Aerospace Engineering

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For the Degree of Bachelor of Science in Aerospace Engineering

The Aerospace Engineering curriculum provides a strong fundamental background in engineering, mathematics, and science, along with the ability to apply this fundamental knowledge to the analysis and design of future aircraft and spacecraft. It also prepares students for lifelong learning and the attainment of their career goals in the field of aerospace engineering and in a wide range of other areas. The concepts of system design are introduced early in the curriculum and culminate in the yearlong senior capstone design experience (AE 442, AE 443), in which students work in teams to respond to a design challenge from industry, government, or a professional engineering society. A total of 18 hours of technical and free electives allows the student to pursue an individualized program of study.

Overview of Curricular Requirements

The curriculum requires 128 hours for graduation and is organized as follows.

Orientation and Professional Development

These courses introduce the opportunities and resources your college, department, and curriculum can offer you as you work to achieve your career goals. They also provide the skills to work effectively and successfully in the engineering profession.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 100</td>
<td>Intro to Aerospace Engineering 1</td>
<td>2</td>
</tr>
<tr>
<td>ENG 100</td>
<td>Engineering Orientation 2</td>
<td>0</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

1 This optional course may be used to help meet free elective requirements.
2 External transfer students take ENG 300 instead.

Founded Mathematics and Science

These courses stress the basic mathematical and scientific principles upon which the engineering discipline is based.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 102</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 103</td>
<td>General Chemistry Lab I</td>
<td>1</td>
</tr>
<tr>
<td>MATH 221</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 225</td>
<td>Introductory Matrix Theory</td>
<td>2</td>
</tr>
<tr>
<td>MATH 231</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>MATH 241</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 285</td>
<td>Intro Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>University Physics: Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>University Physics: Elec &amp; Mag</td>
<td>4</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

1 List of Technical Electives (http://aerospace.illinois.edu/undergraduate-programs/current-students/tech-electives).

Aerospace Engineering Technical Core

These courses stress fundamental concepts and basic laboratory techniques that comprise the common intellectual understanding of aerospace engineering.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE 202</td>
<td>Aerospace Flight Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>AE 311</td>
<td>Incompressible Flow</td>
<td>3</td>
</tr>
<tr>
<td>AE 312</td>
<td>Compressible Flow</td>
<td>3</td>
</tr>
<tr>
<td>AE 321</td>
<td>Mechs of Aerospace Structures</td>
<td>3</td>
</tr>
<tr>
<td>AE 323</td>
<td>Applied Aerospace Structures</td>
<td>3</td>
</tr>
<tr>
<td>AE 352</td>
<td>Aerospace Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>AE 353</td>
<td>Aerospace Control Systems</td>
<td>3</td>
</tr>
<tr>
<td>AE 370</td>
<td>Aerospace Numerical Methods</td>
<td>3</td>
</tr>
<tr>
<td>AE 433</td>
<td>Aerospace Propulsion</td>
<td>3</td>
</tr>
<tr>
<td>AE 442</td>
<td>Aerospace Systems Design I</td>
<td>3</td>
</tr>
<tr>
<td>AE 443</td>
<td>Aerospace Systems Design II</td>
<td>3</td>
</tr>
<tr>
<td>AE 460</td>
<td>Aerodynamics &amp; Propulsion Lab</td>
<td>2</td>
</tr>
<tr>
<td>AE 461</td>
<td>Structures &amp; Control Lab</td>
<td>2</td>
</tr>
<tr>
<td>AE 483</td>
<td>Unmanned Aerial Vehicle (UAV) Navigation and Control</td>
<td>3</td>
</tr>
<tr>
<td>ECE 205</td>
<td>Electrical and Electronic Circuits</td>
<td>3</td>
</tr>
<tr>
<td>ECE 206</td>
<td>Electrical and Electronic Circuits Lab</td>
<td>1</td>
</tr>
<tr>
<td>IE 300</td>
<td>Analysis of Data 1</td>
<td>3</td>
</tr>
<tr>
<td>ME 200</td>
<td>Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>MSE 280</td>
<td>Engineering Materials</td>
<td>3</td>
</tr>
<tr>
<td>TAM 210</td>
<td>Introduction to Statics</td>
<td>2</td>
</tr>
<tr>
<td>TAM 212</td>
<td>Introductory Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>58</td>
</tr>
</tbody>
</table>

1 STAT 400 may be substituted.

Technical Electives

These courses stress the rigorous analysis and design principles practiced in the major subdisciplines of aerospace engineering.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected from the departmentally approved list of Technical Electives, satisfying these distribution requirements: 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chosen from AE Technical Electives 1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Chosen from AE Technical Electives or Non-AE Technical Electives 1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

1 List of Technical Electives (http://aerospace.illinois.edu/undergraduate-programs/current-students/tech-electives).
Liberal Education
The liberal education courses (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) develop students' understanding of human culture and society, build skills of inquiry and critical thinking, and lay a foundation for civic engagement and lifelong learning.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electives from the campus General Education Social and Behavioral Sciences list.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Electives from the campus General Education Humanities and the Arts list.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Electives either from a list approved by the college, or from the campus General Education lists for Social and Behavioral Sciences or Humanities and the Arts.</td>
<td>6</td>
</tr>
</tbody>
</table>

Total Hours: 18

Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course, (ii) one non-western culture(s) course, and (iii) one U.S. Minority Culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western, non-western, and U.S. Minority lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.

