

Undergraduate Handbook



University of Kansas
School of Engineering
Department of
Aerospace Engineering

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Chair's Letter

Welcome to the University of Kansas and the Department of Aerospace Engineering.

Most likely, you have entered our program because of your fascination with things that fly - aircraft, spacecraft, balloons, etc. You share this fascination with all the department faculty and alumni. Some of you might be interested in the problems associated with flight in the atmosphere (Aeronautics). Others will be interested in problems associated with operation in space (Astronautics). The Bachelor of Aerospace Engineering will prepare you for a career in either path. The program is designed to provide you with the basic understanding of the physical world, the mathematics needed to model and analyze these problems, as well as the specific technology that applies these ideas and principles to aerospace vehicles and systems.

Because you are preparing for a 40-year career and no one can imagine what new challenges and opportunities you will face, this program must emphasize the concepts and methods that will always be important, i.e. the laws of nature and mathematical methods. Unfortunately, it is impossible to learn in four years all you will need during your career. You should consider this program as the start of a lifelong experience of education and discovery. The faculty goal is to help you develop the ability and confidence to build on these basic principles to learn what is needed to be successful in the Aerospace Industry.

When you have completed the program and earned your BS, you will be able to enter industry, government organizations including NASA, a branch of the military or continue your education in graduate programs. The purpose of this handbook is to clearly identify the resources, the academic program, the graduation requirements, and the department rules and procedures that define the Aerospace Engineering Program. A similar handbook is available which defines all the graduate programs offered by the department. If you have a question about the program, first look in this handbook. If this does not provide a satisfactory answer, contact your advisor or see me.

Again, welcome.

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*Refer to the glossary for acronym definitions.

Section 1: Department Overview

1.1 Department History

The Kansas Board of Regents approved the Bachelor of Science in Aerospace Engineering degree in 1941. Since the first graduating class in 1944, the department has graduated over 1000 students. The BS in Aerospace Engineering has been continuously accredited by the Engineering Council for Professional Development and the Accreditation Board of Engineering and Technology, Inc. The review by the Accreditation Board assures the quality of the program. The department also offers graduate programs at both the Master and Doctoral levels. The department Advisory Board, made-up of representatives from industry, academia, and the government, annually reviews the department programs. This review assures that graduates of our programs meet the needs of the profession.

1.2 General Description of BS Program

The focus of the BS program in Aerospace Engineering is the design of aerospace vehicles and components. This is accomplished in a four-year academic program. The 1st year consists of basic sciences, mathematics, and communication courses. These courses form the key foundation for the rest of the program. In addition, you will take an Introduction to Aerospace Engineering course that will give you an overview of the BS program. In the second year, you will continue to take basic mathematics and science as well as engineering science courses. The engineering science courses apply the principles you have mastered in the basic sciences and mathematics to the solution of engineering problems. In the third year, you learn the unique nature of aerospace problems. These courses cover the major disciplines within Aerospace Engineering - fluid mechanics and aerodynamics, propulsion, structures, and flight dynamics. You will also have courses in complementary topics including computer graphics and instrumentation. In your fourth year, you have the opportunity to see how all the individual specialized technologies are used to design a vehicle.

Throughout the program, you have the opportunity to take elective courses from the College of Liberal Arts and Sciences. These are referred to as KU Core electives. You will take Aerospace Colloquium for eight semesters in the program. This course is a seminar series in which practicing engineers from industry or government organizations present lectures based upon their experiences, which give you a feel for the Aerospace Engineering profession.

1.3 Aerospace Engineering Faculty

Emily Arnold

Assistant Professor of Aerospace Engineering

Dr. Arnold joined the Department in January 2015. She received her B.S. in Aerospace Engineering in 2009 and Ph.D. in Aerospace Engineering in 2013, both from the University of Kansas. After receiving her Ph.D., Dr. Arnold joined the MITRE Corporation where she worked on the Air Force's BACN E-11A program. Dr. Arnold is both an Amelia Earhart Fellow and NASA Earth and Space Science Fellow, and she played an important role at CReSIS in developing NASA's DC-8 and P-3 polar flying laboratories. Dr. Arnold's research interests include multifunctional structures, airborne platform sensor integration, remote sensing, and UAS. She is a member of AIAA, Sigma Gamma Tau, Tau Beta Pi, and IEEE.

Ron Barrett

Professor of Aerospace Engineering

Dr. Barrett joined the Department in 2005. His research areas include enhancement of transportation related technologies, design, development and testing of unusual uninhabited aerial vehicles, missiles, munitions & adaptive aerostructures. He received his BS and Ph.D. degrees in Aerospace Engineering from KU in 1988 and 1993. He attended the University of Maryland, College Park as a US Army Rotorcraft Fellow where he received his MS in Aerospace Engineering in 1990. Dr. Barrett served for 12 years on the faculty of Auburn University, Alabama where he won every teaching award available for his position. He also served as a USAF Faculty Fellow, flight test engineer & a Visiting Professor for one year at The Technical University of Delft, Holland. His work on adaptive aerostructures has yielded many "firsts" including the first fixed- and rotary-wing aircraft to fly using adaptive materials for flight control. He has more than 100 publications and three patents on adaptive rotors, dragless wings and high performance convertible UAVs. In 1998, he was honored for his work in adaptive aerostructures when he claimed Discover Magazine's Discover Award for Aviation and Aerospace Technology. He has consulted for every major US Aerospace corporation and worked for all branches of the DoD, NASA & the NSF. He has taught short courses on Adaptive Aerostructures and Convertible UAV Design in the US, Sweden, Portugal, Germany, Holland, Singapore, India, Ireland, Scotland and England. He especially enjoys interacting with students and has advised and coached more than a dozen award winning AIAA student papers and design teams. He is currently an Associate Fellow of the AIAA serving as a member of the Adaptive Structures and Aircraft Design Technical Committees and KUAIAA Chapter Advisor and maintains active memberships in the AMA, ASEE, ASME, Phi Beta Delta, SAE, SHPE, SPIE, Sigma Gamma Tau & Tau Beta Pi.

Haiyang Chao

Assistant Professor of Aerospace Engineering

Dr. Chao received the B.S. degree in Electrical Engineering in 2001, the M.S. degree in Electrical Engineering in 2005, both from Zhejiang University, and the Ph.D. degree in Electrical & Computer Engineering from Utah State University in 2010. His research interests are in the areas of estimation, control, & dynamics of unmanned vehicles with an emphasis on unmanned aerial vehicles. He has authored or coauthored one book, two book chapters, & more than 30 peer-reviewed research papers. He is one of the key developers of AggieAir, a low-cost small UAV platform for remote sensing applications, which has won the 1st place in the 2009 AUVSI Student UAS competition. His recent research focuses on vision-aided navigation, wind/gust estimation, cooperative control, remote sensing, and flight avionics development.

Dongkyu Choi

Assistant Professor of Aerospace Engineering

Dr. Choi joined the Department in January of 2012. He received his BS (2001) in Aerospace Engineering from Seoul National University, and his MS (2003) and PhD (2010) degrees in Aeronautics and Astronautics

from Stanford University. Dr. Choi worked as a postdoctoral research associate at the University of Illinois at Chicago before joining the KU as a member of faculty in Aerospace Engineering. He participated in various government-funded projects from the NSF, Defense Advanced Research Projects Agency, and the Office of Naval Research, in addition to funded projects from Korea Institute of Science and Technology. His research interest includes artificial intelligence, cognitive architectures, autonomous vehicles, and robotics.

Mark Ewing

Associate Professor of Aerospace Engineering and Director of the Flight Research Laboratory

Dr. Ewing joined the department in 1992 and served as the Chair of the Department from January 1999 to 2012. His expertise is in the areas of engineering mechanics and the analysis, design and testing of lightweight structures. He received his BS in Engineering Mechanics from the USAF Academy and in 1972, an MS in Mechanical Engineering and a PhD in Engineering Mechanics from Ohio State University in 1978 and 1983 respectively. He served in the US Air Force for 20 years, starting with engineering positions as a Turbine Engine Design Analyst and a Propulsion Staff Officer. He was an Instructor in Civil Engineering from 1978 to 1980 and Associate Professor in Engineering Mechanics from 1983 to 1989 at the USAF Academy. Dr. Ewing closed his Air Force career as Chief of the Analysis and Optimization Branch, and Senior Research Engineer in the Structures Division, Flight Dynamics Directorate, and Wright Laboratory. In 1994, Dr. Ewing was selected as the Outstanding KU Aerospace Engineering Educator. He also was presented with the 1994 Henry E. Gould award for the KU School of Engineering Outstanding Educator.

Saeed Farokhi

Professor of Aerospace Engineering

Dr. Farokhi joined the Department in 1984. He specializes in propulsion and fluid mechanics. He received a BS degree in Aeronautical and Astronautical Engineering in 1975 from the University of Illinois, and then received his M.S. and Ph.D. in Aeronautics and Astronautics from MIT in 1976 and 1981, respectively. His professional experience includes working four years as a Design and Development Engineer and Project Leader in the Gas Turbine Division of Brown, Boveri, and Co. in Baden, Switzerland. In 1989, Dr. Farokhi received both the Burlington Northern Foundation Faculty Achievement Award for his distinguished service to engineering research and the Miller Professional Development Award from the KU School of Engineering. He also received the 1990 and 1997 Henry E. Gould Award for Outstanding Teaching from KU, and was selected to receive the Outstanding Aerospace Educator Award in 1990, 1993, 1997 and 1999. Dr. Farokhi was appointed to John E. and Winifred E. Sharp Teaching Professorship in 1995 and 2012. He has served as the Director of Flight Research Laboratory at KU from 1990 to 1995. Dr. Farokhi was named the Associate Dean of Graduate School in 2004 where he was in charge of the Graduate Program and Dissertation Status review, Preparing Future Faculty and Preparing Future Professional programs and the Graduate Division of The College of Liberal Arts and Sciences. He has served as the National President of the Sigma Gamma Tau, The Honor Society of Aerospace Engineering, in 2000-2003. Dr. Farokhi is a Fellow of ASME, a fellow of the Royal Aeronautical Society, an Associate Fellow of AIAA and a member of SAE, ASEE, APS, Phi Beta Delta, and the American Academy of Mechanics. Dr. Farokhi is the author of Aircraft Propulsion, 2nd Edition, published by John Wiley in 2014 and is a coauthor with Roelof Vos of Delft University of Technology in the Netherlands of a textbook on Transonic Aerodynamics that was published by Springer in 2015.

Rick Hale

Professor of Aerospace Engineering

Dr. Hale joined the department of Aerospace Engineering at the University of Kansas in 1998. His expertise is in the areas of engineering mechanics, experimental mechanics, and composite materials and structures for aerospace applications to include uninhabited air vehicles. He received his BS in Aerospace Engineering from Iowa State University in 1988, his M.S. in Mechanical Engineering from Washington University in

1991, and his Ph.D. in Engineering Mechanics from Iowa State University in 1995. Dr. Hale was a Senior Project Engineer for the Boeing Company (formerly McDonnell Douglas Aerospace) from 1989 to 1998, where he worked on composite design and analysis processes, fiber placement, and structural concepts in advanced design. He is currently the Air Vehicles lead for the NSF Center for Remote Sensing of Ice Sheets. He holds four patents and has authored or co-authored more than forty journal articles and conference proceedings relating to composite materials, knowledge-based design tools, and uninhabited air vehicles. Dr. Hale is an Associate Fellow of AIAA, and is a member of SAE, SEM, SAMPE, ASEE, Tau Beta Pi, Sigma Gamma Tau, Pi Mu Epsilon, and Phi Beta Theta.

Shawn Keshmiri

Associate Professor of Aerospace Engineering

Dr. Keshmiri joined the Department in August of 2008. He received his BS in Mechanical Engineering from College of Engineering, Shiraz University in 1993. After obtaining over five years of industrial experience in energy systems, he attended California State University Los Angeles and worked as a researcher in the Multidisciplinary Flight Dynamics and Control Laboratory where he received his MS in Mechanical Engineering in 2004. He received his PhD in Aerospace Engineering, from the University of Kansas in 2007. After graduation, Dr. Keshmiri worked for the University of Kansas as a postdoctoral engineer and worked for the CReSIS, where he continues to do research. Dr. Keshmiri has also done research for NASA and the U.S. Air Force. His research is diversified in the areas of UAV flight systems and modeling and simulation of hypersonic vehicles with current research in aircraft dynamics, flight planning, flight control, and autonomous flight. Dr. Keshmiri is an Associate Fellow of AIAA and a member of Sigma Gamma Tau, SIAM, and Pi Tau Sigma. Dr. Keshmiri was selected to receive the Outstanding KU Aerospace Educator Award in 2012 and 2015. He was also selected by KU Aerospace Engineering graduate students and honored at the annual Celebration of Teaching, April 2013.

