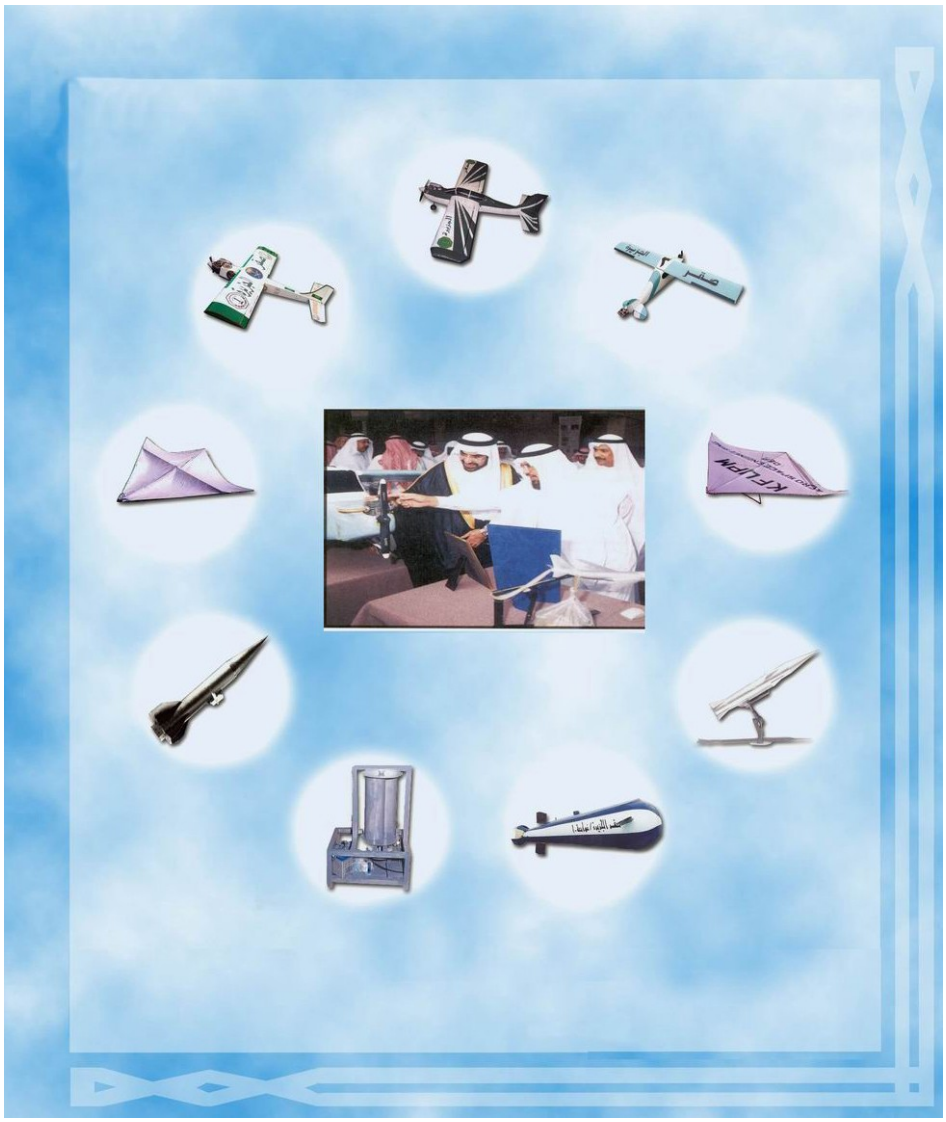
King Fahd University of Petroleum and Minerals

Graduate Bulletin

Aerospace Engineering



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AEROSPACE ENGINEERING

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Graduate Program in Aerospace Engineering

The Aerospace Engineering Department offers a graduate program leading to a Master of Science (M.S.) degree in Aerospace Engineering. The Department started its Master of Science program in 1425-26 (2004-05). The program focuses on academic excellence and the professional development of graduate students. The graduate students are expected to demonstrate competence in a number of professional areas that require creativity. The AE M.S. Program emphasizes the application of theoretical principles to practical problems in the field of Aerospace Engineering and helps to provide the Kingdom with the high-caliber professional engineers that are needed for the development of the country. The graduate (M.S.) Program offers specialization in four major fields of Aerospace Engineering:

- Aerodynamics and Gas Dynamics,
- Flight Dynamics and Control,
- Aerospace Structures and
- Propulsion.

