet these criteria may register for individual courses as a part-time student (space available) but are expected to meet the above criteria prior to being granted candidacy for the degree. Waivers to the criteria may be granted (on an individual basis) by the Department of Systems Engineering and Management.

Degree Requirements

The GSE program requires a minimum of 48 credit hours covering the following program elements: core courses, mathematics or math science requirement, a distribution course requirement, engineering depth to include an applicable education code sequence, an individual thesis or group project, and any additional Air Force and/or ABET requirements. The program elements are discussed below.

Core Courses

There are four Systems Engineering core courses.

- SENG 520 Systems Engineering Design
- SENG 610 Systems Engineering Management
- SENG 640 System Architecture
and either
- CSCE 593 Intro to Software Engineering
or
- SENG 593 Software Systems Engineering

These courses provide a common breadth of knowledge and the basic building blocks for all Air Force and DoD Systems Engineers. All core courses are 4 credit hours.

Mathematic Requirements

Students must complete at least one course in graduate mathematics or math science (3-4 credit hours). Students without a background course in probability and statistics must take a course in this area. Appropriate probability and statistics courses include:

- STAT 583 Introduction to Probability and Statistics
- STAT 527 Introduction to Probability
- STAT 537 Introduction to Statistics

Additional math science courses include:

- MATH 509 Mathematical Methods in the Physical Sciences
- MATH 633 Graph Theory

Distribution Requirement

The distribution requirement includes a course in decision analysis, risk, simulation, project management, risk, leadership, cost analysis, financial management, economics, information/knowledge management and/or human factors. Primary candidate courses (3-4 credit hours) include:

- OPER 543 Decision Analysis (3 credit hours)
- QMGT 680 Project Risk Analysis (3 credit hours)
- LOGM 590 Computer Simulation (4 credit hours)

Additional distribution courses could include:

- IMGT 669 Business Process Improvement (3 credit hours)
- IMGT 680 Knowledge Management (4 credit hours)
- IMGT 684 Strategic Information Management (3 credit hours)
- SENG 560 Human Systems Integration (4 credit hours)
- SENG 570 Lean for Scientists and Engineers (3 credit hours)

Engineering Depth

Systems engineering students will also take appropriate engineering and/or applied science courses in the technology area of their thesis or group design project as recommended by their program and/or thesis advisor. While the number of courses in the engineering depth sequence may vary, it is typically three or more courses (technical electives) for 12 or more credit hours.

Candidate technical (or specialty) sequences will be developed by the student and the academic advisor and approved by the curriculum chair. A candidate sequence should be a cohesive group of classes in a single discipline area with at least one 600-level (or above) course. Our focused technical sequences include, but are not limited to, the following:

Airborne Systems	Decision Analysis
Human Systems	Optimization
Space Systems	Modeling and Simulation
C4ISR Systems	Reliability
Information Ops/ Cyber Warfare	Software Engineering
Sensors	Logistics Systems
MASINT	

Individual Thesis or Group Project

The breadth of the systems engineer is generally captured through an understanding of processes, ranging from general systems engineering processes to specialized aspects of component design, manufacturing, testing and operations. Systems engineering education transcends the normal engineering education by requiring a deep understanding of key technical processes and their supporting methodologies and tools. The processes are most effectively understood through repeated application and the resulting lessons learned, with knowledge often captured through substantial team projects and hands-on experience.

The capstone of the AFIT systems engineering program is the group design project. The students typically form a systems engineering team and perform a group design study, which is defended orally. However, in certain situations for part-time or out-of-cycle single-students, an individual thesis may be performed. In any case, the team or individual works on a major project of DoD or Air Force interest allowing the students to apply the systems approach to a real problem in a controlled environment.

The individual thesis or group project for the GSE program will be minimum of 12 credit hours of SENG 799, typically spread over 3 or more quarters.

Elective Coursework

The Systems Engineering degree is 48 credit hours. Depending on the number of technical sequence and associated prerequisites, additional credit hours to achieve this 48 total may be necessary, which can be fulfilled by any elective courses.

All full-time Air Force students are required to carry an average of twelve credits per quarter, thus will complete a minimum of 72 total credit hours during the normal 6-quarter resident program. The additional 24 credit hours of coursework will be used by the student to meet any prerequisites and to take a second engineering depth sequence. Remaining coursework may be fulfilled by elective courses found from the AFIT catalogue.

Air Force Requirements

Some Air Force officers attending AFIT as full-time quota students are assigned an Advanced Academic Degree Code, or education code. The requirements for the education code are normally met by taking at least three classes as part of an engineering depth sequence (or in addition to optional sequences). Currently supported education codes and their corresponding requirements are listed below:

4TFY: Human Systems

- SENG 560 Human Systems Integration
- HFEN 560 Introduction to Human Factors
- HFEN 610 Human Performance Measurement
- HFEN 663 Human-Computer Interaction
- HFEN 670 Human Interaction Technologies

4THY: Operations Research

- OPER 543 Decision Analysis
- OPER 610 Linear Programming and Network Flows
- OPER 612 Nonlinear Programming
- OPER 621 Multiple Criteria Decision Making
- OPER 643 Advanced Decision Analysis
- OPER 647 Queuing System Analysis
- OPER 561 Discrete Event Simulation

4TIY: Optimization

- OPER 610 Linear Programming and Network Flows
- OPER 612 Nonlinear Programming
- OPER 613 Integer Programming
- OPER 615 Large-scale System Optimization

4TJY: Reliability

- SENG 585 Reliability in Systems Design
- SENG 685 Reliability Engineering
- SENG 687 Advanced Topics in Reliability or Additional Probability and Statistics course

4TKY: Simulation

- OPER 660 Object Oriented Simulation
- OPER 661 Simulation Modeling & Analysis
- OPER 683 Response Surface Methodology

1AUY (Information Resource Management), 0IYY (Information Systems Management), and 1AME (Management Information Systems)

- SENG 520 Systems Engineering Design
- IMGT 561 Applications of Database Management Systems
- IMGT 657 Data Communications
- SENG 640 Systems Architecture

ABET Requirements

Only students possessing an ABET accredited undergraduate degree will be qualified to earn the Master of Science in Systems Engineering. Students admitted to the Systems Engineering program without an ABET accredited undergraduate degree will earn a Master of Science degree accredited by the North Central Association of Colleges and Schools.

Degree Requirements

Coursework

36 hours

A total of 36 hours of coursework is satisfied by four Systems Engineering Core courses, a mathematics course (typically Probability and Statistics), an analysis course (typically Decision Analysis, Risk Analysis or Modeling and Simulation) and an Engineering Depth sequence. Additional elective courses can be added to achieve a minimum of 48 total quarter hours.

Thesis

12 hours

Systems Engineering (PhD.)

Program Description

The Department of Systems Engineering and Management offers a doctoral program which leads to the award of a PhD. 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 – 156V/151Q

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 PhD dissertation.

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.

Student Outcomes (SOs)

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.

SE Graduates will:

- Demonstrate thorough understanding of the SE process from mission area analysis through requirements definition to system development, sustainment, and retirement
- Demonstrate application of the SE process and methods on contemporary problems of interest to the DoD
- 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
- 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
- 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

Capstone Project

4 Hours

Test and Evaluation Certificate (DL)

Program Description

The Test and Evaluation Certificate Program (TECP) is a graduate level education program focused on the application of operational analysis techniques and methodology as applied to the Test and Evaluation (T & E) Community. The program provides an understanding of planning and analysis tools dedicated to supporting the evaluation of test data, test design, and results from test execution. Particular emphasis is given to incorporating past, present, and future DoD T & E examples from all aspects of test (developmental, operational, etc.) into the curriculum to tailor the applications of the methodology and approaches within each course. Current T & E focus in design of experiments (DOE) and reliability, maintainability, and availability (RM&A) analysis are addressed in required courses to complete the program.

Program Outcomes (POs)

Our Program Outcomes (student knowledge/skills/abilities) produce graduate certificate conferees who exhibit:

- The ability to identify and apply basic concepts required for supporting statistical analysis within the T & E Community
- 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
- Improve problem solving ability, critical thinking skills, and test planning skills

School and Program Admission Criteria

Degree Required: Bachelor's degree or equivalent in an appropriate engineering or scientific discipline (mathematics, physical science, engineering, or computer science is highly desirable.)

Mathematics Required: Calculus I and II

Test Required: None

GPA Required: Overall - 3.0; Math - 3.0

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

Related Programs

The TECP includes courses that comprise the Applied Statistics specialty in the Graduate Operations Research in-resident Master's degree program. The TECP is also a specialty area in the distance learning and in-residence Systems Engineering Master's degree program.

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
- OPER 689 – Advanced Statistical Methods for Test

Academic Policies

Associate Dean for Academic Affairs: Paul J. Wolf, PhD.

2950 Hobson Way, Building 641, Room 217

Wright-Patterson AFB OH 45433-7765

Phone: (937) 255-0452

Fax: (937) 255-5989

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 11-week quarters (fall, winter, spring, and summer), each of which includes a week for final exams. Full-time military students assigned to AFIT attend a 4-week technical review session ("short term") commencing in June and September, following Student Orientation. The Graduate School academic calendar can be found in the AFIT Graduate School Catalog, the Student Handbook, or online at http://www.afit.edu/ENER/calendars.cfm . The academic calendar shows holidays and break periods, as well as the beginning and end of each quarter. Published calendars are subject to change with the approval of the Dean.
Auditing	<p>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.</p> <p>Audited courses are billed as graded courses.</p> <p>Audited courses can also be retaken for credit in the future.</p>
Classification of Students	The Graduate School recognizes 12 quarter hours as a minimum course load to be considered as a full-time student. Students who hold either Research Assistantships (RA) or Teaching Assistantships (TA) are considered full-time as long as they enroll in a minimum of 9 quarter hours per term. A student registered in courses totaling fewer than 12-quarter hours is considered part-time, unless stated otherwise in a student's approved curriculum plan. Part-time students are limited to courses totaling no more than eight quarter hours in a single quarter. Once admitted, part time students are subject to the academic rules and regulations that apply to full-time students.
Course Listings and Schedules	Projected course listings for an academic year are typically published on the Graduate School's website. Final class schedules are available one quarter in advance of the quarter when the courses are actually offered. 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.
Enrollment	All students in a degree program are required to maintain continuous enrollment in every term from matriculation to the award of the degree.
Course Changes (Drop/Add)	Courses may be added through the end of the first week of the quarter. Courses may be dropped without record during the first two (2) weeks of the quarter, subject to approval of the student's faculty advisor. Students may withdraw from a course during the third week and through the eighth week with a record. No courses may be added after week 1 and no courses may be dropped after week 8 of the quarter. All course changes after the first week are made using the AFIT

Registration Form and require approval of the instructor, academic advisor, and Department Head. The completed Registration Form must be delivered to the Office of the Registrar.

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 Credit	ENOI 36-167, Transfer Credit Policy, establishes procedures for students in Master's degree programs to transfer up to 12 quarter hours of graduate credit from other regionally-accredited institutions prior to matriculation at the Graduate School of Engineering and Management. For information about the possible transfer of courses taken during or after matriculation at the Graduate School, please refer to ENOI 36-104, Policy for the Removal of Academic Deficiencies for Students in Master's Degree Programs. The Graduate School does not accept transfer credit for PhD. programs. 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.
Registration	Students must be admitted into the Graduate School of Engineering and Management in order to register and earn credit for coursework. The responsibility for being properly registered for courses rests with the student. Registration is required for each term for all students who enter coursework for credit. Registration instructions and guidelines can be obtained from the Registrar's Office, and the registration dates are published on the AFIT website at http://www.afit.edu/ENER/calendars.cfm
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.
Confidentiality of Academic Records	The Family Education and Privacy Act of 1974, as amended, is a federal law that grants to students the right to inspect, obtain copies, challenge, and to a degree control the release of information contained in his/her records. Guidelines and a full text of the law can be obtained from the Registrar's Office.
Change of Address	Students, who have a change in their permanent or local address while attending AFIT, should make changes through Web Advisor or submit the change in writing to the Registrar's Office or Student Services Office. Billing address changes should be reported to the Bursar.
Grade of Incomplete	The grade of Incomplete ("I") is given for failure to complete the required work in a course or thesis. The grade of "I" is subject to approval by the Dean. A student cannot graduate from the AFIT Graduate School with a grade of "I". The student must resolve the grade of "I" with a regular ("A, B, etc.") grade within a reasonable time period as determined by the instructor or thesis advisor. The "Request for Grade of Incomplete," available on the Graduate School (Registrar) website must be completed/submitted as indicated on that request form.
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. 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. Requests for Transcripts are usually processed within 5 duty days after receipt.
Grading System	Academic achievement is indicated by the following letter grades and grade 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	
I	Incomplete ^{1,2}	
P	Progress (PhD) ¹	
S	Satisfactory ^{1,4}	
U	Unsatisfactory	
W	Withdrawn ¹	
NG	No Grade Posted	
AU	Audit ¹	

Further
Clarification

- "S" grades count only toward earned hours and do not affect the grade point average (GPA). "U" grades are also to be assigned for thesis or dissertation credits during which the student's progress toward completion has been unsatisfactory. The grades "IP" and "P" are given for satisfactory progress in thesis and dissertation research courses.
- The instructor or the academic advisor, in coordination with the Dean, will determine the resolution deadline.
- Please see your instructor as soon as possible.
- 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)	<p>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.</p> <p>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.</p> <p>The Air Force Institute of Technology rewards excellent academic performance during graduation by designating certain students as "Distinguished Graduates." The number of distinguished graduates is limited to no more than 10% of the graduating class.</p>

Academic Standards

Academic Integrity	Students are expected to adhere to the highest standards of academic integrity, in accordance with Air University Instruction 36-2309, <i>Academic Integrity</i> . 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	<p>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.</p> <p>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 2.5.</p>
Dismissal	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 recorded on the student's permanent record.

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

Master's Degree Programs

All Master's degree programs typically consist of five elements

- 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
- A specialization area* which provides in-depth knowledge in a chosen field
- Electives* that are used to round the student's experience or provide additional background material.
- A mathematics requirement
- An independent research project, which carries a 12-credit-hour load

*Students choose their electives and specialization courses based on their academic interest and the requirements of the AF 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:

- Complete at least 48 quarter hours of required graduate courses and approved graduate electives
- 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
- 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
- Complete all degree requirements within six calendar years after beginning the first course in an approved program.
- 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 cases 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 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*.

Doctor of Philosophy Programs

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

The Doctor of Philosophy degree is awarded by universities in many parts of the world as the mark of highest achievement in preparation for active scholarship and research. The doctoral program is designed to prepare a student for a lifetime of intellectual inquiry that manifests itself in creative scholarship and research. The program emphasizes freedom of inquiry and expression and development of the student's capacity to make significant contributions to knowledge. An essential element is the development of the ability to understand and evaluate critically the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge. All of this is most effectively accomplished in close association with those experienced in research and teaching.

A central purpose of doctoral programs is the extension of knowledge, but this cannot be accomplished on all fronts simultaneously. Students must choose an area in which to specialize or a professor with whom to work. Individualized programs of study are then developed and committee members are selected cooperatively as course work is completed and research undertaken. When all courses have been taken, the research finished, the dissertation written, and all examinations passed, the student will have acquired the knowledge and skills expected of a scholar and will have extended knowledge in the field. Details of requirements and policies are documented in AFIT instructions, Graduate School of Engineering and Management instructions, and Doctoral Council policy letters. These are available at AFIT.

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

- Complete an approved program of study
- Meet the residency requirement
- Pass specialty examination
- Be admitted into candidacy
- Submit a dissertation
- Successfully defend the dissertation

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

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

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

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 PhD. study are expected to carry a full academic load of 12 credit hours per quarter. Other PhD. 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> <ul style="list-style-type: none"> • The PhD courses are of such advanced nature that a student needs time to understand and assimilate the material contained therein • The limitation allows time to interact with other PhD students and with the faculty • It allows time to explore areas that may intrigue him or her in the pursuit of the course work
Standards of Work	<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> <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 viewed as an ongoing process, in which the "defense" can be adjourned and reconvened (as necessary) until the committee accepts the prospectus.</p>
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> <ul style="list-style-type: none"> • Passing the qualifying examination • An academic record of the student that meets the program and grade point average requirements • Approval of the student's prospectus for the dissertation project • Completion of the residency requirement or approval of a specific plan for meeting

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

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

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

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

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

Financial Assistance for Persons Eligible to Enroll in the AFIT Graduate School

Certain persons eligible to enroll in the AFIT Graduate School may be eligible for financial or scholarship support, some of which carries a commitment of employment or continued employment with the Federal Government. The following is not all inclusive. Inquiries should be directed to the appropriate contacts listed below.

Department of Defense (DoD) Programs

Information concerning the Science, Mathematics and Research for Transformation (SMART) scholarships is available at <https://smart.asee.org>.

United States Air Force (USAF) Programs

CYBERCORPS

The AFIT Graduate School provides scholarship opportunities for U.S. citizens seeking a Master's Degree in Cyber Operations at the AFIT Graduate School. This scholarship is made possible through a grant from the National Science Foundation (NSF) Scholarship for Service (CyberCorps) Program. This 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 support. A typical program length is 24 months. Benefits include full tuition, stipend, computer and book allowances, and conference travel opportunities. For details, visit: <https://www.afit.edu/ccr/cybercorps/>.

PALACE Acquire

As part of the Pathways Programs, the PALACE Acquire (PAQ) Program offers the opportunity to occupy a permanent, full-time position during a two-to-four-year, formal training plan designed to let participants experience both personal and professional growth while dealing effectively and ethically with change, complexity, and problem solving. Participants will receive promotions and yearly salary increases based upon their successful performance and supervisory approval. Upon completion of the formal training plan, the PALACE Acquire Program offers participants a permanent position at the current duty location or within the servicing major command, making it a great opportunity to begin a successful civilian career with Air Force Civilian Service (AFCS).

For details, visit: <http://www.afciviliancareers.com/content/palace-acquire-qualifications/>.

Civilian Developmental Education (CDE) Program

The development and leadership programs offered through the CDE program are designed to prepare future leaders with the skills to meet both corporate Air Force and functional leadership requirements. This is accomplished by selecting the right person at the right time for the right training and putting that training to work in an appropriate follow-on assignment. We encourage you to continue in self-development as the Air Force works to increase the leadership potential of our most important resource—our people. For details, visit: <https://gum-crm.csd.disa.mil/app/login/redirect/home>

Consortia

The Air Force Institute of Technology is a member of two consortia, DAGSI (Dayton Area Graduate Studies Institute) and SOCHE (Southwestern Ohio Council for Higher Education) giving students the ability to benefit from courses and program offerings at member institutions.

Dayton Area Graduate Studies Institute (DAGSI)

The Air Force Institute of Technology is a member institution of the Dayton Area Graduate Studies Institute (DAGSI), along with the University of Dayton and Wright State University. Although scholarships are currently on hold, please contact DAGSI at www.DAGSI.org for general and detailed information concerning academic offerings and program availability at member institutions.

Southwestern Ohio Council for Higher Education (SOCHE)

SOCHE is a consortium of 20 colleges and universities, one foundation, and two corporations (see <http://www.SOCHE.org>). One of its goals is to promote inter-institutional cooperation and one of its programs, the cross-registration program, can be used as a vehicle for AFIT students to obtain courses not otherwise available at AFIT. 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. Students can attend courses at consortium institutions with no charge of tuition. Enrollment is based on the availability of space in the class and courses must be part of an approved program of study leading to a degree.

Specifics can be found at <https://www.soche.org/students>.

AFIT Graduate School Academic Calendar: 2015-2016

Fall Orientation/Review Session 2015

Military Students Arrive	Mon-Friday	17 - 21 Aug
New Student Orientation/In-Processing Begins	Monday	17-Aug
New Student Orientation/In-Processing Ends	Friday	28-Aug
Technical Refresher Course Begins	Monday	31-Aug
AETC Family Day	Friday	4-Sep
Labor Day (Holiday)	Monday	7-Sep
New Student Registration for Fall Quarter Begins	Monday	14-Sep
Technical Refresher Course Ends	Wednesday	30-Sep
New Student Registration for Fall Quarter Ends	Friday	9-Oct

Fall Quarter 2015

Fall Quarter Classes Begin	Thursday	1-Oct
Late Registration for Fall Quarter Begins	Thursday	1-Oct
Late Registration for Fall Quarter Ends	Friday	9-Oct
Last Day to Add a Class	Friday	9-Oct
Columbus Day (Holiday)	Monday	12-Oct
Last Day to Drop a Class Without a Record	Friday	16-Oct
Pre-Registration for Winter Quarter Begins	Monday	2-Nov
Veterans Day (Holiday)	Wednesday	11-Nov
Applications for Graduation w/Academic Evaluations Due	Friday	20-Nov
Last Day to Drop a Class	Wednesday	25-Nov
Thanksgiving Day (Holiday)	Thursday	26-Nov
AETC Family Day	Friday	27-Nov
Final Copies of Dissertations Due in the Thesis Processing Center	Monday	30-Nov
Final Copies of Theses Due in the Thesis Processing Center	Friday	4-Dec
Pre-Registration for Winter Quarter Ends	Friday	4-Dec
Open Registration for Winter Quarter Begins	Monday	7-Dec
Fall Quarter Classes End	Friday	11-Dec
Final Examinations Begin	Monday	14-Dec
Final Examinations End	Thursday	17-Dec
Open Registration for Winter Quarter Ends	Friday	18-Dec
Fall Graduation (degree conferral date-no ceremony)	Thursday	24-Dec
AETC Family Day	Thursday	24-Dec
AETC Family Day	Thursday	31-Dec

Winter Quarter 2016

Winter Quarter Classes Begin	Monday	4-Jan
Late Registration for Winter Quarter Begins	Monday	4-Jan
Late Registration for Winter Quarter Ends	Friday	8-Jan
Last Day to Add a Class	Friday	8-Jan
Last Day to Drop a Class Without a Record	Friday	15-Jan
Martin Luther King, Jr. Day (Holiday)	Monday	18-Jan
Pre-Registration for Spring Quarter Begins	Monday	8-Feb
Presidents' Day (Holiday)	Monday	15-Feb
Applications for Graduation w/Academic Evaluations Due	Friday	19-Feb
Last Day to Drop a Class	Friday	26-Feb
Final Copies of Dissertations Due in the Thesis Processing Center	Monday	7-Mar
Pre-Registration for Spring Quarter Ends	Friday	11-Mar
Winter Quarter Classes End	Friday	11-Mar
Final Copies of Theses Due in the Thesis Processing Center	Friday	11-Mar
Final Examinations Begin	Monday	14-Mar
Open Registration for Spring Quarter Begins	Monday	14-Mar
Final Examinations End	Thursday	17-Mar
Commencement	Thursday	24-Mar
Open Registration for Spring Quarter Ends	Friday	25-Mar

Spring Quarter 2016

Spring Quarter Classes Begin	Monday	28-Mar
Late Registration for Spring Quarter Begins	Monday	28-Mar
Late Registration for Spring Quarter Ends	Friday	1-Apr
Last Day to Add a Class	Friday	1-Apr
Last Day to Drop a Class Without a Record	Friday	8-Apr
Pre-Registration for Summer Quarter Begins	Monday	2-May
Applications for Graduation w/Academic Evaluations Due	Friday	13-May
Last Day to Drop a Class	Friday	20-May
AETC Family Day	Friday	27-May
Memorial Day (Holiday)	Monday	30-May
Final Copies of Dissertations Due in the Thesis Processing Center	Monday	31-May
Spring Quarter Classes End	Friday	3-Jun
Final Copies of Theses Due in the Thesis Processing Center	Friday	3-Jun
Pre-Registration for Summer Quarter Ends	Friday	3-Jun
Final Examinations Begin	Monday	6-Jun
Final Examinations End	Thursday	9-Jun
Open Registration for Summer Quarter Begins	Monday	13-Jun
Spring Graduation (degree conferral date-no ceremony)	Thursday	16-Jun
Air Mobility (Fort Dix) Commencement	Friday	17-Jun
Open Registration for Summer Quarter Ends	Friday	17-Jun

Summer Orientation/Review Session 2016

Military Students Arrive	Thursday	19-May
New Student Orientation/In-Processing Begins	Friday	20-May
New Student Orientation/In-Processing Ends	Thursday	26-May
AETC Family Day	Friday	27-May
Memorial Day (Holiday)	Monday	30-May
Technical Refresher Course Begins	Tuesday	31-May
New Student Registration for Summer Quarter Begins	Monday	13-Jun
Technical Refresher Course Ends	Thursday	23-Jun
New Student Registration for Summer Quarter Ends	Friday	24-Jun

Summer Quarter 2016

Summer Quarter Classes Begin	Monday	27-Jun
Late Registration for Summer Quarter Begins	Monday	27-Jun
Late Registration for Summer Quarter Ends	Friday	1-Jul
Last Day to Add a Class	Friday	1-Jul
Independence Day (Holiday)	Monday	4-Jul
AETC Family Day	Tuesday	5-Jul
Last Day to Drop a Class Without a Record	Friday	8-Jul
Pre-Registration for Fall Quarter Begins	Monday	1-Aug
Applications for Graduation w/Academic Evaluations Due	Friday	12-Aug
Last Day to Drop a Class	Friday	19-Aug
Final Copies of Dissertations Due in the Thesis Processing Center	Monday	29-Aug
Summer Quarter Classes End	Thursday	1-Sep
Final Copies of Theses Due in the Thesis Processing Center	Thursday	1-Sep
Pre-Registration for Fall Quarter Ends	Friday	2-Sep
AETC Family Day	Friday	2-Sep
Labor Day (Holiday)	Monday	5-Sep
Open Registration for Fall Quarter Begins	Monday	5-Sep
Final Examinations Begin	Tuesday	6-Sep
Final Examinations End	Friday	9-Sep
Summer Graduation (degree conferral date-no ceremony)	Thursday	15-Sep
Open Registration for Fall Quarter Ends	Friday	16-Sep

Office of Admissions and the Registrar

Registrar and Director of Admissions: Kathleen K. Hall, M.A.

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)

Office of Admissions

Phone: (937) 255-6234 x3184 (DSN 785-6234 x3184)

Toll Free 800-211-5097 x3184.

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

Email address: ENERAdmissions@afit.edu.

Web link: <http://www.afit.edu/Admissions>.