Craig McLaughlin

Associate Professor of Aerospace Engineering

Dr. McLaughlin joined the faculty of the Aerospace Engineering Department at the University of Kansas in 2007. Before coming to KU, he spent five years in the Department of Space Studies at the University of North Dakota. From 1994-2002 Dr. McLaughlin worked in the Space Vehicles Directorate of the U. S. Air Force Research Laboratory. There he served as principal investigator for formation flying for the TechSat 21 mission and as team lead for the Guidance, Navigation, and Control Team. Before that, he provided mission planning design and support for the MightySat II technology demonstration satellite, which captured the first hyperspectral images taken from space. The MightySat II team won the AFRL Commander's Cup Award in 2002. Dr. McLaughlin received his M. S. and Ph. D. in Aerospace Engineering Sciences at the University of Colorado at Boulder in 1994 and 1998 respectively. He received a B. S. in Aeronautical Engineering from Wichita State University in 1992.

Ray Taghavi

John E. And Winifred Sharp Professor and Associate Chairperson of Aerospace Engineering

Dr. Taghavi joined the Department in 1991 with expertise in fluid mechanics and propulsion. He received his BS in Mathematics from Tehran University in 1965, his M.S. in Aerospace Engineering from Northrop University in 1978, and his Ph.D. in Aerospace Engineering from the University of Kansas in 1988. Dr. Taghavi has had professional experience at NASA's Lewis Research Center from 1986 to 1991, where he supported the NASA's High Speed Research Program. His research activities included supersonic jet noise, excitation & control of shear layers, and mixing enhancement of swirling flows. Dr. Taghavi was selected to receive the Outstanding KU Aerospace Educator Award in 1995. He was the recipient of the 1999 SAE Ralph R. Teetor National Educational Award and the 1999 Spahr Professorship Award from the KU School of Engineering, and was selected as one of the 1999 Boeing Welliver Faculty Fellows. Dr. Taghavi is the recipient of the 2001 AIAA Abe M. Zarem National Educator Award. He is a fellow of ASME, an associate

fellow of AIAA, and a member of SAE, ASEE, Sigma Gamma Tau, and Tau Beta Pi.

Z.J. Wang

Spahr Professor and Chairperson of Aerospace Engineering

Dr. Wang joined the Department in 2012 with expertise in Computational Fluid Dynamics. He received his B.S. in Applied Mechanics from the National University of Defense Technology in 1985, and his Ph.D. in Aerospace Engineering from the University of Glasgow in 1990. Then he conducted post-doctoral research in Glasgow and Oxford before joining CFD Research Corporation in Huntsville, Alabama in 1991 as a Research Engineer, and later becoming a Technical Fellow. In 2000, he joined the faculty of Michigan State University as an Associate Professor of Mechanical Engineering. In 2005 he returned to Aerospace Engineering at Iowa State University. His research areas include adaptive high-order methods for the Navier-Stokes equations, algorithm and flow solver development for structured and unstructured, overset and adaptive Cartesian grids, computational aeroacoustics and electromagnetic, large eddy simulation of transitional and bio-inspired flow problems, high performance computing on CPU and GPU clusters, geometry modeling and grid generation. He is a Fellow of AIAA, and an Associate Editor of the AIAA Journal. He was awarded the degree of Doctor of Science in Engineering by the University of Glasgow in 2008.

Huixuan Wu

Assistant Professor of Aerospace Engineering

Dr. Wu joined the AE department in 2015 and led the Laboratory of Experimental Fluid Mechanics and Complex Systems. He received his M.S. and Ph.D. in Mechanical Engineering from Johns Hopkins University in 2008 and 2011, respectively. After receiving his Ph.D., he visited the Max Planck Institute for Dynamics and Self-Organization in Germany from 2012 to 2014. He became an Alexander von Humboldt scholar in 2013, which also supported his research in applied optics. Dr. Wu's expertise is in the areas of experimental studies of complex fluid and thermal systems, including fundamental turbulence theory, stochastic processes, aerodynamics, fluid-machinery flow, and convection. He uses primarily optical and non-invasive methods, such as particle image velocimetry and holographic interferometry. Dr. Wu is also interested in particle dynamics, flow-structure interaction, heat transfer, applied optics, and laser techniques.

Zhongquan Charlie Zheng

Professor of Aerospace Engineering and Department Graduate Advisor

Dr. Zheng joined the department in 2010. His expertise is in the areas of Aerodynamics, Vortex Dynamics, Computational Fluid Dynamics and Heat Transfer, Aeroacoustics, and Biofluid Mechanics. He received BS and M.S. degrees from Department of Engineering Mechanics at Shanghai Jiao Tong University in 1984 and 1987 respectively, and Ph.D. degree in 1993 from Department of Mechanical Engineering and Mechanics, Old Dominion University. Before joining KU, he had been a faculty member for 9 years in Mechanical and Nuclear Engineering Department at Kansas State University (2001-2010), a faculty member for 5 years in Mechanical Engineering Department at University of South Alabama (1996-2001). Prior to that, he had conducted research first as a graduate student and then as a post-doctoral Research Associate at NASA Langley Research Center for 8 years (1988-1996). In AIAA, he is an Associate Fellow, Editorial Board Member of Journal of Aircraft, and Member of Aeroacoustics Technical Committee. In ASME, he is an Associate Editor of Journal of Fluids Engineering, Vice Chair of Computational Fluid Dynamics Technical Committee.

1.4 Advising System

All students are assigned a faculty advisor when they join the department. This advisor will normally continue to advise the same students throughout the BS program. A student can request a change in advisor through the Department administrative assistant. The Degree Progress Report form that is accessible via the myKU Portal on the internet documents student progress. Each student will see their advisor at least once a semester during pre-enrollment for the following semester. Advisors are available for consultation on any topic related to the student's activities at KU. In particular, students are encouraged to see their advisor as soon as a problem or concern is identified. This assures that all the student services provided by the university (e.g. career counseling, tutoring and study workshops) are utilized as needed during the student's career at KU. If for any reason a student cannot reach their advisor, the student can always make an appointment with the Department Chair.

1.5 Scholarships

All first-time, domestic students applying for admission to the School of Engineering will be considered for scholarships if they apply to the School of Engineering by November 1. Scholarships for upperclassmen are also available through the Aerospace department. The deadline for application is April 1 of each year.

1.6 Cooperative Programs

Since all Aerospace Engineering courses are taught only once each academic year, it has not been possible to setup standard cooperative programs, i.e. alternate semesters of academic course work and work periods. If a student were to miss a semester in the junior or senior year at least one semester would be added to their program in addition to the time lost during the work assignment. Students interested in Cooperative Programs should talk to their advisor as soon as possible.

1.7 Employment Opportunities and Placement Services

Aerospace Engineers are employed by a wide range of industries and organizations. Typical examples are:

Aircraft and Spacecraft Manufacturers

Aircraft and Spacecraft Operators

Research Labs: NASA, Federal Aviation Administration, Department of Defense

Armed Forces: U.S. Air Force, U.S. Navy, U.S. Marine Corps, U.S. Army, U.S. Coast Guard

Aerospace Component Manufacturers

Automobile Manufacturers

Academia

Engineering Consulting Companies

Employment opportunities in engineering, in general (but in Aerospace Engineering in particular), are cyclic. It is a fact, however, that even in poor times, unemployment among engineers is, typically, the lowest of all occupations. This is because an engineer is trained to solve problems (almost any type of problem) - in a logical fashion. This capability is desired by industry and government regardless of the type of engineering degree a person has. For that reason, engineers of all types find it easy to shift into jobs not requiring engineering backgrounds at all, if they so desire.

Students seeking permanent, as well as, summer jobs are encouraged to use the Engineering Career Center (ECC) in room 1410 LEEP2. The ECC provides individual career counseling and conducts career workshops to help prepare students for interviewing and resume preparation. They also assist students in setting up appointments with companies and other organizations that conduct on campus interviews.

1.8 Student Organizations

The University offers a wide variety of student organizations the aerospace engineering students can join. Student organizations of particular interest to aerospace engineering students are listed below:

American Institute for Aeronautics and Astronautics (AIAA)

The aerospace professional society on campus is the AIAA. There is an active student branch at the University of Kansas, which organizes technical and social meetings throughout the academic year. It is highly recommended that aerospace students become active in AIAA for status in the profession, career development and career motivation.

Faculty Sponsor: Ron Barrett

Microgravity Team (MGT)

The KU Microgravity Team helps organize students into groups to work on projects and to assist in the application process for the Reduced Gravity program at NASA. The Reduced Gravity Student Flight Opportunities Program provides a unique academic experience for undergraduate students to successfully propose, design, fabricate, fly and evaluate a reduced gravity experiment of their choice at the NASA Johnson Space Center.

Faculty Sponsor: Steven Hawley – Department of Astronomy and Physics

Sigma Gamma Tau (SGT)

SGT is the aerospace engineering national honor society in which membership is by invitation only. Students with exceptional scholastic performance are eligible for membership and will be invited by the campus chapter. Technical and social meetings are held throughout the academic year.

Faculty Sponsor: Ray Taghavi

Society of Women Engineers (SWE)

The Society of Women Engineers is a national, professional, educational organization of engineers, and men and women with equivalent engineering experience, dedicated to the advancement of women in the engineering profession. There is an active student chapter of SWE on campus open to all engineering students and faculty who are interested in the goals of the organization.

Tau Beta Pi

Membership is by invitation only in this engineering national honor society. Students with exceptional scholastic performance in all engineering disciplines are eligible for membership and will be invited by the campus chapter.

Faculty Sponsor: Shannon Blunt – Department of Electrical Engineering & Computer Science

Jayhawk Rocket Design

Jayhawk Rocket Design designs, constructs, and shoots off both model and high powered rockets. Projects include: full attitude control rockets, small hybrid rocket motors, and traditional high powered rockets.

Physics & Engineering Student Organization (PESO)

PESO promotes the pursuit of both physics and engineering for all students. This is a multi-disciplinary group that focuses on the project-based science and engineering tasks that contribute to a wider learning experience for the students in the group. Projects include 3D printing, small-scale wind tunnels, motion controlled laser-harp, tesla coils, jet engines and many more.

Unmanned Aerial Vehicle KU Student Organization

UAV KU Student Organization is focused on the learning and development of unmanned aerial vehicles.

They are committed to furthering the fields of small aircraft design, construction, programming, navigation, and control.

1.9 Faculty and Student Responsibilities

At the start of a university career students quickly discover that life in college is very different from life in high school. Students at a college or university are rightly treated as adults. Much of what you do will be your responsibility. The faculty and staff will not monitor your progress or performance. They will provide any assistance you need but generally, you will have to request help. You will prosper or fail due to your own actions. To assist you in this new environment, a clear definition of your responsibilities and those responsibilities of the faculty is useful.

Consider first the responsibilities of the faculty. Each professor may use a different set of guidelines or rules in running a class. It is the faculty's responsibility to define the rules to be used in terms of attendance, grading policy, assignments, and class schedule. If a faculty member does not provide this information or if the rules or procedures are unclear, it is recommended the student discuss this with the faculty member.

Next, consider the student's responsibilities. Once the faculty defines the course requirements, it is the student's responsibility to follow the guidelines including attending lectures and laboratories on time, submitting assignments on time, and taking all examinations. If for any reason, the student will not be able to attend class or take a test it is expected that the student notify the professor **before the absence**. Although there is no single set of rules for handling such situations, each faculty member has a set of rules. It is also the student's responsibility to obtain the information and course material presented when the student failed to attend a lecture. This includes changes in assignments or test dates. Your professor may be willing to provide this information if the absence had prior approval or if it involved an emergency.

Each student is expected to use their initiative in utilizing the university libraries and related material available in other facilities as needed. There are workshops and special lectures available to show students how to use the extensive resources provided by the university and it is the student's responsibility to seek help.

2.1 Academic Misconduct

The AE Department regards academic misconduct as a very serious matter. Students who violate conduct policies will be subject to severe penalties, up to and including dismissal from the School of Engineering. Please refer to the KU Policy Library website under Academic at <http://www.policy.ku.edu/> and the School of Engineering [handbook](#) for specific guidelines about actions considered to be academic misconduct and the repercussions of such action.

These actions include, but are not limited to disruption of classes, threatening an instructor or fellow student in an academic setting; giving or receiving of unauthorized aid on examinations or in the preparation of notebooks, themes, reports or other assignments; knowingly misrepresenting the source of any academic work; unauthorized changing of grades; unauthorized use of University approvals or forging of signatures; falsification of research results; plagiarizing of another's work; violation of regulations or ethical codes for the treatment of human and animal subjects; or otherwise acting dishonestly in research.