In addition, the M.S. Program offers a wide selection of graduate courses and research activities with a flavor of aviation needed by the local industry. Thereby the student can fulfill his degree requirements, complete and defend his thesis based on the original work in one of the major areas of Aerospace Engineering.

The AE M.S. Program has been designed to continually evolve by taking account of modern trends and the latest developments in the area of Aerospace Engineering. The graduate courses are designed to provide the student with the opportunity to deepen and broaden his knowledge base in the various subjects, thus providing motivation for the student to sharpen his skills in problem solving, creative thinking, research, technical report writing and presentation. The graduate courses are listed below:

AE Course #	Title
AE 520	Aerodynamics of Compressible Flow
AE 524	Aerodynamics of Viscous Flow
AE 528	Aerospace Computational Fluid Dynamics
AE 530	Aerospace Structures I
AE 534	Aerospace Structures II
AE 540	Flight Dynamics and Control I
AE 544	Flight Dynamics and Control II
AE 546	Fundamentals of Helicopter Flight
AE 548	Aerospace Avionics, Navigation and Guidance
AE 550	Aircraft Propulsion
AE 554	Rocket Propulsion
AE 560	Aerospace and Aviation Maintenance
AE 564	Air Traffic Control
AE 566	Flight and Aviation Safety
AE 568	Flight and Aviation Law
AE 570	Fundamentals of Astronautics
AE 590	Special Topics
AE 599	Seminar
AE 610	M.S. Thesis

Teaching and Research Facilities

The research activities of the Department of Aerospace Engineering are exceptionally diverse and broad. Research is conducted in the following major Aerospace fields: Aerodynamics and Gas Dynamics, Flight Dynamics and Control, Aerospace Structures, Propulsion and Aviation. The Aerospace Engineering Department has the following laboratories with advanced equipment for teaching and research purposes:

1. Aerodynamics and Flight Dynamics Laboratory

The laboratory is equipped with several small-scale sub-sonic wind tunnels and is primarily used to complement the concepts covered in Aerospace Engineering courses. The lab can be used for the teaching and research of such aspects as measurements of lift and drag for an airfoil, smoke visualization of flow over variously shaped bodies and static pressure measurements. The lab also has a pulse jet test unit to study the concepts of jet propulsion and reaction power and a wind tunnel to demonstrate flight simulation.

2. Wind Tunnel Laboratory

The laboratory is primarily designed to carry out both fundamental and applied research in shear flows, aerodynamics of streamlined and bluff bodies, super-sonic flow, etc. The laboratory has a sub-sonic wind tunnel with a 0.8 m x 1.1 m test-section with a maximum flow speed of 40 m/s, an internal six-component wind tunnel strain gauge balance, with attitude mechanisms, computerized software operation & calculation and graphical analysis; a shock tube and a Ludwig-tube supersonic-tunnel capable of producing a jet of Mach number 2.57; measurement equipment including a multi-channel hot-wire anemometer system, an intelligent flow analyzer, frequency analyzers, filters, correlators, a data acquisition and storage system, a remote-controlled traverse system, load cells, oscilloscopes, manometers, scanivalves and a flow visualization system with a laser light source.

3. Airplane Laboratory

The AE Department is equipped with a Royal Saudi Air Force aircraft BAC-167 (Strike Master). The students use this lab to become familiar with the principles of the real aircraft and to do several measurements related to aerodynamic performance, flight dynamics & control, flight structures, propulsion and avionics system.

4. Aerospace Structures and Materials Laboratory

This laboratory contains several pieces of equipment such as different structures made of different materials, an engine, landing gear and other aircraft parts that are used for demonstration, inspection and experimental purposes.

5. PC Applications Facility

The Department has a good number of state-of-the-art computers and benefits from a highly sophisticated LAN (Local Area Network) system through which all the computers are inter-connected inside KFUPM and worldwide.

6. Other Facilities Inside and Outside the University

- Inside the University, the Department has cooperative links with various departments in the College of Engineering and other colleges, such as the Mechanical Engineering Department, which has laboratories like the Advanced Materials Science Laboratory, Dynamics Laboratory, Fluid Mechanics Laboratory, Heat Transfer Laboratory and Materials Science Laboratory. Moreover, the AE Department

has close ties with the Research Institute of the University, which is an excellent and well established research center.

- Outside the University, the Department also has a close working relationship with the aerospace and aviation industry. The University is located next to King Abdul-Aziz Air Force Base and Dhahran Airport, and is a few kilometers from King Fahd International Airport and Saudi Aramco Aviation. The AE Department utilizes the wide spectrum of technical facilities offered by these excellent organizations.