ADMISSION TO THE AFIT GRADUATE SCHOOL

Who May Apply	<p>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, civilians employed by certain defense industry contractors, and military officers from select foreign countries. The Office of Admissions will assist all interested parties with their admission and application questions. Please contact Admissions at http://www.afit.edu/Admissions or apply online at http://www.afit.edu/Admissions/AFITApplicationProcess. Applicants who happen to be on veterans, or otherwise eligible, may qualify for the education benefits offered through the Veterans Administration, see "Financial Assistance."</p>
Admissions Standards	<p>The faculty determines the admissions standards for the Graduate School of Engineering and Management. The standards maintained by the Graduate School and individual departments and programs are applied to ensure that applicants admitted to the Graduate School have adequate undergraduate and graduate preparation in their proposed field of study and possess a reasonable expectation of successfully completing a graduate program.</p> <p>Prospective students may apply for admission to the Graduate School of Engineering and Management during or after their final year of undergraduate study, but must furnish proof of graduation before the end of their first quarter of enrollment. Prospective students applying for admission to a graduate degree program in a field of specialization in which they already hold that same degree or its equivalent may do so only if the previous degree program was of substantially different character or was not regionally accredited.</p> <p>Applicants who apply for admission to the Graduate School are evaluated on the individual merits of their academic achievements and scholarly potential to complete graduate-level coursework and curriculum requirements. Admission is granted only upon the recommendation of the department and approval of the Dean. The decision to admit an applicant to a program is based primarily on a combination of the following criteria and according to the academic requirements of the specific graduate program.</p>
Academic Eligibility Criteria – Master's Degree	<p>Applicants, applying for Master's programs, who meet the criteria below are generally considered fully-qualified and can immediately enter a Master's degree program, and have a greater potential to successfully complete a Master's degree program in the nominal time of 18 months.</p> <p>Hold an appropriate bachelor's degree in an area relevant to the Master's program of interest from a regionally accredited college or university in the United States, or the equivalent of this degree from another country. Meet or exceed grade point average of 3.00 based on a 4.00 scale. Submit satisfactory scores on standardized examinations like the Graduate Record Examination (GRE) or, depending on the program, the Graduate Management Admissions Test (GMAT). The recommended GRE scores are 153 verbal and 148 quantitative (or 500 verbal and 600 quantitative for GREs taken prior to 1 Aug 2011).</p> <p>The recommended GMAT score is 550 or higher.</p>

Academic Eligibility Criteria – Doctoral Degree

Admission to PhD. programs is open to qualified individuals who:

- 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
- Hold a Master's degree from a regionally accredited college or university in the United States, or the equivalent of this degree in another country
- Grades averaging at least a 3.50 in an area relevant to the doctoral program of interest
- GRE scores of at least 156 verbal and 151 quantitative (or 550 verbal and 650 quantitative for GREs taken prior to 1 August 2011)
- Depending on the program, a GMAT score of 650 or higher
- Two (2) Letters of Recommendation are required from thesis advisor.

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 unless specifically coordinated and approved by HQ AFPC and the functional area manager at the Air Staff.

Academic Eligibility Criteria for Certificate Programs and Non-Degree Seeking Applicants

The entry requirements for certificate programs and non-degree seeking status are the same as those stated above for Master's degree programs, with the exception that a standardized test (GRE, GMAT) is not required. Students enrolled in a certificate program are limited to the classes required for the certificate program, therefore, taking additional classes requires department approval, or a change of enrollment to another certificate program or to a degree program. A maximum of 12 quarter hours of graduate credit, earned in a non-degree status and/or transferred from another regionally-accredited institution may be permitted for application toward an advanced degree, once the student obtains acceptance into a degree program.

Non-degree seeking 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. Admission in a non-degree-seeking status is reserved for those interested in course enrollment for professional development, intellectual enrichment, or exploring the possibility of applying later for a graduate degree program or certificate program. Non-degree students may earn a maximum of 12 quarter hours, either in non-degree status and/or transferred from another regionally-accredited institution. In addition, non-degree students may only register for up to 12 quarter hours of coursework. If the non-degree seeking student desires to take more classes, they must complete a "Change of Enrollment" form and choose non-degree-seeking status under a different academic focus, or move to a certificate or degree program.

General Application Process

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

Applicants must submit their application packages in order to be received, processed, and the applicant admitted to the Graduate School, no later than the last day of the first week of the first term the applicant plans to attend. General inquiries for admission should be addressed to:

Office of Admissions
Graduate School of Engineering and Management
AFIT/ENER, Bldg 641, Room 1022950 Hobson Way
Wright-Patterson Air Force Base OH, 45433-7765
1-800-211-5097 x3184;
<http://www.afit.edu/Admissions>

Note: Officers, enlisted personnel, and federal civil servants applying for full-time graduate study who are interested in attending the Graduate School of Engineering and Management under the sponsorship of their

respective military service or government agency must seek selection through a process defined by their respective service. All sponsored selection processes include establishing academic acceptance by the Graduate School's Admissions Office

Required Documentation for Master's and Doctoral Degree Programs

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

- A completed online application form
- One complete set of official transcripts from each school attended reflecting all undergraduate and graduate work completed or in progress. Each transcript must bear the signature of the registrar, the institution's official seal, years of attendance, courses taken, grades received, and if applicable, the degree, certificate or diploma received
- For doctoral programs only, if you did not receive a Master's degree from the AFIT Graduate School of Engineering and Management, please submit two letters of academic recommendation, preferably from faculty involved in or aware of your Master's thesis
- The Graduate School of Engineering and Management graduate degree programs require applicants to submit standardized test scores applicable to the program requested. The Graduate Record Examination (GRE) is acceptable for all Master's and doctoral degree programs. The GMAT is accepted by several Master's and doctoral degree programs. Please contact Admissions if you cannot determine which standardized test are accepted under the academic department's web pages. Examination scores should be sent directly to the Admissions Office by the appropriate testing agency. AFIT's institutional code for the GRE and GMAT is 1827, and we are listed in the GRE/GMAT booklets under the State of Ohio.
- AFIT exists within the framework of the United States Air Force; therefore, with the exception of international military officers sponsored by their governments, all U.S. Government civilian employees and civilians employed by certain defense industry contractors must provide proof of U.S. citizenship prior to being admitted to the AFIT Graduate School.

For more information about these tests, you may visit the GRE/GMAT websites (www.gre.org or www.gmat.org)

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:

- A completed online application form
- An official transcript from the institution which granted the highest degree. In the event that the applicant holds equivalent level higher degrees, the most recently awarded degree transcript is required
- AFIT exists within the framework of the United States Air Force; therefore, with the exception of international military officers sponsored by their governments, all U.S. government civilian employees and civilians employed by certain defense industry contractors, must provide proof of U.S. citizenship prior to being admitted to the AFIT Graduate School

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

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

International Military Officers

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

Application Process for

Application packages for admission eligibility should arrive at the AFIT Graduate School's International Student Military Office no later than 31 March of each year, in preparation for entrance to the AFIT Graduate

International
Military
Officers

School the following September. The international military officer seeking admission to the AFIT Graduate School must have the following documents submitted:

- Official academic transcripts, either in English or accompanied by an English translation, from every academic institution attended. **The AFIT Graduate School strongly recommends that all official academic transcripts be accompanied by a foreign course-by-course credential evaluation by an independent evaluation service that is a member of the National Association of Credential Evaluation Services (NACES) in order for courses to be considered for credit at the AFIT Graduate School.** In order for it to be considered official, the course-by-course evaluation must be sent directly from the NACES-affiliated evaluation service to the AFIT Graduate School or to the United States Security Assistance Office (SAO) at the United States Embassy in the international military officer's home country. A full list of NACES members is available online. Applicants are responsible for the payment of that fee.
- The Test of English as a Foreign Language (TOEFL) is required for all international military officers except as noted below. Two TOEFL's are acceptable, the Internet-Based Testing with a minimum TOEFL score of 76, or under Computer-Based Test, a minimum score of 207 is required for admission to the AFIT Graduate School. A satisfactory command of the English language is required for admission to the AFIT Graduate School. Therefore, international military officers from non-English speaking countries are required to validate their fluency in English through the Test of English as a Foreign Language (TOEFL). For more information about this test, you may visit the TOEFL website (<http://www.ets.org/toefl>). The Defense Security Assistance Agency (DSSA) publishes an exemption list annually and these countries are exempted from the TOEFL requirement: Antigua, Australia, Bahamas, Barbados, Belize, Brunei, Canada, Dominica, Grenada, Guyana, India, Ireland, Jamaica, Malta, Mauritius, Netherlands, New Zealand, Norway, Singapore, St. Kitts, St. Lucia, St. Vincent, Trinidad, and the United Kingdom. Students from Pakistan and Kenya scheduled for senior Professional Military Education courses are also exempt from the TOEFL requirement.
- An official score report from the Graduate Record Examination (GRE) or, if applicable to the particular program, the Graduate Management Aptitude Test (GMAT). The recommended GRE scores for a Master's program are 153 verbal and 148 quantitative (or 500 verbal and 600 quantitative if taken prior to 1 Aug 2011). The recommended GMAT score is 550.
- For doctoral programs, GRE scores of at least 156 verbal and 151 quantitative (or 550 verbal and 650 quantitative if taken prior to 1 August 2011) or a GMAT score of 650 or higher. The Educational Testing Service will be updating the GRE percentile ranks, and possibly the test scores, after 1 July 2012, thus our GRE scores may change. The GMAT is only accepted in certain programs or not at all. Thus, taking the GRE is highly recommended, as it is accepted by all departments.
- Send all score reports (GRE, GMAT, TOEFL) 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 (GRE/GMAT) prior to making an admission decision. Thus, if the applicant chooses to submit an application without a GRE or GMAT it should be submitted no later than 1 March in the year of the desired program start date.

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

Academic
Waivers

Waivers to the above admission standards may be granted on an individual basis at the discretion of the faculty. Therefore, individuals whose academic credentials fall below any of the entry criteria are

encouraged to apply for a graduate program. Applicants who do not meet these criteria may be conditionally admitted and/or the department may grant individual waivers to the entrance requirements.

Applicants, such as military personnel, international military officers, and civilians who apply for full-time graduate study under the sponsorship (full pay and allowances) of a military service or government organization, but fall short of admission standards mentioned above may be admitted after department review.

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

The GRE (or GMAT, if applicable) is required for admission unless waived by the academic department. The Graduate School of Engineering and Management may evaluate applications for admission to Master's degree programs for active duty service members who have not taken the GRE (or GMAT, if appropriate), provided the request to do so is made by their personnel agency based upon official agency needs.

Unconditional Admission

Students admitted to full (or unconditional) degree-seeking status must have submitted official transcripts from each college or university attended, and at least one of those official transcripts must indicate conferral or award of a baccalaureate or Master's degree from a regionally accredited institution.

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 must meet all the general requirements of the Institute and the specific program requirements of the department in which the student plans to pursue study.

Conditional Admission

Students may be admitted to conditional status because:

- The applicant has not graduated from their undergraduate or Master's program, yet is expected to do so within 9 months
- 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
- The applicant has majored in another field with a creditable record but has not yet clearly demonstrated abilities in the proposed new field
- The prerequisite coursework in the chosen field is insufficient
- The previous academic record is borderline (e.g. low cumulative GPA, low GRE/GMAT scores, etc.)

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

Air Force personnel seeking an Advanced Academic Degree assignment cannot be offered conditional admission. Air Force Personnel Center needs to know whether or not the service member will mostly likely succeed in their studies and graduate prior to selection for assignment. The Graduate School does, on a case-by-case situation, offer AF Personnel extended program length options.

Students may be admitted to conditional status because:

- The applicant has not graduated from their undergraduate or Master's program, yet is expected to do so within 9 months
- 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
- The applicant has majored in another field with a creditable record but has not yet clearly demonstrated abilities in the proposed new field
- The prerequisite coursework in the chosen field is insufficient
- The previous academic record is borderline (e.g. low cumulative GPA, or GRE/GMAT scores)

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

Air Force personnel seeking an Advanced Academic Degree assignment cannot be offered conditional admission. Air Force Personnel Center needs to know whether or not the service member will mostly likely succeed in their studies and graduate prior to selection for assignment. The Graduate School does, on a case-by-case situation, offer AF Personnel extended program length options.

CHANGES AFTER ADMISSION

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

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

Changing Degree Programs Students admitted to an AFIT Graduate School program may change programs, however to do so is considered a Change of Enrollment and requires faculty approval. Students wishing to change programs must consult with their academic advisor and complete the "Change of Enrollment" form mentioned in the "Change of Enrollment Status" section (above). 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 based upon the needs of their respective service or agency, and thus changing a program requires approval from various agencies and personnel centers. Fully sponsored students who seek a program change must follow guidelines available within their department designed to insure the change continues to meet the needs of the Air Force or their particular service or agency. Any change of degree program will require written justifications and concurrences presented to the Office of Admissions prior to changing a degree program.

Termination Admission status will terminate for students (excluding service sponsored military personnel) who are admitted either conditionally or unconditionally, that do not enroll in any course within one year of the term for which admission was requested. For all students, both degree and non-degree seeking, who have taken at least one course, continuation in their enrollment status is at the discretion of the academic department, the chair of the graduate program, and the Dean of the Graduate School, consistent with the policies and practices of the Graduate School and the graduate program. Also see "Probation and Dismissal" under the Academic Information section of this catalog.

Office of the Registrar

Phone: (937) 255-6234 x3192 (DSN 785-6234 x3192)

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

E-mail address: registrar@afit.edu

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

Mission	<p>The mission of the AFIT Registrar is:</p> <ul style="list-style-type: none">• Incorporate best practices from major universities within the Registrar's offices.• Provide accurate, timely response to all requests for service and/or information. <p>Upgrade technology as available and appropriate to ensure our ability to provide efficient and effective service to our customers.</p>
Goals	<p>To fulfill that mission, the Office of the Registrar has established the following goals:</p> <ul style="list-style-type: none">• To serve the constituency in an attentive and cordial manner• To provide a well coordinated registration process that is student oriented, accurate and efficient• 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• To maintain academic records that are accurate, easily understood, and available in a timely fashion.• To supply concise information regarding academic policies, transfer credit acceptability, grades, and graduation certification
AFIT Website	<p>Website for AFIT, general and detailed information about the Graduate School, and its departments and programs - http://www.afit.edu</p>
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 official interpretation of the policy.</p>
Transcripts Release	<p>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.</p> <p>Such studies must be conducted in such a manner as not to 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</p>

Transcript
Requests

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

There is no fee for transcript service.

Bring photo identification to our office, or you may obtain a transcript request form by using the link: <http://www.afit.edu/docs/AFIT%20EN%20Transcript%20Request%20Form.pdf>

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

- Your name, maiden name, and any other previous names (if applicable)
- Social Security number/AFIT Student Identification number
- Birth date
- Dates of attendance
- Complete address where you would like the transcript sent
- Your current address and phone number in case we have questions

Your signature authorizing the release of the transcript

Send
requests to

OFFICE OF THE REGISTRAR
AFIT/ENER BUILDING 641
2950 HOBSON WAY
WRIGHT PATTERSON AFB OH 45433-7765

Or email to: registrar@afit.edu

Or fax to: (937) 255-2791 or (DSN 785-2791)

Research

Dean for Research: Heidi R. Ries, PhD

Phone: 937-255-3636 x4544

Director of Sponsored Programs: Michael J. Caylor, PhD

937-255-3636 x7104

Air Force Institute of Technology

Office of Research and Sponsored Programs, AFIT/ENR

2950 Hobson Way, Building 641, Room 101A

Wright-Patterson AFB, OH 45433-7765

Fax: (937) 656-7139

E-mail address: research@afit.edu

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

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

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

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

Research Centers

Autonomy & Navigation Technology (ANT) Center The Autonomy and Navigation Technology Center is a forward-looking navigation research center seeking to identify and solve tomorrow's most challenging navigation and autonomy problems. The ANT Center's goal is to develop navigation and autonomous system technologies that ensure we can operate anywhere, anytime, using anything. The ANT Center focuses on three research thrusts: autonomous and cooperative systems, non-GPS precision navigation, and robust GPS navigation/NAVWAR. <http://www.afit.edu/ANT/>

Center for CyberSpace Research (CCR) The Center for Cyberspace Research, established in March 2002, conducts defense-focused cybersecurity research at the Master's and PhD levels. The CCR is a national Center of Academic Excellence in Information Assurance Research, as designated by the Department of Homeland Security and the National Security Agency. AFIT is also an NSA-designated Center of Academic Excellence in Cyber Operations and a National Science Foundation CyberCorp institution. On June 19, 2008, the Secretary and Chief of Staff of the Air Force designated AFIT as the Air Force Cyberspace Technical Center of Excellence (CyTCoE). Under the AF CyTCoE charter, the Center works with the Air Force leadership to develop and maintain the cyberspace workforce via cutting-edge graduate and continuing education. The CCR is forward-looking and responsive to the changing educational and research needs of the Air Force, Department of Defense, and the federal government. The CCR affiliated faculty teach and direct graduate research focusing on understanding and developing advanced cybersecurity-related theories and technologies. These theory and technology advancements have included efforts in critical infrastructure protection,

network intrusion detection and avoidance, insider threat mitigation, cyberspace situational awareness, malicious software detection and analysis, software protection, and anti-tamper technologies. <http://www.afit.edu/CCR/>

Center for Directed Energy (CDE) The Center for Directed Energy supports Air Force and DOD agencies in transitioning Directed Energy weapons, such as high energy lasers (HELs), to the battlefield through vigorous scientific experiments, engineering research and diverse consulting activities, in conjunction with educational programs offered through the Department of Engineering Physics. The CDE conducts both field and laboratory experiments that have allowed it to develop and maintain the world's most comprehensive simulation packages for atmospheric effects (LEEDR - Laser Environmental Effects Definition and Reference) and the effects of the environment on the propagation of HELs (HELEEOS - High Energy Laser End-to-End Operational Simulation). These models each have over 200 DOD and industry users, and the CDE is actively using experimental measurements it and other groups have collected for verification and validation of its models. The CDE's primary sponsors include the High Energy Laser Joint Technology Office, the Air Force Research Laboratory's Directed Energy and Sensors Directorates and Air Force Office of Scientific Research, and agencies within the intelligence community. <http://www.afit.edu/CDE/>

Center for Operational Analysis (COA) The Center for Operational Analysis is dedicated to solving real-world operations and logistics challenges facing the Air Force and other organizations within the DoD. The COA directly supports our collaboration sponsors with faculty-led operationally relevant research conducted by AFIT students and contractors. Working for the Department of Operational Sciences, the COA is focused on developing our military and civilian students as elite Operational Analysts and Logistics Officers. Our faculty and students work directly with our DoD sponsors to apply graduate-level expertise to operational and logistics problems. The goal is to keep our military students connected to their respective services during their 12 – 36 month academic programs, and to help make AFIT an indispensable problem-solving resource to the DoD. The COA's major research focus areas are: Mobility Modeling, Logistics Modeling and Analysis, Test and Evaluation, Resource Optimization, Data Mining, Irregular Warfare, Depot Sustainment, Change Management, and Social Network Analysis. <http://www.afit.edu/COA/>

Center for Space Research and Assurance (CSRA) The Center for Space Research and Assurance develops the technical space cadre through world-class research and immersive hands-on graduate education. It performs research into novel highly-valued resilient, responsive and reliable space capabilities for the DoD and Intelligence Community. The CSRA executes leading-edge space technology development, science, and space experiments in collaboration with government organizations to meet the challenges of tomorrow. <http://www.afit.edu/CSRA/>

Center for Technical Intelligence Studies and Research (CTISR) The Center for Technical Intelligence Studies and Research, formerly known as the Center for MASINT Studies and Research (CMSR), is focused on Air Force, DOD, and the U.S. Intelligence Community's scientific, technical, and operational activities through graduate research programs. CTISR has an active, interdisciplinary research portfolio of projects addressing DOD and Intelligence Community requirements. CTISR's strategic partnerships with world-class intelligence and research organizations have allowed the CTISR to maintain relevancy to the requirements and needs of these communities. CTISR has truly become a national resource for the technical intelligence community for educating a new generation of technical intelligence professionals to assure the preeminence of our air and space, ground, and naval forces. <http://www.afit.edu/CTISR/>

Office of the Secretary of Defense Scientific Test and Analysis Techniques in Test and Evaluation Center of Excellence (OSD STAT T&E COE) The STAT T&E COE was established in 2012. During development of the Test & Evaluation Master Plan (TEMP), the COE works with acquisition program managers and the program's Chief Developmental Tester to improve test effectiveness and ensure efficient use of scarce resources. Utilizing a combination of rigorous scientific methods and lessons learned, the COE determines where test designs can be improved and efficiencies gained, and then applies this knowledge to the program's T&E strategy development. The COE consists of an interdisciplinary group of DOD T&E professionals that possess knowledge and experience of DOD T&E planning, execution and assessment; knowledge and experience in warfare areas, and statistical expertise. In addition to injecting more STAT into program test strategy planning, the COE experts ensure the organic test and evaluation team gain a better understanding of STAT and how it should be executed within developing testing methodologies. The COE also provides the development of case studies; collects, develops, and promotes best practices; and supports work force development through input to course development on scientific and statistical approaches within T&E planning, execution and assessment. <http://www.afit.edu/STAT/>

Library Services

AFIT/ENWL
2950 Hobson Way, Bldg. 642, Room
1400B Wright-Patterson AFB, OH
45433-7765
Phone: (937) 255-3005
Fax: (937) 656-7746
E-mail address:
Website: <http://www.afit.edu/library/>

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

Location The D'Azzo Research Library is housed in a centrally located, 40,000 sq. ft. facility. The library also maintains a 6,000 sq. ft. annex facility that stores retrospective journal titles. A reserve room contains materials selected by faculty for students to use in conjunction with their courses. The facility features 12 student seminar rooms, two conference rooms, and a computer classroom with 20 public workstations. An additional 26 public workstations are located throughout the library, and 24 networked computers are on the second floor for student and faculty use.

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

- The book collection primarily has print titles and a growing collection of ebooks that support the curricular subject areas of aeronautics and astronautics, electrical and computer engineering, physics, mathematics and statistics, operational sciences, and systems engineering and management.
- The library holds or has access to paper and electronic foreign and domestic journal subscription titles covering the social, basic, and applied sciences.
- A comprehensive collection of conference reports, proceedings, and transactions is available to library users. These reports are available in paper, electronic and multiple micro-formats.
- The Library holds a complete collection of AFIT graduate student theses and dissertations.
- A small, circulating collection of non-print media is available including CDs, DVDs and audio materials.
- The Reference collection contains standard and specialized reference works for that support the AFIT curriculum.
- Various materials relating to AFIT history, including annual histories, accreditation reports, inspection reports and other special reports dating back to 1919, are held in the AFIT archival collection in the library.

Access to resources AFIT maintains subscription and license agreements for databases and journals that support AFIT curricular and research requirements

A sample of databases includes: The Aerospace Database, Compendex, EBSCO Academic Search and Business Source, IEEE Xplore, INSPEC, MathSciNet, ScienceDirect, and Science Citation Index Expanded

A complete list of databases and journals is available at the library's homepage:
www.afit.edu/library

Students, faculty and staff may use the library's interlibrary loan service to request materials that are not owned by The D'Azzo Research Library. Registration for an interlibrary loan account, (using ILLiad), is available on the library homepage

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

Consortia Memberships 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. The library also has a representative on the Library Council for SOCHE (Southwest Ohio Council for Higher Education), a consortium of more than 22 colleges in southwest Ohio that collaborate on the education, employment and engagement of students and faculty in the area. Wright State University and the University of Dayton, the area's largest academic libraries, provide Institute faculty members and graduate students with borrowing privileges

Financial Assistance

Director, Financial Management: Ms Amber L. Richey

AFIT/FM

2950 Hobson Way, Building 643, Room 209

Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-8400 x3611 (DSN 785-8400 x3611)

Fax: (937) 656-4775 (DSN) 986-4775

E-mail address: amber.richey@us.af.mil

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.

Effective 1 October 2014, AFIT will allow Air Force military and civilian personnel, whose education is not sponsored by the Air Force, the opportunity to enroll tuition free on a space-available basis. Students are required to submit an approved SF182. As per the 88th FSS/FSDE Installation Training Guide, Section 7.11, even when no tuition costs are involved the SF182 is required for all training requests of eight hours or more of class time (not credit hours). Please check with your Unit Training Manager or Base Education Office for details. DL students only: Submit either an approved SF182 OR an e-mail from your supervisor stating that the course work will not be done during duty hours.

Please forward a copy of your Registration Form and Approved Funding Documentation (i.e. SF 182, SMART Acceptance letter) to the AFIT Bursar before the beginning of classes.

AFIT/FMA

ATTN: Carol Autry, Bursar

Bldg 643, Room 209

2950 Hobson Way

Wright-Patterson AFB OH 45433-7765

937-255-8400 x3623 DSN 785-8400

x3623 carol.autry@afit.edu or

Bursar@afit.edu

Tuition Rates All rates are subject to change. Contact the Bursar for current rates.

Refund Policy Tuition refunds can only be given if the payment was made via credit card on the Pay.Gov web site. Invoices are not sent until after the drop period has passed. 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 individuals unit to be in the best interest of the Air Force to fulfill mission essential activities (such as deployments). In this case, the student's supervisor should contact the AFIT Bursar's Office with specific details.

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

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

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

- Prior to the Monday beginning the fourth week of classes 100%
- After Monday, beginning the fourth week of classes 70%

- After the Monday of the fifth week of classes 0%

Research Assistantships (RA)	The Air Force Institute of Technology engages the services of Research Assistants who are pursuing a degree at other academic institutions through a contract with the Southwestern Ohio Council for Higher Education (SOCHE). Civilian students must be US citizens. To request additional information contact Ms. Maggie Varga, (937)258-8890 or e-mail Maggie.Varga@soche.org .
Financial Assistance	Financial Assistance is 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 https://smart.asee.org .
Tuition Assistance	AFIT will no longer accept Tuition Assistance.
VA Education Benefits	Students can use their VA Education Benefits. Contact the Admission's office for more details.

Computer Support

Director, Communications and Information, Marnita Eaddie, Maj, USAF

AFIT/SC

2950 Hobson Way, Building 642, Room 2200

Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-6565 x4228 (DSN 785-6565 x

4228) Fax: (937) 656-7080 (DSN 986-7080)

E-mail address: afit.sc@afit.edu

Website: <http://www.afit.edu/help.cfm>

Mission Statement	Air Force Institute of Technology's (AFIT) Directorate of Communications and Information (SC) provides a broad range of information resources and services to the students, faculty and staff of AFIT. Services provided by SC include network and voice communications, central and end-user computing support, information systems planning and support, Campus Help Desk, applications development, visual information support and information management. Additional information can be found at: http://www.afit.edu/help.cfm
Student, Staff and Faculty Support	SC establishes computer accounts for every enrolled student, faculty and staff member following their verified security training. These accounts enables users access to electronic mail (e-mail), software applications, information and database storage and retrieval, network access and similar functions necessary for the conduct of classes and other mission needs. Accounts are to be used for AFIT related and official government business only by the person assigned the account. Most students will automatically be assigned a computer account upon arrival through SC's coordination with the Directorate of Admissions/Registrar. If you have not been automatically assigned a computer account, you'll need to submit a request to the AFIT Help Desk, through your faculty advisor.
Scientific workstations and computer programs available	AFIT's computing capabilities include a variety of mathematical, statistical, simulation and modeling applications available on various Unix-, Linux- and Intel-based platforms. There is also a wide array of programming languages for use while completing class projects, assignments, theses and research projects. Over 300 dual/dual core - processor workstations throughout AFIT provide access to these applications and programming languages
Help for computer concerns	In addition to the scientific workstations, AFIT also maintains over 2,000 desktop and notebook computer systems for general office automation functions such as e-mail, word processing, spreadsheet, database, and presentation software. Assistance and problem resolutions are available through the Campus Help Desk during normal duty hours. High-speed black-and-white and color laser printers for hard copy output are readily available for coursework and thesis production
Internet acces	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 are available	AFIT is a member of the Ohio Higher Education Computing Council (OHECC) and the Ohio Academic Research Network (OARNET). Authorized students and faculty also have access to the supercomputing facilities at Wright-Patterson AFB's Major Shared Resource Center (MSRC)

Student Services

Director: Richard Gammon, MBA

AFIT/ENES, Building 641, Room 102

2950 Hobson Way

Wright Patterson AFB OH 45433 -7765

Voice: (937) 255-6234 x4217 (DSN 785-6234 x4217)

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

E-mail address: student.services@afit.edu ; richard.gammon@afit.edu

Website: <http://www.afit.edu/StudentServices/index.cfm>

STUDENT SUPPORT DIVISION

Services provided to AFIT Students

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

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

International Military Student Office

Director and International Military Student Officer (IMSO), Annette Rowell Robb, M.Ed.