Composition
These courses teach fundamentals of expository writing.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHET</td>
<td>Writing and Research</td>
<td>4</td>
</tr>
</tbody>
</table>

Advanced Composition (satisfied by completing the sequence AE 442 + AE 443 in the Aerospace Engineering Technical Core )

Total Hours: 4

Free Electives
These unrestricted electives, subject to certain exceptions as noted at the College of Engineering Advising Website (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Free+Electives?src=search), give the student the opportunity to explore any intellectual area of unique interest. This freedom plays a critical role in helping students to define research specialties or to complete minors.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Free electives. Additional unrestricted course work, subject to certain exceptions as noted at the College of Engineering advising Web site, so that there are at least 128 credit hours earned toward the degree.</td>
<td>6</td>
</tr>
</tbody>
</table>

Suggested Sequence
The schedule that follows is illustrative, showing the typical sequence in which courses would be taken by a student with no college course credit already earned and who intends to graduate in four years. Each individual’s case may vary, but the position of required named courses is generally indicative of the order in which they should be taken.
AE 442  Aerospace Systems Design I  3  
AE 460  Aerodynamics Propulsion Lab  2  
AE 483  Unmanned Aerial Vehicle (UAV) Navigation and Control  3  
Technical elective  7  
Free elective  4  
AE 433  Aerospace Propulsion  3  

Semester Hours  18  

Second Semester  
AE 443  Aerospace Systems Design II  3  
AE 461  Structures Control Lab  2  
Technical elective  7  

Semester Hours  9  

Total Hours:  128  

1  Entering freshmen are expected to enroll in AE 100 in the fall of the first year. This optional course may be used to help meet free elective requirements.  
2  MATH 220 may be substituted with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.  
3  Liberal education electives (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) must include 6 hours of social & behavioral sciences and 6 hours of humanities & the arts course work from the campus General Education lists. The remaining 6 hours may be selected from a list maintained by the college, or additional course work from the campus General Education lists for social & behavioral sciences or humanities & the arts. Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.  
4  RHET 105 may be taken in the first or second semester of the first year as authorized. The alternative is a liberal education elective.  
5  STAT 400 may be substituted.  
6  Sequence satisfies the General Education Advanced Composition requirement.  
7  Technical elective credits totaling twelve hours, selected from a departmentally approved list of Technical Electives (http://aerospace.illinois.edu/undergraduate-programs/current-students/tech-electives), satisfying these distribution requirements: (i) six hours of AE Technical Electives; (ii) six hours of AE Technical Electives or Non-AE Technical Electives.  

AE Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/AE)  

Courses  

AE 100  Intro to Aerospace Engineering  credit: 2 Hours.  
Introduction to the Aerospace Engineering curriculum and career. A typical section topics include aircraft and rocket design and flight. Overviews of the topics are presented along with theory to be experimentally verified.  

AE 199  Undergraduate Open Seminar  credit: 0 to 5 Hours.  
Undergraduate Open Seminar. Approved for Letter and S/U grading. May be repeated.  

AE 202  Aerospace Flight Mechanics  credit: 3 Hours.  
Fundamental principles of aerospace flight mechanics applied to spacecraft and aircraft. Orbital mechanics, rocket propulsion, and dynamics and control applied to spacecraft design. Aerodynamics, maneuvering, stability and flight performance applied to aircraft design. MATLAB examples and assignments. Prerequisite: Credit or concurrent registration in TAM 212.  

AE 298  Special Topics  credit: 1 to 4 Hours.  
Lectures and discussions relating to new areas of interest. See class schedule for topics and prerequisites. May be repeated if topics vary.  

AE 302  Aerospace Flight Mechanics II  credit: 3 Hours.  
Fundamentals of aircraft and spacecraft dynamics and orbital mechanics; aircraft performance in various flight attitudes; aircraft stability and control; spacecraft attitude dynamics and control; the two-body problem of orbital mechanics; orbit transfer. Prerequisite: AE 352.  

AE 311  Incompressible Flow  credit: 3 Hours.  
Equations of motion for incompressible flow, both inviscid and viscous; potential flow theory, inviscid airfoil theory: two- and three-dimensional, Navier-Stokes equations, laminar boundary layer and transition to turbulence. Prerequisite: Credit or concurrent registration in AE 202 and MATH 241.  