The Aerospace Engineering Program at KFUPM conducts and promotes scientific research in terms of publications, patents and research projects. The AE Department faculty have to their credit several research awards, such as King Abdul-Aziz Al-Saud Legion of Honor Medal for the first degree for Scientific Patent; the Distinguished Researcher Award in KFUPM; the Distinguished Engineering Scientist Award in KSA; and the American-Romanian Academy of Arts and Sciences Book Award. They also have many publications in **leading reputable journals in AE**, such as AIAA (published in 6 out of 6 major AIAA journals) and leading British, Canadian and Japanese AE journals in the areas of Aerodynamics, Aerospace Structures, Flight Dynamics and Control, Propulsion and other areas. The faculty of the AE Department has by far the **highest percentage of publications per faculty in the AE field in the whole Arabian region with over 160 publications (most of them in reputable international journals) in the last 10 years**. The following represent some of the research activities in the Department:

- Hypersonic Plane Cooling.
- Reliability Study in Aviation.
- Airfoil Performance Analysis.
- Inverse Airfoil Design Methods.
- Optimization in Aircraft Performance.
- Hybrid Airfoil Design.
- Aerospace System Maintenance.
- Aerodynamics.
- Satellite Engineering.
- Flight Dynamics and Control.
- Computational Fluid Dynamics.
- Propulsion.
- Guidance and Navigation.

Admission Requirements

The minimum requirements for admission to the Master of Science program in the Deanship of Graduate Studies as regular graduate students with full standing in Aerospace Engineering are:

1. A Bachelor's degree in Aerospace Engineering or some other engineering or science degree from an institution whose undergraduate program is equivalent in length, content and quality to that of KFUPM. An applicant whose academic credentials do not meet regular admission requirements may be given some deficiency courses depending on the individual case.
2. A Grade Point Average (GPA) of 3.00 or higher (on a 4-point scale).
3. A good score in the Test of English as a Foreign Language (TOEFL). Applications from KFUPM and other universities in which English is the medium of instruction may request exemption from the TOEFL requirement.
4. Satisfactory scores in the Graduate Record Examination (GRE) General.
5. Fulfillment of the general University requirements for admission.

Academic Program

In addition to meeting the overall requirements of KFUPM, AE M.S. students must satisfy the following requirements:

1. A student should satisfactorily complete a minimum of **30 credit** hours including 8 courses, AE 599 (seminar) and AE 610 (M.S. Thesis). The distribution of the courses is mentioned below in items 2 to 6.
2. **Two core courses: AE 520 and AE 540**
3. **One Mathematics core course** (MATH 513/514/550) depends on the emphasis of the Program; other Math courses can be considered with the approval of the AE Department.
4. **Two AE elective courses** from AE courses.
5. **Two technical elective courses** from AE courses or from any other department (such as Engineering Depts., Mathematics Dept., Systems Engineering Dept.). These technical electives must be taken from technical fields such as Engineering and Science.
6. **One free elective course** from the AE Department or any other department. **The AE elective courses and the technical/free elective courses require the approval of the AE Department.**
7. Graduate courses are strongly encouraged for the M.S. Program. However, under certain conditions, a maximum of two senior-level undergraduate courses (one as AE elective course and the other as technical elective course from the AE Department or any other department) may be taken for graduate credit towards the M.S. degree. These two courses must be approved by the AE Department.
8. The student has to maintain a minimum GPA of 3.00 (out of 4.00) throughout the course of study.
9. The expected duration of the M.S. Program is two years.

M.S. Degree Plan

Course #	Title	LT	LB	CR	
First Semester					
AE 520	Aerodynamics of Compressible Flow	3	0	3	
AE xxx	AE Elective I*	3	0	3	
MATH 5xx	Advanced Mathematics**	3	0	3	
		9	**0**	**9**	**9**
Second Semester					
AE 540	Flight Dynamics and Control I	3	0	3	
AE 5xx	AE Elective II*	3	0	3	
XX xxx	Technical Elective I*	3	0	3	
AE 599	Seminar	1	0	0	
		10	**0**	**9**	**18**
Third Semester					
XX xxx	Technical Elective II*	3	0	3	
XX 5xx	Free Elective***	3	0	3	
		6	**0**	**6**	**24**
Fourth Semester					
AE 610	Thesis	0	0	6	
		0	**0**	**6**	**30**