AFIT/ENES, Building 641, Room 111

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

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

The International Affairs Office provides all functions related to AFIT International Programs, starting with inquiries about AFIT programs, request for evaluations for admissions, and final admissions results which the IMSO sends back to country. Coordinates all training for foreign countries through the Air Force Security Assistance Training Command (AFSAT), embassies around the world, and the Office of the Secretary of the Air Force, International Affairs (SAF/IA).

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

- Educates and supports international military officers', Ministry of Defense personnel and their families
- Enables AFIT to accomplish US Security Assistance Objectives: teaching international recognized human rights, democracy, interrelationships of culture, ethics, economy, social diversity and free enterprise
- Maintains a critical academic International database, manages Invitational Travel Orders and is responsible for in-processing and out-processing international students
- Manage all aspects of disciplinary problems, academic issues, language concerns, medical problems, passport issues and leave requests
- Maintains academic records and training reports
- Manages a sponsor program and the Congressionally mandated Field Studies Program

AFIT Student Association

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

Membership

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

Purpose

To serve students by providing information on programs and events directly related to morale and services. Liaison between student body and AFIT leadership to plan special events and activities for students, input to awards given to faculty and staff, and provide copiers for use in the library.

Primary Point of Contact: AFIT.ASA@afit.edu

The student association web page (<https://www.facebook.com/AFITStudentAssociation/info>) contains information on student events and a means to contact the current leadership with questions and/or ideas.

Security

Chief, Security Office/Foreign Disclosure Officer, Michelle J. Phillips, GG-14, DAFC
AFIT/XPQ
2950 Hobson Way, Building 643, Room 106
Wright-Patterson AFB OH 45433-7765
Phone: (937) 255-6565 x3186 (DSN 785-6565 x
3186) Fax: (937) 656-9435 (DSN 986-9435)
E-mail address: afit.security@afit.edu

Mission Statement

Provide professional security service to the Air Force Institute of Technology (AFIT). The Foreign Disclosure Program administers methodology of foreign disclosure release for all of AFIT. The Personnel Security program processes associated Personnel Security clearance documents, including oversight of all Security Information Files (SIF). The Information Security Program administers procedures for the classification and protection of classified national defense and other sensitive information originated or controlled by organizational activities. The Industrial Security program administers and implements compliance with the National Industrial Security Program Operating Manual (NISPOM) and installation security programs. Operation Security (OPSEC) & Antiterrorism/Force Protection (AT/FP) programs prevent the compromise of Air Force activities and information through the enemy as collection of unclassified information potentially harmful to US military actions or intentions. The Special Security Representative (SSR) provides management of the Sensitive Compartmented Information (SCI) programs.

Help for Security Concerns

The gateway to all things related to security at AFIT can be reviewed at the AFIT Security Office Homepage listed on the AFIT Intranet under support organizations (SECURITY). The information on the homepage provides guidance on Security programs including listed related topics:

- Foreign Travel Guidance
- Visit Request Procedures
- Renewal of Security Clearance Procedures
- In/Out processing
- Security Education & Awareness Training
- Contractors Information & Common Access Card (CAC) Procedures
- Security Newsletters & Tips of the Week

Aeronautics and Astronautics (ENY)

Department Head: Bradley S. Liebst, PhD

2950 Hobson Way, Building 640, Room 349

Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-3069 (DSN 785-

3069) Fax: (937) 656-7053 (DSN

986-7053)

E-mail address: eny@afit.edu

Web <http://www.afit.edu/ENY/>

Introduction

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

Facilities

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

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

The facilities are housed in two different buildings. Building 640 has 13,000 square feet of general laboratory facilities, including the computational dynamics and design laboratory which is equipped with high-performance Linux workstations and access to local Linux-based computer clusters, the Combustion Optimization and Analysis Laser Laboratory, supersonic wind tunnel facilities, and a robust materials testing laboratory. Building 644 has 5246 square feet of laboratory space housing a 44" x 31" wind tunnel, 5 kip shaker with digital controller, Simulated Satellite (SIMSAT), the Space Propulsion Analysis and System Simulator (SPASS), thermal vacuum chambers, the vibration lab, a 9 inch low velocity wind tunnel, and three rapid prototype builders. The department, also, cooperates and collaborates with research personnel from the Air Force Research Lab (AFRL) co- located on the base and which houses experimental facilities that students have utilized for many years for thesis research projects. Such projects have included experiments on aircraft stability and control, scramjet engine combustor ignition and control, turbine heat transfer and reciprocating engines for UAVs.

Support instrumentation and sensors include: digital data acquisition systems, high speed infrared and video recording equipment, a planar laser induced fluorescence (PLIF) system, emissions measurement equipment, one and three component laser velocimeter, hot wire anemometers systems, optical equipment, schlieren, Moire, shadowgraph, modal analyzers, frequency spectrum analyzers, multi-port pressure measuring systems, material preparation facility, and a full range of transducers.

Programs

Master of Science

- Aeronautical Engineering
- Astronautical Engineering

- Materials Science
- Space Systems

Doctor of Philosophy

- Aeronautical Engineering
- Astronautical Engineering
- Materials Science

Certificate

- Space Systems Certificate

Faculty

Professor

Paul I. King propulsion and aerodynamics

Bradley S. Liebst dynamics and control

Shankar Mall (Distinguished Professor) structures and materials

Anthony Palazotto (Distinguished Professor) structural mechanics

Mark F. Reeder fluid dynamics

Marina B. Ruggles-Wrenn structures and materials

William E. Wiesel astrodynamics

Associate Professor

Richard G. Cobb structural dynamics and control

Robert B. Greendyke fluid dynamics, physical chemistry, air weapons

Donald L. Kunz dynamics and control

Marc D. Polanka combustion and heat transfer

Assistant Professor

Bradley J. Ayres dynamics and control

Brook I. Bentley fluid dynamics

Michael J. Caylor dynamics, systems and control

Darrell S. Crowe fluid dynamics

Anthony M. DeLuca fluid dynamics and air weapons

Christopher D. Geisel dynamics and control

Carl R. Hartsfield propulsion and spacecraft/aircraft design

David Liu propulsion and air weapons

James L. Rutledge fluid mechanics and heat transfer

Ronald J. Simmons propulsion and dynamics

Eric Swenson solid mechanics and structures

Professor Emeritus

Delmar W. Breuer air weapons

Robert A. Calico dynamics and control

William C. Elrod propulsion

Milton E. Franke aerodynamics, propulsion, and weapons

Andrew J. Shine fluid dynamics

Peter J. Torvik dynamics

Electrical and Computer Engineering (ENG)

Department Head: Nathaniel J. Davis IV, PhD

2950 Hobson Way, Building 640, Room 315

Wright-Patterson AFB, OH 45433-7765

Phone: (937) 255-2024 (DSN 785-

2024) Fax: (937) 656-7061 (DSN

986-7061)

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

The Department of Electrical and Computer Engineering is home to graduate programs in Electrical Engineering, Computer Engineering, Computer Science, and Cyber Operations. 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:

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

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

Programs

Master of Science

- Computer Engineering
- Computer Science
- Cyber Operations
- Electrical Engineering

Doctor of Philosophy

- Computer Engineering
- Computer Science
- Electrical Engineering

Certificate

- Information Assurance Certification

Faculty

Professor

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

Michael J. Havrilla Electromagnetism, guided waves, material characterization, low observables

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

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

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

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

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

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

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

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

Associate Professor

Stephen C. Cain Digital systems, image processing, optics

Peter J. Collins Low observables, electromagnetic materials design and remote sensing along with the underlying foundational disciplines of electromagnetic theory, computational electromagnetics, and signature metrology

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

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

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

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

Assistant Professor

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

Phillip M. Corbell Radar and signal processing, electronic warfare

Douglas D. Hodson Software engineering

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

Michael J. Mendenhall Statistical Machine Learning and Big Data Analytics, Critical Infrastructure Protection, Enabling Technologies for Cyber Operations, Hyperspectral Signal and Image Processing

John M. Pecarina Process mining, petri nets, access control and auditing

Scott J. Pierce Non-GPS navigation, image processing, stochastic estimation

Benjamin W. Ramsey Wireless networks, network security, critical infrastructure protection

Mason J. Rice Network and Telecommunication Systems Security, Cyberspace Deterrence Strategies

Michael D. Seal plasmonic surfaces, optical and infrared signatures

Samuel J. Stone Critical infrastructure security, semi-conductor anti-tamper/security, software/hardware physical layer verification

Jeremy P. Stringer Radar, SAR, beamforming, computational verification

Kevin P. Vitayaudom Adaptive optics, imaging through turbulence

Brian G. Woolley artificial intelligence, evolutionary computation, software engineering

Professor Emeritus

Constantine H. Houppis Guidance, navigation, control systems

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

Engineering Physics (ENP)

Department Head: Nancy C. Giles, PhD.

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3636) Fax: (937) 656-6000 (DSN 986-6000)

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

Introduction

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

Facilities

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

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

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

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

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

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

Programs

Master of Science

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

Doctor of Philosophy

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

Certificate Programs

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

Faculty

Professor

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

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

Gordon D. Hager research faculty, chemical physics

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

Kirk A. Mathews computational nuclear engineering, nuclear weapons

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

David E. Weeks computational chemical physics

Paul J. Wolf atomic, molecular and optical physics, Associate Dean of Academic Affairs

Yung K. Yeo electrical and optical characterization of semiconductors

Associate Professor

William F. Bailey plasma physics, space physics

Christoph Borel-Donohue research faculty, image processing

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

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

James C. Petrosky nuclear engineering, radiation effects on materials
Heidi R. Ries nonlinear optical materials, electron paramagnetic resonance imaging spectroscopy, laser processing of materials, Dean for Research
Ronald F. Tuttle measurement and signature intelligence

Assistant Professor

Ariel O. Acebal space physics, space weather
Kevin Bartlett, atmospheric sciences
David J. Bunker research faculty, advanced technical intelligence applications
Justin A. Clinton, nuclear engineering
Salvatore J. Cusumano high energy lasers, directed energy systems, adaptive optics, beam control
Manuel R. Ferdinandus optics, fast-pulse lasers, nonlinear optics
Anthony Franz lasers, optics
Eric M. Golden materials physics, point defects in solids
Kevin C. Gross molecular spectroscopy, remote sensing; dir CTISR
Michael R. Hogsed engineering physics, radiation effects on devices
C. David Lewis computational physics
Douglas Lewis biodefense, weapons of mass destruction
Robert D. Loper quantum scattering, computational physics
John W. McClory nuclear engineering, radiation effects on electronics
Stephen McHale radiation effects on electronics and materials, computational modeling, surface science
Briana J. Singleton nuclear engineering, radiation effects on laser fibers
Robert s. Wacker atmospheric sciences, microwave remote sensing

Professor Emeritus

Charles J. Bridgman nuclear weapons effects
George John mossbauer spectroscopy, nuclear radiation detection

Adjunct Faculty

Christian R. Benjamin radiation and health physics
Matthew J. Bohn lasers, nonlinear optics, materials, THz spectroscopy and applications
John r. Bruzzese, lasers, photonics
Xiaofeng Frank Duan computational chemistry and materials science
Michael T. Eismann hyperspectral imaging
Alan Garscadden plasma physics, directed energy
David W. Gerts nuclear engineering, radiation transport
F. Kenneth Hopkins directed energy, photonic devices
Gary S. Kedziora computational chemistry and materials science
Benjamin Kowash nuclear engineering
James J. Lange measurement and signature intelligence
Joseph Meola, hyperspectral imaging
Donald L. Noah medical/radiation physics
Kenneth L. Schepler solid-state lasers, nonlinear optics
James L. Schmitz image and signal analysis
Mark Spencer adaptive optics, directed energy
Karl C. Walli image processing, remote sensing

Mathematics and Statistics (ENC)

Department Head: Alan V. Lair, PhD

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

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.

Programs

Master of Science

- Applied Mathematics

Doctor of Philosophy

- Applied Mathematics

Faculty

Professor

Alan V. Lair partial differential equations, functional analysis

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

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

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

Associate Professor

William P. Baker asymptotic and perturbation methods, wave propagation

Dursun A. Bulutoglu design of experiments, combinatorial optimization

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

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

Assistant Professor

Benjamin F. Akers nonlinear waves, numerical analysis, fluid mechanics

Benjamin F. Bennett corporate finance, governance and executive compensation

Andrew J. Geyer design of experiments, combinatorial optimization

Ryan Kappedal machine learning, big data, inverse problems, gradient gravimetry

Brian K. McBee numerical partial differential equations, fluid dynamics, geodetic science

Dustin G. Mixon applied harmonic analysis, frame theory, compressed sensing, signal processing

Jesse D. Peterson applied harmonic analysis, frame theory

Jonah A. Reeger Painleve equations, Padé methods for ODEs, optimal control, nonlinear optimization

Professor Emeritus

Dennis W. Quinn partial differential equations

Daniel E. Reynolds environmental statistics

Operational Sciences (ENS)

Department Head: Dr. Joseph J. Pignatiello

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Website: <http://www.afit.edu/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
- providing an environment of rigor and mentorship that fosters academic excellence

Facilities

The Department of Operational Sciences is home to two research centers at AFIT.

The Center for Operational Analysis (COA) is a multidisciplinary research and education center focused on defense-related operational modeling and analysis. The COA was formally recognized in March of 2003. Expanding the mission of the former Center for Modeling, Simulation, and Analysis, the COA is dedicated to research and education in operational analysis with an emphasis on enhancing warfighter efficiency and effectiveness at all levels.

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

The Scientific Test and Analysis Techniques in Test and Evaluation Center of Excellence (COE) received its initial funding in 2012, following a request by the Office of the Deputy Assistant Secretary of Defense, Developmental Test and Evaluation (DASD, DT&E) that Air Education and Training Command designate such a center within the AFIT Graduate School. This request reflects acknowledgment of AFIT as a leader in the field of Test and Evaluation (T&E). Goals of the new COE are to improve T&E planning, execution, and assessment, and to develop more rigorous, scientific, and statistically based T&E design methodologies.

In addition to the COA and the COE, three research-focused laboratories reside within the department, providing tools, methods, and analysis to support students and their research:

- Combat Modeling Laboratory <http://www.afit.edu/ENS/page.cfm?page=191>
- Future Operations Investigation Laboratory <http://www.afit.edu/ENS/page.cfm?page=191>
- Sensor Fusion Laboratory <http://www.afit.edu/ENS/page.cfm?page=191>

Programs

Master of Science

- Logistics and Supply Chain Management
- Operations Research
- Logistics (IDE Air Mobility)
- Operations Management

Doctor of Philosophy

- Logistics
- Operations Research

Graduate Certificate

- Supply Chain Management (distance learning)
- Test and Evaluation (distance learning)

Faculty

Professors

Kenneth W. Bauer, Jr. pattern recognition, applied multivariate statistics, statistical aspects of neural networks, all usually within the specific application area of automatic target recognition and more recently hyper-spectral imaging processing

William A. Cunningham, III strategic mobility, cost/benefit analysis, econometric modeling, costing privatization and A-76 studies, modal choice networks, location analysis, supply chain management, RFID

Richard F. Deckro information operations and information assurance, reconstruction and stabilization, measure of effectiveness and assessment, behavioral modeling including social network analysis, modeling fourth generation operations, counter insurgency and irregular warfare, applied mathematical programming and optimization, project and program management, modeling and analysis, space applications, campaign modeling, technology selection and management, scheduling, network models, advanced manufacturing methods, multi-criteria decision making, and decision analysis

Raymond R. Hill, Jr. applied statistics in the application of design of experiments methodologies to test and evaluation, mathematical optimization in the use of heuristic search methods for addressing particularly hard problems, and applied simulation modeling and analysis with particular interests in the area of agent-based modeling and the validation of such models

Joseph J. Pignatiello statistical process monitoring, change-point models, design and analysis of experiments, reliability, statistical data analysis, robust design, and six sigma methods

Associate Professors

James W. Chrissis mathematical programming, optimization, engineering design optimization, simulation-driven optimization, and integer modeling

Alan W. Johnson space logistics, strategic mobility, discrete-event simulation, logistics management, reliability and maintainability, and discrete optimization and heuristics

John O. Miller computer simulation, ranking and selection, agent based modeling, combat modeling, network centric warfare, high performance computing, applied statistics, and nonparametric statistics

Jeffrey A. Ogden supply chain management, supply base reduction ERP, implementation e-marketplaces RFID, supply chain quality purchasing, strategies buyer-supplier relationships, supply chain interoperability, supply chain services, and qualitative research methods

Kenneth L. Schultz improving operations management models by including the consideration of behavior issues including motivation and peer pressure in production systems and process flows

Jeffery D. Weir decision analysis, large-scale optimization, deterministic optimization, and mathematical programming

Assistant Professors

Darryl K. Ahner approximate dynamic programming applications to control of complex systems, mathematical representation of information flow from sensors to decision makers, mathematical control theory and model predictive control of complex systems, missile defense, combat modeling algorithm development, artificial intelligence of robotic systems, and representations of irregular warfare

Matthew A. Douglas transportation and operational safety, cross-functional relationships/integration, and ethics and decision-making

Joseph R. Huscroft, Jr. supply chain management, reverse logistics, reverse logistics metrics, innovation and flexibility in the supply chain, operations management, information systems impact on the supply chain, and transportation and distribution

Michael P. Kretser logistics networks, systems engineering techniques: system-of-systems, design structure matrices, and network clustering, social networks, lean, business process reengineering

Brian J. Lunday network interdiction, game theoretic resource allocation, and public service application, mathematical modeling, global optimization algorithms, and heuristic development

Robert E. Overstreet leadership in the supply chain, organizational innovativeness, lean and agile logistics, transportation, and humanitarian logistics

Adam D. Reiman airlift metrics, routing, scheduling, fuel efficiency; energy efficiency, supply and demand, value focused thinking, heuristic search algorithms

Matthew J. Robbins applied mathematical programming, applied statistics, approximate dynamic programming, decision making under uncertainty, game theory, and stochastic modeling, problems related to defense such as stability operations management, MEDEVAC location and dispatching, military inventory routing, and missile defense and problems within the general area of public health such as vaccine economics and transportation regulatory policies

Brian B. Stone design of experiments, response surface methodology, statistical quality control, and regression analysis

Joshua K. Strakos government and non-government related energy topics, disaster relief supply chain management, and humanitarian logistics and supply chain management

Heidi M. Tucholski decision analysis, incentive theory, statistical data analysis, game theory, behavioral and experimental economics

Adjunct Faculty

Bradley E. Anderson inventory management, operations management, forecasting, scheduling, space logistics, and supply chain management, as well as evolutionary algorithms, deterministic modeling, heuristic algorithms

Trevor J. Bihl control systems, cyber security, power systems, sensor data exploitation, statistics, data mining, signal processing

Brett A. Bush optimization, design of experiments, and military operations research

Martha C. Cooper supply chain management, partnership and other inter-firm relationships, the role of customer service in corporate strategy, and international logistics

Steven L. Forsythe theory of command and control which involves laying a mathematical foundation to C2, modeling and simulation of command center workflow, workforce forecasting and optimization of design of experiments

Mark A. Friend pattern recognition techniques applied to the area of automatic target recognition, applied multivariate statistics, and mobility modeling and analysis

Mark A. Fryman statistical process control (SPC), quality tools management, supply chain management, and logistics

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

Alex J. Gutman design of experiments, computer experiments, supersaturated designs, response surface methodology, Bayesian statistics, machine learning, regression modeling, classification, and decision analysis

Shane N. Hall determining the optimal allocation/utilization of scarce or high-valued resources with specific applications in the health-care and military sectors

Benjamin T. Hazen empirical research in innovation, reverse logistics, supply chain management/information systems interface

Sharon G. Heilmann employee turnover, mentoring, and training transfer

Jennifer L. K. Kensler design of experiments and reliability

Daniel D. Mattioda collaboration and flexibility in the supply chain, reverse logistics, international logistics, and using simulation to model supply chain processes

James F. Morris leveraging operations research, social network analysis, practical application within the intelligence community

Francisco Ortiz, Jr. design of experiments, advance regression techniques, multiple response optimization and genetic algorithms, metallurgy and control systems

Carl R. Parson dynamic programming, stochastic processes, military operations research, stochastic resource allocation, optimization

David M. Ryer biometrics, pattern recognition, optimization, military cost-effectiveness analysis, multivariate data analysis, transportation and network flow analysis, heuristic algorithms and methods, computer modeling and simulation, space and cyberspace military analysis

James R. Simpson quality engineering, statistically designed experiments, response surface methods, statistical process control, robust regression methods, engineering statistics, simulation, operations research, and supply chain management

Leonard F. Truett, III application of design of experiments to DoD testing, test design and analysis for system reliability requirements, and application of statistics to live fire and operational testing

G. Geoffrey Vining use of experimental designs for quality improvement, response surface methodology, statistical quality control, and regression analysis

Systems Engineering and Management (ENV)

Department Head: Michael R. Grimaila, PhD, CISM, CISSP

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The Department of Systems Engineering and Management provides defense-focused graduate education through interdisciplinary research projects developing integrated solutions for the US Air Force, the Department of Defense, and various national agencies. The department has three primary thrust areas: Engineering and Technology Management, Environmental Engineering and Science, and Systems Engineering. The department offers a Doctor of Philosophy (PhD.) degree in Systems Engineering and Master of Science degrees in five major multi-disciplinary fields: Cost Analysis, Engineering Management, Environmental Engineering and Science, Industrial Hygiene, and Systems Engineering.

Facilities

The Department of Systems Engineering and Management maintains several laboratory facilities in support of its academic and research programs. The laboratory facilities include the following dedicated areas:

- Analytical Chemistry Laboratory
- Environmental Microbiology Laboratory
- Environmental Remediation Laboratory
- Field Research Platform: Vertical Flow Wetland for Remediation of Chlorinated Ethene Contamination
- Human Systems Laboratory
- Industrial Hygiene Laboratory
- Quantum Key Distribution (QKD) Laboratory
- Systems Integration Laboratory
- Unmanned Aerial System (UAS) Laboratory

Programs

Master of Science

- Cost Analysis
- Engineering Management
- Environmental Engineering & Science
- Industrial Hygiene
- Systems Engineering

Master of Engineering

- Applied Systems Engineering

Doctoral Programs

- Systems Engineering with several available specialization options (e.g., cyber, environmental systems, information systems, industrial hygiene, infrastructure systems, quantum information, space systems, unmanned aerial systems)

Certificates

- Systems Engineering Certificate
- Human Systems Certificate

Faculty

Professor

Adedeji B. Badiru project systems modeling and control, economic analysis, computer simulation, mathematical modeling, industrial technology transfer

Mark N. Goltz environmental engineering, environmental modeling, environmental technology transfer, fate and transport of contaminants

Michael R. Grimaila computer and electrical engineering, information/network security, mission assurance, modeling and simulation, quantum cryptography, systems engineering

Michael L. Shelley system dynamics modeling, systems analysis, environmental science, environmental engineering, ecological engineering, pharmacokinetic analysis

Associate Professor

John M. Colombi systems engineering, system of systems (SoS) engineering, architecture (DoDAF), design optimization, complex systems science, human-systems integration (HSI), DoD acquisition research, modeling & simulation

Willie F. Harper, Jr. water quality, biological treatment, biosensing, resource recovery, unit process modeling, theoretical biochemistry

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

Alfred E. Thal, Jr. facility/infrastructure management, engineering management, project management, risk management, economic analysis, innovation, sustainability

Assistant Professor

John J. Elshaw technology impact on individual/group behavior, workgroup/team effectiveness, organizational climate and culture, employee-employer relationships, organizational justice, leadership, project management

Robert D. Fass cost analysis, risk analysis, decision analysis and optimization, leadership, organizational performance, research methods, government acquisition system, strategic alliances

Jason K. Freels reliability growth testing, accelerated life testing, accelerated degradation testing, competing risk analysis

Thomas C. Ford systems engineering, system architecting, interoperability, resiliency, system classification

Gregory D. Hammond engineering management, emergency management, evacuation planning, risk analysis, civil engineering

David M. Kempisty environmental engineering, environmental health, risk assessment, sampling and analysis, emerging contaminants, environmental remediation, sustainability

Brent T. Langhals systems engineering, human systems integration (HSI), information systems, network design and analysis, information resource management, knowledge management

Eric Mbonimpa sustainability and life cycle assessment, surface water quality modeling, disinfection of water using solar radiation

Michael E. Miller human systems integration (HSI), human factors, human machine interface design, lighting and display design

Kyle F. Oyama complex systems, risk analysis, systems modeling and simulation, technology and R&D management, new product development, project/program management

Jeffrey C. Parr human factors, human systems integration, helmet mounted displays, neck injury criteria evaluation

Jonathan D. Ritchel cost analysis, economic institutional analysis, acquisition reform, public choice

Christina Rusnock human factors, human performance modeling, simulation of cognitive workload, project management

Vhance V. Valencia infrastructure asset management, infrastructure systems risk, critical infrastructure protection, geographic information systems, additive manufacturing for civil engineering, systems engineering

Dirk P. Yamamoto industrial hygiene, pharmacokinetic modeling, air sampling, burn pit emission

Instructor Faculty

Robbyn Turner technical and ethical writing

Adjunct Faculty

Paul Cotelleso civil engineering, engineering management, construction management

Dave Mattie alternative and biobased jet fuel toxicity, development of toxicity screening methods, fuel-induced hearing loss, perchlorate and new propellants

Darrin Ott breathing air quality management, sensing in aerospace environmental aerosol exposure assessment chem., bioagent detection

Robert E. Patterson cognitive engineering

Joseph Pellettiere biomechanics, crash dynamics and passenger safety

J. Robb Wirthlin new/rapid product development, complex systems development, acquisition, modeling and simulation, risk management, systems engineering, project/program management, lean thinking

Professor Emeritus

Charles A. Bleckmann environmental remediation, environmental microbiology

Anthony P. D'Angelo logistics management, federal financial management

Jan P. Muczyk leadership, business strategy, implementation, streamlining bureaucracy
Freda F. Stohrer communication
David K. Vaughan scientific and technical communication, Air Force history

Course Descriptions

AERO 500 - Introduction to Aeronautical Engineering

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

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

AERO 517 - Fluid Measurement

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. Instrumentation includes os sensors, Schlieren flow visualization, and other measurement systems at the discretion of the instructor.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites AERO-533 or Permission of Instructor

Corequisite AERO-517L

Terms Offered Spring

AERO 517L - Fluid Measurement Lab

Lab associated with AERO-517.

Instructional Method Lab

Min Hours 0

Corequisite AERO-517

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.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-533

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

Instructional Method Lecture

Min Hours 4

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 the method of characteristics.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter and 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 and compressible 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisite Permission of Instructor

Corequisite AERO-543L

Terms Offered Spring

AERO 543L - Advanced Computational Modeling for Aerodynamics Lab

Lab associated with AERO-543.