Section 2: Admission

2.1 Admission Directly From High School

Students may enter the Department of Aerospace Engineering as freshmen, but all admissions (both in state and out-of-state), are on a selective basis. General requirements for admission to the University are included under Admission in the General Information section of the Undergraduate catalog. Students from foreign institutions are not accepted directly into the school, but may apply for transfer after at least one semester in the College of Liberal Arts and Sciences or in some other U.S. institution.

To be considered for admission to the Department of Aerospace Engineering, all applicants must meet or exceed minimum academic standards. Admission is on a competitive basis following a review of an individual's achievements considering factors such as high school record, class standing, scores on national tests, advisor recommendation, and trend of grades. High school transcripts and ACT scores (or equivalent SAT scores) are required.

Minimum Academic Standards for Admission:

To be considered for admission to the Department of Aerospace Engineering, beginning first-year students must meet or exceed the following minimum standards:

- Have a 3.0 grade-point average on a 4.0 scale
- Be in the top 50 percent of the graduating class of an accredited high school or the equivalent
- Have a mathematics ACT score of 26 (or math SAT score of 600)

Important: Simply meeting these requirements will not guarantee admission to the Department of Aerospace Engineering. Students who perform beyond these minimums will have a better probability of being admitted.

2.2 Admission as a Transfer Student

Students who wish to transfer into the BS in Aerospace Engineering program from other institutions are evaluated on a case-by-case basis. Transfer students must have a college grade-point average of 2.5 or higher to be considered. Students must submit mathematics ACT or SAT scores or proof of competence in calculus (grade of C or higher).

Transfer credits for all courses are evaluated by the Office of Admissions. Transfer credits will be further reviewed at the time of initial advising by the Aerospace Engineering Department. Only courses in which a grade of C or better was obtained will be granted transfer credit. Courses graded Pass/Fail will not be granted transfer credit. No upper-level engineering credits from non-ABET-accredited engineering programs are acceptable as transfer credit for engineering programs. All transfer students must take their last 30 hours of credits while enrolled in the KU School of Engineering to be eligible to graduate from the University of Kansas.

Students currently enrolled in another school at the University of Kansas who wish to transfer to the department of Aerospace Engineering must fill out a Change of School form. Students within the School of Engineering that would like to transfer to the department of Aerospace Engineering must fill out a Change of Major form. The student must then submit the form to the School of Engineering Student Success Suite in 1415 LEEP2.

Section 3: Graduation Requirements

3.1 General Requirements

To graduate with the Bachelor of Science degree in Aerospace Engineering the student must complete a published curriculum in effect at the time of entry or beyond. This curriculum consists of a distribution of required courses in English, mathematics, basic sciences, engineering sciences, and Aerospace Engineering. In addition to these required courses, each candidate must take approved Technical Electives and approved KU Core electives. The student must complete the required courses with at least a 2.0 grade point average in all courses taken at KU as well as at least a 2.0 grade point average in all engineering courses taken at KU. The student must also take 30 hours of credit while enrolled in the KU School of Engineering.

Note: The curriculum is constantly under review by the faculty and may change during a four-year period. For this reason, a student can select any published curriculum in effect from the time of their entry in the program to the program in effect at the time of graduation. The student should notify their advisor which program is to be used and all the requirements listed in this published program must be satisfied.

3.2 Specific Requirements for BS Degree in Aerospace Engineering

The program requirements for students entering the program in Fall 2015 and later are detailed in Table 3.1. Rigid prerequisites exist for each course. This is to insure that students are adequately prepared to take a specific course. Detailed descriptions of the Aerospace courses are given in Appendix B. Detailed descriptions of the other required courses can be found in the university's undergraduate catalog.

Table 3.2 presents the recommended 4-year sequence of courses. The prerequisite sequence is shown in Figure 3.1. This is the recommended sequence for students who are prepared to enter the program directly, and who are full-time students without other time consuming activities, e.g. part-time work, ROTC, intercollegiate sports, band, or other student activities. Many students who are involved in nonacademic, time-consuming activities take more than 4 years to graduate. A typical 5-year sequence of courses is given in Table 3.3 as a guide. Students who believe they may plan to take more than 4 years are strongly advised to discuss this with their advisor or the Department Chair. Note that many courses may be taken in the summer at either KU or other universities and junior colleges.

A total of 133 credit hours is typical for the B.S. Degree in Aerospace Engineering as shown in Table 3.1.

3.3 Requirements for Enrollment in Junior Level Aerospace Courses

Enrollment in junior-level aerospace courses is limited to students who have received grades of C or higher in all first- and second-year courses in mathematics, physics, ME 312, CE 301, CE 310, AE 245, AE 345, and AE 445.

3.4 Mid-year Graduation

For students who would be eligible to graduate after 4 ½ years except that the second design course has not been completed, it is possible to substitute for the second design course, i.e., AE 522 or AE 523 or AE 524, in the fall semester. The substitution must not only be four hours but also must have four hours of design activity equivalent to the second design courses. The recommended substitution is AE 721 - Aircraft Design Laboratory I. Both the student's advisor and the department Chair must approve any other substitution. Students who plan to take these options and graduate in December are urged to discuss this with their advisor as soon as possible.

3.5 Credit/No Credit and Correspondence Courses

The department does not permit the use of any Credit/No Credit or correspondence courses to fulfill degree requirements. This applies to courses taken at KU or at other institutions. The only exceptions are AE 241, 242, and 441 in special circumstances.

3.6 Dual Degrees

Some students, because of a broad interest or specific career plan, elect to pursue two Bachelor's degrees simultaneously. In such cases, the student must satisfy the requirements of both degrees. This must also involve an additional 30 hours of credit beyond the first degree. Because of the desire to minimize the time and effort of the student and due to the complexities involved, it is strongly recommended the student make their plans known to their advisor. In addition, the student should coordinate their program with an advisor from the second department.

3.7 Co-Enrollment in the BS and Graduate Programs

Often, students in the last semester of their BS program will not have a full course load. These students can enroll in up to 6 hours of graduate courses that will count toward the Master of Science in Aerospace Engineering Degree. To be co-enrolled, the student must apply and be accepted in the graduate program. In addition, the student must announce to both their advisor and the Department administrative assistant which courses are to be used to complete the requirements for the BS and which courses should be counted toward the Master of Science degree.

3.8 Graduating with Honors

In order to graduate from the Aerospace Engineering program with honors, students must have a KU GPA of 3.5 or higher and take at least one department honors course. Department honors courses include: AE 546, AE 573, AE 509, AE 552, and AE 593.

Table 3.1 Required Courses for BS Degree in Aerospace Engineering

| Engineering Courses (76 hours) | | Hours |
|--|---|--------------|
| AE 245 | Introduction to Aerospace Engineering (Goal 5) | 3 |
| AE 290 | Aerospace Colloquium (Goal 2.2 and 5) | 2 |
| AE 345 | Fluid Mechanics | 3 |
| AE 360 | Introduction to Astronautics | 3 |
| AE 421 | Aerospace Computer Graphics (Goal 2.2) | 3 |
| AE 430 | Aerospace Instrumentation Lab | 3 |
| AE 445 | Aircraft Aerodynamics & Performance | 3 |
| AE 507 | Aerospace Structures I (Goal 5) | 3 |
| AE 508 | Aerospace Structures II (Goal 2.2 and 5) | 3 |
| AE 510 | Aerospace Materials & Processes (Goal 5) | 4 |
| AE 521 | Aerospace Systems Design I (Goal 2.1 and 6) | 4 |
| AE 522 | Aerospace Systems Design II (Goal 2.2 and 6) | \ |
| OR | | |
| AE 523 | Spacecraft Design (Goal 2.2 and 6) | 4 |
| OR | | |
| AE 524 | Propulsion System Design (Goal 2.2 and 6) | / |
| AE 545 | Fundamentals of Aerodynamics | 4 |
| AE 550 | Dynamics of Flight I (Goal 2.2) | 4 |
| AE 551 | Dynamics of Flight II | 4 |
| AE 571 | Fundamentals of Aircraft Reciprocating Propulsion Systems | 3 |
| AE 572 | Fundamentals of Jet Propulsion | 3 |
| AE 590 | Aerospace Senior Seminar (Goal 5) | 1 |
| AE 211 | Computing for Engineers | 3 |
| CE 301 | Statics & Dynamics | 5 |
| CE 310 | Strength of Materials | 4 |
| ME 312 | Basic Engineering Thermodynamics | 3 |
| EECS 316 | Circuits | 3 |
| EECS 318 | Circuits Laboratory | <u>1</u> |
| Science and Mathematics Courses (30 hours) | | |
| CHEM 150/130 | Chemistry for Engineers (Goal 3.3) | 5 |
| PHSX 210 | General Physics I (Goal 1.1) | 3 |
| PHSX 216 | General Physics I Laboratory | 1 |
| PHSX 212 | General Physics II | 3 |
| PHSX 236 | General Physics II Laboratory | 1 |
| MATH 125 | Calculus I (Goal 1.2) | 4 |
| MATH 126 | Calculus II | 4 |
| MATH 220 | Differential Equations | 3 |
| MATH 290 | Linear Algebra | 2 |
| MATH 127 | Calculus III | 4 |
| Other Required and Elective Courses (27 hours) | | |
| KU Core Electives (Goals 2.1, 3H, ECON, 4.1 and 4.2) | | 18 |
| Technical Electives | | <u>9</u> |
| Grand Total | | <u>133</u> |

Table 3.2 Recommended 4 Year Course Sequence for BS in Aerospace Engineering

| Freshman Year | | | | | |
|-----------------------|----------------------------------|-------|---------------|----------------------------------|-------|
| Fall | | | Spring | | |
| MATH 125 | Calculus I* | 4 | MATH 126 | Calculus II* | 4 |
| CHEM 150 | Chemistry for Engineers**** | 5 | PHSX 210 | Physics I* | 3 |
| AE 245 | Intro to Aero Engineering* | 3 | PHSX 216 | Physics I Lab | 1 |
| AE 290 | Aerospace Colloquium | .25 | AE 290 | Aerospace Colloquium | .25 |
| | KU Core Written Communications** | 3 | AE 211 | Computing for Engineers | 3 |
| | | 15.25 | | KU Core Written Communications** | 3 |
| | | | | KU Core Elective** | 3 |
| | | | | | 17.25 |
| Sophomore Year | | | | | |
| Fall | | | Spring | | |
| MATH 220 | Applied Differential Equations* | 3 | AE 445 | Aerodynamics & Performance* | 3 |
| CE 301 | Statics & Dynamics* | 5 | AE 360 | Intro to Astronautics | 3 |
| PHSX 212 | Physics II* | 3 | MATH 127 | Calculus III | 4 |
| PHSX 236 | Physics II Lab | 1 | CE 310 | Strength of Materials | 4 |
| AE 345 | Fluid Dynamics* | 3 | ME 312 | Thermodynamics* | 3 |
| AE 290 | Aerospace Colloquium | .25 | AE 290 | Aerospace Colloquium | .25 |
| | KU Core Elective** | 3 | | | 17.25 |
| | | 18.25 | | | |
| Junior Year | | | | | |
| Fall | | | Spring | | |
| AE 507 | Aerospace Structures I | 3 | AE 508 | Aerospace Structures II | 3 |
| AE 550 | Dynamics of Flight | 4 | AE 551 | Dynamics of Flight II | 4 |
| MATH 290 | Elementary Linear Algebra* | 2 | AE 572 | Jet Propulsion | 3 |
| AE 571 | Reciprocation Propulsion | 3 | AE 421 | Aero Computer Graphics | 3 |
| AE 545 | Aerodynamics | 4 | EECS 316 | Circuits, Elec. & Inst | 3 |
| AE 290 | Aerospace Colloquium | .25 | EECS 318 | Circuits, Elec. & Instr Lab | 1 |
| | | 16.25 | AE 290 | Aerospace Colloquium | .25 |
| | | | | | 17.25 |
| Senior Year | | | | | |
| Fall | | | Spring | | |
| AE 521 | Aircraft Design I | 4 | AE 522/3/4 | Design II | 4 |
| AE 510 | Materials & Processes | 4 | AE 430 | Aerospace Instrumentation | 3 |
| AE 590 | Aerospace Senior Seminar | 1 | AE 290 | Aerospace Colloquium | .25 |
| AE 290 | Aerospace Colloquium | .25 | | Tech Elective*** | 6 |
| | Tech Elective*** or AE 560***** | 3 | | KU Core Elective** | 3 |
| | KU Core Elective** | 3 | | | 16.25 |
| | | 15.25 | | | |

*Students must pass with C or higher for course to count towards degree.

**Students must ensure the electives they choose fulfill all remaining KU Core requirements.

***Technical electives are selected from upper level aerospace courses, approved courses from other engineering department or approved math courses.