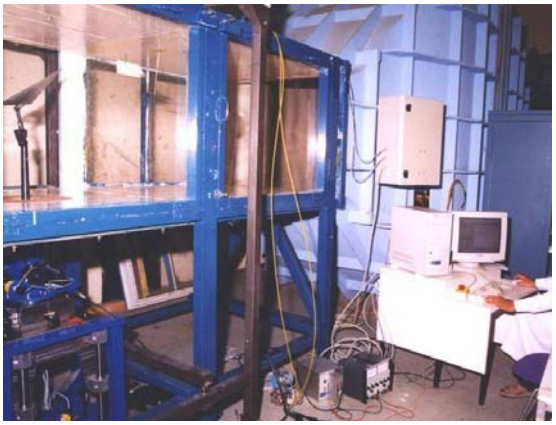
* AE xxx (AE Elective I) and XX xxx (Technical Elective I) are 500 level. However, a maximum of two undergraduate courses can be taken for credit with the approval of the AE Department.

** MATH 513/514/550 depends on the emphases of the program; other Math courses can be considered with the approval of the AE Department.

*** One free elective course from the AE Department or any other department.

Transfer From Other Universities

The number of credit hours to be acknowledged for transfer students of other universities should not exceed 6, and they can only be considered as elective courses. These courses must be approved by the Aerospace Engineering Department.



Courses Description

AE 520 Aerodynamics of Compressible Flow (3-0-3)

Review of compressible inviscid gas dynamics. Unsteady wave motion; linearized flow. Numerical techniques for steady supersonic flow; three-dimensional flow; transonic flow; hypersonic flow; high-temperature flow. Introduction to computational aerodynamics.

Prerequisite: AE 325 or Equivalent

AE 524 Aerodynamics of Viscous Flow (3-0-3)

Review of potential flow. Dynamics of viscous flow; laminar boundary layer for incompressible and compressible flows; flow instabilities and transition flow; turbulent flow. Airfoil design and flow about three-dimensional bodies. Navier-Stokes equation. Numerical solutions of viscous flow with aerospace applications.

Prerequisite: AE 333 or Equivalent

AE 528 Aerospace Computational Fluid Dynamics (3-0-3)

Introduction to computational fluid dynamics. Partial differential equations impact on CFD. Grids, discretization and transformation with CFD techniques. Numerical solutions in aerospace applications.

Prerequisite: AE 325 or Equivalent and Graduate Standing

AE 530 Aerospace Structures I (3-0-3)

Analysis of stress and strain; constitutive relations of elastic materials, isotropic and anisotropic; beam, plate and shell theories. Introduction to composite structures. Modeling of thermal stresses and practical applications in aerospace structures. Numerical solutions in aerospace structures.

Prerequisite: AE 328 or Equivalent

AE 534 Aerospace Structures II (3-0-3)

Discrete systems structural vibration; dynamics of continuous structures; vehicle structural dynamics; flutter of elastic structures exposed to aerodynamic loading. Introduction to aero-elastic phenomenon and methods of analysis. Case studies of aerospace structural vibration and flutter. Numerical solutions in aerospace structures.

Prerequisite: AE 530

AE 540 Flight Dynamics and Control I (3-0-3)

Review of the equation of motion, static and dynamic stability. Response to control or inputs. Classical approach for automatic control theory. Modern control theory and application to autopilot design. Numerical solutions in flight dynamics and control.

Prerequisite: AE 426 or Equivalent

AE 544 Flight Dynamics and Control II (3-0-3)

Review of atmospheric flight. Dynamic effects of structural flexibility. Flying and handling qualities. Parametric optimization and optimal control design. Altitude, flight path and tracking, active, digital adaptive control systems. Helicopter flight control. Application to atmospheric and space vehicles. Numerical solutions in flight dynamics and control.

Prerequisite: AE 540

AE 546 Fundamentals of Helicopter Flight (3-0-3)

Introduction to hovering theory; hovering and axial flight performance; concepts of blade motion and control; aerodynamics and performance of forward flight. Introduction to aeroacoustics. Methods to solve rotor dynamics problems. Helicopter stability and control.

Prerequisite: ME 201 or Equivalent and Graduate Standing

AE 548 Aerospace Avionics, Navigation and Guidance (3-0-3)

Principles of avionics, navigation and guidance. Deterministic and stochastic linear perturbation theory. Position fixing and celestial navigation with redundant measurements. Recursive navigation and Kalman filtering. Pursuit guidance, proportional navigation, ballistic guidance and velocity-to-be-gained guidance. Hardware mechanization.