Instructional Method Lab

Min Hours 0

Corequisite AERO-543

Terms Offered Spring

AERO 551 - Numerical Methods for Computational Fluid Dynamics

Application of numerical finite-difference methods to selected model equations from fluid mechanics and heat transfer; classification of partial differential equations (PDEs); development and analysis of finite difference representations of partial derivatives; analysis of consistency, stability, and accuracy of explicit and implicit finite difference solution schemes; implementation of selected finite difference schemes in FORTRAN or MATLAB.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-533

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.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-536

Terms Offered Spring

AERO 627 - Turbulence

The course approaches turbulence predominantly from an experimental point of view. A statistical description of turbulence is presented in order to quantify the variations in the flow caused by turbulence. This leads to order of magnitude estimates for diffusion, transport, and dissipation of turbulence. These quantities are understood relative to the fundamental length scales that they occur at. The second part of the course looks closely at the fundamental equations when subjected to fluctuations around the mean levels. Reynolds time averaging of the Navier Stokes equations is presented along with discussion of the closure problem. Several methodologies are presented to solve the N-S equations including turbulent energy and vorticity balances. Turbulence modeling methods are presented and some application to Computational Fluid Dynamics is developed. The turbulence equations are then applied to Boundary-free shear flows and wall-bounded shear flows for internal and external flows.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-551 and 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

AERO 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

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 generations; 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 vicious solution schemes in Fortran.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-652 or permission of instructor

Terms Offered Spring

AERO 799 - Independent Study

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 member and are presented in a formal oral report. Ordinarily this study extends over four quarters and no credit is given until the end of the last quarter.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

AERO 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

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 member of the department faculty and are defended in a formal oral defense. As a full-time effort, this study ordinarily extends over at least six quarters.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

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 with an emphasis on mechanical systems is covered. Analysis techniques include classical analysis in the continuous time domain and frequency domain as well as modern state space analysis techniques for linear systems.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

ASYS 530 - Introduction to Space Programs and Operations

This course examines the history and current status of military space operations. Topics include the history of space flight, the relationships between military and civil space programs, space law, U.S. space policy, military space missions, U.S. military space organizations, and non-U.S. space programs. Introduction to standard space mission analysis software.

Instructional Method Lecture

Min Hours 3

Prerequisites Permission of Instructor

Terms Offered Fall

ASYS 531 - Space Mission Analysis and System Design

This course provides a detailed introduction to the application of space systems engineering processes throughout the life cycle with an emphasis on space mission analysis, systems design, and systems engineering management. Topics include: space mission concept definition and analysis, concept of operations, engineering system requirements, system functional and physical partitioning, system integration, verification and validation, decision making, technical reviews, configuration and interface management, cost analysis, and risk management.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite ASYS-531L

Terms Offered Winter

ASYS 531L - Space Mission Analysis and System Design Lab

Lab associated with ASYS-531.

Instructional Method Lab

Min Hours 0

Corequisite ASYS-531

Terms Offered Winter

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 U.S. and foreign space systems and related topics of DoD interest. NOTE: This is a single 3 credit course divided over three quarters (students must enroll in all three quarters.)

Instructional Method Seminar

Min Hours 1

Terms Offered Fall, Winter, and Spring

Restrictions US Citizenship Required, Secret Clearance Required

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.

Instructional Method Lecture

Min Hours 5

Prerequisites Permission of Instructor

Terms Offered Winter

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; feedback systems analysis, root locus, Bode, and Nyquist analysis, state space feedback systems analysis, and control system compensation design.

Instructional Method Lecture

Min Hours 4

Prerequisites ASYS-525

Terms Offered Winter

ASYS 625 - Non-Linear Systems Analysis and Control

This course serves as an introduction to the fundamental results of modern nonlinear control. The first half of the course will concentrate on the analytical tools that can be used to study a nonlinear system. Specific topics in this area are phase-plane analysis, stability, and Lyapunov theory, perturbation methods and describing functions. The second half of the course will cover several nonlinear control synthesis techniques such as feedback linearization, sliding mode, and model reference adaptive control.

Instructional Method Lecture

Min Hours 4

Prerequisites ASYS-525 and ASYS-565

Terms Offered Summer

ASYS 630 – Analysis and Design for Weapons Delivery

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

ASYS 631 - Spacecraft Systems Engineering

This course provides a detailed introduction to the design of complex space systems. The key elements and subsystems of several important classes of space systems are presented. The systematic approach necessary to effectively design space systems is illustrated through case studies. Individual or group design projects are conducted and presented.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-532 or Permission of Instructor

Terms Offered Spring

ASYS 632 - Satellite Design and Test

This course provides a comprehensive overview of 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisite MECH-632 or Permission of Instructor

Corequisite ASYS-632L

Terms Offered Summer

ASYS 632L - Satellite Design and Test Lab

Lab associated with ASYS-632.

Instructional Method Lab

Min Hours 0

Corequisite ASYS-632

Terms Offered Summer

ASYS 635 - Conventional Explosives and Effects

Introduction to conventional explosives engineering and the blast effects of conventional explosives. Chemical and thermodynamic theory of explosive compounds. Nonreactive and reactive shock waves. Shock wave effects in air and solids.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

Restrictions US Citizenship Required, Secret Clearance Required

ASYS 640 - Aircraft Combat Survivability

Introduction into aircraft combat survivability engineering and effects of conventional weapons on aircraft systems. Probability theory, radar fundamentals, infrared fundamentals, counter-measures, weapons effects.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

Restrictions US Citizenship Required, Secret Clearance Required

ASYS 650 – Advanced Explosives and Warhead Design

An examination of basic warhead physics and advanced explosive phenomenon such as initiation and detonation. The course will also study the design of multiple warhead types such as fragmentation, blast, direct energy, and kinetic energy rod warheads.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

ASYS 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

ASYS 765 - Robust Control

This course covers the fundamentals of linear multivariate control systems, with an emphasis on the design of robust and optimal controllers. Extensions to basic linear system theory are covered emphasizing multivariate analysis. Performance specification and limitations are discussed along with the selection of weighting functions to achieve desired levels of performance and stability robustness. Linear quadratic controller designs are presented.

Instructional Method Lecture

Min Hours 4

Prerequisites ASYS-565

Terms Offered Spring

ASYS 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisite NENG-651

Terms Offered Winter

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. The chemistry and physiochemical properties of chemical agents important to their production, employment, and effects will be presented. Technology relevant to personnel protection will be reviewed.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

CHEM 675 - Upper Atmospheric Chemistry

This course focuses on the physical and chemical characteristics of the upper atmosphere of which the ionosphere is a vital and integral part of this region. The principle ionization sources are photoionization and energetic particle collisions with ambient atoms and molecules. A variety of processes that operate in the upper atmosphere will be identified and related to input and output parameters by detailed mathematical and physical descriptions of the processes. This course should bridge the gap between elementary studies in the fields of physics and research literature in upper atmosphere physics and chemistry.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-519

Terms Offered Spring

CHEM 720 - Kinetics of Fast Reactions

Advanced level investigation of the rates and mechanism 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

CHEM 840 - Advanced Chemical Kinetics

A seminar course covering the theoretical aspects of chemical kinetics; calculation of rate constants from consideration of the fundamental properties of atoms and molecules; analysis of classical methods, such as Slater or RRRKM; and introduction to quantum and statistical solutions involving the Liouville equation.

Instructional Method Lecture

Min Hours 4

Prerequisites CHEM-720 and CHEM-825

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-655

Terms Offered As Needed

COMM 680 - Technical Reports and Theses

Analysis of the communication situation in which engineering reports are generated and of specific expository problems involved. Selecting, organizing, and presenting technical information within local and more general conventions to meet the reader's needs. Style and format in formal engineering (with special emphasis on the MS thesis) and consideration of related problems of grammar, syntax, and mechanics as necessary. Locating and using published technical information. Written assignments to demonstrate competence in organizing the student's thesis whenever possible. Approximately one third of the subject matter is presented as formal oral reports by the students. This course should be taken in the quarter in which the thesis topic is chosen.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

COST 510 - Principles of Cost Estimating

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

COST 520 - Advance Concepts in Cost Estimating

This course builds upon the foundational topics of cost analysis and estimating from COST 510. The techniques, methodologies, and concepts of acquisition estimating are incorporated through the standardized DoD cost estimating and analysis software suite, Automated Cost Estimating and Integrated Tools (ACEIT). Additional topics relevant to the cost estimator are explored. These topics include: cost management, activity based costing, labor rate derivation, earned value management, O&S estimating, aging system issues, software estimating and source selection processes.

Instructional Method Lecture

Min Hours 3

Prerequisites COST-510

Terms Offered Winter

COST 610 - 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.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-525

Terms Offered Spring

COST 630 - Defense Cost Economics

This course is divided into two parts. The first part of the course provides the economic foundation of defense as a public good and establishes the role institutions, bureaucracy, collective action, rent-seeking, and public policy play in the defense realm. This first part of the course establishes the framework in which the cost estimator operates. The second part of the course examines topics of interest to cost estimators and relates these to the economic foundations of the first half. These topics include: portfolio analysis, cost growth, acquisition reform, and commercial derivatives.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

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 structure of the colloquium consists of approximately 15 presentations by individuals from the cost analysis community during the course of the graduate program. Each guest speaker typically makes a one hour presentation on a selected topic (e.g., a current independent cost analysis) which is followed by an open discussion to allow as much interaction between the guest speaker and students as possible. The presentations focus on cost estimating management, processes, problems, and action taken to mitigate the problems.

Instructional Method Seminar

Min Hours 0

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites COST-510

Terms Offered Winter

COST 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

COST 799 - Independent Study

This independent study provides the student the opportunity to conduct and report independent research on a topic of interest to the Air Force cost estimating community. The student develops a research proposal in conjunction with a qualified faculty advisor. Based upon the objectives identified in the proposal, the student conducts research and presents the results of the research as a Master's thesis prior to graduation. The purpose of the thesis is to allow the student to develop research and communications knowledge and skills that can be applied to future problems during each student's career. The thesis also allows the student to integrate and apply many of the qualitative and quantitative theories and techniques that have been learned throughout the program. Many theses are developed to help solve various real-world cost analysis problems encountered by the Air Force cost estimating community. Recommendations from these theses are often implemented as problem solutions. Each student must present the results of the research in an open forum. Ordinarily this study extends over three quarters and no credit is given until the last quarter.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-486L

Terms Offered Summer

CSCE 486L - Fundamentals of Data Structures and Program Design Lab

Lab associated with CSCE-486.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-486

Terms Offered 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites CSCE-486

Corequisite CSCE-489L

Terms Offered Summer

CSCE 489L - Operating Systems Lab

Lab associated with CSCE-489.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-489

Terms Offered 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.

Instructional Method Lecture

Min Hours 4

Terms Offered 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 theorem-proving, reasoning), and knowledge-based systems (expert systems, natural language processing, vision, planning).

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-531 and CSCE-586

Terms Offered Winter

CSCE 525 - Introduction to Cyber Warfare and Security

This course studies the nature of Cyber Warfare and its ramifications for information system security and survivability, and information assurance. It provides a foundational understanding of operational considerations, tactical capabilities, limitations, strategic ramifications, policy, and legal guidelines associated with offensive and defensive cyberspace operations. Simultaneously, it engenders a systems-oriented viewpoint, while examining national information infrastructures, their vulnerabilities, interdependencies, threats, and opportunities for exploitation.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

CSCE 526 - Secure Software Design and Development

This course provides instruction for secure development of software. We place emphasis on managerial and technical aspects of software development. This includes coverage of federal software development policies, software design and implementation decisions, and numerous errors software developers make when writing source code. A comprehensive project highlights the course, providing valuable insight into how malicious hackers use poorly written software to gain control of a computer, and potentially, an entire network.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-526L

Terms Offered Fall

CSCE 526L - Secure Software Design and Development Lab

Lab associated with CSCE-526.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-526

Terms Offered Fall

CSCE 527 - Cyber Forensics

This seminar 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

CSCE 528 - Cyber Defense and Exploitation I

This course discusses the hardware/software tools and techniques associated with the protection of computer systems and networks. Students will learn how to defend network resources against adversarial exploitation using various commercial and DoD tools. Course topics include techniques to hunt, identify and eradicate malicious actors. A cyber defense focused exercise will be conducted as a capstone for the course.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-528L

Terms Offered Winter

CSCE 528L - Cyber Defense and Exploitation I Lab

Lab associated with CSCE-528.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-528

Terms Offered Winter

CSCE 531 - Discrete Mathematics

This course provides more in-depth coverage, analysis, and application of set theory, binary relations, functions, and first-order predicate calculus from an undergraduate discrete math class. 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

CSCE 532 - Automata and Formal Language Theory

The objective of this course is to prepare the student with a basic foundation in the concepts of automata and formal language theory. Topics covered will include Turing machines, finite state automata, combinatorics, and formal language theory.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-531

Terms Offered Winter

CSCE 544 - Data Security

This course presents the rudiments of data security. The emphasis is on cryptography, beginning with simple ciphers, and extending to public key cryptography based on sophisticated number-theoretic considerations. Other topics include key management, access controls and inference controls.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

CSCE 554 - Fundamentals 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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583 or STAT-586

Terms Offered Fall and 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 emphasis topics.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

CSCE 581 - Digital Avionics Systems I

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.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-581L

Terms Offered As Needed

CSCE 581L - Digital Avionics Systems I Lab

Lab associated with CSCE-591.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-581

Terms Offered As Needed

CSCE 586 - Design and Analysis of Algorithms

This course emphasizes the structure of data and the efficient and effective manipulation 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 uses 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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-486

Terms Offered Fall

CSCE 587 - Microprocessor Design and Synthesis

This course 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 design, program, simulate, synthesize, and implement various microprocessors and related components.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-492 or Permission of Instructor

Terms Offered Spring

CSCE 593 - Introduction to Software Engineering

This course is concerned with the development of large-scale software systems. 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). Techniques to facilitate the engineering of secure software systems are introduced. Hands-on experience is provided through individual homework problems and a group project.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-593L

Terms Offered Fall and Summer

CSCE 593L - Introduction to Software Engineering Lab

Lab associated with CSCE-593.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-593

Terms Offered Fall and Summer

CSCE 623 – Statistical Machine Learning

This course introduces statistical machine learning and pattern recognition. Topics include supervised and unsupervised learning for classification, regression and clustering. Techniques include feature selection, feature transformation, linear and nonlinear modeling, as well as model performance assessment and interpretation. The course emphasizes making decisions in the trade space of learning theory, machine learning algorithm design and application.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-523

Terms Offered Spring

CSCE 625 – Formal Analysis of Security Systems

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

CSCE 629 - Cyber Attack

Course provides an introduction to cyber attack. Students learn to apply exploitation and attack methods to design and execute a viable attack strategy against computer systems/networks and humans using tools and techniques via hands-on labs and projects. Topics include identifying targets, reconnaissance, enumeration and scanning, gaining unauthorized access, denial of service attacks, maintaining access, and hiding attack evidence.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-629L

Prerequisites CSCE-560 or Permission of Instructor

Terms Offered Winter

CSCE 629L - Cyber Attack Lab

Lab associated with CSCE-629.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-629

Terms Offered Winter

CSCE 631 - Machines, Languages and Logic

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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-531, CSCE-532, and CSCE-586

Terms Offered Winter

CSCE 644 - Cryptanalysis

Covers the art and science of breaking codes and ciphers using both theoretical and real-world techniques for defeating cryptosystems. Theoretical and implementation-based attacks on classical and modern cryptographic systems and methods include attacks on stream and block ciphers, cryptographically strong hash functions, and public key systems. Topics include linear/differential cryptanalysis, factoring algorithms, side-channel attacks, time/memory tradeoffs, and attacks on randomness.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

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, simulations 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-586

Terms Offered Spring

CSCE 660 - Mobile, Wireless, and SCADA Device Security

This course provides instruction on the vulnerabilities of mobile networks and associated devices. Students learn about the communication network operation, to include message/call routing and supporting hardware elements, as well as the mobile network's evolution and development. Vulnerabilities of various devices (smart phones, tablets, SCADA, etc) are discussed, providing opportunities for exploitation and implementation of security measures through lab exercises.

Instructional Method Lecture with Lab

Min Hours 4

Corerequisites CSCE 660L

Terms Offered Spring

CSCE 660L - Mobile, Wireless, and SCADA Device Security Lab

Lab associated with CSCE-660.

Instructional Method Lab

Min Hours 0

Corerequisites CSCE 660

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, GPS guided weapons, wide area augmentation systems (WAAS) and scientific visualization and monitoring of air space, etc.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites CSCS-581

Corequisite CSCE-681L

Terms Offered As Needed

CSCE 681L - Digital Avionics Systems II

Lab associated with CSCE-680.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-681

Terms Offered As Needed

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 to 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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-586

Terms Offered Spring

CSCE 687 - Advanced Microprocessor Design Laboratory

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. A final report is required.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-687L

Terms Offered Summer

CSCE 687L - 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. A final report is required.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-687

Terms Offered Summer

CSCE 689 - Distributed Software Systems

The objective of the course is to rigorously extend the fundamentals of computer operating systems into distributed systems and to map those concepts to the implementation of actual systems. Topics include distributed operating systems, multiprocessor operating systems, distributed file systems, distributed scheduling (including deadlock issues), fault tolerance, distributed transaction processing and client server systems. Emphasis is given to the mathematical modeling and analysis of the advanced features to determine required system properties as well as hands-on implementation of these features over a heterogeneous local area network (LAN).

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-489 and CSCE-492

Terms Offered Winter

CSCE 693 - Software Evolution

This course explores the management, modification, and quality assurance of large-scale secure software systems as they evolve over time. Relevant techniques and processes from CSCE-593 and CSCE-694 are discussed as they apply to the evolution software. Emphasis is on case-studies of software evolution within commercial and governmental organizations. Additional concepts such as program understanding, reverse-engineering, configuration management, and the role and use of software engineering tools are also introduced and applied. Course concepts are reinforced through individual homework exercises and a group software evolution project.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-593

Terms Offered Winter

CSCE 698 – Research Seminar

This course provides a forum for the 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. This information will be provided as needed during the student's program, phased in accordance with the typical GCE/GCS program; therefore students are required to attend this course for 6 quarters (2 Summer, 2 Fall, 1 Winter, 1 Spring). The course will typically meet for only a few of the ten weeks each quarter.

Instructional Method Seminar

Min Hours 0

Prerequisites CSCE-593

Terms Offered Winter and Spring

CSCE 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-623

Terms Offered Summer

CSCE 725 - Reverse Engineering

This course introduces the fundamentals of reverse engineering software binaries. The emphasis is on extracting information from compiled code and making targeted modifications. Other topics include reverse engineering wireless devices, network protocols, and cyber-physical systems.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite CSCE-725L

Terms Offered Spring

CSCE 725L - Reverse Engineering Lab

Lab associated with CSCE-725.

Instructional Method Lab

Min Hours 0

Corequisite CSCE-725

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisite CSCE-560

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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-656

Terms Offered Summer

CSCE 793 - Advanced Topics in Software Engineering

This course covers advanced current topics in the area of software engineering. Specific topics are oriented toward Air Force interest, local research needs, student interest and trends in software engineering research and practice.

Instructional Method Lecture

Min Hours 4

Prerequisites 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. A master's degree candidate must enroll in CSCE 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

CSCE 823 - Artificial Neural Networks

This course provides a review of major Artificial Neural Network paradigms to include the multi-layer perceptron, 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites CSCE-686

Terms Offered Summer

CSCE 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

CWMD 596 - Physiological Effects of CBRN

A general knowledge of physiology and toxicology is critical to understanding the myriad of health effects that can occur from exposure(s) to chemical, biological, radiological, and/or nuclear agents. This course will cover the physiological effects of each of the agent classes. Human anatomy and physiology are inherent topics in the instruction. The course provides a foundation in the human health effects of CBRN agents, which will ultimately result in better informed decision-making concerning CBRN threat assessments and response and recovery operations.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

CWMD 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

CWMD 791 – Non-Proliferation of WMD Agents and Technologies

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 weapons and biological 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.

Instructional Method Lecture

Min Hours 4

Prerequisites Permission of Instructor

Terms Offered Winter

Restrictions US Citizenship Required

CWMD 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the re-search are required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisite Approval of Department

Terms Offered All Four Quarters

ECON 520 - Managerial Economics

ECON 520 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 allowing 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).

Instructional Method Lecture

Min Hours 3

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

EENG 501 - Electro-Optical Systems

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

EENG 502 - Radio Frequency Systems

This course will provide an overview of radio frequency (RF) sensing systems and their components along with a theoretical and practical understanding of their applications. Emphasis is on the top-level parameters that describe the capabilities and performance of such systems. Topics include basic properties of radar theory and application, electronic warfare (EW) theory and application including electronic attack (EA), electronic protection (EP), and electronic support (ES), and RF hardware considerations in RF system design. Particular applications to air-to-air fire control radar, air-to-ground imaging radar, EW active jamming and passive sensing and supporting hardware will be emphasized. By the conclusion of this course, the student will be able to make systems level design estimates of various RF sensors and 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

EENG 503 - Automatic Target Recognition 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 classifier design, an overview of ATR applications, methodologies for handling unknown targets, data collection design and data characterization, the use of synthesis data in ATR systems, evaluation of an ATR system in an underdetermined 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

Restrictions US Citizenship Required

EENG 509 - Fundamentals of Electronic Warfare

This course studies the nature of information operations (and information warfare) and its ramifications for information system security and survivability. It provides a foundational understanding of radio communications systems, radar and sensor systems, and electronic warfare techniques. Tactical and operational EW doctrine and employment in military applications are also explored. Examples may be drawn from current, historical and emerging capabilities and scenarios.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

EENG 510 - Linear Systems

The objective of this course is to develop tools for the analysis and simulation of linear dynamic systems. Emphasis is placed on state space analysis for estimation and control theory applications. Topics covered include: linearization of a nonlinear system, derivation of linear time-invariant and time varying state equations, and the continuous time solution; relations between the state equations and the system transfer function; eigenvalue/eigenvector and singular value analysis of the state equations; transformations to canonical forms; and controllability and observability properties.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

EENG 524 - Introduction to Electromagnetic Waves

This course focuses on the study of Maxwell's equations in the time and frequency domain. Faraday's and Ampere's laws are studied to illustrate the coupling of time-varying electric and magnetic fields. The dynamics and properties of electromagnetic wave propagation and polarization is explored for a variety of both lossless and lossy media. This naturally leads to an intensive study of transmission lines using both analytic (circuit models) and graphical (Smith Chart) methods. Then field boundary conditions and the interactions at media interfaces are introduced in order to study the phenomena of reflection, refraction, and diffraction. Finally a variety of waveguides including optical fibers are studied to introduce wave theoretic models for transmission lines or guided waves.

Instructional Method Lecture

Min Hours 4

Prerequisite Permission of Instructor

Terms Offered Fall and Winter

EENG 527 - Introduction to Fourier Optics

This course presents a systems approach to the analysis and design of both coherent and incoherent optical systems, with emphasis on application. Topics covered include: methods of analysis of two dimensional linear systems, scalar diffraction theory, Fourier transform properties of lenses, frequency analysis of imaging systems, spatial filtering concepts with selected applications, and holography. Important applications of Fourier Optics to Air Force systems are stressed throughout the course.

Instructional Method Lecture

Min Hours 4

Prerequisite Permission of Instructor

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. Applications to Air Force Systems are emphasized throughout the course.

Instructional Method Lecture

Min Hours 4

Prerequisite Permission of Instructor

Terms Offered Summer

EENG 530 - Fundamentals of Radio Frequency (RF) Analysis

This course will provide students with an understanding of modulated analog signal analysis techniques and basic RF "front end" transmitter/receiver design. Topics include: modeling of modulated carrier signals with analysis of amplitude, frequency, and phase modulation and demodulation techniques. For a given communications, navigation, or radar system and signal description students will derive and explain analytical expressions of amplitude and angle modulated signals in the time and frequency domain. Students will demonstrate the proper application of LTI system principles, Fourier analysis, and a system's transfer function. Students will develop a fundamental knowledge of common real-world analog signals, Software Defined Radio (SDR) architectures, as well as basic signal analysis of digitally sampled analog amplitude and angle modulated signals in Matlab.

Instructional Method Lecture

Min Hours 4

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. Examples may be drawn from current National Technical Sensors.

Instructional Method Lecture

Min Hours 3

Prerequisites EENG-530

Terms Offered All Four Quarters

Restrictions Foreign Citizen Requirement, Secret Clearance Required

EENG 533 - Navigation Using the Global Positioning System

This course provides a theoretical and practical foundation for understanding the Global Positioning System (GPS). Emphasis is on determining navigational information such as user position and velocity. Topics include satellite orbits, control, space, and user segments, signal structure, measurements, least-squares solution position and clock errors, error sources, dilution of precision, availability, differential GPS, modernization, and Global Navigation Satellite Systems.

Instructional Method Lecture

Min Hours 4

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. Examples are taken from current and planned Air Force systems.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lab

Min Hours 1

Prerequisites EENG-532

Terms Offered All Four Quarters

Restrictions Foreign Citizen Requirement, Secret Clearance Required

EENG-550 Introduction to Autonomy

This course gives a broad overview of autonomy and autonomy-related technology. It is intended to expose students to all aspects of autonomy and provide a common framework for understanding the challenges of developing, testing, and deploying autonomous systems within the Air Force and DoD enterprise. Topics include autonomy definitions and frameworks, cyber and autonomy, test and evaluation of autonomous systems, autonomy ethical considerations, artificial intelligence, unmanned aerial systems, and human/machine teaming.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

EENG 562 - Feedback Systems

This course covers the fundamental characteristics and design of linear feedback control systems. Root locus and frequency response methods of design are developed. A variety of electrical, mechanical, thermal and hydraulic systems are considered and are represented by block, signal flow, and simulation diagrams. System stability, performance and use of cascade compensation to improve performance are included. The state equation modeling of systems includes the use of physical variables and the transformation to phase variable and diagonal or normal form. Simulation and signal flow diagrams are used to represent the state equation formula. Use of CAD design programs are emphasized.

Instructional Method Lecture

Min Hours 4

Corequisite 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 signals, multiplexing, demodulation, multiple access, coding, orbits, look angles, satellite hardware and link analysis.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-524 or EENG-622

Terms Offered Fall and Spring

EENG 580 - Introduction to Signal Processing

This course presents an introduction to signal processing. Topics include I/O descriptions of discrete-time systems, Discrete Fourier Transforms, Fast Fourier Transforms, Z-transforms, sampling theory, and Finite Impulse Response filter design. This course will be taught at the level of Oppenheim and Schaffer's Discrete-Time Signal Processing.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Prerequisite Permission of Instructor

Terms Offered Fall

EENG 599 - Master's Level Special Study

Directed study at a beginner 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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Corequisite 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-622

Corequisite EENG-624L

Terms Offered Winter

EENG 624L - Electromagnetic Characterization of Materials Lab

Lab associated with EENG-624.

Instructional Method Lab

Min Hours 0

Corequisite EENG-624

Terms Offered Winter

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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-622

Terms Offered Winter

EENG 627 - RCS Analysis, Measurement, and Reduction

Radar Cross-Section (RCS) characteristics of simple and complex shapes. Methods of RCS reduction. Radar Absorbing Materials (RAM) and Radar Absorbing Structures (RAS). Design requirements and performance of RCS measurement systems. Frequency and time domain analysis of RCS data. Statistical processing of RCS data. Includes extensive laboratory RCS measurements.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-630

Corequisite EENG-627L

Terms Offered Summer

Restrictions US Citizenship Required

EENG 627L - RCS Analysis, Measurement, and Reduction Lab

RCS Analysis, Measurement and Reduction Lab.