****Chemistry 130 can be substituted for Chemistry 150.

*****AE 560 is offered to students who will be taking AE 523 as their Capstone requirement.

Table 3.3 Recommended 5 Year Course Sequence for BS in Aerospace Engineering

| | | First Year | | | |
|----------|----------------------------------|--------------------|------------|----------------------------------|--------------|
| | | Fall | | Spring | |
| MATH 125 | Calculus I* | 4 | MATH 126 | Calculus II* | 4 |
| AE 245 | Intro to Aerospace* | 3 | PHSX 210 | Physics I * | 3 |
| AE 290 | Aerospace Colloquium | .25 | PHSX 216 | Physics I lab | 1 |
| | KU Core Written Communications** | 3 | AE 290 | Aerospace Colloquium | .25 |
| | KU Core Elective** | 3 | AE 211 | Computing for Engineers | 3 |
| | | <u>13.25</u> | | KU Core Written Communications** | 3 |
| | | | | | <u>14.25</u> |
| | | Second Year | | | |
| | | Fall | | Spring | |
| MATH 220 | Applied Differential Equations* | 3 | ME 312 | Thermodynamics* | 3 |
| MATH 127 | Calculus III* | 4 | CE 310 | Strength of Materials* | 4 |
| CE 301 | Statics & Dynamics* | 5 | AE 290 | Aerospace Colloquium | .25 |
| PHSX 212 | Physics II* | 3 | | KU Core Electives** | 6 |
| PHSX 236 | Physics II Lab | 1 | | | <u>13.25</u> |
| AE 290 | Aerospace Colloquium | .25 | | | |
| | | <u>16.25</u> | | | |
| | | Third Year | | | |
| | | Fall | | Spring | |
| AE 345 | Fluid Mechanics* | 3 | AE 445 | Aerodynamics & Performance* | 3 |
| AE 507 | Aero Structures I | 3 | AE 508 | Aero Structures II | 3 |
| MATH 290 | Elementary Linear Algebra* | 2 | EECS 316 | Circuits, Elec. & Inst | 3 |
| CHEM 150 | Chemistry for Engineers***** | 5 | EECS 318 | Circuits, Elec. & Inst | 1 |
| AE 290 | Aerospace Colloquium | .25 | AE 360 | Intro to Astronautics | 3 |
| | | <u>13.25</u> | AE 290 | Aerospace Colloquium | .25 |
| | | | | | <u>13.25</u> |
| | | Fourth Year | | | |
| | | Fall | | Spring | |
| AE 550 | Dynamics of Flight I | 4 | AE 551 | Dynamics of Flight II | 4 |
| AE 571 | Reciprocating Propulsion | 3 | AE 572 | Jet Propulsion | 3 |
| AE 545 | Aerodynamics | 4 | AE 421 | Computer Graphics | 3 |
| AE 290 | Aerospace Colloquium | .25 | AE 430 | Aerospace Instrumentation | 3 |
| | | <u>11.25</u> | AE 290 | Aero Colloquium | .25 |
| | | | | | <u>13.25</u> |
| | | Fifth Year | | | |
| | | Fall | | Spring | |
| AE 521 | Aircraft Design I | 4 | AE 522/3/4 | Design II | 4 |
| AE 510 | Materials & Manufacturing | 4 | | Tech Electives*** | 6 |
| AE 590 | Senior Seminar | 1 | | KU Core Elective** | 3 |
| | Tech Electives*** or AE 560***** | 3 | | | <u>13</u> |
| | | <u>12</u> | | | |

*Students must pass with C or higher for course to count towards degree.

**Students must ensure the electives they choose fulfill all remaining KU Core requirements.

***Technical electives are selected from upper level aerospace courses, approved courses from other engineering department or approved math courses.

****Chemistry 130 can be substituted for Chemistry 150.

*****AE 560 is offered to students who will be taking AE 523 as their Capstone requirement.

Section 4: KU Core

4.1 Purpose

The KU Core establishes six educational goals for all undergraduates at the University of Kansas. The KU Core is designed to yield fundamental skills, build a broad background of knowledge, generate capacities and opportunities for blending and creating ideas, strengthen an appreciation of cultural and global diversity, and cultivate ethical integrity.

The KU Core is not a prescribed set of courses that students must take. Hundreds of courses and experiences have been approved as part of the KU Core. Students can select the courses or experiences that match their interests and areas of study. This selection allows each student to create a unique undergraduate experience.

4.2 Fulfilling the KU Core

Goal 1, Outcome 1, Critical Thinking: PHSX 210

Goal 1, Outcome 2, Quantitative Literacy: MATH 125

Goal 2, Outcome 1, Written Communications: Meet via KU Core requirements

Goal 2, Outcome 2, Oral Communications: AE 290, 421, 508, 550, 521, 522, 523, 524

Goal 3, Outcome 1, Arts and Humanities: Meet via KU Core requirements

Goal 3, Outcome 2, Natural Science: CHEM 150 or CHEM 130

Goal 3, Outcome 3, Social Sciences: ECON 104, 142, or 144

Goal 4, Outcome 1, Diversity in the United States: Meet via KU Core requirements

Goal 4, Outcome 2, Global Awareness: Meet via KU Core requirements

Goal 5, Outcome 1, Ethics and Social Responsibility: AE 245, 290, 507, 508, 510, and 590

Goal 6, Outcome 1, Capstone: AE 521, 522, 523, or 524

Details of the KU Core can be found at kucore.ku.edu. Some required courses in the AE curriculum satisfy a KU Core goal and/or outcome. For these courses, the goal/outcome code is given in parentheses after the course on the pages above. Where required courses do NOT specifically satisfy KU Core goals (Goals 2.1, 3H, and 4) students must choose from a list of several means to satisfy the required goals.

Section 5: Technical Electives

5.1 Purpose

The purpose of the Technical Elective courses is to allow the student to select advanced courses in one or more areas that are of special interest. Each student must take at least 9 hours of Technical Electives, of which a minimum of 3 hours must be Aerospace Engineering courses. The satisfaction of this requirement can be accomplished by several methods as listed below.

5.2 Suggested Technical Electives

Table 5.1 lists courses that have been reviewed by the Aerospace Faculty and are approved for use as Technical Electives. A maximum of 3 hours of AE 592 can be used as a technical elective. The student is responsible for either verifying that all prerequisites are satisfied or that permission is received from the instructor. The student should be aware that not all courses listed in Table 5.1 are available each semester. For detailed descriptions of the Aerospace Engineering courses see the Department's Graduate Handbook. For other courses, see Appendix C.

5.3 Focus Area

The department recognizes, however, that some students would like to focus their technical electives on one aspect of aerospace engineering. To help students select their technical electives, the department has compiled lists of appropriate courses that form focus areas. Table 5.2 contains recommended courses for focus areas in Aerodynamics, Propulsion, Structures, Flight Dynamics and Control, Vehicle Design, Astronautics, and Manufacturing. It is also possible for a student, working with an advisor, to create other focus areas.

5.4 Course Substitution Petition

If a student wants to take a course not listed in Table 5.1 as a Technical Elective, the student needs the approval of their advisor and must document this by filing a Course Substitution Petition with the department administrative assistant. The form must be signed by their advisor. This form will be filed in the student's academic folder.

5.5 Reserve Officer Training Corps (ROTC)

A student enrolled in one of the ROTC programs can receive 3 hours of Technical Electives credit if the ROTC program is completed. If the student does not complete the ROTC program, no Technical Elective credits are awarded. Students in ROTC may not use flight training courses (e.g. AE 241 and 441) to satisfy Tech Elective requirements.

5.6 Mathematics Minor

A Mathematics minor consists of 18 hours of math courses, 12 hours of which must be numbered 300 and above, excluding MATH 365. This means that a student needs to take 4 courses more than those required for the AE BS degree. Therefore, a student who elects to take 6 hours of Mathematics as a Technical Elective would only need two extra Mathematics courses beyond the AE BS degree.

Table 5.1 Approved Technical Electives

The following courses are approved as Technical Electives for the BS program.

| | | |
|----|-----|--|
| AE | 241 | Private Flight Course (1) |
| AE | 441 | Advanced Flight Training (1-3) |
| AE | 560 | Spacecraft Systems (3) |
| AE | 592 | Special Projects in Aerospace Engineering* (1-3) |
| AE | 670 | Aerospace Propulsion III (3) |
| AE | 701 | Structural Design (3) |
| AE | 704 | Dynamics and Vibrations (3) |
| AE | 705 | Structural Vibrations and Modal Testing (4) |
| AE | 707 | Aerospace Structural Loads (3) |
| AE | 708 | Aerospace Structures III (3) |
| AE | 709 | Structural Composites (3) |
| AE | 710 | Advanced Structural Composites (3) |
| AE | 712 | Techniques of Engineering Evaluation (3) |
| AE | 713 | Stochastic Systems, Estimation and Identification in Aerospace Engineering (3) |
| AE | 721 | Aircraft Design Laboratory I (4) |
| AE | 722 | Aircraft Design Laboratory II (4) |
| AE | 724 | Propulsion System Design & Integration (3) |
| AE | 725 | Numerical Optimization & Structural Design (3) |
| AE | 730 | Advanced Experimental Fluid Dynamics (3) |
| AE | 731 | Supersonic Aerodynamics Laboratory (1) |
| AE | 732 | Flight Test Principles & Practice (3) |
| AE | 743 | Compressible Aerodynamics (3) |
| AE | 744 | Introduction to Turbulent Flow (3) |
| AE | 745 | Applied Wing and Airfoil Theory (3) |
| AE | 746 | Computational Fluid Dynamics (3) |
| AE | 747 | Transonic Aerodynamics (3) |
| AE | 748 | Helicopter Aerodynamics (3) |
| AE | 750 | Applied Optimal Control (3) |
| AE | 751 | Advanced Airplane Dynamics (2) |
| AE | 752 | Linear Multivariable Control (3) |
| AE | 753 | Digital Flight Controls (3) |
| AE | 754 | Missile Dynamics (3) |
| AE | 756 | Rule-Based Control Systems (3) |
| AE | 757 | Rule-Based UAV Control Lab (1) |
| AE | 758 | Introduction to Robotics (3) |
| AE | 759 | Estimation and Control of Unmanned Autonomous Systems (3) |
| AE | 760 | Spacecraft Systems (3) |
| AE | 765 | Orbital Mechanics (3) |
| AE | 766 | Spacecraft Attitude Dynamics and Control (3) |
| AE | 767 | Spacecraft Environments (3) |
| AE | 768 | Orbit Determination (3) |
| AE | 771 | Rocket Propulsion (3) |
| AE | 772 | Fluid Mechanics of Turbomachinery (3) |
| AE | 781 | Introduction to Adaptive Aerostructures (3) |
| AE | 790 | Special Problems in Aerospace Engineering (1-3) |
| AE | 941 | Hypersonic Aerodynamics I (3) |

Table 5.1 Approved Technical Electives (Continued)

MATHEMATICS

| | | |
|------|-----|--|
| MATH | 526 | Applied Mathematical Statistics I (3) |
| MATH | 542 | Vector Analysis (2) |
| MATH | 590 | Linear Algebra (3) |
| MATH | 627 | Probability (3) |
| MATH | 628 | Mathematical Theory of Statistics (3) |
| MATH | 646 | Complex Variables and Applications (3) |
| MATH | 647 | Applied Partial Differential Equations (3) |
| MATH | 648 | Calculus of Variations (3) |
| MATH | 650 | Nonlinear Dynamical Systems (3) |
| MATH | 735 | Introduction to Optimal Control Theory (3) |
| MATH | 750 | Stochastic Adaptive Control (3) |
| MATH | 781 | Numerical Analysis I (3) |
| MATH | 865 | Introduction to Stochastic Processes (3) |
| MATH | 866 | Stochastic Processes II (3) |

CIVIL ENGINEERING

| | | |
|----|-----|--|
| CE | 625 | Applied Probability and Statistics (3) |
| CE | 710 | Structural Mechanics (3) |
| CE | 721 | Experimental Stress Analysis (3) |
| CE | 767 | Introduction to Fracture Mechanics (3) |

ELECTRICAL ENGINEERING and COMPUTER SCIENCE

| | | |
|------|-----|------------------------------------|
| EECS | 360 | Signal Analysis (3) |
| EECS | 461 | Probability and Statistics (3) |
| EECS | 562 | Intro to Communication Systems (4) |

MECHANICAL ENGINEERING

| | | |
|----|-----|--|
| ME | 508 | Numerical Analysis of Mech Engr Problems (3) |
| ME | 612 | Heat Transfer (3) |
| ME | 708 | Microcomputer Applications in Mechanical Engineering (3) |
| ME | 770 | Conductive Heat Transfer (3) |
| ME | 774 | Radiative Heat Transfer (3) |

*The department does not accept internships to count towards technical elective hours.