Prerequisite: Graduate Standing and Consent of the Instructor

AE 550 Aircraft Propulsion (3-0-3)

Advanced analysis of aircraft propulsion; gas turbine cycles for aircraft propulsion. Engine off-design performance. The environmental impact. Aircraft propulsion case study design. Numerical solutions in aircraft propulsion.

Prerequisite: AE 422 or Equivalent

AE 554 Rocket Propulsion (3-0-3)

Advanced analysis of rocket propulsion; multi-stage rockets, trajectories in power flight; electric propulsion, space propulsion. The environmental impact. Rocket propulsion case study design. Numerical solutions in rocket propulsion.

Prerequisite: AE 422 or Equivalent

AE 560 Aerospace and Aviation Maintenance (3-0-3)

General regulations for aerospace and aviation maintenance. Hydraulic, power, electrical and electronic, instrument landing and support systems maintenance. Troubleshooting procedures, evaluation, repair, installation and inspection techniques. Aviation maintenance systems management, maintenance planning, forecasting and cost control, reliability; safety and flight schedule. Field project.

Prerequisite: Graduate Standing

AE 564 Air Traffic Control (3-0-3)

Fundamentals of air traffic control (ATC) system. Federal aviation administration (FAA). Navigational aids, airspace, communication, federal aviation regulations (FARs), ATC procedures control tower operations; non-radar operations, radar operations. Instrument flight rules (IFR) in the enroute and terminal ATC facilities; human factors; air traffic safety and management. Aviation weather. Field Project.

Prerequisite: Graduate Standing

AE 566 Flight and Aviation Safety (3-0-3)

Personal and organizational safety procedures and goals; safety philosophies, human factors. Principles of accident investigation, aircraft accident reports; accident prevention programs and accident statistics; impact of accident on aviation industry. Air traffic control factors. Aviation and airport securities. Field project.

Prerequisite: Graduate Standing

AE 568 Flight and Aviation Law (3-0-3)

Bilateral and multilateral agreements and security interest in aircraft; international conferences; airline dispatch operations; federal aviation regulations; flight management for aviation/aerospace systems; airport planning and design standards; airport administration and finance; airline management; international aviation management; airline/airport marketing; role of transportation engineering. Field Project.

Prerequisite: Graduate Standing

AE 570 Fundamentals of Astronautics (3-0-3)

Introduction to the solar system, launching. Fundamental law of astrodynamics (space mechanics); orbit maneuvering and determination. Applications in rocket trajectories; optimal trajectories. Communication satellite and spacecraft altitude. Re-entry and hypersonic heating considerations.

Prerequisite: Graduate Standing and Consent of the Instructor

AE 590 Special Topics (3-0-3)

Advanced topics are selected from the broad area of aerospace engineering to provide the student with knowledge of recent advances in analysis and design in aerospace engineering and in aviation including optimization of aerospace engineering designs, aerodynamics and gas dynamics, aerospace structures and materials, flight dynamics and control, propulsion, helicopter flight, avionics, navigation and guidance, aircraft maintenance, flight and aviation safety, air traffic control, aviation law, astronautics and other related fields such as marine engineering. The content of the course will be provided in detail one semester before the offering. Approval of the Departmental Graduate Committee and the graduate council must be secured before offering this course.

Prerequisite: Graduate Standing

AE 599 Seminar (1-0-0)

Graduate students working towards the M.S. degree in any emphasis area of aerospace engineering (aerodynamics and gas dynamics, aerospace structures, flight dynamics and control and propulsion) and aviation are required to attend the seminars given by faculty, visiting scholars and fellow graduate students. Additionally, each student must present at least one seminar on a timely research topic. Among other things, this course is designed to give the student an overview of research in the department, and a familiarity with the research methodology, journals and professional societies in his discipline. This course is graded on a pass or fail basis.

AE 610 M.S. Thesis (0-0-6)

Involves individual studies by students in the field of aerospace engineering and aviation. The work should be original and the concept, data and the conclusions should contribute new knowledge to the field of aerospace engineering. The quality of the work should reflect the student's proficiency in research and creative thinking.

Following preliminary studies and a literature survey on the thesis subject, each student will present his proposed thesis subject orally and also submit a written proposal to the college of graduate studies for approval. On satisfactory completion of his thesis work, the student is required to make a formal defense of his research thesis.