Instructional Method Lab

Min Hours 0

Corequisite EENG-627

Terms Offered Summer

Restrictions US Citizenship Required

EENG 628 - Advanced Electromagnetic Waves

The focus of this course is methods for analyzing the propagation of electromagnetic waves. It begins with a review of plane wave propagation in unbound media and the reflection and transmission of waves at planar interfaces. The uniqueness of solutions to Maxwell's equations to the homogeneous vector wave equation are then addressed. Solutions to the wave equation in rectangular, cylindrical and spherical coordinates are examined. Numerous boundary value problems are considered including rectangular and circular waveguides and cavities, the spherical cavity, and scattering by cylinders and spheres. The course concludes with a look at constructing Green's functions for boundary value problems involving the inhomogeneous scalar wave equation.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-622

Terms Offered Winter

EENG 629 - Electronic Warfare I

Graduate level course with an in-depth analysis, synthesis, and design of electronic warfare (EW) systems. Radar electronic protection (EP) systems and electronic warfare electronic attack (EA) and electronic support (ES) interactions and EW component and system design considerations will be studied. Detailed analysis of EA countermeasures and ES techniques versus modern radars that employ pulse compression, pulse Doppler, monopulse, ultra-low sidelobes, and other EP systems will be accomplished during the course. This course is unclassified with open enrollment.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-535

Terms Offered Fall and Summer

EENG 630 - Applications of Electromagnetic Theory

Analytical and numerical techniques to solve electromagnetic radiation and scattering problems. Both low and high frequency methods are discussed. The principal subjects are the geometrical theory of diffraction, physical optics, and the method of moments. The strengths and limitations of these methods as applied to complex practical problems are discussed. A substantial amount of computer programming of the methods is involved.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 biconical, 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-625

Terms Offered Spring

EENG 633 - Global Navigation Satellite System Receiver Design

This course covers analog and digital signal processing of Global Navigation Satellite System (GNSS) receivers including GPS. Laboratory projects involve incremental development of a sample-level baseband GNSS signal simulator and processor. Labs culminate in a GNSS software receiver that processes live sky sampled data files to produce pseudo-range and accumulated Doppler range measurements. Topics include: GNSS signal structures, link budget, RF front-end architectures, correlation processing, signal acquisition and tracking techniques (FLL, PLL, DLL), C/N0 and other special baseband functions, bit and frame synchronization, navigation message decoding, channel control state machine design and range measurement computation. Also covers advanced topics such as interference/multipath mitigation techniques and signal quality monitoring.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-533

Terms Offered Spring

EENG 634 - Computational Methods in Electromagnetics

This course develops the numerical techniques commonly used to solve electromagnetic radiation and scattering problems. Focusing on the two major branches of the "First Principle Methods" (Integral 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 implementations of the methods through computer projects. While this course stands on its own, it is designed to be a companion course to EENG 630 Applications of Electromagnetic Theory together providing the student a firm grasp of all the major modeling and simulation tools used for electromagnetic analysis and design.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 strapdown 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 systems alignments are examined. System response to inertial instrument errors and initial misalignments are studied in frequency and time domains. System analysis tools, such as MATLAB, are used.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-534

Terms Offered Winter

EENG 636 - Micro-Electro-Mechanical 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 micromolding. 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 L- Edit, and submitted for fabrication in the silicon MUMPS process. The fabrication designs will be ready for testing in the follow-on course for this class EENG 777 Advanced MEMS.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite EENG-636L

Terms Offered Winter

EENG 636L - Micro-Electro-Mechanical Systems (MEMS) Lab

Lab associated with EENG-636.

Instructional Method Lab

Min Hours 0

Corequisite EENG-636

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

Restrictions US Citizenship Required

EENG 653 - Introduction to VLSI Design

The purpose of this course is to equip the student with the fundamentals of VLSI design, including semiconductor physics at the introductory level and CMOS logic, technology, interconnections, design rules, layout, simulation, and verification. The focus is on each element of the design cycle. At each stage in the cycle, both the theoretical concepts and the appropriate computer-aided design (CAD) tools are presented together. Practical experience is gained through the design of circuits of relatively low complexity.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite EENG-653L

Terms Offered Fall

Restrictions US Citizenship Required

EENG 653L - Introduction to VLSI Design Lab

Lab associated with EENG-653.

Instructional Method Lab

Min Hours 0

Corequisite EENG-653

Terms Offered Fall

Restrictions US Citizenship Required

EENG 658 - Light Detection and Ranging 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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-586 and EENG-580

Terms Offered Winter and Spring

EENG 663 - Signal Detection and Estimation

This course covers methods of extracting information from noisy observations of a signal. In particular, this includes random and non-random parameter estimation and methods of detection and classification. The estimation theory includes maximum likelihood, minimum mean squared error, and maximum posteriori estimators, and Cramer-Rao lower bound. The detection theory includes Bayesian, minimax, and Neyman-Pearson detection; multiple hypotheses; composite detection; and receiver operating characteristics.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-665

Terms Offered Spring

EENG 665 - Random Signal and Systems Analysis

An introduction to the theory of random signals. The concepts developed include: random signals, moments, correlation functions, stationarity, ergodicity, power spectral density, joint processes and their cross-correlation, random signals in linear systems, specific types of random processes, and adaptive filter theory.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-535

Terms Offered Spring

EENG 669 - Digital Communications I

This course presents significant considerations for designing and analyzing digital communication systems, with primary emphasis on baseband performance. The course develops a mathematical representation of digital signals including signal space concepts. 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. Techniques of block and convolutional channel coding are summarized, hard and soft decision decoding is discussed and system performance is analyzed.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-530 and STAT-586

Terms Offered Winter

EENG 670 - Digital Communications II

This course presents significant considerations for designing and analyzing digital communication systems, with emphasis on bandpass signaling and multiple access applications. The course examines coherent and noncoherent detection of digital bandpass signals in Gaussian channels 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, to include an introduction to spread spectrum systems.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-669 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-527 and EENG-665

Terms Offered Winter and Spring

EENG 673 - Spread Spectrum Communications

This course focuses on multiple access (MA) communications, with design and analysis of spread spectrum (SS) communications systems used to introduce fundamentals. Various forms of MA communications are considered in light of current and emerging techniques being employed for commercial digital communications. This include direct sequence SS, frequency hopping SS, time and frequency division multiplexing and orthogonal frequency division multiplexing (OFDM). 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-670

Terms Offered Summer

EENG 675 - Semiconductor Devices

This course is the focal point of the electronic devices sequence. The major types of semiconductor devices will be analyzed in terms of the physical effects which govern device operation. From this study, design equations, circuit models and performance limitations are developed. After a review of quantum mechanics and pertinent conduction theory, the major device categories are presented. These topics include PN-junction diodes, bipolar and field effect transistors, and metal-oxide semiconductor devices.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-570

Terms Offered Winter

EENG 676 - Microwave Electronic Devices

The theory of operation and design models for microwave devices in three general areas are developed: signal transmission components, thermionic power devices in microwave systems. Topics include microwave bipolar and field effect transistors, Gunn effect devices, avalanche-effect devices, PIN diodes, mixer and detector diodes, high electron mobility transistors as well as TWT's and magnetrons.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-576 and EENG-675

Terms Offered Winter and Spring

EENG 677 - Optical Communication Systems

A systems approach to the analysis and design of guided and unguided optical communication systems. The concepts include: photon statistics, detector characteristics, noncoherent and coherent detection of optical signals, receiver models, optical transmitters, link calculations, free-space system design, optical fiber fundamentals, and fiber communication system design.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-530 and EENG-665

Terms Offered Spring

EENG 679 - Information 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 techniques such as data compression and error-correcting codes that are key enablers for modern data acquisition, processing storage and transmission.

Instructional Method Lecture

Min Hours 4

Terms Offered As Needed

EENG 680 - Multidimensional Signal and Image Processing

This course will study multidimensional signal and image processing techniques, to include: sampling in multiple dimensions, multi-dimensional Fourier transforms, sensor geometry models, projection theory, filtering, reconstruction, compression, and analysis.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-580 and MATH-521

Terms Offered Spring

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 datapath 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-653 and CSCE-492

Corequisite EENG-695L

Terms Offered Winter

Restrictions US Citizenship Required

EENG 695L - VLSI System Design Lab

Lab associated with EENG-695.

Instructional Method Lab

Min Hours 0

Corequisite EENG-695

Terms Offered Winter

Restrictions US Citizenship Required

EENG 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Seminar

Min Hours 1

Terms Offered All Four Quarters

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 specialized topics related to their research. The goals of this course are to foster an awareness of the many on-going areas of guidance, navigation and control research and to improve the student's ability to publicly present technical data.

Instructional Method Seminar

Min Hours 1

Terms Offered Fall

EENG 714 - Advanced Topics in Radar Applications

This capstone radar course provides the student theoretical and practical exposure to advanced radar applications of continuing and/or emerging interest within the radar community. Instructor-led lectures develop the core mathematical, signal and image processing, modeling and simulation, and measurement methods as applicable to various radar applications. In addition, students conduct laboratory experiments and measurements, and/or modeling and simulation according to methods and techniques in the current literature.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-535 and EENG-668

Terms Offered Summer

EENG 716 - Imaging Through Turbulence

In this course the student is introduced to adaptive, speckle and hybrid imaging in the presence of the atmosphere. A collection of over 20 seminal papers as well as extensive faculty notes are used to introduce topics ranging from basic effects of atmospheric turbulence on optical propagation and conventional imaging to advanced imaging applications such as adaptive optical, speckle, and hybrid imaging. These advanced imaging applications are all techniques used to mitigate the detrimental effects of the earth's atmosphere on conventional imaging.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-672

Terms Offered Spring and Summer

EENG 717 - Advanced Topics in Microelectronic Devices

This course is a continuation of EENG-675. An associated processing technology laboratory provides students with hands-on experience in device fabrication. The subject matter in the course focuses on current Air Force problems. Topics include the reliability and degradation of IC's, radiation damage and hardening of solid-state devices, compound semiconductors, charge control devices, electro-optic devices and magnetic bubble memories.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-675

Corequisite EENG-717L

Terms Offered Spring and Summer

EENG 717L - Advanced Topics in Microelectronic Devices Lab

Lab associated with EENG-717.

Instructional Method Lab

Min Hours 0

Corequisite EENG-717

Terms Offered Spring and 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 include 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-765

Corequisite EENG-734L

Terms Offered Spring

EENG 734L - Multi-Target Tracking Lab

Lab associated with EENG-734.

Instructional Method Lab

Min Hours 0

Corequisite EENG-734

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-635 and 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-510, EENG 562 and STAT-586

Terms Offered Winter and Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-766

Terms Offered Spring and Summer

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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-636

Corequisite EENG-777L

Terms Offered Summer

EENG 777L - Advanced Micro Electro Mechanical Systems (MEMS) Lab

Lab associated with EENG-777.

Instructional Method Lab

Min Hours 0

Corequisite EENG-777

Terms Offered Summer

EENG 779 - Nanotechnology

This course covers selected topics in nanometer-scale technology relevant to Air Force and DoD systems. The focus is on topics related to nanoelectronic materials, devices, and systems including sub-micrometer silicon-based integrated circuits, molecular electronics, quantum-effects in materials and devices, and nanoelectromechanical systems. Other topics include monolayer crystal growth, nanometer synthesis, fabrication, and assembly techniques, quantum dots, nano-magnetics, carbon nanotubes, and nanobiological devices, tags/labels, and sensors. The course also includes discussions of specialized laboratory measurement techniques including atomic-force microscopy and scanning tunneling microscopy. The class includes a course project and a weekly three-hour laboratory wherein students perform modeling and simulation studies of nanometer-scale materials and devices, and fabricate and test selected nanoelectronic materials and devices.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite EENG-779L

Terms Offered Winter and Summer

EENG 779L – Nanotechnology Lab

Lab associated with EENG-777.

Instructional Method Lab

Min Hours 0

Corequisite EENG-779

Terms Offered Winter and Summer

EENG 780 - Statistical Image Processing

This course covers topics related to image reconstruction from incomplete data and advanced image registration problems. Models for both linear shift variant imaging systems and non-linear imaging systems will be introduced. Statistical descriptions of various kinds of image data will be covered so that estimation theory can be applied to practical imaging systems. Emphasis will be placed on understanding key elements of astronomical, coherent and hyper-spectral imaging problems.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-663 and EENG-658

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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites EENG-695

Corequisite EENG-795L

Terms Offered Spring

Restrictions US Citizenship Required

EENG 795L - Advanced Topics in VLSI Systems Lab

Lab associated with EENG-795.

Instructional Method Lab

Min Hours 0

Corequisite EENG-795

Terms Offered Spring

Restrictions US Citizenship Required

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. 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

EENG 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Seminar

Min Hours 0

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.

Instructional Method Seminar

Min Hours 0

Terms Offered Winter

EMGT 503 – Critical Review of Research Literature

This seminar provides students with an introduction to research literature in a specific area of engineering and/or environmental management and prepares students for conducting critical reviews of such literature. Several seminar groups are formed, led by faculty members, and defined by more focused research areas. Students will lead discussions within their groups on published research papers. Literature review documentation and thesis proposal requirements will also be discussed.

Instructional Method Seminar

Min Hours 0

Terms Offered Spring and Summer

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 current status of the work in a concise manner. 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. For large classes, the seminar is scheduled over two academic quarters and is designated as EMGT 505 in the second quarter.

Instructional Method Seminar

Min Hours 0

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. 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.

Instructional Method Seminar

Min Hours 0

Terms Offered Fall

EMGT 550 - Engineering Economic Decision Analysis

This course studies the analytical techniques necessary to optimize the economic outcome of technical and managerial decisions. Traditional engineering economic concepts such as basic cost concepts and time value of money are reviewed before presenting more complex concepts including comparison of alternatives, economic analysis, capital budgeting, analysis of risk and uncertainty, and decision models.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

EMGT 611 - Topics in Crisis Management

The topics in crisis management course will provide the student with a broad background of this emergent area of research and theory. The course will focus on the frameworks and perspectives developed in the literature to aid practitioners in working in crisis environments. The student will come away from the course with a vocabulary and knowledge set ready to be applied to the specific environments they may encounter after they graduate. The purpose of the course is to teach students to view crises as systems and to understand means and mechanisms by which they can be influenced.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

EMGT 612 - Crisis Management Systems

The crisis management systems course is divided into three modules. Through this course, students will gain an appreciation and understanding of quantitative tools that can be used to prepare for and manage crises. The knowledge developed in EMGT 611 will be applied to analysis and application in real-world situations to aid the students to function effectively in such situations in the future.

Module 1 focuses on natural disasters; using tools such as ArcGIS and R, students will collect data to analyze natural disasters. Module 2 focuses on a system model of crisis management. Students will apply a systems perspective to understand the causes of crises and possible interventions. Module 3 is intended to provide students with an overview of the techniques used in probabilistic risk analysis.

Instructional Method Lecture

Min Hours 3

Prerequisites EMGT-611

Terms Offered Winter

EMGT 621 - Asset Management I

This course covers a wide variety of topics in infrastructure asset management. Fundamental concepts of asset management such as inventory, assessment, condition state, levels of service, and program development are presented to establish a framework for an asset management system. Infrastructure assets are explored from a variety of perspectives to include a systems perspective, an Air Force policy perspective, and a national/current events perspective.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

EMGT 622 - Asset Management II

This course explores infrastructure asset management concepts from a systems engineering perspective. It presents foundational systems principles and techniques as applied in the management of infrastructure systems. Topics to be covered include: systems modeling, system risk, monte carlo simulation, sampling methods, and decision modeling analysis techniques.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-535 and OPER-501

Terms Offered Spring

EMGT 631 - Advanced Topics in Construction Management I

This course will study inspection methods utilized in the construction industry to oversee major projects. The course presents the material in three main thrust areas to help students develop a better understanding of the inspection process: specific criteria and methods, safety, and contingency construction. The topics to be covered include site work, asphalt, concrete, steel, masonry, roofing, underground piping, electrical, HVAC and mechanical systems, and OSHA safety.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

EMGT 632 - Advanced Topics in Construction Management II

Knowledge of construction inspection, engineering, and materials is a necessity for today's Air Force civil engineers. This class provides information on how vertical and horizontal projects should be inspected to include OSHA regulations and ASTM requirements. Construction engineering analysis provides information on how to calculate structural, mechanical, electrical and hydraulic loadings of horizontal and vertical construction.

Instructional Method Lecture

Min Hours 3

Prerequisites EMGT-631

Terms Offered Summer

EMGT 641 - Construction Contracts and Law

This course is intended to provide a practical introduction to the legal topics and issues related to the construction process; it is not intended to train the student as a construction lawyer. This course will present the theories, principles, and established rules students are likely to encounter in the construction industry. Topics include the legal aspects of contract documents, drawings, and specifications; owner-engineer-constructor relationship and responsibilities; bids and contract performance; labor laws; governmental administrative and regulatory agencies; and ethics.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

EMGT 642 - System Dynamics Analysis

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 management, social, political, and environmental interactions. The primary objective of the course is to instill a systems thinking approach in the mind set of the student. The examples within the course are chosen for applicability to current engineering management issues. In addition, the student will master a modeling tool to facilitate this approach to problem solving.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite EMGT-642L

Terms Offered Winter

EMGT 642L - System Dynamics Analysis Lab

Lab associated with EENG-642.

Instructional Method Lab

Min Hours 0

Corequisite EMGT-642

Terms Offered Winter

EMGT 643 – Introduction to Geographic Information Systems: A Computing Perspective

This course presents an overview of Geographic Information Systems (GIS). There are two distinct topic areas to be covered in this course: (1) computational and data aspect of GIS and (2) GIS operations and functions. In the first topic area, the technology, theories, models, and representations of GIS data and systems will be presented. The method of delivery will primarily be through lectures and class discussions on weekly assigned readings. For the second topic area, experiential learning will be employed. Experiential learning is emphasized through the weekly laboratories accomplishing online tutorials followed by application exercises. The course is designed to develop student expertise in spatial data management, spatial reasoning, problem definition, and skilled application of ESRI's ArcGIS software.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites STAT-525

Corequisite STAT-535 and EMGT-643L

Terms Offered Winter and Spring

EMGT 643L – Introduction to Geographic Information Systems: A Computing Perspective Lab

Lab associated with EMGT-643.

Instructional Method Lab

Min Hours 0

Corequisite EMGT-643

Terms Offered Winter and Spring

EMGT 680 - Advanced Project Management

This course builds on foundational material presented in SENG 610 by presenting more advanced tools, techniques, and models for comprehensive project management and risk management in an integrated project management decision framework. The primary goal of the course is to provide the student with sufficient background knowledge and basic tools to confidently manage a project or contribute effectively as a project team member. This is an advanced graduate course that requires substantial independent work outside the classroom.

Instructional Method Lecture

Min Hours 4

Prerequisites SENG-610

Terms Offered Winter

EMGT 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

EMGT 713 – Advanced Topics in Crisis Management

Advanced Topics in Crisis Management is a capstone course for the crisis management specialty track. Working in small groups, the students will devise and execute a crisis management research project of relevance to the AF Civil Engineer community. Topic selection is up to the students but possible topics could include quantitative natural hazard risk assessments for AF installations or modeling AF emergency response performance. Projects will apply the principles and techniques learned in EMGT 611 and EMGT 612.

Instructional Method Lecture

Min Hours 3

Prerequisites EMGT-611 and EMGT-612

Terms Offered Spring

EMGT 799 – Independent Study

An in-depth study of a research topic selected from 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

ENVR 501 - GES/GIH Seminar

This course presents the principles of organizing and conducting research and will assist students in completing their thesis prospectus. There is a significant focus on literature review. Other specific topics: ethics/plagiarism, thesis checklist process, and PA approval process. Students from the class matriculating one year earlier will present and discuss their research. Faculty and guests may also provide lectures detailing current research topics.

Instructional Method Seminar

Min Hours 0

Terms Offered Fall

ENVR 502 - GES/GIH Seminar

Students will utilize this time to meet with their thesis advisor and research group. Faculty and guests may also provide lectures detailing current research topics.

Instructional Method Seminar

Min Hours 0

Terms Offered Winter

ENVR 503 - GES/GIH Seminar

In this course, students learn how to communicate research results. Students are introduced to the thesis style guide. Other topics include how to prepare and submit papers for publication in technical journals and how to present platform presentations and posters at conferences.

Instructional Method Seminar

Min Hours 0

Terms Offered Spring

ENVR 504 - GES/GIH Seminar

This course includes discussion on applicable business, managerial, and leadership skills relevant to graduating students. Discussions will include techniques, skills, and tools necessary for managers/leaders. Guest speakers will provide their personal leadership philosophies and views on mentorship, especially when faced with diverse, multidisciplinary teams. Faculty and guests may also provide lectures detailing current research topics.

Instructional Method Seminar

Min Hours 0

Terms Offered Summer

ENVR 505 - GES/GIH Seminar

This course provides students an opportunity to informally present their thesis research before their student peers and faculty, in order to demonstrate effective communication skills and articulate their research to a larger audience. Students will receive critical feedback from both fellow students and faculty. All students will be exposed to the thesis work of their peers and gain a broader perspective on current research issues and the various methods being employed. Faculty and guests may also provide lectures detailing current research topics.

Instructional Method Seminar

Min Hours 0

Terms Offered Fall

ENVR 511 - Environmental Management and Policy

This course is designed to provide an intensive introduction to the field of environmental management and policy, including basic concepts and approaches, major elements of American environmental policy, political processes and institutions, public policy tools, and environmental policy analysis.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

ENVR 532 - Air Resources Management

An air pollution survey course to advance the student's knowledge of the sources, emissions, health and environmental effects, dispersion and transport, atmospheric interactions, and federal regulations dealing with air pollution. It includes a discussion of current air pollution topics including ozone depletion, acid rain, and global warming needed for the management of the air resources in our society. Also included is basic design of air pollution control systems.

Instructional Method Lecture

Min Hours 3

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 examination of current topics and ecosystems through an individual extensive review of the ecosystem of choice.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

ENVR 535 - Solid and Hazardous Waste Management

This course provides an understanding of the problems of solid waste and hazardous waste management. Collection, storage, treatment, and disposal technologies and regulations will be discussed, with emphasis on sound engineering and economic solutions. Public health and risk communication issues will be addressed, as will the responsibilities of waste generators, transporters, and managers of waste generators, transporters, and managers of waste control facilities such as landfills and incinerators.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter and Summer

ENVR 541 - Industrial Hygiene Applications I

This course provides the anticipation/recognition portions of the "anticipate, recognize, evaluate, control" (AREC) paradigm of classical industrial hygiene. This course provides the student with a background of industrial hygiene history and development, and an overview of all hazard types (chemical, biological, and physical). Topics include: IH history and regulations; exposure limit basis, interpretation, and application; chemical hazards and indoor environmental quality; biological hazards; and physical hazards (noise, thermal stress, ergonomics).

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

ENVR 543 - Industrial Hygiene Applications II

This course provides the evaluation portion 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. Topics include: lab-based and direct-reading instrument sampling and analysis of gases, vapors, and aerosols; biological monitoring and evaluation; dermal exposure assessment; noise evaluation; exposure distributions; sampling strategies; and data interpretation.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites ENVR-541

Corequisite ENVR-543L

Terms Offered Spring

ENVR 543L - Industrial Hygiene Applications II Lab

Lab associated with ENVR-543.

Instructional Method Lab

Min Hours 0

Corequisite ENVR-543

Terms Offered Spring

ENVR 546 - Applied Science Studies

This course provides an introduction to the applied sciences of human physiology, toxicology, and epidemiology. The physiology of each major organ system, along with the types of toxicological illnesses/injuries that can occur from occupational and environmental exposures will be covered. Epidemiological concepts including disease frequency, association, causation, bias, confounding, along with appropriate study design (e.g., case-control and cohort studies) will also be covered.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

ENVR 547 - Non-Ionizing and Ionizing Radiation

This course covers the health and safety problems involved with the use of ionizing and non-ionizing radiation with an emphasis on identification (detection), control, radiation types, and interactions with matter. Specific areas covered include lasers, microwave radiation, medical and dental x-ray equipment, industrial x-ray, and personnel dosimetry. Radiation safety elements are discussed in detail.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

ENVR 548 - Industrial Hygiene Applications III

This course completes the "anticipate, recognize, evaluate, control" (AREC) paradigm of classical industrial hygiene by providing control mechanisms competency. Lecture and laboratory sessions acknowledge the control hierarchy (substitution, engineering controls, administrative controls, then personal protective equipment-PPE), but focus on engineering controls. Students will learn industrial ventilation design and hazardous noise controls. Confined spaces, occupational safety, and environmental/safety/occupational health (ESOH) management will also be covered.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites ENVR-543

Corequisite ENVR-548L

Terms Offered Summer

ENVR 548L - Industrial Hygiene Applications III Lab

Lab associated with ENVR-548.

Instructional Method Lab

Min Hours 0

Corequisite ENVR-548

Terms Offered Summer

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

ENVR 556 - Sustainable Life Cycle Design

This course covers a wide variety of subject areas related to life cycle cost, life cycle assessments and sustainable design concepts. The class covers the use of life cycle assessment tools to help quantify energy and natural resource consumption as well as air, water and solid waste emissions for any product or process. Sustainable design is a broad concept and is approached in this course by going through the major areas that influence the sustainability of a product or process. The major areas covered in this class are pollution prevention legislation, life cycle assessment, life cycle cost, energy sustainability, air and solid waste emissions, global and human health impacts of sustainability and sustainability issues in the military.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

ENVR 575 - Applied Environmental Health

The class will include coverage of basic environmental health topics/concepts. The format will be periodic lectures from the instructor and presentation/discussion of student/team projects. Topics covered will include basics of public health, intelligence data gathering, toxic industrial chemicals, physical hazards, and global environmental health issues. Contemporary issues pertinent to the deploying military member will be discussed.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

ENVR 615 - Industrial Hygiene Site Surveys

This course provides exposure to various industrial workplaces in the local area, in order to better understand the industrial hygiene "anticipate, recognize, evaluate, control" (AREC) paradigm. Students will go on several field trips and will write trip reports to summarize their occupational, environmental, safety, and management observations.

Instructional Method Lecture

Min Hours 1

Corequisite ENVR-541 or Permission of Instructor

Terms Offered Fall

ENVR 616 - Advanced Industrial Hygiene

This course provides students the opportunity to demonstrate the knowledge and skills to competently and ethically implement and practice applicable scientific, technical, and regulatory aspects of industrial hygiene. This course also serves as a capstone to the GIH program and provides an exhaustive review for those preparing to take the Certified Industrial Hygienist (CIH) exam, offered by the American Board of Industrial Hygiene.

Instructional Method Lecture

Min Hours 2

Prerequisites ENVR-548 or Permission of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 4

Prerequisites ENVR-550

Terms Offered Spring

ENVR 625 - Environmental Microbiology

The principles of biological sciences, as they relate to and impact environmental systems, are described. 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, are investigated. Specific topics include microbial physiology and genetics, aerobic and anaerobic systems, biochemical pathways, nutrient cycles, pathogens and wastewater, and bioremediation of soils and groundwater.

Instructional Method Lecture

Min Hours 4

Prerequisites ENVR-550

Terms Offered Summer

ENVR 628 - Physiology of NBC Weapons Effects

This course analyzes physiological effects of various forms of radiological emissions of various energies as well as the physiological effects (intended and unintended) of chemical weapon agents and their antidotes. Engineering design of shielding for protection of personnel from radiological effects is included as well as the chemical antidote strategy in the field to include dosing, timing, and minimization of unwanted side-effects to keep personnel alive and mission capable as long as possible.