Table 5.2 Recommended Focus Area Courses

I. Aerodynamics Focus – Coordinators: Farokhi & Zheng

| | | |
|------|-----|--|
| AE | 712 | Techniques of Engineering Evaluation |
| AE | 730 | Advanced Experimental Fluid Dynamics |
| AE | 743 | Compressible Aerodynamics |
| AE | 744 | Introduction to Turbulent Flow |
| AE | 745 | Applied Wing & Airfoil Theory |
| AE | 746 | Computational Fluid Dynamics |
| AE | 747 | Transonic Aerodynamics |
| AE | 748 | Helicopter Aerodynamics |
| AE | 772 | Fluid Dynamics of Turbomachinery |
| AE | 840 | Aerodynamics of Viscous Fluids |
| AE | 941 | Hypersonic Aerodynamics I |
| MATH | 646 | Complex Variables |
| MATH | 647 | Applied Partial Differential Equations |
| MATH | 781 | Numerical Analysis I |

II. Structures Focus – Coordinators: Ewing & Hale

| | | |
|------|-----|---|
| AE | 704 | Dynamics and Vibration |
| AE | 705 | Structural Vibrations and Modal Testing |
| AE | 709 | Structural Composites |
| AE | 710 | Advanced Structural Composites |
| AE | 725 | Numerical Optimization and Structural Design |
| MATH | 590 | Linear Algebra |
| MATH | 646 | Complex Variables |
| MATH | 647 | Applied Partial Differential Equations |
| MATH | 648 | Calculus of Variations and Integral Equations |
| AE | 803 | Aeroelasticity |

III. Propulsion Focus – Coordinators: Farokhi & Taghavi

| | | |
|------|-----|--|
| AE | 724 | Propulsion System Integration Design |
| AE | 771 | Rocket Propulsion |
| AE | 772 | Fluid Mechanics of Turbomachinery |
| ME | 612 | Heat Transfer |
| MATH | 646 | Complex Variables |
| MATH | 647 | Applied Partial Differential Equations |
| MATH | 781 | Numerical Analysis I |

IV. Configuration Design Focus – Coordinator: Barrett

| | | |
|----|-----|-------------------------------|
| AE | 522 | Aero Systems Design II |
| AE | 721 | Aircraft Design Laboratory I |
| AE | 722 | Aircraft Design Laboratory II |

Table 5.2 Recommended Focus Area Courses (continued)

V. Dynamics & Control Focus – Coordinator: Keshmiri

| | | |
|------|-----|--|
| AE | 713 | Stochastic Systems, Estimation and Identification in Aerospace Engineering (3) |
| AE | 750 | Applied Optimal Control |
| AE | 751 | Advanced Airplane Dynamics |
| AE | 752 | Linear Multivariable Control |
| AE | 753 | Digital Flight Controls |
| AE | 754 | Missile Dynamics |
| AE | 755 | Robust Control of Nonlinear Systems |
| AE | 756 | Rule-Based Control Systems |
| AE | 757 | Rule-Based UAV Control Lab |
| AE | 758 | Introduction to Robotics |
| AE | 759 | Estimation and Control of Unmanned Autonomous Systems |
| AE | 766 | Spacecraft Attitude Dynamics and Control |
| MATH | 648 | Calculus of Variations and Integral Equations |
| MATH | 650 | Nonlinear Dynamical Systems (3) |
| MATH | 735 | Introduction to Optimal Control Theory (3) |
| MATH | 750 | Stochastic Adaptive Control (3) |
| MATH | 865 | Introduction to Stochastic Processes (3) |
| MATH | 866 | Stochastic Processes II (3) |

VI. Manufacturing Focus – Coordinator: Hale

| | | |
|------|-----|--|
| ME | 528 | Mechanical Design IB (follow-on to ME 428~AE510) |
| ME | 607 | Computer Aided Manufacturing |
| ME | 627 | Automotive Design & Manufacturing |
| ME | 706 | Industrial Robotics |
| MATH | 627 | Probability |
| MATH | 628 | Statistics |
| BUS | 637 | Advanced Statistics |
| BUS | 704 | Total Quality Management |
| BUS | 719 | Operations Management |

VII. Astronautics Focus – Coordinator: McLaughlin

| | | |
|------|-----|--|
| AE | 560 | Spacecraft Systems |
| AE | 760 | Spacecraft Systems |
| AE | 765 | Orbital Mechanics |
| AE | 766 | Spacecraft Attitude Dynamics and Control |
| AE | 767 | Spacecraft Environments |
| AE | 768 | Orbit Determination |
| AE | 771 | Rocket Propulsion |
| EECS | 360 | Signal Analysis |
| EECS | 461 | Probabilistic Analysis |
| EECS | 562 | Introduction to Communication Systems |
| MATH | 627 | Probability |
| MATH | 628 | Mathematical Theory of Statistics |

Section 6: Department Research and Facilities

6.1 Introduction

The School of Engineering and the Department of Aerospace Engineering at the University of Kansas have extensive facilities to support our undergraduate and graduate education and research missions.

All faculty members are active in funded and unfunded research. If a student is interested in becoming involved in research they should contact the appropriate faculty member. Undergraduate students can receive academic credit for research performed by enrollment in AE 592, Special Projects in Aerospace Engineering.

6.2 Research Facilities

Each student will have the opportunity to work with a broad range of experimental equipment as well as industry-standard computational and design software, including ANSYS FLUENT for Computational Fluid Dynamics, ASK Satellite Toolkit for orbital analysis, MSC NASTRAN/PATRAN for structural analysis, Siemens NX for detailed design, and DARC Corp AAA for preliminary aircraft design.

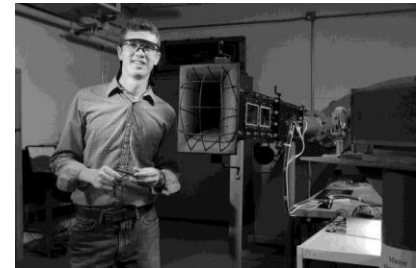


**Closed Circuit Subsonic
Wind Tunnel**

The Closed Circuit Subsonic Wind Tunnel, shown on the left, has a 36" by 51" test section and a maximum speed of 200 mph. This tunnel is equipped with a six-component strain-gauged balance and computerized data acquisition system. Flow visualization techniques include a laser light sheet, smoke, helium bubbles, and surface oil streak-line methods. A computerized, two-axis traversing system is available for flow field mapping. The test section and operator's station is located in Room 1180 of Learned Hall.

The Open Circuit Subsonic Wind Tunnel has a 21" by 30" test section and a maximum speed of 120 mph. This tunnel is useful for fundamental fluid mechanics experiments due to its low turbulence factor. The Department's helium bubble system can be used in this tunnel.

The Supersonic Wind Tunnel, pictured on the right, has a 2" by 3 ¼' test section with a Mach number range of 1.5 to 3.0. The tunnel is a draw-down type equipped with a Schlieren system and wall static pressure ports for pressure measurements. This tunnel is located in Room 1180, Learned Hall.



**Supersonic Wind
Tunnel**

The Small Water Tunnel has a 6" wide, 6" deep and 7' long channel. Water is pumped in a closed loop. The maximum speed at the experimental section is 3ft/sec. The turbulence level is 0.5%. This facility is mainly used for education and research. It allows particle image velocimetry measurements and dye-based flow visualization. The water tunnel is located in Room G445 LEEP2.

The Structural Dynamics and Acoustics Laboratory consists of a modal test system and an acoustics data acquisition system. The Data Physics / MeScope Modal Test System is used to determine the vibratory "signature" of structures using vibration data from various sensors, including piezoceramic accelerometers. This professional-grade system is augmented by a PC-based National Instruments data acquisition system with a high speed (1M sample/sec.) 32-channel analog-to-digital board. Vibration excitation is provided by both an electrodynamic shaker and a modal hammer. The Acoustical Data Acquisition System is used to measure sound in support of structural acoustics research. The system is based on a PC with a 32-channel analog-to-digital board.

Mechanical Testing Facilities are shared with the Departments of Mechanical and Civil Engineering. These facilities provide testing capabilities for articles ranging from material coupons to large-scale structures. Available test equipment includes 222 kN and 89 kN MTS servo-hydraulic test machines, a 489 kN Instron servo-hydraulic test machine, 267 kN and 107kN Baldwin hydraulic test machines and instrumentation including extensometers, load cells, strain gages and digital data acquisition systems. Additional equipment for experimental stress analysis includes a reflection polariscope and a portable four beam Moiré interferometer.

The Composite Materials Laboratory addresses applied and developmental research in environmental remote sensing, energy and transportation. This laboratory supports researchers to design and construct aircraft, sensors and systems to enable airborne environmental remote sensing, with the primary funded research addressing ice-penetrating radar that can assist CReSIS researchers in the quest to capture data and create accurate 3-D maps of ice sheets all the way to the bedrock. Sensor suites have also been developed for fine scale measurements of terrestrial ecosystem structure and biomass. Past projects include small and large unmanned aircraft, radar arrays and fairings, wind turbine blades, telescopes and fuel containment devices. Teams of faculty, staff and students in recent years have designed, fabricated and flight-tested unmanned aircraft and manned aircraft sensor suites, predominantly for remote sensing in Greenland and Antarctica.



The composite lay-up facility is a 59 m² “clean” room with a 6.7 m² lay-up table and 24.3 m³ of –30° C material storage. The composite tooling and processing laboratory encompasses 128.4 m², and contains a radial diamond saw, 17.8 cm diamond blade precision sectioning saw, 22.9 cm abrasive cutter, two hydraulic specimen mounting presses, orbital and vibrating polishers and a microhardness tester. Sample inspection and documentation is aided with a Nikon Epiphot inverted reflected light photomicroscope capable of magnification to 1000X, with Polaroid

and 35mm film or digital video capture. The composite curing facility encompasses 66.3 m² and includes an autoclave for curing thermoset and thermoplastic composite materials, 107kN and 667 kN electrically heated water cooled platen presses, and electronically controlled ovens. The autoclave is rated to 2.4 MPa and 370° C and has a usable space of 30x30x91 cm. The smallest oven is rated to 370° C and has a usable space of 51x51x46 cm. and the intermediate oven is rated to 370C and has a usable space of 1.5m x 1 m x .8m. The composite materials laboratory also houses an electronically controlled walk-in curing oven capable of 260° C, with a usable space of 2.1 x 2 x 6.1 m.



The Cooperative Unmanned Systems Laboratory (CUSL) is a multi-disciplinary research lab at the University of Kansas (KU) that focuses on the design, development, and testing of teams of unmanned systems for cooperative sensing and cooperative control missions. The research objectives of CUSL include autonomous system development, gust/wake sensing and wind soaring using UAVs, design of cooperative sensing and estimation algorithms, and networked cyber-physical systems.

The Nondestructive Evaluation Laboratory is a shared facility with the Department of Civil Engineering. Available equipment includes a SONIX CSF1000-3X digital 3-axis automated immersion ultrasonic scanning system (pictured at left) with capabilities for A-scan, B-scan and C-scan testing in through-transmission or pulse-echo mode. Current equipment provides a scanning envelope of 0.8x0.9x1.2 m. In addition, the laboratory houses a combination digital acoustic

emission acquisition and analysis, and low frequency ultrasonic generation, acquisition and analysis system. Acoustic emission and ultrasonic inspection capabilities are enhanced by state of the art data acquisition software running on PC workstations. Finally, the laboratory has an ultrasonic flaw detector. These systems are used for laboratory and field-testing and inspection of materials and structures.

Textron Aviation Aerospace Engineering Design Lab consists of a general work area equipped with 43 PC workstations with shared high-speed printer support. Specialized design software includes DARC Corp AAA, MSC NASTRAN / PATRAN, ASK Satellite Tool Kit, ANSYS FLUENT and Siemens NX.

The Cognitive Control Systems Laboratory is designed as a one-stop research and development facility for small robots and unmanned aircraft. It features student workstations, a 3D printing equipment, and a protected, indoor flight range with a 14-camera VICON tracking system. Faculty and students can design, build, and operate robots and unmanned aircraft in this laboratory, while performing research for the goal of cognitively-inspired intelligent machines.

Aerospace Manufacturing Facilities

The Department of Aerospace Engineering maintains a research machine shop with two milling machines, a lathe, sheet metal break and shear equipment, band saws and drill presses. In addition, the School of Engineering maintains a fully-equipped machine shop with multiple milling machines, surface grinders, vertical and horizontal band saws, drill presses, welding equipment, and a paint booth. New acquisitions include a Stratasys Prodigy fused deposition modeling rapid prototyping center and a computer numerically controlled (CNC) mill with five axes of motion and 48" x 20" x 20" travel in translational axes.



AST 4000 Fixed Base

The Adaptive Aerostructures Laboratory (AAL) maintains unique capabilities supporting the design, fabrication and testing of aerospace structures with adaptive materials. Unlike conventional materials, adaptive materials change some property as a function of an applied control signal or stimulus. The AAL maintains a range of stocks of piezoelectric, electrostrictive, shape-memory-alloy, magnetostrictive, magnetorheological, and other adaptive materials and processing equipment. In addition to supporting work with adaptive materials, the AAL has generated many aerospace "firsts" in subscale uninhabited aerial vehicles, morphing aircraft, missiles and munitions. It is currently host to a unique ballistics laboratory where guided bullets and cannon shells are being designed and tested in the 40mm x 10m and 20mm x 5 m gas guns. More than 50 subscale aircraft are housed in the 1200+ sq. feet facility as well as 9 grades of graphite-epoxy composites, 4 grades of Kevlar, composite cure oven, diamond saws and precision post processing machines.

In the Computational Thermal Fluids Laboratory we develop state-of-the art CFD algorithms and tools on modern computer platforms such as CPU and GPU clusters. In addition, we apply these tools to solve challenging fluid dynamics problems such as flow over high lift configurations, helicopters, flow inside jet engines, noise generated by moving bodies, to name just a few. Our research has been supported by AFOSR, DOE, NSF, DARPA, ARO, NASA, ONR.

The Acoustic Reverberation Suite includes two adjacent, acoustically reverberant ("echoing") rooms with a 4-foot by 8-foot aperture ("window") between them. The suite is designed to measure Transmission Loss (TL) for room or vehicle walls and Absorption Coefficients of sound-absorbing materials used in walls or interior furnishings. Flat or slightly curved panels are inserted into the aperture to measure the TL

when sound—generated and measured in the south room—is transmitted to the north room. The difference in the measured sound pressure level (SPL) is resolved as the TL on which the panel Noise Isolation Class (NIC) rating is based. Alternatively, the acoustic absorption of objects placed in one of the rooms may be measured by comparing the room reverberation time with and without the test objects. This facility is currently primarily used to devise and evaluate alternative test methods associated with noise reduction and for testing the noise reduction qualities of panels fabricated with new materials and/or new noise reduction schemes. The types of panels to be evaluated include aircraft fuselage side-walls and new building walls. Coefficients of absorption will be measured for various architectural materials including fabric used for variable reverberation control in auditoriums and similar spaces.

The Mal Harned Propulsion Laboratory consists of a test cell capable of testing gas turbine engines up to 8,000 pounds of thrust, as well as reciprocating engines. The control room is equipped with basic engine testing instrumentation. This facility is located in the Department's hangar at the Lawrence Airport.

The Garrison Flight Research Center (GFRL) was established in 2004 with the renovation of the existing 18,000 square foot university hangar. The GFRL, now upgraded to 22,000 square feet, has a classroom, machine shop, electronics shop, offices, an AST 4000 fixed base simulator and hangar space for several aircraft. These provide resources for developing intelligent vehicle systems for the flight research of both piloted and uncrewed air vehicles. Additional shop and assembly space, along with a propulsion test cell, are available in an adjacent building, the KUAE "Hawkworks".

The Garrison Flight Research Center houses the department's Cessna 172 Skyhawk and Cessna 182 RG. The Cessna 172 is used both for transportation and research, while the Cessna 182 is dedicated to flight research activities. The Cessna 182 is specifically configured to accommodate in-flight test instrumentation.



Cessna 172

In addition, KUAE has recently invested in an AST 4000 Fixed Base Simulator, produced by American Simulation Technology. This flight simulator is PC based with programmable LCD Instrument Panels and programmable digital aircraft dynamic models. The "vehicle" can accommodate our experimental autopilot module, and offers an out the window projection system and built-in weather and turbulence effects with a programmable control loader. Student designed vehicles may be entered in the flight characteristics module such that vehicles may be "flown" and experienced by the design team.



Cessna 182

Appendix A: The Aerospace Engineering Advisory Board

The Advisory Board serves as an overview group for the Department of Aerospace Engineering. It provides guidance in planning and assists in maintaining the effectiveness of the education program. Its functions include:

- Reviewing of curriculum and courses, the development of recommendations for revisions.
- Assisting in the formulation, structuring and promotion of future development programs
- Assisting in the determination of new technology areas in which research activities should be initiated.
- Assisting the Department in its efforts to communicate with industry, prospective students and the general public

Members of the Advisory Board are drawn from Aerospace organizations outside the university and university officials. The external members include senior engineers from aerospace companies, government laboratories, and federal agencies.

Appendix B: Detailed Descriptions of Aerospace Courses

AE 211 Computing for Engineers (3) Introduction to computing concepts. Introduction to the MatLab computing language using a suite of simulations in physics and engineering in a progression which adds new MatLab constructs—as well as logical and mathematical constructs—with each simulation. Simulations include numerical integration of differential equations, coordinate transformations and primitive reinforcement learning constructs. Introduction to programming languages appropriate for simulating elementary cognitive architectures for artificial intelligence

Prerequisite: Math 125

AE 241 Private Flight Course (1) One hour of academic credit is given upon the awarding of the private pilot's license by the Federal Aviation Administration. Required documentation includes a letter from the FAA designated examiner giving the check ride and a copy of the private license. Note: The Department of Aerospace Engineering provides no ground or flight instruction. This course will be graded pass/fail.

Prerequisite: Aerospace Engineering Student & Consent of instructor

AE 242 Private Flight Aeronautics (3) Three hours of academic credit is given for the successful completion of the FAA private pilot's written examination. Required documentation is a copy of the written score. Available only to Aerospace Engineering transfer students as a course substitute for AE 245. This course will be graded pass/fail.

Prerequisite: Aerospace Engineering Student & Consent of instructor

AE 245 Introduction to Aerospace Engineering (3) Basic systems of an aerospace vehicle, meteorology, vehicle performance, navigation and safety. Specific examples emphasize general aviation.

Co-requisite: MATH 104

Topics: aerospace history * engineering & math concepts * operational environments * gas dynamics * propulsion systems * materials & structures * stability & control * navigation & guidance * flight path & performance determination * flight safety * vehicle design.

AE 290 Aerospace Colloquium (0.25) This is a required course for all aerospace engineering majors each semester. Topics of importance and new developments are discussed by aerospace industry representatives and representatives of FAA, DoT, DoD, NASA, related sciences and engineering disciplines. A forum for student activities at all levels. Grading based on unexcused absences: 0=A, 1=B, 2=C, 3=D, 4 or more=F

Topics: various aspects of aerospace engineering

AE 292 Aerospace Industrial Internship (1) Engineering internship in an approved company. Internship hours do not satisfy any course requirements for the bachelor's degree in Aerospace Engineering but will appear on the official transcript. Credit assigned after review of report on internship experience. Graded on a pass/fail basis.

Prerequisite: Completion of freshman year

AE 345 Fluid Mechanics (3) Study of fundamental aspects of fluid motions and basic principles of gas dynamics with application to the design and analysis of aircraft.

Co-requisite: CE 301 or Math 220

Topics: fluid properties * fluid Statics * fluid Dynamics * fluid kinetics * control volume analysis * differential analysis * dimensional analysis * viscous effects * flow over immersed bodies.

AE 360 Introduction to Astronautics (3) Introduction to Astronautical engineering. The history of astronautics, including rocketry and space flight. Fundamentals of astronautics, including space environment, astrodynamics and the analysis and design of spacecraft systems. Design, construction and launch of a prototype earth-satellite using a high-altitude balloon.

Prerequisite: Math 126

Co-requisite: A course in computer programming

Topics: rocketry & spacecraft history * the environment of space * astrodynamics (the 2-body orbital problem) * spacecraft propulsion * spacecraft attitude determination & control * spacecraft electrical power * spacecraft thermal control * spacecraft configuration, structures, & mechanisms * spacecraft communications * spacecraft command, telemetry & data handling * design, construction & flight of a prototype space vehicle.

AE 390 Aerospace Industrial Internship (1) Engineering internship in an approved company. Internship hours do not satisfy any course requirements for the BS degree in Aerospace Engineering but will appear on the official transcript. Credit assigned after review of report on internship experience. This course will be graded pass/fail.

Prerequisite: Completion of sophomore year.

AE 421 Aerospace Computer Graphics (3) Development of skills in depicting aerospace vehicles and their components and subsystems for the purpose of illustration, design, and analysis using traditional and modern (Computer Aided Design) drafting tools.

Prerequisite: None

Topics: various aspects of engineering graphics.

AE 430 Aerospace Instrumentation Laboratory (3) Review and hands-on laboratory experiments with basic electronic elements (resistors, capacitors, conductors, transistors, linear circuits, logic devices and integrated circuits). Overview and hands-on laboratory experiments using various experimental techniques available to the aerospace engineers (pressure probes, thermocouples, strain gauges, hot-wire anemometer, laser Doppler velocimeter & flow visualization techniques).

Prerequisite: AE 445 and EECS 318

Topics: AC and DC circuits * resistors * capacitors * conductors * transistors * logic devices * integrated circuits * pressure probes * temperature probes * strain gauges * hot wire anemometry * laser Doppler velocimetry * flow visualization techniques (smoke, dye, helium bubbles, schlieren, shadowgraph) * special projects.

AE 441 Advanced Flight Training (1-3) One hour of academic credit is given for the successful completion of advanced flight training beyond the private pilot rating. One hour is given for each of the following: commercial, instrument rating, certified flight instructor. The Aerospace Engineering Department provides no ground or flight instruction. This course will be graded pass/fail.

Prerequisite: AE 241

AE 445 Aircraft Aerodynamics and Performance (3) Study of airfoil and wing aerodynamics, component drag, static and special performance, and maneuvers of aircraft

Prerequisite: AE 345 and CE 301

Topics: atmospheric properties * basic aerodynamic principles & applications * airfoil theory * wing theory * airplane drag * airplane propulsion systems * propeller theory * fundamentals of flight mechanics * climb performance & speed * take-off & landing performance * range & endurance * maneuvers & flight envelope * laboratory.

AE 490 Aerospace Industrial Internship (1) Engineering internship in an approved company. Internship hours do not satisfy any course requirements for the BS degree in Aerospace Engineering but will appear on the official transcript. Credit assigned after review of report on internship experience. This course will be graded pass/fail.

Prerequisite: Completion of junior year

AE 507 Aerospace Structures I (3) Introduction to the analysis and design of aerospace structure. Analysis topics include stress, deflection and (buckling) stability analysis of aerospace structures undergoing extension, torsion and bending. Design exercises focus on highly stressed structural components, which tend to be strength-limited, as well as wing and fuselage structures, which tend to be buckling-limited. Introduction to material selection and manufacturing.

Prerequisites: CE 310

Topics: production of aerospace structures * aerospace loads * strength of aerospace materials * design of connections * design of beams (especially tubes) in extension, bending & torsion * stress & deflection analysis of thin-walled beams * stress & deflection analysis of semimonocoque structures * buckling of beams (especially tubes), panels, and stiffened panels * design of wing and fuselage structures.

AE 508 Aerospace Structures II (3) Stress and deflection analysis of aerospace structures using the finite element method. Introduction to work-energy principles, including Castigliano's Theorems, for the analysis of statically indeterminate structures. Rod, beam, shaft, membrane and plate finite elements.

Prerequisite: AE 507

Topics: matrix algebra * computer calculations * Castigliano's theorems * displacement method * springs, rods, beams, membranes * large-scale structure.

AE 510 Aerospace Materials and Processes (4) Properties and application of aircraft materials, forming methods, and manufacturing processes.

Prerequisite: AE 507 and CHEM 130 or 150

Topics: material behavior & selection criteria for metal alloys, ceramics, polymers, composites * material selection exercises * manufacturing processes, to include forming, material removal, joining, surface treatment, measurement, testing and inspection, automation, computer-aided manufacture, safety, & economics * design of manufacturing processes.

AE 521 Aerospace Systems Design I (4) Preliminary design techniques for an aerospace system. Aerodynamic design, drag prediction, stability and control criteria, civil and military specifications. Weight and balance, Configuration integration, design and safety, design and ethics.

Prerequisite: AE 421, AE 508, AE 551, AE 572

Topics: configuration sizing to a given specification * configuration layout design * initial tail and control surface selection * weight and balance calculation * drag prediction * design for stability & control * inboard profile development * landing gear layout design * structural layout design * Performance calculation * V-N diagrams loads estimation.

AE 522 Aerospace Systems Design II (4) Preliminary design project of a complete aircraft system.

Prerequisite: AE 521

Topics: organization of technical work * organization of technical groups * management theory and practice * PERT theory and application * how to motivate engineers * engineering liability

AE 523 Space Systems Design I (4) Preliminary design project of a complete space system.