Instructional Method Lecture

Min Hours 3

Prerequisites 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.

Instructional Method Lecture

Min Hours 3

Prerequisites ENVR-550

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, convection-dispersion (transport with fluid momentum), filtration, and adsorption are discussed, with examples showing how each process affects containment 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 containments move about and change in the environment, as well as how transport processes can be engineered to control contamination.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 3

Corequisite STAT-525 and ENVR-550

Terms Offered Fall

ENVR 661 - Environmental Sampling and Analysis

This course will cover the basics of environmental sampling and the statistical basics of sampling. Topics to be addressed include normal and lognormal distributions, sampling strategies for statistical considerations, sample preparation, and laboratory instrumentation. Analytical procedures including solids analysis, gas chromatography and spectroscopy will be discussed and demonstrated in the laboratory.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites STAT-525

Corequisite ENVR-661L

Terms Offered Spring

ENVR 661L - Environmental Sampling and Analysis Lab

Lab associate with ENVR-661.

Instructional Method Lab

Min Hours 0

Corequisite ENVR-661

Terms Offered Spring

ENVR 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 3

Prerequisites ENVR-640, ENVR-624, and ENVR 625

Terms Offered Fall

ENVR 799 - Independent Study

An in-depth study of a research topic selected from 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

ENVR 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Lecture

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

HFEN 560 - Introduction to Human Factors

This course examines the study and application of humans and the system interface, including the knowledge of human cognitive/social/physical behavior, capabilities, and limitations. Topics include anthropometrics, sensation-perception, decision-making, mental workload, situational awareness, display/control design, warnings/alerts, human error and accident investigation. Numerous case studies are used to highlight course topics.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

HFEN 610 - Human Performance Measurement

Theories, concepts, and methods for measuring and evaluating human performance will be discussed with an emphasis on facilitating the design of systems having enhanced human performance and satisfaction. The student will gain practice in measuring human performance and applying the results to suggest and validate system design improvements. Influence of fatigue, environmental/task stressors, and social/team factors will be discussed.

Instructional Method Lecture

Min Hours 4

Terms Offered As Needed

HFEN-620 Human Systems Modeling

This course introduces students to using discrete event simulation to model complex human-machine systems. Through this course students will gain an appreciation of defining systems, processes, and workflows using task network analysis. This course is intended to provide students with the requisite knowledge to construct and validate discrete event simulations as well as use simulation outputs to interpret system behavior and evaluate potential solutions with respect to impacts on system performance, human performance, and operator workload.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583, STAT-587 or Equivalent

Terms Offered Winter, Spring, and Summer

HFEN 660 - Human Factors Engineering

This course examines the application of human factors engineering to the system interface, including the knowledge of human cognitive/social/physical behavior, capabilities, and limitations. Topics include anthropometrics, sensation-perception, decision-making situational awareness, display/control design, warnings/alerts, automation, human error, and accident investigation. Students are expected to apply this knowledge through design projects. Additionally, each student will analyze state of the art research within a selected topic area of interest in this field.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

HFEN 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 machines (including machine response to changes in user state), algorithms and programming of the interface itself, engineering concerns that arise in the design and construction of interfaces, the process of specification, design, and implementation of interfaces, and design trade-offs.

Instructional Method Lecture

Min Hours 4

Prerequisites HFEN-560

Terms Offered Summer

HFEN 670 - Human Interaction Technologies

Robust human-system interaction requires information flow between the system and human brain. This course will introduce technologies available to mediate this flow of information, discussing the important characteristics and considerations for input and output technologies. Emphasis will be provided on visual information processing and visual display design. Human auditory processing and various input device technologies will also be discussed.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

HFEN 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

HFEN 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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 both a user's and designer's perspective the concept of database management systems (DBMSs); DBMS security, integrity, recovery, and concurrency considerations; DBMS data models (the relations will be emphasized, but the hierarchical, network, and object-oriented models will also be covered), data manipulation, and database design. Additional emphasis is placed on emerging technologies, 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 database and database related programs when opportunities arise. The four credit hours for this course consist of three lecture hours and two hours in the laboratory.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite IMGT-561L

Terms Offered Spring

IMGT 561L - Applications of Database Management Systems Lab

Lab associated with IMGT-561.

Instructional Method Lab

Min Hours 0

Corequisite IMGT-561

Terms Offered Spring

IMGT 657 - Data Communications for Managers

Introduces concepts of data communication systems, balancing technical and managerial issues, to prepare managers to participate in decisions regarding data communication applications. Topics addressed include industry standards, hardware and software requirements for controlling the flow of data, transmission media, security, and trends in the telecommunications industry.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

IMGT 662 - Database Security

Information stored in databases is a valuable asset that needs to be protected from damage. Conceptual frameworks for discretionary and mandatory access control data integrity, availability and performance, secure database design, data aggregation, data inference, secure concurrency control, and secure transactions processing are studied. Models for multilevel secure databases for both relational and object-relational databases are analyzed. Practical applications of database security concepts are applied.

Instructional Method Lecture

Min Hours 3

Corequisite IMGT-662L

Terms Offered Spring

IMGT 662L - Database Security Lab

Lab associated with IMGT-662.

Instructional Method Lecture

Min Hours 1

Corequisite IMGT-662

Terms Offered Spring

IMGT 669 - Business Process Improvement

This course introduces students to the concepts of business process improvement, including the most popular approach to this concept, Business Process Reengineering, by Hammer and Champy. 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 organization's customers.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall and Summer

IMGT 680 - Knowledge Management

This seminar-based course is based in 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 relationship 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.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter and Summer

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 the 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 to those assets, and infrastructure vulnerabilities; Understand and apply concepts and techniques of risk management to analyze problems under conditions of risk 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 link 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter (DL and in-residence)

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. REMARKS: This course is open only to students in the Fort Dix Air Mobility Program.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

Location Fort Dix

LOGM 542 - Management of Logistics Organizations

This is a survey course covering the behavior of individuals and groups as it pertains to logistics organizations and the Air Force. Topics include, but are not limited to, decision theory and biases, motivation, cognition, individual differences, teams, and culture.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter (In-residence and Fort Dix) and Summer (DL)

LOGM 545 Introduction to Management and Organizations

This is a survey course covering the behavior of individuals and groups as it pertains to organizations and the Air Force. Topics include, but are not limited to, decision theory and biases, motivation, cognition, individual differences, teams, and culture.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter and Spring

Location Fort Dix

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter (DL) and Spring

LOGM 567 – Lean Operations Management

Creating, sustaining, and employing military capability is the purpose of military leadership and management. Operations management theory outlines how organizations perform the systematic direction and control of the processes that transform inputs into finished goods and services. In the past decades, the concept on leanness has emerged as a management philosophy that can facilitate increased productivity while simultaneously reducing costs and improving service to the customer/warfighter. This course presents basic operations management concepts as well as the lean principles with a focus on how lean changes traditional operations management.

Instructional Method Lecture

Min Hours 4

Terms Offered As Needed

LOGM 568 - Introduction to Supply Chain Management

This class provides an introduction to and overview of supply chain management concepts and practices with an emphasis on the areas related to logistics (a sub-area of supply chain management). Supply chain management and its supporting activities of strategic planning, purchasing, operations management, and logistics represent one of the cornerstones of competitive strategy for most organizations, including the Department of Defense. This course introduces the concepts and tools that will enhance the student's understanding of supply chain management and their ability to effectively manage various supply chain operations.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter (DL), Spring, and Summer (Fort Dix)

LOGM 569 - Maintenance and Production Management

This course explores operations management functions as applied to an Air Force environment. The course familiarizes the student with a variety of operations management techniques which are being applied in maintenance as well as a variety of other operations management settings. Course topics include productivity, facility layout, location, capacity planning, quality control, scheduling, project management, queuing theory, inventory management, forecasting, and current operations management innovations.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall (DL and in-residence)

LOGM 570 - Principles of Inventory Management

This course develops fundamental understanding of the design and operation of inventory management systems. Specifically, this course provides students with a broad survey of methods and issues concerning inventory systems such as (1) the logistics pipeline with emphasis on the DoD, (2) demand data and forecasting methods, (3) consumable and repairable item inventory models, (4) information theory, and (5) management implications.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring (DL and in-residence)

LOGM 590 - Computer Simulation for Managers

The course concentrates on the concept of designing a model, running experiments with that 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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites MATH-291, STAT-525, and STAT-535

Corequisite LOGM-590L

Terms Offered Spring

LOGM 590L - Computer Simulation for Managers Lab

Lab associated with LOGM-590.

Instructional Method Lab

Min Hours 0

Prerequisites MATH-291, STAT-525, and STAT-535

Corequisite LOGM-590

Terms Offered Spring

LOGM 601 - Principles and Methods of Research

The course provides information on how to conduct an appropriate review of literature to identify gaps and opportunities surrounding the problem area, and to identify and to evaluate approaches for data collection and analysis leading to valid inference about the topic into answerable research and investigation questions leading to a formal research proposal. The broadest cope of qualitative and quantitative research methods is discussed. Application of appropriate research designs and analysis tools are course outcomes.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall (Fort Dix) and Spring (DL and in-residence)

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall (Fort Dix), Winter, and Summer (DL)

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall and Spring (Fort Dix)

LOGM 620 - Activity Based Costing/Management

The course is designed to give the students knowledge of Activity Based Costing (ABC), why traditional accounting practices do not support managerial decision-making, and techniques to perform ABC. Activity Based Management will be introduced to enable the student to utilize the output from ABC. The development and application of non-financial metrics will be covered. Students will be introduced to the Theory of Constraints, and Balanced Scorecard will be covered. Examples from DoD and the commercial sector will be used to illustrate the application of ABC.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer (DL and in-residence)

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.

Instructional Method Lecture

Min Hours 3

Prerequisites LOGM-617

Terms Offered Winter (Fort Dix)

LOGM 626 Supply Chain Management Capstone

This is a program capstone course that concentrates on the relationship of key business processes within the firm and across the network of firms that comprise the supply chain, in any organization. Key emphasis is on the senior leader and manager perspective of managing a complex organization and supply chain, developing various leadership strategies to execute the objective, being able to map key supplier/customer relationships, and ensuring personnel develop and utilize proper metrics to gauge performance of the organization. A capstone project and case study culminate the learning.

Instructional Method Lecture

Min Hours 3

Terms Offered Spring and Summer

Location Fort Dix

LOGM 627 - Supply Chain Management

This course concentrates on the cross-functional integration of key business processes within the firm and across the network of firms that comprise the supply chain in both commercial and DoD organizations. Emphasis is on managing the complexity of the supply chain, developing supply chain strategies, selecting metrics and mapping supply chain networks. The concept of business partnerships will also be explored. A capstone project provides students with hands-on experience in managing the integration of functional skills, such as planning, forecasting, inventory management and distribution.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall (DL), Winter, and Spring (Fort Dix)

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 developments will be brief with an intent to survey a wide variety of concepts. Forecasting methods covered include: moving average; exponential smoothing; regression; econometric; and Box-Jenkins.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-525 and 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 the 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 in 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 implications.

Instructional Method Lecture

Min Hours 3

Prerequisites MATH-291, STAT-525 and STAT-535

Terms Offered Summer

LOGM 634 - Reliability, Maintainability and Supportability

Creating and sustaining military capability is the purpose of military leadership and management. Reliability and maintainability (R&M) are component characteristics which define the ability of a product to perform its specified functions throughout its operational life. Component R&M of the military system are primary determinants of military capability. This course teaches fundamental R&M and product warranty concepts. Additionally, probability theory is discussed and employed as a tool to quantitatively define these concepts. Topics discussed include the measures which quantitatively define component R&M, the relationships between reliability, maintainability, and availability, and the prediction of R&M measures.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-525 and STAT-535. Fort Dix Students LOGM-525

Terms Offered Fall and Winter (Fort Dix)

LOGM 636 - Service Operations Management

The body of knowledge pertaining to the management of operations has evolved largely in the context of manufacturing. However, the majority of operations in both the commercial and defense sectors are more properly classified as services, whose outputs are less tangible. This course draws on production management techniques to enhance the effectiveness of managers of service operations. Topics covered include characteristics of services, establishing customer service levels, designing service delivery systems, measuring system performance, the psychology of waiting lines, and scheduling personnel and capacity.

Instructional Method Lecture

Min Hours 3

Prerequisites LOGM-568

Terms Offered Winter (Fort Dix)

LOGM 644 - Current Topics in Logistics

This course is a seminar-based investigation into current and emerging topics which originate in, or affect, logistics thought or action. The purpose of this course is to provide knowledge depth to students on critical issues most likely to affect the logistics field in the coming years. The main source of these issues will be recent academic and trade publications. Following individual, in-depth critiques of these works, class members will discuss topics in an open discussion format. Students will be challenged to take and defend their positions on a variety of issues relevant to the field of logistics. A final project will allow each student to more deeply explore an area of special interest within the field of logistics.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

LOGM 651 - Seminar in Petroleum Management

This course will provide an overview of the primary aspects of petroleum management within the Department of Defense. Major topics to be 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.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

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.

Instructional Method Lecture

Min Hours 3

Terms Offered Fall

LOGM 675 – Logistics Management Colloquium

This course introduces students to current issues, concerns, and practices of logistics management through a series of presentations by key logistics personnel during the graduate program.

Instructional Method Seminar

Min Hours 0

Terms Offered All Four Quarters

LOGM-699 Master's Level Special Study

Special topics of study for masters students in Logistics and Supply Chain Management under the direction of a member of the Logistics faculty.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Approval of Instructor

Terms Offered All Four Quarters

LOGM 768 - Advanced Topics in Logistics

This course is intended for students planning advanced study and research in the areas of logistics and supply chain management. A continuation of material covered in LOGM 627, the course covers in more detail the theoretical properties of product support and physical distribution systems found in defense and commercial sector contexts. Course topics are drawn from the current literature.

Instructional Method Lecture

Min Hours 3

Prerequisites LOGM-627

Terms Offered Fall

LOGM 770 - Advanced Inventory Theory

This course develops advanced concepts in the design and operation of inventory management systems. Specifically, this course will examine various research methods to study advanced inventory theories. Students will investigate inventory theoretic issues such as demand data, forecasting of inventory requirements, dependent and independent inventory modeling, and select topics as determined by the professor. The emphasis is on both analytic development and data analysis.

Instructional Method Lecture

Min Hours 3

Prerequisites LOGM-570

Terms Offered Fall

LOGM 791 - Research Project for Mobility Managers

A research topic is selected from mobility problems of interest to USAF and DoD. This topic is thoroughly investigated by the student, and the findings, recommendations, and conclusions are presented as a graduate research paper under the supervision of an AFIT faculty member.

Instructional Method Thesis

Min Hours 1

Max Hours 7

Terms Offered All Four Quarters

LOGM 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 in a formal thesis under the supervision of a departmental professor.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

LOGM 899 Doctoral Level Special Studies

Special topics of study for doctoral students in logistics under the direction of a member of the logistics faculty.

Instructional Method Independent Study

Min Hours 1

Max Hours 12

Prerequisites Approval of Instructor

Terms Offered All Four Quarters

LOGM 999 Dissertation Research

Dissertation research conducted in logistics; including, but not limited to, selection of research advisor and topic, formation of research committee, supervision of the research, presentation and defense of the dissertation in accordance with Doctoral Council policy letters.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

MATH 291 - Calculus for Engineering Managers

Preparatory course in which the student reviews and studies mathematical prerequisites required for the core courses in graduate mathematics programs. This course establishes competence with standard material in differential and integral calculus, including multivariable calculus.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

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 for nonhomogeneous second-order equations, the method of variation parameters for non-homogeneous second-order equations, power series solutions of nonconstant coefficient differential equations, 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.

Instructional Method Lecture

Min Hours 4

Prerequisite Calculus

Terms Offered Summer

MATH 504 - Differential Equations of Mathematical Physics

This course builds proficiency with series solutions for ordinary differential equations having variable, complex coefficients. It provides specific information on Bessel and 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 functions, singularities, power series expansions, contour integration and residue theory.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

MATH 508 - Applied Numerical Methods

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

Instructional Method Lecture

Min Hours 4

Terms Offered Winter and 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.

Instructional Method Lecture

Min Hours 4

Terms Offered All Four Quarters

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' theorem. Fourier series expansions. Complex numbers, analytic functions of a complex variable, complex integrals, Cauchy's integral formula, power series.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall, Winter, and Summer

MATH 513 - Methods of Applied Mathematics II

Introductory graduate level course in methods of applied mathematics. Laurent series and integration by the methods of residues. Bessel functions and Legendre polynomials. Partial differential equations of applied science. 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 to topics that arise in applications.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Spring

MATH 523 - Numerical Analysis and Linear Algebra

This course presents the basic concepts necessary for the qualitative and quantitative analysis of mathematical systems. The goal is to understand the underlying mathematical concepts as well as be able to explain the numerical issues when faced with a computational technique. Topics include vector spaces, systems of linear equations, norms, eigenvalues, and numerical iterative methods.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

MATH 600 - Mathematical Analysis

This course provides the transition from elementary calculus to advanced courses (6XX, 7XX, 8XX) which require mathematical analysis with rigor. Topics include basic notions of set theory, point set topology, limits and continuity, derivatives, functions of bounded variation, Riemann-Stieltjes Integration, uniform convergence of sequences and series of functions and their consequences thereof, and Lebesgue measure and integration theory.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-600 or MATH-602

Terms Offered Summer

MATH 602 - Modern Applied Mathematics I

Introduction to the foundations and applications of modern applied mathematics for students of applied science. Topics include distribution theory and Green's functions applied to one-dimensional boundary value problems, classical and weak solutions, alternative theorems, functions and transformations, Banach and Hilbert spaces, linear functionals, basic properties of linear and metric spaces including topology, continuity, differentiability, convergence of sequences and series of functions.

Instructional Method Lecture

Min Hours 4

Prerequisite Permission of Department

Terms Offered Fall

MATH 604 - Modern Applied Mathematics II

This is a course in applied functional analysis. Topics include linear operator theory and applications to (approximate) solutions of boundary value problems of applied science, closed operators, the inverse operator, adjoint and compact operators, spectrum, contraction mappings, Fredholm integral equations.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-600 or MATH-602

Terms Offered Winter

MATH 611 - Introduction to Partial Differential Equations

Introduction to the fundamental concepts of partial differential equations and applications emphasizing the use of these basic concepts. Topics considered include classification, reduction to canonical form, existence of solutions, variational principles, methods of obtaining solutions of the basic types of equations using analytical methods. Some numerical methods are presented.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-521

Terms Offered Fall and Spring

MATH 631 - Algebraic Structures

An introduction to the algebra of semigroups, monoids, groups, rings, integral domains, fields and categories. Emphasis is placed on gaining a fundamental understanding of these basic algebraic structures so that the successful student will be able to apply the material in familiar and unfamiliar settings.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-600 or Permission of Department

Terms Offered Winter

MATH 633 - Graph Theory

An introduction to the theory and application of graphs. Topics include introductory concepts and definitions, digraphs, connected and disconnected graphs, graph traversals, connection problems, trees, planar and nonplanar graphs, Eulerian and Hamiltonian graphs, coloring problems, graph isomorphisms, multigraphs.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 analyses for each topic.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-508 or both MATH-511 and MATH-521

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. Variational formulation, Ritz-Galerkin method, finite element spaces, approximation theory.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH 508 or both MATH 511 and MATH 521

Terms Offered Fall

MATH 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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, Close Graph theorem, and topics in spectral theory.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-600 and either MATH-621 or MATH-672

Terms Offered Spring

MATH 799 - Independent Study

The topic for an independent study is selected from a wide variety of problems usually of current interest to the Air Force. The results of the study are reported in a thesis written under the supervision of a department faculty member and are presented in a formal oral report. Ordinarily this study extends over four quarters and no credit is given until the end of the last quarter.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisites Permission of Department

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-705

Terms Offered Fall

MATH 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered Fall, Winter, Spring

MATH 999 - Dissertation Research

Dissertation research conducted in mathematical analysis, including both the research itself and the preparation and defense of the prospectus and dissertation. Selection of the research advisor and topic, formation of the research committee, supervision of the research, presentation and defense of the dissertation, and so on, are conducted in accordance with the Doctoral Council Policy letters. Remarks: This course is graded on a P (progress) or U (unsatisfactory) basis.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

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, strengthening mechanics, fatigue, creep, residual stress, fracture, and mechanical testing.

Instructional Method Lecture

Min Hours 4

Prerequisites Permission of Instructor

Terms Offered Fall

MATL 560 - Electronic, Magnetic and Optical Properties of Materials

Introduction to the theory and engineering applications, magnetic, and optical materials. Atomic bonding, crystal structure, crystal defects, lattice properties, diffusion, electrical properties of materials, metals, dielectrics, semi-conductors, 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, super-conductors, and optical devices are treated.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

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 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Winter

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-670

Terms Offered Summer

MATL 680 - Materials Characterization

This course provides an integrated view of materials characterization as a process requiring the application of many methods. This course will focus on several representative methods, including methods based on photons (IR, visible, UV, X-ray), on electrons, and on atoms/ions/neutrons. Acoustic, microwave and mechanical test methods will be introduced. Advanced understanding of the interactions between the material and the sensor or probe used in the characterization will be stressed.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

MATL 685 - Materials Selection and Processing

This course provides an introduction to the principles and techniques that are used in selection, fabrication, and processing of bulk, thin film and nanoscale materials for applications in electronic and structural systems, including risk and cost assessments. A selected group of fabrication methods will be emphasized. Techniques and underlying principles for synthesis and assembly of materials with one or more micro- to nanoscale dimensions will be presented.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

MATL 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

MATL 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of the research are required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisite Permission of Instructor

Terms Offered All Four Quarters

MATL 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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. The principle of Minimum Potential Energy is applied to beams in tension, shear, and bending. Torsion of bars with non-circular cross-section is analyzed by applying St. Venant's Semi-Inverse Principle.

Instructional Method Lecture

Min Hours 4

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, and relevant algorithms. Both metallic and non-metallic 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring and Summer

MECH 515 - Theory of Vibrations

Free and forced vibrations of damped and undamped systems with a finite number of degrees of freedom. Characteristic 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, and bending vibrations of beams. Energy Methods. Undergraduate dynamics and ordinary differential equations recommended.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521 or Permission of Instructor

Terms Offered 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

MECH 529 - Dynamics and Control of Flight Vehicles

Aerodynamic considerations 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521

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, and basic orbital maneuvers. Formulation and description of basic attitude dynamics and control concepts, including spin, dual-spin, three-axis, and gravity gradient stabilization.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Winter

MECH 541 - Mechanics 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-500

Terms Offered Winter

MECH 542 - Introduction to Finite Element Analysis and Computer-Aided Design

Introduce finite element analysis and Computer-Aided Design tools for analyzing, pre- and post-processing finite element models. Review historical development of finite element analysis and related computational tools. Demonstrate finite element process for Truss elements. Program simple finite element code for Trusses. Learn graphics software in AFIT computer environment to model one-, two-, and three-dimensional structures. Use pre-processor to create geometric models and associated finite element meshes. Use post-processor to generate deformed geometry, X-Y plots, and contour plots. Present modeling guidelines and adaptive meshing techniques.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites ASYS-525 and MECH-500 or MECH-545

Corequisite MECH-542L

Terms Offered Winter

MECH 542L - Introduction to Finite Element Analysis and Computer-Aided Design Lab

Lab associated with MECH-542.

Instructional Method Lab

Min Hours 0

Corequisite MECH-542

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

MECH 600 - Elasticity

A review of linear, infinitesimal continuum theory. Introduction to nonlinear elasticity. Solutions in curvilinear coordinate problems. Introduction to plate theory. Buckling and instability.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-500 or Permission of Instructor

Terms Offered Winter

MECH 601 - Introduction to Time-Dependent Material Behavior

The course provides a fundamental background in inelastic solid mechanics. Phenomenological aspects of inelastic material behavior and inelastic constitutive models are discussed. Topics include Kelvin-Voigt, Maxwell and Standard Linear Solid models for materials with internal variables, creep, stress relaxation, linear and nonlinear viscoelasticity. In addition, rate-independent plasticity, viscoplasticity, yield criteria, yield surfaces, and isotropic and kinematic hardening rules are discussed.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-500

Terms Offered Summer

MECH 605 - Fracture Mechanics

The course is designed to acquaint students with analytical and experimental techniques used to solve current fracture problems. Specific course objectives are to develop the linear elastic fracture mechanics principles which allow one to predict the critical crack size for a given component (i.e., predict fatigue crack growth, stress corrosion cracking, etc.) The role fracture mechanics can play in assuring fracture prevention is discussed, with emphasis on current USAF requirements.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-500 or MECH-545 or Permission of Instructor

Terms Offered Spring

MECH 620 - Systems Optimization

This course covers theory and procedures for optimizing multi-variable, nonlinear objective functions that measure system performance. Topics include: formulation of classical and Karush-Kuhn-Tucker (KKT) optimality conditions, numerical algorithms for solving different classes of problems, linear programming, gradient algorithms, search techniques for nonlinear problems, multi-objective optimization theory, and special topics illustrated with problems in aerospace design.

Instructional Method Lecture

Min Hours 4

Prerequisites MATLAB Program

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 constraints are considered. 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.

Instructional Method Lecture

Min Hours 4

Prerequisites ASYS-565

Terms Offered Winter and 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-529 and ASYS-565

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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521 and MECH-532

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.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521

Corequisite MECH-532 or Permission of Instructor

Terms Offered Spring and Summer

MECH 642 - Finite Element Methods for Structural Analysis I

Energy Principles are used throughout. Consideration is given to the formulation of Truss, Plane Stress and Strain, Beam, Plate and Shell elements. Isoparametric elements are considered. Vibration formulation of structures is presented. The use of Matlab coding and Abaqus is made use of throughout the course.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-542 or Permission of Instructor

Terms Offered Spring

MECH 644 - Finite Element Methods for Structural Analysis II

Advanced topics in finite elements techniques. Formulation and solution of the system equations. Application to free forced response, stability, and nonlinear analysis.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-642

Terms Offered As Needed

MECH 662 - Introduction 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.

Instructional Method Lecture

Min Hours 4

Prerequisites AERO-533 and MECH-515

Terms Offered Spring

MECH 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

MECH 712 - Nonlinear Oscillations

Geometric theory of dynamical systems. Motion of single degree of freedom autonomous systems about equilibrium points. Stability of multi-degree of freedom autonomous systems, Liapunov's direct method. Nonautonomous systems, linear systems with periodic coefficients, Floquet theory. Perturbation techniques, secular terms, Linstedt's method, KBM method.

Instructional Method Lecture

Min Hours 4

Prerequisites 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. Method of instruction will include both lecture and laboratory sessions.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites MECH-515 and ASYS-565 or Permission of Instructor

Corequisite MECH-719L

Terms Offered Fall

MECH 719L - Vibration Damping and Control Lab

Lab associated with MECH-719.

Instructional Method Lab

Min Hours 0

Corequisite MECH-719

Terms Offered Fall

MECH 720 - Analytical Mechanics

Elements of the calculus of variations, virtual work, D'Alembert's principle, Lagrange's and Hamilton's equations of motion, applications to holonomic and nonholonomic systems, with emphasis on rigid body motion and gyroscopic instruments.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521

Terms Offered Fall

MECH 731 - Modern Methods of Orbit Determination

Introduction to probability theory. Statistical mission assessment. Derivation of the method of least squares in linear and nonlinear problems. Sequential estimation methods, including numerical instabilities and time weighting. Applications to the problem of determining and updating the orbital elements of satellites.

Instructional Method Lecture

Min Hours 4

Prerequisites 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, and periodic motion.

Instructional Method Lecture

Min Hours 4

Prerequisites MECH-521

Terms Offered Winter

MECH 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Research Advisor

Terms Offered All Four Quarters

MENG 501 - Aerospace Propulsion

This course provides the student with an understanding of the essential elements of airbreathing 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. Performance trade-offs are reviewed relative to military applications.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

MENG 530 - Chemical Rocket Propulsion

Development of performance parameters, analyses 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

MENG 531 - Space Propulsion and Power Systems

Concept, theory and performance of chemical and nonchemical 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Spring

MENG 571 - Fundamentals of Heat Transfer

Course will cover the fundamentals of conduction, convection, and radiation heat transfer. The derivation and solution of the general heat conduction equation for one- and two- dimensional, steady and unsteady conduction problems will be covered. Solution techniques will be studied for forced convection in laminar and turbulent flows on internal and external surfaces. Lastly, an introduction to general radiation with solutions to relevant situations is included.

Instructional Method Lecture

Min Hours 4

Prerequisites Permission of Instructor

Terms Offered Winter, Spring, and Summer

MENG 633 - Fundamentals of Combustion

This course is designed to provide an understanding of the fundamentals of combustion and combustion aerodynamics. An overview of the variety of topics in combustion will be covered including: Chemical thermodynamics; Chemical kinetics; Gas dynamics of reacting flows; Deflagration and detonation of premixed gases; Laminar flames, and Turbulent flames. Details of flame temperatures, structures, flame speeds, and flame lengths will be analyzed. Real combustion systems such as the Well Stirred Reactor, the Ultra Compact Combustor, and the Pulsed Detonation Engine will be discussed.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

MENG 674 - Convection Heat Transfer

This course provides a treatment of convection heat transfer. Laminar and turbulent flows, internal and external flows, forced and free convection and steady and unsteady heat transfer are considered. High speed effects and experimental methods are examined with particular emphasis on thermal management. Various boundary conditions are examined along with two phase flows.

Instructional Method Lecture

Min Hours 4

Prerequisite MENG-571 or Equivalent

Terms Offered Spring

MENG 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Instructor

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites MENG-501

Terms Offered Spring

MENG 733 - Air Breathing 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 heat suited to the requirements of a specified aircraft mission. Computer analysis is used extensively in mission analysis, on-design engine performance analysis, and in component design.

Instructional Method Lecture

Min Hours 4

Prerequisites MENG-501 and MENG-732 or Permission of Instructor

Terms Offered Summer

MENG 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Permission of Research Advisor

Terms Offered All Four Quarters

METG 610 - Radiative Transfer

This course covers topics in radiative transfer for visible, infrared, and acoustic energy including emission, absorption, scattering, and atmospheric refraction. Application of the theory will be examined in operational models, such as Electro-optical Tactical Decision Aid, Integrated Refractive Effects Prediction System, and Radio Physical Optics.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

METG 620 - Advanced Dynamic Meteorology

This course covers geophysical fluid dynamics including the development of the fundamental equations governing atmospheric motion, basic approximations, simplified flows, and physical interpretation of the corresponding theory. It also includes circulation theory, vorticity, planetary boundary layer, quasi-geostrophic, ageostrophic and linear theories and introductory numerical modeling concepts.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter and Spring

METG 642 - Radar Meteorology

Covers the theory of remote sensing using radar. Particular emphasis will be given to current Doppler radar technology, interpretation techniques and forecasting. The algorithms used to generate radar products in the Weather Surveillance Radar-1988 Doppler (WSR-88D, NEXRAD) will be examined in relationship to meso-scale meteorological principles, covering phenomena such as turbulence, wind shear, meso-scale convective complexes, nocturnal jets, and severe weather.

Instructional Method Lecture

Min Hours 4

Prerequisites METG-610

Terms Offered Winter and Spring

METG 644 - Satellite Meteorology

This course will provide students with a broad foundation on the history, theory, data, and application of meteorological satellites/sensors, so that they will be able to interpret and fully utilize these data for operational and/or research applications and understand their capabilities and limitations. It includes techniques, research, and operational applications related to satellite-based remote sensing of the atmosphere and their applications in numerical weather prediction.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

METG 799 - Independent Study

An in-depth study of a research topic selected from a 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. 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 is required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisite Permission of Department

Terms Offered All Four Quarters

NENG 500 - Nuclear Weapons Strategy and Policy

This course provides students with a professional understanding of the historical and current US nuclear policy and the implementation of that policy by the Department of Defense and the Air Force. The course starts with analysis of the current Nuclear Posture Review and then reviews the historical development of nuclear weapons policy and strategy. The course then provides a functional and critical understanding of how national and Air Force policy is implemented through current force structures, nuclear surety, and weapons employment. The course also incorporates current debates and case studies.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall, Winter, and Spring

Restrictions US Citizenship Required

Location Distance Learning

NENG 585 - Introduction to Modern Fortran With Application 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

Restrictions US Citizenship Required

NENG 591 - Nuclear Weapons and Proliferation

This course examines the elements and technology involved in building a nuclear weapons capability, including producing or obtaining nuclear fuel; assembling a weapon; fuzing and firing; testing, storage, surety, and delivery; and how a proliferator might clandestinely complete the steps. The course covers elements of the United States nuclear weapon program, from fuel production to the maintenance of a nuclear arsenal at an unclassified level.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall, Winter, and Summer **Restrictions** US Citizenship Required **Location** Distance Learning

NENG 596 - Nuclear Weapons Effects

This course provides an understanding of the unique effects of nuclear weapon detonations: blast, thermal, radiation, electromagnetic, and fallout. Each effect is treated by examining its generation, transmission, and mechanisms of interaction with the environment. The course covers the physical origin of each effect, the manner in which these effects impact targets, and how these effects can shape a battle space both tactically and strategically. The course also covers survivability/vulnerability issues at the unclassified level.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall, Spring, and Summer

Restrictions US Citizenship Required

Location Distance Learning

NENG 601 - Research Apprenticeship

Students will work on special problems related to individual professors 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Corequisite NENG-651

Terms Offered Winter

Restrictions US Citizenship Required, Secret Clearance Required

NENG 612 - Nuclear Engineering Laboratory

Experimental techniques in nuclear engineering. Typical projects include the analysis of environmental radiation from natural and man-made sources, and of stable components of airborne particulates. General techniques include gamma-ray spectrometry, coincidence methods, activation with fast and thermal neutrons, X-ray fluorescence. Special techniques include Mossbauer spectrometry and Rutherford scattering of protons. Individual and group project approach is used. Students must set criteria, decide what to measure, how to measure it and analyze results.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites NENG-650 and NENG-631

Corequisite NENG-612L

Terms Offered Summer

NENG 612L - Nuclear Engineering Lab

Lab associated with NENG-612.

Instructional Method Lab

Min Hours 3

Corequisite NENG-612

Terms Offered Summer

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.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-651 and MATH-508

Corequisite NENG-605

Terms Offered Winter

NENG 625 - Electromagnetic Pulse Effects

Source, propagation, and interaction of the nuclear weapon generated electromagnetic pulse. Source generation is developed for high altitude burst, surface burst and system generated situations. Propagation of the radiated signal is developed from classical electromagnetism (solution of Maxwell's equations) 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.

Instructional Method Lecture

Min Hours 4

Prerequisite PHYS-531 and NENG-605

Terms Offered Summer

Restrictions US Citizenship Required

NENG 630 - Radiation Health Physics

This course in radiation health physics provides the foundation for understanding the biological effects of ionizing radiation and protecting individuals and population groups. The content depends in part on the students' 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 the design of radiologically safe equipment, processes, and environments with the intent on assessing the radiological impact on humans. In some offerings of the course, the effects of non-ionizing radiation may be included. This course will be useful to bioenvironmental engineers, environmental managers, radiation safety officers, nuclear research officers, or medical personnel who will have responsibility for managing radiation safety programs and managing environmental activities of military installations that have nuclear sources (hospital, PMEL, or nuclear weapons) or who must interact in their environmental management jobs with the Department of Energy

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-651

Corequisite NENG-650

Terms Offered Spring

Restrictions US Citizenship Required

NENG 631 - Prompt Effects of Nuclear Weapons

Topics include source, transmission and mechanisms of interaction of x-ray, blast, thermal, neutron and prompt gamma radiation. X-ray interactions include shock generation and propagation. The conservation equations of fluid dynamics are used to describe shocks. These same equations are applied to blasts in air and underwater shock. Shock "jump conditions" and scaling laws are derived and applied. Thermal transmission is examined. The heat transfer equation is used to study thermal interaction. Buildup factors and fits of transport calculations are employed to study neutron and gamma transmission. Various neutron and gamma interaction phenomena are studied. In the case of each effect, systems response is examined, hardening techniques are surveyed, and design trade-offs are discussed. Some secret (RD) material is discussed.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-605

Terms Offered Spring

Restrictions US Citizenship Required, Secret Clearance Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-605

Terms Offered Spring and Summer

Restrictions US Citizenship Required

NENG 650 - Nuclear Instrumentation

Radiation detectors and detection systems; characteristics, applications, and principles of operation of gas-filled detectors, scintillation detectors, semiconductor detectors; applications and principles of electronic components such as single and multi-channel analyzers, pulse amplifiers, discriminators, scalars, etc. units, etc. Counting statistics, probability and data reduction are applied to nuclear measurements.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites NENG-651

Corequisite NENG-650L

Terms Offered Winter

Restrictions US Citizenship Required

NENG 650L - Nuclear Instrumentation Lab

Lab associated with NENG-650.

Instructional Method Lab

Min Hours 0

Corequisite NENG-650

Terms Offered Winter

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-556

Terms Offered Fall

Restrictions US Citizenship Required

NENG 660 - Radiation Effects on Electronics

This course covers the range of damage and effects that gamma rays, neutrons and charged particles can have on modern electronic devices. Emphasis will be on the effects and possible measures for protection. Temporary and permanent damage will be investigated. Topics to be discussed include: bulk effects, latch-up, charge trapping and single event upsets.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-605 and NENG-631

Terms Offered Spring

Restrictions US Citizenship Required

NENG 664 - Radiation Effects on Electronics Laboratory

Experimental procedures used in radiation effects testing. Typical projects will include ionizing and non-ionizing radiation dosimetry, optical and electrical measurements, and irradiation of devices. The course will cover practical dosimetry, device modeling, characterization, development of a test plan, modeling device changes, irradiation of devices, and interpreting data. Special techniques include; calibrating a PIN diode dosimeter, foil activation dosimetry, device irradiation, and development of systems and controls. Students must establish test criteria, model effects, develop system controls and interpret data.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites NENG-650 and NENG-660

Terms Offered Summer

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

Restrictions US Citizenship Required

NENG 685 - Computational Nuclear Engineering

Develops the fundamental tools for the numerical solutions to problems involving linear algebra, differential and integral equations, eigenvectors and eigenvalues, and partial differential equations.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-585 and MATH-504

Terms Offered Spring

Restrictions US Citizenship Required

NENG 699 - Master's Level Special Study

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.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

Restrictions US Citizenship Required

NENG 705 - Methods of Radiation Transport

The transport of X-rays, gamma rays and neutrons is examined by analysis and numerical solution of the Boltzmann transport equation. Theoretical analysis includes discussion of various approximations to the transport equation, such as particle streaming and one-speed transport theory. Numerical methods of radiation transport such as the P(n) and S(n) methods, are derived and then used by the students to solve nontrivial transport problems.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-504 and NENG-605

Terms Offered Spring

Restrictions US Citizenship Required

NENG 720 - Nuclear Reactor Systems

A survey of current systems from a design point of view. An advanced course in that the prerequisites involve similar theory, both statics and kinetics, for explosive systems, some heat transfer, and a study of reactor effluents. The same theory and methods are applied to nuclear chain reactors in this course. Large civilian power production reactors, small military power reactors and space nuclear systems are examined. Safety, cost and performance are included.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-631 and NENG-635

Terms Offered Winter

Restrictions US Citizenship Required

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 assigned as a group design project.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-631

Terms Offered Spring and Summer

Restrictions US Citizenship Required

NENG 725 - Monte Carlo Methods of Radiation Transport

Monte Carlo calculation techniques are introduced and developed. The technique is applied to problems of X-ray, neutron and gamma transport from and in nuclear explosives. Monte Carlo techniques are contrasted with and compared to Boltzmann equation solutions considered in NENG 705.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-705

Terms Offered Spring

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-674 or NENG-685

Terms Offered Fall

Restrictions US Citizenship Required

NENG 791 – Non-Proliferation of Nuclear Weapons and Technologies

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.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-635

Terms Offered Winter

Restrictions US Citizenship Required

NENG 799 - Independent Study

A research problem is selected from a wide variety of problems of current interest to DoD and the results are presented in a formal thesis. The student works under the supervision of a department professor; however, the burden of analysis and solution falls upon the student. 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 project is required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-705

Terms Offered Winter

Restrictions US Citizenship Required

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.

Instructional Method Lecture

Min Hours 4

Prerequisites NENG-631 and NENG-635

Terms Offered Summer

Restrictions US Citizenship Required

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

Restrictions US Citizenship Required

OENG 616 - Electro-Optical Systems

A laboratory and lecture course that introduces laboratory techniques for the measurement of optical observables (emissions or reflections of optical radiation from aerospace vehicles). The weekly two-hour-long lecture period is used to discuss the design of experiments, safe and practical laboratory techniques, and the communication (in written and oral form) of experimental results. The experiments are in the areas of spectroradiometry, optical cross section measurement, TV sensors, and IR sensors.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites OENG-650

Corequisite OENG-616L

Terms Offered Summer

OENG 616L - Electro-Optical Systems Lab

Lab associated with OENG-616.

Instructional Method Lab

Min Hours 0

Corequisite OENG-616

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640 and PHYS-556 or PHYS-655

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640

Terms Offered Winter and Spring

OENG 645 - Wave Optics I

This course introduces the student to light propagation through Earth's atmosphere using theoretical and simulation approaches. Topics covered include solving Maxwell's equations in a random medium, key atmospheric statistical parameters such as the mutual coherence function, and simulating light propagation in both vacuum and atmospheric turbulence.

Instructional Method Lecture

Min Hours 4

Prerequisites EENG-672 and either OENG-644 or EENG-527

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.

Instructional Method Lecture

Min Hours 2

Prerequisites OENG-645

Terms Offered Winter, Spring, and 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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640 and OENG-650

Terms Offered Summer

OENG 650 - Optical Radiometry and Detection

Develops the solid state and semiconductor technology necessary for an understanding of optical detection. Specific application will be made to photomissive, photconductive and photodiode detectors. In order to describe the detection of radiation, the language of radiation measurement must be studied. Thus, radiometry is included as an integral part of this course.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640

Terms Offered Winter

OENG 651 - Optical Diagnostics

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.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites OENG-620 and PHYS-542

Corequisite OENG-651L

Terms Offered Summer

OENG 651L - Optical Diagnostics Lab

Lab associated with OENG-651.

Instructional Method Lab

Min Hours 3

Corequisite OENG-651

Terms Offered Summer

OENG 660 - Introduction to Non-Linear Optical Devices

This course is designed to develop those areas of electromagnetic wave interaction with matter necessary for an understanding of nonlinear optical devices. Plane wave propagation in anisotropic media, commonly called crystal optics, is stressed. Passive optical devices, such as wave plates, polarizers and compensators, are designed. Parametric processes are introduced and applications such as amplitude and frequency modulation, second harmonic generation, and parametric oscillation are considered.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640

Terms Offered Winter and Spring

OENG 681 - Digital Image Processing

The principle objectives of this course are to develop the concepts and techniques of digital image processing and lay a foundation that can be used as the basis for research in this field. Topics covered include the characteristics of digital images, image transforms, image enhancement, image restoration, image segmentation, and image representation and description.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640

Terms Offered Spring

OENG 699 - Master's Degree Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

OENG 720 - Laser Devices and Applications

Treats specific laser systems of importance to the commercial world and Air Force in particular. The course stresses current laser technology and engineering analysis of specific systems. Topics covered typically include operations characteristics, such as power and energy output, their scalability, spectral and temporal characteristics, and beam quality and the factors limiting the performance. Where appropriate, design issues associated with specific systems are also discussed. In addition to the laser systems commercially available, laser systems appropriate for the Air Force and other military applications, such as laser ranging, target designation, imaging, electro-optic countermeasure, and laser weapons, are discussed.

Instructional Method Lecture

Min Hours 4

Prerequisites 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. The course concludes with a design project of an optical system using a state-of-the-art computer optical design code.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-640

Terms Offered As Necessary

OENG 775 - Introduction to Photonic Devices

Provides an introduction to photonic components and devices, focusing on their basic principles of operation and applications. This course covers the basic components that are used in photonic devices: dielectric waveguides; semiconductor lasers, including distributed feedback and quantum well lasers; semiconductor detectors; acousto-optic modulators; and fiber optics. Specific photonic devices are covered, including directional couplers, phase modulators, intensity modulators, photonic switches, bitable optical devices, and self-electro-optic-effect devices.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter

OENG 780 - Infrared Technology

This course presents the principles and technology required for the design and analysis of electro-optic systems, with emphasis on those systems operating in the infrared, and considers the overall problem of the reduction of optical observables by studying the aircraft infrared signature scenario. Sources of radiation, propagation through the atmosphere, detection of radiation, and reduction of infrared signature are all discussed.

Instructional Method Lecture

Min Hours 4

Prerequisites OENG-650

Terms Offered Spring

OENG 799 - Independent Study

This course is an in-depth study of a research topic selected from a wide variety of problems of current interest to the Air Force, with the results presented in a formal thesis and defense. Ordinarily, this course extends over several quarters, and no credit is given until the end of the last quarter. An oral presentation and defense of research are required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisite Permission of Department

Terms Offered All Four Quarters

OENG 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

OENG 999 - Dissertation Research

This course consists of dissertation research conducted in optical sciences and engineering, including both the research itself and the preparation and defense of the dissertation. Selection of both 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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Permission of Department

Terms Offered All Four Quarters

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.

Instructional Method Seminar

Min Hours 1

Terms Offered Spring

OPER 500 – Operational Sciences Seminar

This seminar acquaints students with the application of operations research to Air Force and DoD issues and with faculty research interests. This course also provides a forum for lectures by distinguished visitors.

Instructional Method Seminar

Min Hours 0

Terms Offered All Four Quarters

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 queueing theory.

Instructional Method Lecture with Lab

Min Hours 3

Corequisite OPER-501L

Terms Offered Fall

OPER 501L - Quantitative Decision Making Lab

Lab associated with OPER-501.

Instructional Method Lab

Min Hours 0

Corequisite OPER-501

Terms Offered Fall

OPER 510 - Introduction to Mathematical Programming

In this breadth-oriented course, students learn the art and science of formulating mathematical programs and are exposed to classical problems in linear programming, nonlinear programming, integer programming, and dynamic programming. Selected solution methods and their theoretical underpinnings for each realm are introduced and motivated, as well as the use of commercial solvers and interpretation of results. Concepts such as duality and optimality conditions will be given a limited treatment, primarily to understand how to better utilize and tailor settings for commercial software.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-523 or Approval of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583 or STAT-587 or Approval of Instructor

Terms Offered Winter

OPER 543 - Decision Analysis

This course presents a logical, systematic procedure for transforming complex decision problems into simpler, more manageable decision problems by a sequence of transparent steps. A theoretical foundation is developed, including: structuring a decision problem w/decision trees & decision diagrams, treating uncertainty using probability as a measure of belief, treating risk attitude using von Neumann-Morgenstern expected utility theory, & examining the value of information. Techniques for applying Decision Analysis in practice are introduced. Focuses on decision problems with a single value measure.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583 or STAT-587 or Approval of Instructor

Terms Offered Winter

OPER 544 - Operational Decision Support Systems

This course blends techniques from the fields of operations research, management sciences, artificial intelligence and information systems to create decision support systems primarily using Excel, including Excel VBA and specialized add-ins for analysis. This course will integrate the use of spreadsheets with operations research topics such as decision analysis, Monte-Carlo simulation and optimization models.

Instructional Method Lecture with Lab

Min Hours 2

Prerequisites OPER-543, OPER-561 and OPER-610 or Approval of Instructor

Corequisite OPER-544L

Terms Offered Summer

OPER 544L - Operational Decision Support Systems Lab

This course is a 1 credit lab taught in conjunction with OPER 544 lecture.

Instructional Method Lab

Min Hours 1

Prerequisites OPER-543, OPER-561 and OPER-610 or Approval of Instructor

Corequisite OPER-544

Terms Offered Summer

OPER 561 - Discrete-Event Simulation

This is an introductory course on the use of computer simulation modeling to analyze complex military systems. The focus of the course is on the development of discrete-event simulation models and the analysis of simulation model input and output. A modern simulation language is taught to provide a modeling framework and the means for implementing a computerized model. Basic concepts important to simulation studies such as random number and random variate generation, model verification and validation, and output analysis are discussed. Examples are oriented toward DoD operational systems.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583 and STAT-587 or Approval of Instructor

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 3

Terms Offered As Needed

OPER 601 – Operations Research Seminar

This course is designed to provide students, primarily those in the doctoral program with information relating to the state-of-the-art within the Operations Research field. Prominent speakers in the field will be invited and used whenever possible. This course may also be used by the faculty to present recent developments in their research and by doctoral candidates to present progress reports on their dissertation research.

Instructional Method Seminar

Min Hours 0

Terms Offered All

OPER 610 - Linear Programming

In this depth-oriented course, students learn the theoretical concepts that motivate and enable key exterior and interior solution methods for linear programming as a basis for future studies. While refining mathematical programming skills, they learn to implement these solution methods with emphasis on key concepts: identifying an initial feasible solution, iterating to assure a convergent sequence of improving feasible solutions, and identifying an optimal or epsilon-optimal solution. Selected methods are enhanced by a rigorous understanding and application of duality theory.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510 and MATH-523 or Approval of Instructor

Terms Offered Winter

OPER 612 - Nonlinear Programming

This course is a detailed study of nonlinear programming techniques. The differential calculus and Karush-Kuhn-Tucker results for constrained optimization are presented, including convexity, local and global optima, and saddle point conditions. A thorough treatment of duality theory and Lagrangian duality constitutes a major portion of the course, and serves to unify several key points. Various classes and types of techniques for solving nonlinear programs are presented, including geometric programming. Modern derivative-free optimization methods are also introduced.

Instructional Method Lecture

Min Hours 3

Prerequisites 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510 and OPER-504 or OPER-540 or Approval of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-610 or Approval of Instructor

Terms Offered Winter

OPER 617 - Networks

This course is an introduction into the study of networks. Topics include basic graph terminology, formulation of problems involving graphs, maximum flow, shortest path, minimum cost flow, minimum spanning tree, and network design. The algorithms and their corresponding computational complexity are discussed motivated by a wide variety of applications including routing and inventory management.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510 or Approval of Instructor

Terms Offered Spring

OPER 621 - Multicriteria Optimization

This course exposes students to a variety of solution methods for multicriteria optimization problems with an emphasis on theory and applications. Topics covered include efficient points, goal programming, weighted sum and scalarization techniques, multiobjective linear programming, multiobjective combinatorial optimization, and multiobjective versions of well known easy and hard optimization problems.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-501 or OPER-510, or Approval of Instructor

Terms Offered Winter

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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-501 or OPER-510, or Approval of Instructor

Terms Offered Spring

OPER 626 - Scheduling Theory

The course covers the theory and solution methods for scheduling several tasks over time. Topics include terminology, measures of performance, single machine sequencing, flowshop scheduling, the job shop problem and priority dispatching. Side constraints within scheduling, such as precedence, release dates, and due dates are addressed.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510 or Approval of Instructor

Terms Offered Summer

OPER 638 - Assessing Operational Cost and Risk

This course develops the theory of operational cost analysis, the evaluation of operational risk, and game theory. The effects of time on economic and monetary evaluation are studied, and risk and its impact on decision making is investigated. Specific topics covered include cost estimation, economic evaluation, risk assessment, value and utility functions, and multiattribute utility theory. A systems analysis perspective is used in the presentation of course material.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-510, OPER-540, OPER-543 and STAT-587 or Approval of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER 540 or Approval of Instructor

Terms Offered Spring

OPER 643 - Multiobjective Decision Analysis

This course examines the multiattribute value problem. Topics covered include: identifying and structuring objectives, selecting appropriate attributes to measure achievement of objectives, developing value functions that accurately reflect decision-maker preference structures, and analysis techniques for obtaining insight from the developed model. Particular emphasis is placed on understanding the relationship between preference statements, value functions, and value trade-offs.

Instructional Method Lecture

Min Hours 3

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.

Instructional Method Lecture

Min Hours 4

Prerequisites OPER-540 or Approval of Instructor

Terms Offered Summer

OPER 647 - Queueing 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 queueing 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-540 or Approval of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-561 or Approval of Instructor

Terms Offered Summer

OPER 661 - 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-561 or Approval of Instructor

Terms Offered Fall

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 used for DoD analysis are used for class projects and examined in the context of support to major analytical simulation studies.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-561 or Approval of Instructor

Terms Offered Summer

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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-671 or Approval of Instructor

Terms Offered Winter

OPER 674 - Joint Mobility Modeling

The purpose of this course is to present mobility modeling from an application oriented, large-scale point of view. Models currently in use for DoD analysis are examined. Particular attention will be given in the air mobility problem and its relation to land and sea mobility. Both strategic and theater mobility are explored.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

Location Fort Dix

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. This course is open to U. S. military students only.

Instructional Method Lecture

Min Hours 3

Terms Offered Summer

Restrictions Military Only, US Citizenship Required

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.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-583 or STAT-587 or Approval of Instructor.

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-583 or STAT-587, or Approval of Instructor.

Terms Offered Fall

OPER 683 - Response Surface Methodology

This is a course on advanced experimental design. Topics include process improvement with steepest ascent, design optimality criteria, designs for fitting response surfaces, analysis of non-linear response functions, and designs subject to randomization restrictions. State-of-the-art experimental design and analysis methods are included as special topics.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-679 or STAT-696 and OPER-688 or Approval of Instructor

Terms Offered Fall

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.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-583 or STAT-587, or Approval of Instructor

Terms Offered Winter

OPER 685 - Applied Multivariate Analysis I

This course is oriented toward the computer-assisted analysis of multidimensional data. The course will present statistical techniques such as multiple regression, principal components analysis, canonical correlation, factor analysis, cluster analysis, discriminate analysis, and neural networks. Emphasis will be on practical application to data sets using computerized statistical packages.

Instructional Method Lecture

Min Hours 3

Prerequisites STAT-587 or Approval of Instructor

Terms Offered Fall and 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-679 or STAT-696 or Approval of Instructor

Terms Offered Summer

OPER 689 - Advanced Statistical Methods for Test

This course builds upon the material in the prerequisite course providing advanced coverage in time series modeling, generalized linear models, and advanced experimental design. Examples and projects are focused on problems from the test and evaluation enterprise.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-679 and OPER-688

Terms Offered Winter

Location Distance Learning

OPER 699 - Master's Level Special Study

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 requirements of the course are determined by the faculty member directing the study. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisites Approval of Instructor

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 3

Prerequisites 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-612

Terms Offered Fall and 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.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER-613

Terms Offered Fall

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

Instructional Method Lecture

Min Hours 3

Prerequisites Take at least two of the following courses: OPER 543, OPER 621, OPER 643, OPER 645, or Approval of Instructor.