Prerequisite: AE 521 and AE 560

Topics: mission design * spacecraft environment * astrodynamics * spacecraft propulsion * launch systems * atmospheric flight * on-board power systems * thermal control * attitude control * communication systems * command systems * structures * configuration design * cost estimation

AE 524 Propulsion Systems Design I (4) Preliminary design project of a complete propulsion system, including airframe.

Prerequisite: AE 521

Topics: aerodynamic and structural design of aircraft engine components including inlets, compressors and fans, combustion chamber, turbines, afterburners, mixers, and exhaust systems * aircraft design and engine matching studies.

AE 545 Fundamentals of Aerodynamics (4) Basic gas dynamic equations, potential flow for airfoils and bodies, thin airfoil theory, finite wing, subsonic similarity rules, one and two dimensional supersonic flow, boundary layers, heat transfer and laboratory experiments.

Prerequisite: AE 445, ME 312, and MATH 220

Topics: basic gas dynamic equations * potential flow for airfoils and bodies * thin airfoil theory * finite wing * introduction to compressible fluids * one dimensional compressible flow * waves * wings in compressible flow * laminar flow * transition * turbulent flow * laboratory.

AE 550 Dynamics of Flight I (4) General equations of motion of rigid airplanes and reduction to steady state flight situation. Steady state forces and moments. Stability derivatives. Static stability, control and trim. Trim envelope. Relationships with handling quality requirements. Engine-out flight. Effects of the control system. Implications to airplane design.

Prerequisite: AE 445, Math 220, and Math 290

Topics: equations of motion of a rigid airplane and specialization to steady state flight * development of mathematical and physical models for the aerodynamic and thrust forces and moments; stability derivatives * static stability and control and airplane trim; trim envelope and design implications * engine-out flight * effects of the flight control system * handling qualities * general four dimensional trim formulation * nosewheel lift-off.

AE 551 Dynamics of Flight II (4) General equations of motion of rigid airplanes and reduction to perturbed state flight situations. Perturbed state forces and moments. Stability derivatives. Dynamic stability, phugoid, short period, dutch roll, roll, spiral and other important modes. Transfer functions and their application. Relationships with handling quality requirements. Fundamentals of classical control theory and applications to automatic flight controls. Implications to airplane design.

Prerequisite: AE 550

Topics: general equations of motion of a rigid airplane and specification to perturbed state flight * Development of mathematical and physical model for the aerodynamic and thrust perturbed forces and moments dimension less and dimensional stability derivatives * dynamic stability of airplanes: Phugoid, short period, spiral, roll, Dutch roll, degenerate modes, design specifications * transfer functions and applications * handling qualities and relation to design * frequency response of linear systems, bode plots and example applications * classical closed loop control theory, bode method, root locus method and example applications * basic stability augmentation systems: angle-of-attack and angle or sideslip feedback, yaw dampers, pitch dampers * basic autopilot modes: pitch angle hold, bank angle hold, heading hold.

AE 560 Spacecraft Systems (3) Fundamentals of spacecraft systems and subsystems. Spacecraft systems engineering, space environment; basic astrodynamics; and the following spacecraft subsystems; attitude determination and control; electrical power; thermal; propulsion; structures and mechanisms; command, telemetry, and data handling; and communications.

Prerequisite: AE 360, 507, EECS 318, MATH 124, and ME 312

Topics: spaceflight history * spacecraft systems engineering * space environment * basic astrodynamics * spacecraft propulsion * spacecraft attitude determination & control * spacecraft subsystems * spacecraft reliability & quality assurance.

AE 571 Fundamentals of Airplane Reciprocating Propulsion Systems (3) Study of the basic principles of operation and systems of internal and external combustion engines with emphasis on airplane reciprocating engines. Cycle analysis, propeller theory, propeller selection and performance analysis.

Prerequisite: AE 445 and ME 312

Topics: review of thermodynamics principles * air standard cycles * fuel-air-cycles * actual engine cycles * airplane engine components * propeller theory, operation, types & selection * carburetion * aviation fuels and engine knocks * ignition systems * lubrication systems * induction systems, supercharging and exhaust systems * laboratory.

AE 572 Fundamentals of Jet Propulsion (3) Lecture and laboratory, study of basis principles of propulsion systems with emphasis on jets and fan systems. Study of inlets, compressors, burners, fuels, turbines, jets, methods of analysis, testing, performance; environmental considerations.

Prerequisite: AE 545

Topics: introduction to jet propulsion and combustion chemistry * propulsion fundamentals * one dimensional steady compressible flow: isentropic, adiabatic, heat addition, frictional * thermodynamics of air breathing jet propulsion systems: ramjet, turbojet, turbofan, turboprop and turboshaft * inlets & nozzles * combustions and flame temperature * axial compressors * centrifugal compressors * turbines * matching turbine/compressor * turbomachinesm.

AE 590 Aerospace Seminar (1) Presentation and discussion of technical and professional paper reports. Methods for improving oral communication. Discussion of topics such as ethics, registration, interviewing, professional societies, personal planning.

Prerequisite: Senior standing.

Topics: career planning * human behavior * decision analysis * management, planning & decision making * technical communications * project management * engineering economics * personal financial planning * engineering ethics.

AE 592 Special Projects in Aerospace Engineering (1-5) Directed design and research projects in aerospace engineering.

Prerequisite: Consent of instructor.

AE 670 Aerospace Propulsion III (3) Advanced theory of turbojet, fanjet (multi-spool), variable cycle engines, ramjet and bypass air breathing propulsion systems. Theory and design of inlets, compressors, burners and turbines. Component matching, cooling, regenerative systems, test methods and corrections.

Prerequisite: AE 572.

Appendix C: Detailed Description of Aerospace Technical Electives

AE 701 Structural Design (3) Design and internal construction of major structural components: wing, fuselage, empennage, landing gear, engine pylons. Layout of major structures and system interfaces, internal geometry, material alternates, manufacturing alternates and design constraints. Certification and proof of design requirements.

Prerequisite: AE 421, AE 508, and AE 510

AE 704 Dynamics and Vibrations (3) This course presents problems in engineering dynamics and vibrations. Topics include applications of generalized forces and coordinates, and LaGrange equations and a study of the performance of single and multiple degrees of freedom in vibrational systems. (Same as CE 704)

Prerequisite: AE 508

Topics: free vibration of single degree of freedom system * forced vibration of single degree of freedom system and harmonic loading * impact loading of single degree of freedom systems * fourier analysis of single degree of freedom system * free vibration of multiple degree of freedom system * forced vibration of multi-degree of freedom system * Eigenvalue analysis of vibration problem * modal analysis and uncoupling technique * Lagrange equations of motion * stiffness and flexibility formulation of differential equations of motion.

AE 705 Structural Vibrations and Modal Testing (4) Classical theory of structural vibrations; single and multiple degree of freedom, free and forced vibration; theory of modal summation; measurement techniques for dynamic data, and methods of identifying modal parameters from measurement data. Numerous laboratory and computational projects.

Prerequisite: AE 508

Topics: free vibration * harmonic excitation * transient excitation * multiple degree of freedom systems * continuous systems * modal summation theory * dynamic finite elements * dynamic measurement techniques * modal model parameter estimation * modal testing laboratories.

AE 707 Aerospace Structural Loads (3) This course discusses steady state spanwise and chordwise airloads, windshears, gusts, landing gear loads, bird strike, traumatic loads, and special commercial and military load requirements.

Prerequisite: AE 507 and AE 545

Topics: specifications * mass properties * ground loads * air loads * self-equilibrating loads * paneling * load factor distribution * trauma * special loads * emergency landing * introduction to dynamic loads.

AE 708 Aerospace Structures III (3) This course presents modern methods in aircraft structural analysis, and computer solutions of linear problems of elastic structures. Also discussed are orthotropic panels, effects of buckling non-linearity, and structural optimization.

Prerequisite: AE 508

Topics: loads * trauma * structural analysis * thermal stress * repeated loads * static stability * coupled static failure.

AE 709 Structural Composites (3) This course presents fiber materials, tapes, cloths, and resin systems; general anisotropic theory, elastic constants, and stiffness matrix formulation; computer analysis, strength, and theory of failure, and introduces design with composites, preliminary design, and manufacturing.

Prerequisite: CHEM 150, C&PE 121, AE 508 or CE 761, and AE 510 or ME 346 or CE 710.

Topics: fiber materials * anisotropic theory * computer analysis * design.

AE 710 Advanced Structural Composites (3) The course objectives are to provide each student with a more in-depth understanding of and practical hands-on experiences with available fiber and matrix materials, manufacturing methods, and the mechanical behavior of composite materials and structures. Modern software tools and manufacturing methods are addressed, to include optimization techniques and design for manufacturability. Classical plate theory, bending, buckling, and vibration of anisotropic plates is addressed. Damage tolerance and repairability, as well as nondestructive evaluation techniques are also covered. Skills learned in previous composite courses will be utilized to design, analyze, and fabricate structures of current industrial relevance.

Prerequisite: AE 508 or similar, AE 709 or similar, or consent of instructor.

AE 712 Techniques of Engineering Evaluation (3) This course discusses the formulation of problems arising in aerodynamics, heat transfer, stress analysis, thermodynamics and vibrations. Also discussed is the expression of these problems in a form amenable to quantitative evaluation by dimensional reasoning, analog techniques, relaxation methods and classical analysis.

Topics: curve fitting and approximation * review of some solution techniques of linear ordinary differential equation * matrix differential equations * numerical methods for solving differential equations * methods of asymptotic expansions * introduction to partial differential equations * some applications of perturbation methods to partial differential equation * approximate solution of partial differential equations * calculus of variations * matrix eigenvalue problems * theory of a complex variable and integral transforms.

AE 713 Stochastic Systems, Estimation and Identification in Aerospace Engineering

(3) Stochastic adaptive control theory is concerned with recursive estimation of unknown parameters and control for systems with uncertainties modeled as random variables or random processes. The theory is motivated by applications in such diverse areas as aerospace guidance and control, signal processing and communications, manufacturing processes, and financial economics. Mathematical theory of stochastic adaptive control for models based on stochastic difference equations such as autoregressive processes and stochastic differential equations as Markov diffusion processes have been developed and will be presented. This course focuses on filtering and system identification theory.

Prerequisite: AE 430, AE 550, AE 551, AE 750, MATH 590 and MATH 627 or equivalent.

AE 721 Aircraft Design Laboratory I (4) This course provides Aerospace Engineering students with an opportunity to gain more in-depth airplane design education through team design work involving detailed design efforts in such areas as landing gear design, systems design, propulsion system integration, structures design and aerodynamic design.

Prerequisite: AE 507, AE 521, AE 545, AE 551 and AE 571 (AE 521 may be taken concurrently)

Topics: team design of a civil or military airplane.

AE 722 Aircraft Design Laboratory II (4) This course provides Aerospace Engineering students with an opportunity to gain more in-depth airplane design education through team design work involving detailed design efforts in such areas as landing gear design, systems design, propulsion system integration, structures design and aerodynamic design.

Prerequisite: AE 507, AE 521, AE 545, AE 551 and AE 571 (AE 521 may be taken concurrently)

Topics: team design of a civil or military airplane.

AE 724 Propulsion System Design and Integration (3) Theory and design of propulsion systems for both low and high-speed aircraft and their integration into the overall configuration are presented. Internal and external design and analysis of inlets and nozzles including their effect on the external aerodynamics of the aircraft, as well as engine/inlet compatibility and the problems of matching both steady and dynamic characteristics to obtain peak, stable performance are also discussed.

Prerequisite: AE 521 and AE 572

Topics: review of propulsion systems and their operational characteristics * aircraft performance and demands placed on the propulsion system * propulsion system and engine selection to meet aircraft design requirements * integration of the engine, inlet and nozzle into the total configuration * inlet design and analyses * engine/inlet compatibility; steady state and dynamic * nozzle design and performance * airframe/propulsion systems * propulsion system testing and evaluation in flight and in ground facilities * design project.

AE 725 Numerical Optimization & Structural Design (3) Classical theories of unconstrained and constrained optimization. Numerical techniques for unconstrained optimization, including the steepest descent, conjugate gradient and Newton's methods. Numerical techniques for constrained optimization, including sequential approximate problem techniques as well as the method of feasible directions. Computer aided solutions to practical structural design problems in Aerospace Engineering using commercially available software. Includes a final design project.

Prerequisite: MATH 220 and 290 or junior status

Topics: optimum design problem formulation * theory of optimization * linear programming methods * approximate numerical methods * practical design optimization * final design project

AE 730 Advanced Experimental Fluid Dynamics (3) This course includes theory, operation and hands-on laboratory experiments on various flow measurement techniques including: multi-hole directional pilot probes, hot-wire anemometry, laser-Doppler velocimetry and particle image velocimetry. Flow visualization techniques including smoke injection, dye injection, helium bubbles, etc. are presented.