Terms Offered Fall and Winter

OPER 746 - Advanced Topics in Reliability

This course develops advanced mathematical concepts for application in the reliability and maintainability areas. Topics include censored reliability data analysis, optimal preventive maintenance policies, warranty analysis, burn-in strategies and other topics of current interest. The emphasis is on both analytic development as well as actual application to data analysis. The course will consider the implications of reliability during the system design phase as well as the system operational phase. Simulation software as well as "solver" software will be utilized in class exercises.

Instructional Method Lecture

Min Hours 3

Prerequisites OPER 540

Terms Offered Fall and Winter

OPER 785 - Applied Multivariate Analysis II: Pattern Recognition

This course is a survey course in pattern recognition. Theory, parameters estimation, linear discriminant functions, multilayer neural networks, and other topics. Real-world applications will be emphasized.

Instructional Method Lecture

Min Hours 3

Prerequisites 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.

Instructional Method Lecture

Min Hours 3

Prerequisites 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. Available only for students enrolled in the Test and Evaluation Certificate Program (TECP) or the Intermediate Developmental Education (IDE) program. This course is offered as the 3 credit hour capstone course (distance learning) for TECP students. It may also be taken in residence for 6-7 credit hours by IDE students.

Instructional Method Independent Study

Min Hours 1

Max Hours 7

Terms Offered All Four Quarters

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. On site research is conducted as required. An oral presentation and defense of research work results are required.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

OPER 899 - Doctoral Level Special Studies

Special topics of study for doctoral students under the direction of a member of the Department of Operational Sciences faculty.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Prerequisite Approval of Instructor

Terms Offered All Four Quarters

OPER 999 - Dissertation Research

Dissertation research conducted in Operations Research; including, but not limited to, selection of research advisor and topic, formation of research committee, supervision of the research, presentation and defense of the dissertation in accordance with Doctoral Council policy letters.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

ORSC 501 – ISL Research Colloquium

The purpose of this course is to discuss potential topics of interest to ISL students for their Graduate Research Project, to 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.

Instructional Method Seminar

Min Hours 0

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Winter

ORSC 647 - Organizational Policy and Strategic Management

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 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 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.

Instructional Method Lecture

Min Hours 4

Prerequisites ORSC-542 or Permission of Instructor

Terms Offered Summer

PENG 799 - Research Project

Project completion course. Credit given for completion of research project.

Instructional Method Thesis

Min Hours 8

Terms Offered All Four Quarters

PENP 798 - IDE Research Project

Project completion course. Credit given for completion of research project.

Instructional Method Thesis

Min Hours 9

Terms Offered All Four Quarters

PENS 791 - Research Project Completion

Project completion course. Credit given for completion of research project.

Instructional Method Thesis

Min Hours 1

Max Hours 7

Terms Offered All Four Quarters

PENV 798 - Group Design Project Completion

Project completion course. Credit given for completion of research project.

Instructional Method Lecture

Min Hours 1

Max Hours 9

Terms Offered All Four Quarters

PHYS 519 - The Space Environment

The near-earth space environment is that in which artificial satellites and astronauts must operate. This course is concerned with the general conditions encountered in the Earth's atmosphere, the ionosphere, and the magnetosphere, and specific effects studied are spacecraft thermal equilibrium, spacecraft charging, and space-to-ground communications. Other topics include atmospheric chemistry, radiation belts and solar activity.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

PHYS 521 - Space Surveillance

This course covers the fundamental physics necessary for an understanding of remote sensors with an emphasis on visible light and infrared systems. Beginning with the sources of electromagnetic radiation, the following aspects of the problem are treated phenomenologically; the interaction of light with matter, atmospheric absorption and scattering, radiometry, optical systems, spectral and spatial resolution and imaging, and electro-optical detectors. Where appropriate, examples are chosen from current Air Force technology.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall (DL) and Winter

PHYS 531 - Electromagnetism

An intermediate level course stressing basic principles of electromagnetic field theory. 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.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-504

Terms Offered Summer

PHYS 542 - Optics Laboratory Course

A fundamental laboratory course with experiments in coherence, diffraction, lenses, interference, polarization and lasers. Selected topics such as error calculation, radiometry, spectrometry, and detectors are introduced. Lectures will introduce selected topics in laboratory practice such as error calculation, radiometry, spectrometry, coherence, and detectors.

Instructional Method Lecture with Lab

Min Hours 2

Prerequisites PHYS-640

Corequisite PHYS-542L

Terms Offered Spring

PHYS 542L - Lab for Optics Laboratory Course

Lab associated with PHYS-542.

Instructional Method Lab

Min Hours 0

Corequisite PHYS-542

Terms Offered Spring

PHYS 556 - Introduction to Quantum Physics

Basic mathematical and conceptual principles of quantum physics. Includes black body radiation, photoelectric effect, Rutherford scattering, Bohr theory of the atom, wave-particle duality, Schrödinger wave equation and applications, one electron atom, atomic spectra, X-rays, periodic table, statistical physics, and statistical distribution functions.

Instructional Method Lecture

Min Hours 4

Terms Offered Summer

PHYS 570 - Physics of Solid State Devices

Basic solid state physics for the non-physicist who needs an understanding of solid state devices. Topics include quantum theory, quantum statistics, crystal structure and binding, reciprocal lattice, crystal lattice dynamics, free electron theory, energy band theory, and semiconductors.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-556 or Permission of Instructor

Terms Offered Fall

PHYS 598 - Engineering Physics Seminar

This seminar, offered once a week for the first four quarters, is designed primarily to assist engineering physics and electro-optics students in the pursuit of their careers as R&D officers. 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. This series is also used to present possible areas for thesis work, problem-solving techniques, as well as the necessary background for writing and defending the final thesis document.

Instructional Method Seminar

Min Hours 1

Terms Offered Spring

PHYS 600 - Dynamics

Treatment of theoretical mechanics at the advanced level. Develops Lagrangian and Hamiltonian formulations of dynamics from variational principles. Applications include central force problems, rigid body motion by matrix transformations, and coupled oscillators.

Instructional Method Lecture

Min Hours 4

Prerequisites MATH-504

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-531 or permission of instructor

Terms Offered Fall

PHYS 620 - Directed Energy Effects

The effectiveness of directed energy systems is analyzed and assessed. Laser and high power microwave missions are presented; target vulnerabilities are then analyzed and translated into system requirements. Laser-target interactions will include thermal soak, ablation, vaporization, impulsive damage and plasma formation. Microwave interactions with a variety of targets will also be addressed and related to the full range of desired effects.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

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, 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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-531 or PHYS 601

Terms Offered As Needed

PHYS 635 - Thermal Physics

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

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-556 or PHYS-655

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

PHYS 650 - Kinetic Theory of Plasmas

Study of the basic concepts and definitions of plasma physics and the parameters that characterize plasma behavior. Includes applications of the Boltzmann equation and kinetic theory to such basic plasma phenomena as Debye shielding, plasma waves, magnetic confinement, and Ionospheric physics.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-531 or PHYS-601

Terms Offered Spring

PHYS 655 - Quantum Mechanics I

An introduction to the Schrodinger 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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

PHYS 661 - Atomic and Molecular Spectroscopy

Treats selected topics in atomic and molecular physics. Includes atomic spectroscopy, rotation, vibration and electronic transitions in diatomic and triatomic molecules, line shape, line broadening, and interaction of radiation fields with matter, particularly in lasers.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-655

Terms Offered Winter

PHYS 670 - Introduction 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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-635 and PHYS-655

Terms Offered Spring

PHYS 686 - Computational Methods for Atmospheric and Space Sciences

Develops fundamental computational techniques, while emphasizing modern programming practices, with a focus on terrestrial and space weather applications. Topics include numerical integration, linear and nonlinear ODE's, finite difference discretization of PDE's and data assimilation.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

PHYS 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 the solids (crystal optics), coherence theory, and diffraction theory of aberration.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-601 and PHYS-640

Terms Offered Winter

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-655

Terms Offered Fall

PHYS 756 - Quantum Mechanics III

Advanced quantum mechanics: examines topics of in-variance 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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, anharmonic effects, dielectric properties, semiconductor properties, defects, magnetism, and superconductivity.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-770

Terms Offered As Needed

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

An in-depth study of advanced topics in solid state physics. Special emphasis will be given to the topics covering the optical properties and optical processes in semiconductors, dealing with the interactions among photons, electrons, holes, and impurities in semiconductor crystals. Topics include energy states, radiative and non-radiative transitions, emissions, and absorptions in semiconductors, processes and p-n junctions, and photovoltaic effects on semiconductors.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites 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 plasma-wave interactions, Van Allen belts, auroral phenomena.

Instructional Method Lecture

Min Hours 4

Prerequisites 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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-635 and PHYS-650

Terms Offered Spring

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-755

Terms Offered As Needed

PHYS 781 - Laser Spectroscopy

A first course in laser spectroscopy designed to provide the student with the fundamental principles underlying modern spectroscopic methods utilizing lasers. Topical coverage includes the discussion of elements of radiation physics relevant to laser spectroscopy, characteristics of lasers as a spectroscopic tool, and spectroscopic instrumentation including various detection techniques. These topics are followed by an overview of selected experimental techniques such as laser induced fluorescence, laser Raman, and two photon absorption spectroscopy.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-661 AND OENG-620

Terms Offered Summer

PHYS 791 - Operational Assessments in Atmospheric and Space Sciences

In this course, students will study the current operational aspects of USAF space and terrestrial environmental forecasting and observing. Additionally, students will then attempt to solve a current or future DoD operational environment-related problem through a class design study. Possible examples include: improving satellite-anomaly analysis procedures; writing satellite-anomaly case studies; validating forecasting rules; comparison of operational models.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-775

Terms Offered Winter

PHYS 792 - Space and Terrestrial Weather Laboratory

This laboratory course introduces the student to the space and terrestrial weather computer codes used to provide operational weather support to DoD, including solar wind, magnetospheric, ionospheric, thermospheric, and terrestrial 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 observe the environment. Finally, students will be exposed to experiments that illustrate how space and terrestrial weather affects operations.

Instructional Method Lecture with Lab

Min Hours 2

Corequisite PHYS-791 and PHYS-792L

Terms Offered Winter

PHYS 792L - Space and Terrestrial Weather Lab

Lab associated with PHYS-792.

Instructional Method Lab

Min Hours 2

Corequisite PHYS-792

Terms Offered Winter

PHYS 798 - Departmental Seminar

This seminar is offered once a week during the academic quarters for all students in Doctoral and Master's programs in the Department of Engineering Physics. This seminar is intended to provide the student with information on a wide range of topics from current scientific research to practical engineering design. Where possible, the focus is on specific Air Force needs and programs in areas related to their studies and the structure and organization of the R&D community within the Air Force.

Instructional Method Seminar

Min Hours 1

Terms Offered All Four Quarters

PHYS 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. 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.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisite Permission of Department

Terms Offered All

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.

Instructional Method Lecture

Min Hours 4

Prerequisites PHYS-730 and PHYS-755

Terms Offered As Needed

PHYS 880 - Positron Physics and Chemistry

Advanced treatment of physics and chemistry of positrons 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 porimetry, materials applications, and 5) quantum computational methods to model positron chemistry.

Instructional Method Lecture

Min Hours 4

Prerequisites CHEM-780, CHEM-850 or PHYS-755 or Permission of Instructor

Terms Offered As Needed

PHYS 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisite Permission of Department

Terms Offered All Four Quarters

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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisite Permission of Department

Terms Offered All Four Quarters

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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-525

Terms Offered All Four Quarters

RDMT 541 - Operational Technology and Innovation

This course has three components. Part one is the theory on innovation and technology ranging from the dynamics of innovation and technology S-curves, to disruptive technologies through dominate designs, and from lead users to corporate regeneration. Part two is an overview of the current state of technology in our fielded systems from fighters to satellites to communication systems. Part three is a look at the technologies developed or being developed in our laboratories, universities, and commercial firms and how these technologies may be applied in current and future defense and commercial systems. Some lectures will be held at the secret level.

Instructional Method Lecture

Min Hours 3

Terms Offered Winter

RDMT 554 - Management in R&D Organizations

Technological change and innovation have impacted the socio-political economic systems in our society in a variety of ways. These changes often play a dual role - they disrupt the existing order and create new opportunities. Although most innovations and technological changes fail, companies that do not pursue innovation often fail too. Therefore, managing innovation is often considered one of the most difficult challenges a manager faces. The focus of the course is on the management of product and process innovation, both sustaining and disruptive innovations will be discussed.

Instructional Method Lecture

Min Hours 3

Terms Offered As Needed

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 and can be applied in the Air Force and other DOD organizations. Items covered will be the results of student and faculty research, their implications and implementation. Other topics will be integrative in nature aimed at bringing together lessons from the entire curriculum. This is a capstone class aimed at preparing students to take leadership positions in all aspects of the defense research and development community.

Instructional Method Seminar

Min Hours 3

Terms Offered Winter

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 measures, 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 determine how close to the truth they have come in their own efforts.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-525 or Permission of Instructor

Terms Offered Winter and Spring

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.

Instructional Method Lecture

Min Hours 3

Prerequisites RSCH-630

Terms Offered Summer

SENG 520 - Systems Engineering Design

This course provides a broad introduction to a systematic approach for the conceptualization, design, analysis, operation, and sustainment of complex systems within the Department of Defense (DoD). While this course serves as a stand-alone introduction to Systems Engineering, it also provides the foundation for further study in Systems Architecture and Engineering Software Systems.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall(DL) and Summer (RES)

SENG 550 - Small UAS Concept Definition and Preliminary Design

This is the first in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In developing their own UAS, students will address early systems engineering concepts such as mission analysis, concept definition, requirements refinement, and preliminary system design. The course culminates in a preliminary design review of the selected UAS concept.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites SENG-520 and ASYS-525 or EENG-510

Terms Offered Winter

SENG 560 - Human Systems Integration

A human-centered design approach (i.e., "system" includes people within an organization that apply technology to accomplish a task) is explored through readings, discussion and a project. Included are discussions of the Human Systems Integration domains (manpower, personnel, training, human factors, system safety, environmental safety, occupational health and survivability) and a method for considering these domains within the Systems Engineering Lifecycle.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Spring

SENG 570 - Lean for Scientists and Engineers

Lean is a process improvement methodology. However, translating the principles of Lean, Six Sigma, and other methodologies into the sciences and engineering has lagged. How does Lean apply to the work of scientists and engineers? This course will answer this question. Topics include people, process, technology and management dimensions across a Lean Enterprise focusing on applications for scientists and engineers. The course includes lectures, active learning exercises, a possible plant tour, talks by industry practitioners, and videos. A key deliverable of this course is a team project.

Instructional Method Lecture

Min Hours 4

Terms Offered Winter and Spring

SENG 585 - Reliability in Systems Design

The purpose of this course is to introduce students to the probabilistic models and statistical methods used by reliability engineers. This first course gives basic definitions and terminology, investigates parametric lifetime models, non-parametric methods, coherent systems analysis. Markov analysis techniques and an introduction to repairable system analysis. Emphasis will be placed on using these mathematical tools to models RAM as a dynamic process, develop test plans, perform graphical and statistical inference, as well as model product improvement the development process.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583

Terms Offered Winter

SENG 593 - Software Systems Engineering

This course provides a foundation for System Engineers into both design and management of software intensive systems. Topics include requirements elicitation, object-oriented modeling using the Unified Modeling Language (UML), design patterns, and iterative software development. Then, the course examines software management through DoD/AF guidance, project case studies, software management best practices and software estimation.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Winter

SENG 610 - Project Management

Provides knowledge and tools to manage projects or effectively contribute as a project member. Framed by the systems development cycle, course explains challenges specific to three major project types: systems engineering, software systems, and construction. Basic topics include project life cycle, project planning/selection, cost estimating, scheduling, and risk management. Advanced topics include critical chain analysis, adaptive project management, acquisition logistics and contracting. A one hour lab illustrates course principles using Microsoft Project software.

Instructional Method Lecture with Lab

Min Hours 4

Corequisite SENG-610L

Terms Offered Spring and Summer

SENG 610L - Project Management Lab

Lab associated with SENG-610.

Instructional Method Lab

Min Hours 0

Corequisite SENG-610

Terms Offered Spring and Summer

SENG 620 – Quantitative Analytical Methods

This course builds on the material presented in SENG 520, presenting additional depth and breadth in topics related to systems engineering. The focus of this course is on the quantitative analysis of engineering-related problems using mathematical/statistical techniques to assist with various aspects of system development, particularly those related to system dynamics, decision-making, and value assessments. Topics may include decision/analysis, utility theory, decision trees, optimization and queueing theory.

Instructional Method Lecture Via E-Learning

Min Hours 4

Prerequisite SENG-520

Terms Offered Fall

Location Distance Learning

SENG 629 - Research Methods Seminar

This course provides preparatory research methods for students planning their Systems Engineering thesis. It provides an understanding of the basic methods and tools for planning and conducting research, and concepts related to scientific inquiry. The course will provide a foundation for students in planning, scoping, defining objectives, purpose and approach of their own engineering and research project.

Instructional Method Seminar

Min Hours 0

Terms Offered Fall

Location Distance Learning

SENG 640 - Systems Architecture

This course provides the foundation for developing and evaluating system architectures through an intensive study of the relationships between different types of system representations and the methodologies used to obtain them. Approaches include a variety of model-based systems engineering (MBSE) techniques and heuristics to assess behavior and performance. Students will select a military concept, and iterate its design solution guided by the DoD Architecture Framework (DoDAF).

Instructional Method Lecture

Min Hours 4

Prerequisites SENG 520 and SENG-593 or Permission of Instructor

Terms Offered Winter (RES) and Spring (DL)

Location Distance Learning

SENG 650 - Small UAS Detailed Design

This is the second in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In this course, students will iterate and mature their preliminary system design from SENG 550 into a detailed design, with allocated functional and performance requirements. The course culminates in a critical design review of the selected UAS design, to include full traceability of established requirements.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites SENG-550

Corequisite SENG-650L

Terms Offered Spring

SENG 650L – Applications of SE II

This is the second in a three course specialty sequence encompassing an in-depth application of systems engineering. In this second course, students iterate the preliminary design into a detailed design, with allocated functional and performance requirements. Communications and software architecture will be highlighted. Students will perform a critical design review, traceable to the operational requirements identified in SENG 550.

Instructional Method Lab

Min Hours 0

Corequisites SENG-650

Terms Offered Spring

SENG 651 - Small UAS Test and Evaluation

This is the third in a three-course specialty sequence in which systems engineering is applied in depth to an Unmanned Airborne System (UAS). In this course, students must implement their detailed design from SENG 650 through appropriate test planning and execution, making design modifications as necessary to meet system requirements. This course culminates in an operational flight test of the student's design.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites SENG-650

Corequisites SENG-651L

Terms Offered Summer

SENG 651L – Applications of SE II

This is the third in a three course specialty sequence encompassing an in-depth application of systems engineering. SENG 651 will provide students the opportunity to work key systems engineering issues associated with building prototypes, conducting a Safety Review Board/Test Review Board, flight testing and data collection/analysis. Design of Experiments will be introduced as a method to insure test objectives are met in a cost effective manner. In addition to a final presentation, students will build a working prototype of a collaborative set of small unmanned airborne systems.

Instructional Method Lab

Min Hours 0

Corequisites SENG-651

Terms Offered Summer

SENG 653 - Concept Definition and System Analysis

This course provides students with theory and process to perform mission area analysis, definition of operational need, concept formulation, analysis of alternatives, program formulation, and risk management. A current DoD mission area will be chosen as the theme for the course in order to provide a relevant educational experience with defense systems. Topics for this course include the overall mission analysis and requirements development processes used to develop a weapon system and allocation of mission needs to system and subsystem functional requirements. In the latter half of the course, students transition from operational requirements to allocated functional performance requirements and synthesizing these into an affordable and operationally effective system design. The focus during this phase will be on risk identification/mitigation and cost affordability. U.S. citizens only.

Instructional Method Lecture

Min Hours 4

Prerequisites SENG-520 and SENG-640

Terms Offered Winter

Restrictions US Citizenship Required

Location Distance Learning

SENG 685 - Reliability Engineering

This course is a continuation of SENG 585. 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.

Instructional Method Lecture

Min Hours 4

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 areas of reliability, maintainability, and availability applied to system design. Comparison of current Eastern/Western approaches to design is focus of course. Emphasis is on the application of design of experiments to improve quality of complex systems.

Instructional Method Lecture

Min Hours 4

Prerequisites SENG-685 and STAT-601 or Permission of Instructor

Terms Offered Summer

SENG 695 – Systems Engineering Research Seminar

This seminar will guide students in selecting a research topic and a thesis advisor as part of the resident Graduate Systems Engineering (GSE) program. Students will be presented the principles of organizing and conducting research and will be introduced to the fundamentals of literature reviews, a variety of research methods and thesis construction. Thesis development and time lines will also be discussed.

Instructional Method Seminar

Min Hours 0

Prerequisites SENG-685 and STAT-601 or Permission of Instructor

Terms Offered Fall, Winter and Spring

SENG 699 - Master's Level Special Study

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.

Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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 Architectures, 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. A research paper is required which emphasizes operational capability, requirements definition and measurement, architectural design modeling and trade-space evaluation.

Instructional Method Lecture

Min Hours 4

Prerequisites SENG-640

Terms Offered Winter and Summer

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.

Instructional Method Thesis

Min Hours 4

Terms Offered Fall

Location Distance Learning

SENG 798 - Master's Capstone Project

A topic is selected from a wide variety of problems of current interest to the Air Force and/or the Department of Defense. The Capstone Project is performed as a group or individual project under the supervision of departmental faculty. Results are provided in a formal written report. This course is similar to SENG 799, but is for non-thesis students.

Instructional Method Thesis

Min Hours 1

Max Hours 9

Terms Offered All Four Quarters

Location Distance Learning

SENG 799 - Independent Study

A topic is selected from a wide variety of problems of current interest to the Air Force and the Department of Defense. The independent study is performed as a group or individual project under the supervision of a departmental faculty. Results are reported in a written thesis and presented in a formal oral presentation.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

SENG 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

SENG 999 - Dissertation Research

An in-depth study of a research topic selected from variety of problems of current interest to the Air Force, with the results presented in a formal dissertation written under the supervision of a departmental professor.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

STAT 521 - Applied Statistical Data Analysis

This course provides statistical tools for the analysis of data in the decision-making process. The course covers descriptive statistics, probability theory, and statistical inference. Concepts discussed include methods on how to specify what data is wanted, collect data, extract information from existing sources of data, test the validity of key concepts, estimate problem parameters, and relate one decision variable to another (ANOVA and regression).

Instructional Method Lecture with Lab

Min Hours 5

Corequisite STAT-521L

Terms Offered As Needed

STAT 521L - Applied Statistical Data Analysis Lab

Lab associated with STAT-521.

Instructional Method Lab

Min Hours 0

Corequisite STAT-521

Terms Offered As Needed

STAT 525 - Applied Statistics for Managers I

This course covers descriptive statistics, probability theory and statistical inference. Descriptive statistics covers both numerical and graphical techniques to illustrate data. Probability theory covers theoretical underpinnings of both discrete and continuous random variables. Statistical inference includes topics such as the central limit theorem, confidence interval and hypothesis testing (one sample and two), and nonparametric techniques.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall and Summer

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).

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites STAT-525

Corequisite STAT-535L

Terms Offered Winter

STAT 535L - Applied Statistics for Managers II Lab

Lab associated with STAT-535.

Instructional Method Lab

Min Hours 0

Prerequisites STAT-525

Corequisite STAT-535

Terms Offered Winter

STAT 583 - Introduction to Probability and Statistics

Basic concepts of probability and statistics with applications are covered. Topics include: Permutations and combinations; random variables; probability distributions; estimation and confidence intervals; hypothesis testing.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall, Winter, and Summer

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.

Instructional Method Lecture

Min Hours 4

Terms Offered Fall

STAT 587 - Applied Probability and Statistical Analysis

This course presents the basic concepts of probability and statistics. Emphasized topics are basic probability axioms and laws, discrete and continuous random variables, joint probability distributions, expectations, conditional probability, the central limit theorem, sampling theory, estimation, and hypothesis testing.

Instructional Method Lecture

Min Hours 4

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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-583 and either MATH-509 or MATH-511

Terms Offered Fall

STAT 602 - Mathematical Statistics

This course provides the student with a solid foundation in the basic 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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-601

Terms Offered Winter

STAT 641 - Analysis of Variance

This course introduces classical analysis of variance (ANOVA) techniques which includes one-way, two-way, and three-way ANOVA. Additionally, an introduction to design of experiments will be presented (i.e., full/fractional factorial, split-plot, and incomplete-block designs).

Instructional Method Lecture with Lab

Min Hours 3

Prerequisites STAT-602, STAT-696 and either MATH-521 or MATH-621

Corequisite STAT-641L

Terms Offered Spring

STAT 641L - Analysis of Variance Lab

Lab associated with STAT-641.

Instructional Method Lab

Min Hours 1

Prerequisites STAT-602, STAT-696 and either MATH-521 or MATH-621

Corequisite STAT-641

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.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-602

Terms Offered Summer

STAT 694 - Design of Experiments

This course gives an introduction to the linear statistical model and its associated forms of inference with special emphasis on analysis of variance models. The classical experimental design models are analyzed with emphasis on fractional factorial designs and their application to engineering problems. The successful student will be able to pose a research question in statistical terms and design an experiment to answer that question including determination of Expected Mean Square (EMS) and F-tests.

Instructional Method Lecture

Min Hours 4

Prerequisites STAT-696

Terms Offered Summer

STAT 696 - Applied General Linear Models

Theory and application of the general linear statistical models. Population distribution and parameters are tested using regression and analysis of variance in the context of the general linear model. Topics covered include general regression and correlation analysis, basic analysis of variance, and multifactor analysis of variance.

Instructional Method Lecture with Lab

Min Hours 4

Prerequisites STAT-583

Corequisite STAT-696L

Terms Offered Fall

STAT 696L - Applied General Linear Models Lab

Lab associated with STAT-696.

Instructional Method Lab

Min Hours 0

Prerequisites STAT-583

Corequisite STAT-696

Terms Offered Fall

STAT 699 - Master's Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

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. 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 four quarters and no credit is given until the end of the last quarter.

Instructional Method Thesis

Min Hours 1

Max Hours 12

Prerequisites Permission of Department

Terms Offered All Four Quarters

STAT 899 - Doctoral Level Special Study

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. Requires submission of Special Studies Form and syllabus to the department for registration.

Instructional Method Special Study Course

Min Hours 1

Max Hours 12

Terms Offered All Four Quarters

STAT 999 - Dissertation Research

Dissertation research conducted in probability or 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.

Instructional Method Dissertation

Min Hours 1

Max Hours 12

Prerequisites Approval of Research Advisor

Terms Offered All Four Quarters

TENC 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENC 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Mathematics and Statistics. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

TENG 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENG 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Electrical and Computer Engineering. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

TENP 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENP 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Engineering Physics. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

TENS 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENS 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Operational Sciences. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

TENV 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENV 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Systems Engineering and Management. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

TENY 799 - Thesis Completion

Thesis Completion course for graduating students to be taken during the last quarter of study. Registration in TENY 799 for 12 non-billable credit hours is required for all master's students whose research advisors are in the Department of Aeronautics and Astronautics. The grade assigned to this course is the official thesis grade.

Instructional Method Thesis

Min Hours 12

Terms Offered All Four Quarters

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