Prerequisite: AE 430, AE 545, or consent of instructor

Topics: general concepts * multi-hole directional pilot probes * hot-wire anemometry * laser-doppler velocimetry * particle image velocimetry * flow visualization using water dye injection * smoke flow visualization * flow visualization by helium bubbles and tufts * final experimental design project.

AE 731 Supersonic Aerodynamics Laboratory (1) Supersonic wind tunnel and shock tube operation, techniques, and instrumentation are presented, as well as flow study and model testing.

Prerequisite: AE 545

Topics: Schlieren * supersonic nozzle flow * pressure and force measurements in supersonic flow * moving shock waves in tunnels

AE 732 Flight Test Principles and Practice (3) This course presents aerodynamic structural and/or power plant instrumentation and measurement of aircraft in flight for analytical evaluation.

Prerequisite: AE 550

Topics: introduction to flight test * the atmosphere * principles of air data measurements * air data system calibration techniques and procedures * ground tests prior to flight: weight and balance, in flight CG determination, inertial measurement * performance testing principles * performance data analysis and correction procedures: takeoff and landing, climb, cruise and descent * non-steady state performance measurements: energy concepts, and acceleration, climb and maneuvering determination * stability and control measurements * in-flight thrust measurement: reciprocating and turboprop turbojet and turbofan * flight test instrumentation: probes and sensors; calibration and corrections: data recording and transmission; databases and data analysis, & pre and post flight checks.

AE 743 Compressible Aerodynamics (3) This course presents advanced supersonic flow theory for aircraft and space vehicles. Navier-Stokes equation, method of characteristics, separated flows, and real gas effects are presented.

Prerequisite: AE 545

Topics: equations of compressible flow * shock polar, pressure-deflection diagram * Fanno and Rayleigh flow * normal and oblique shocks * expansion waves * wave-wave interaction * one dimensional unsteady flows * shock tube * conical flows and conical shocks with numerical solutions * method of characteristics * transonic flow * hypersonic flow * real gases

AE 744 Introduction to Turbulent Flow (3) Reynolds averaged equations for turbulent flow, basic energy relations in turbulent flow, analysis of turbulent boundary layer, turbulence models and simulation. Topics covered are Definition of turbulence and introductory concepts, Equations of motion for turbulent flow, Energy relations in turbulent flow, Turbulent boundary layer, and Turbulence models and simulation.

Prerequisite: AE 545 or equivalent, or consent of instructor.

AE 745 Applied Wing and Airfoil Theory (3) Applications of potential flow theory to aerodynamics of airfoil sections, wings and wing-body combinations are presented. This course also introduces high angle-of-attack and transonic aerodynamics.

Prerequisite: AE 545

Topics: fundamental equations and similarity rules * flow singularities * methods of flow singularities in 2-D flow * methods of flow singularities in 3-D flow * wing design * aerodynamics of low aspect-ratio wings * transonic flow * high angle-of-attack aerodynamics.

AE 746 Computational Fluid Dynamics (3) This course presents applications of numerical techniques and digital computers in solving fluid flow problems. Solutions involving incompressible and compressible flows and inviscid and viscous flows are also discussed. Also included are finite difference techniques for different types of partial differential equations governing the fluid flow.

Prerequisite: AE 545

Topics: fluid dynamic equations * mathematical behavior of P.D.E * grid generation and finite-difference methods * inviscid flow solutions * viscous flow solutions * advanced topics.

AE 747 Introduction to Transonic Aerodynamics (3) Review of Fundamental Equations, Transonic Similarity Laws, Shock-Expansion Theory, Method of Characteristics (MOC), Aerodynamics of Non-Lifting Bodies, Airfoil Aerodynamics and Aerodynamics of Swept Wings.

Prerequisite: AE 545

AE 748 Helicopter Aerodynamics (3) Included in this course are helicopter components and their functioning; rotor aerodynamics, performance, stability and control; aeroelastic and vibrations.

Prerequisite: AE 551

Topics: aerodynamics of hovering flight * aerodynamics of vertical flight * aerodynamics of forward flight * blade airfoils * rotor flapping * trim * stability & control analysis * aeroelastic and dynamic problems

AE 750 Applied Optimal Control (3) This course introduces optimal control for multi-input/multi-output control system design. Also discussed are continuous regulator and non-zero set point (servo) problems; advanced controller structures including control rate weighing and proportional-integral form, and problems taken from aerospace applications including autopilot designs.

Prerequisite: AE 551 or consent of instructor

Topics: state variable formulation * linear regulator * non-zero set point problem * advanced control structures * autopilot application * estimator designs.

AE 751 Advanced Airplane Dynamics (2) This course presents theory of elastic airplane stability and control using quasi-steady math models. This course further introduces theory of nonlinear airplane stability and response behavior. Also included are roll and pitch coupling phenomena, and Lyapunov stability and approximate inverse Laplace transform methodology. Airplane response to atmospheric turbulence using power spectral density methods and Lagrangean dynamics are also presented.

Prerequisite: AE 551

Topics: aerodynamic influence coefficients * structural influence coefficients * matrix solutions to elastic airplane stability and control derivatives * pitch and roll coupling * Lyapunov stability theory * approximate inverse Laplace transforms applied to nonlinear differential equations * modeling of atmospheric turbulence * power spectral density * Lagrangean dynamics.

AE 753 Digital Flight Controls (3) Introduction to the analysis and design of digital flight control systems including a review of continuous linear control theory, typical flight control structures, effects of digital implementation, mathematical model of a digital computer, Z-transforms, Z-plane analysis of digital systems, and direct digital design in the Z-plane.

Prerequisite: AE 551 or permission of instructor

Topics: review of continuous linear control theory * typical flight control structures * effects of digital implementation * mathematical model of a digital computer * Z-transforms * Z-plane analysis of digital systems * direct digital design in the Z-plane.

AE 754 Missile Dynamics (3) This course includes design of missile configuration; general equations of motion; aerodynamics of missiles in subsonic through hypersonic flight regimes; theory of missile trajectory; linear and nonlinear theories of missile flight dynamics; introduction to guidance and control; launching problems, and free flight dispersions.

Prerequisite: AE 551

Topics: missile aerodynamics * missile trajectories * simple angular motion and applications * linear theory of missile flight dynamics * special topics in missile dynamics * guidance techniques and control of guided missiles.

AE 756 Rule-Based Control Systems (3) Introduction to rule-based systems with an emphasis on a cognitive architecture. Realistic examples of using such systems will be covered in the context of unmanned aircraft control. A brief review of programming in LISP language, on which the cognitive architecture is based.

Prerequisite: EECS 316 and 318, AE 550, AE 551 or equivalent

AE 757 Rule-Based UAV Control Lab (1) A guided experience on building an unmanned aircraft system. Uses an existing radio-controlled platform, and thus does not require an expertise in fabrication. Focuses on building the communication hardware and software that enables the use of a rule-based control system on a computer to control the aircraft remotely.

Prerequisite: none. **Co-requisite:** AE 756

AE 758 Introduction to Robotics (3) An introduction to robotics covering spatial descriptions and transformations, manipulator kinematics, Jacobians, and dynamics and control of manipulators. The successful completion of this course will prepare students for advanced studies in robotics.

Prerequisite: CE 301 or equivalent, AE 551 or equivalent, and MATH 290 or equivalent; or by consent of instructor

AE 760 Spacecraft Systems (3) Fundamentals of spacecraft systems and subsystems. Spacecraft systems engineering, space environment; basic astrodynamics; and the following spacecraft subsystems; attitude determination and control; electrical power; thermal; propulsion; structures and mechanisms; command, telemetry, and data handling; and communications. Same as AE 560 with the addition of a research paper. Not available for students that have taken AE 560.

Prerequisite: AE 360, 507, EECS 318, and ME 312 or equivalents

Topics: spaceflight history * spacecraft systems engineering * space environment * basic astrodynamics * spacecraft propulsion * spacecraft attitude determination & control * spacecraft subsystems * spacecraft reliability & quality assurance.

AE 765 Orbital Mechanics (3) This course discusses the motion of space vehicles under the influence of gravitational forces, as well as two body trajectories, orbit determination, orbital transfer, universal variables, gravity assist trajectories, and mission planning using patched conics. Rendezvous and proximity operations are also discussed.

Prerequisite: MATH 220 and MATH 290 and CE 301 or equivalent.

Topics: two-body orbital mechanics * orbit determination from observation * basic orbital maneuvers, rendezvous and proximity operations * position and velocity as a function of time.

AE 766 Spacecraft Attitude Dynamics and Control (3) Dynamics of rigid spacecraft; attitude control devices including momentum exchange, mass movement, gravity gradient and reaction rockets, and design of feedback control systems for linear and bang-bang control devices are presented.

Prerequisite: AE 551 or permission of instructor

Topics: fundamental spacecraft dynamics * attitude maneuvers * attitude control devices * automatic attitude control * special problems.

AE 767 Spacecraft Environments (3) Fundamentals of spacecraft environments. Description and analysis of the natural environment in which spacecraft operate post-launch. Includes optical, electromagnetic, corpuscular radiation, plasma, and dust from low Earth orbit, through outer heliosphere.

Prerequisite: PHSX 212 required, PHSX 313 or PHSX 351 recommended.

AE 768 Orbit Determination (3) Develops the theory of batch and sequential (Kalman filter) estimation theory related to orbit estimation, including a review of necessary concepts of probability and statistics. Course work includes a term project that allows students to apply classroom theory to an actual satellite orbit determination problem.

Prerequisite: AE 360. Corequisite: AE 560 or AE 760.

AE 771 Rocket Propulsion (3) This course presents basic elements of rocket propulsion: systems, propellants and performance.

Prerequisite: AE 545 or equivalent

Topics: classification of types of rocket engines * definitions and fundamental relationships for flow, thrust, efficiency and other performance parameters * nozzle theory and thermodynamic relations for ideal and real rockets * heat transfer, principles and application * rocket vehicle performance, forces, equations, staging, performance calculations, temperature of combustion (Stoichiometry) * design of liquid and solid propellant rockets.

AE 772 Fluid Mechanics of Turbomachinery (3) Fundamentals of two and three- dimensional flows in turbo machinery. Study of secondary flows and losses; flow instabilities in axial flow compressors (stall and surge); aerodynamic design of multistage axial flow compressor; noise associated with a transonic axial flow compressor; turbine blade cooling; calculation of stresses and blade life estimation in axial flow turbines, and fundamentals of radial flow turbomachinery.

Prerequisite: AE 572 or consent of instructor

Topics: axial flow compressor * axial flow turbine * radial flow turbomachinery

AE 781 Introduction to Adaptive Aerostructures (3) This course covers the basic material properties and modeling techniques for structures that are capable of changing some physical property in response to a command signal. The course will be useful for students from nearly every branch of engineering and includes a fabrication and testing practicum introducing basic post processing and integration techniques used with piezoelectric, shape memory alloy and magnetorheological materials. The course concludes with an overview of applications and examples of adaptive products.

Prerequisite: ME 311 or equivalent.

AE 790 Special Problems in Aerospace Engineering (1-5) This course offers directed studies of advanced problems in Aerospace Engineering.

Prerequisite: Open to graduate students with departmental approval

Topics: student choice with faculty approval

AE 941 Hypersonic Aerodynamics I (3) The gasdynamics of aerospace vehicles operating in the speed range above Mach 5. Rarified and dissociated gas flows; magnetogasdynamic and heat transfer problems.

Prerequisite: Consent of instructor.

Glossary

ABET – Accreditation Board for Engineering and Technology
AFRL – Air Force Research Laboratory
AIAA – American Institute of Aeronautics and Astronautics
AMA – Academy of Model Aeronautics
APS – American Physical Society
ASEE – American Society for Engineering Education
ASME – American Society of Mechanical Engineers
BACN – Battlefield Airborne Communication Node
CFD – Computational Fluid Dynamics
CREGIS – Center for Remote Sensing of Ice Sheets
DoD – Department of Defense
DPR – Degree Progress Report
IEEE – Institute of Electrical and Electronics Engineers
NASA – National Aeronautics and Space Administration
NSF – National Science Foundation
SAE – Society of Automotive Engineers
SAMPE – Society for the Advancement of Material and Process Engineering
SEM – Society of Experimental Mechanics
SHPE – Society of Hispanic Professional Engineers
SIAM – Society for Industrial and Applied Mathematics
SPIE – Society of Photographic Instrumentation Engineers
UAS – Unmanned Aircraft Systems
UAV – Unmanned Aerial Vehicle
UAVSI – Association for Unmanned Vehicle Systems International
USAF – United States Air Force