AE 312  Compressible Flow  credit: 3 Hours.  
Dynamics of compressible fluid; conservation of mass, momentum, and energy; one-dimensional and quasi-one-dimensional flow; oblique shock waves & Parandtl-Meyer expansion fans; unsteady wave motion; linearized theory. Application to nozzles, diffusers, airfoils, shock tubes and other geometries. Prerequisite: AE 202 and MATH 285. Credit or concurrent registration in ME 300.  

AE 321  Mech of Aerospace Structures  credit: 3 Hours.  
Fundamental concepts in the linear theory of elasticity, including stress, strain, equilibrium, compatibility, material constitution and properties. Failure mechanisms and criteria. Application to plane stress-strain problems, beams in extension and bending, and shafts in torsion. Prerequisite: MATH 285 and TAM 210.  

AE 323  Applied Aerospace Structures  credit: 3 Hours.  

AE 352  Aerospace Dynamical Systems  credit: 3 Hours.  
Particle kinematics and dynamics; Lagrange's equations; vibration of multiple degree-of-freedom systems; rotational kinematics and dynamics of rigid bodies. Credit is not given for both AE 352 and TAM 412. Prerequisite: MATH 225, MATH 285, and TAM 212.  

AE 353  Aerospace Control Systems  credit: 3 Hours.  
Modeling of linear dynamic systems; Laplace transform techniques; linear feedback control systems; stability criteria; design techniques. Credit is not given for both AE 353 and either GE 320 or ME 340. Prerequisite: MATH 225, MATH 285, and TAM 212.  

AE 370  Aerospace Numerical Methods  credit: 3 Hours.  
Numerical methods used in aerospace engineering. Numerical integration, curve fitting, root finding, numerical solution of ODE, solution of linear systems of equations. Finite difference. Rayleigh-Ritz, and Finite element methods. Applications to simple structural mechanics and aerodynamics problems encountered in aerospace engineering. Prerequisite: Credit or concurrent registration in AE 311 or AE 312; credit or concurrent registration in AE 321 or AE 323.  

Information listed in this catalog is current as of 03/2018  

AE 395 Honors Project  credit: 1 to 4 Hours.
Special aerospace engineering project or reading course for James Scholars in engineering. Prerequisite: Consent of instructor.

AE 396 Honors Seminar  credit: 1 to 4 Hours.
Special lecture sequences or discussion groups arranged each term to bring James Scholars in engineering into direct contact with the various aspects of engineering practices and philosophy. Prerequisite: Consent of instructor.

AE 397 Independent Study  credit: 1 to 3 Hours.
Independent theoretical and experimental projects in aerospace engineering. May be repeated. Prerequisite: Consent of instructor.

AE 398 Special Topics  credit: 1 to 4 Hours.
Lectures and discussions relating to new areas of interest. See class schedule for topics and prerequisites. May be repeated if topics vary.

AE 402 Orbital Mechanics  credit: 3 or 4 Hours.
Analysis of orbits in an inverse-square gravitational field; elementary rocket dynamics, impulsive orbit transfer and rendezvous, and Lambert's Theorem with applications; patched-conic trajectories, planetary gravity-assist maneuvers, and linearized orbit theory with application to simplified analytical models; perturbations. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 202.

AE 403 Spacecraft Attitude Control  credit: 3 or 4 Hours.
Theory and applications of spacecraft attitude dynamics and control; Euler angles, direction cosines, quaternions, and Gibbs-Rodrigues parameters; attitude sensors and control actuators; spin, three-axis active, reaction wheel, control moment gyro, and gravity gradient control systems; environmental effects. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 352 and AE 353.

AE 410 Computational Aerodynamics  credit: 3 or 4 Hours.
Computational technologies as solution tools for various aerodynamic problems; modeling and solution of one-and two-dimensional, incompressible and compressible, steady and unsteady inviscid external flow fields. Computational laboratory for practical experience. Same as CSE 461. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 311; credit or concurrent enrollment in AE 312.

AE 412 Viscous Flow & Heat Transfer  credit: 4 Hours.
Momentum and thermal transport in wall-boundary-layer and free shear flows, solutions to the Navier-Stokes equations for heat conducting laminar and turbulent shear flows; similarity concepts; thermal boundary layers in ducts and high-speed aerodynamic boundary layers. Same as ME 411. 4 undergraduate hours. 4 graduate hours. Prerequisite: AE 311 or ME 310.

AE 416 Applied Aerodynamics  credit: 3 or 4 Hours.
Two-dimensional and finite wing theory with emphasis on the mechanisms of lift and drag generation; Reynolds number and Mach number effects; drag analysis; high-lift wing systems; propeller and rotor aerodynamics; control surface design; application of V/STOL aerodynamics. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 311.

AE 419 Aircraft Flight Mechanics  credit: 3 or 4 Hours.
Steady and quasi-steady aircraft flight performance; take-off and landing, climbing and diving, cruise, level turn, and energy methods; longitudinal, directional, and lateral static stability and control; longitudinal and lateral motion and dynamic stability. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 202 and AE 353.

AE 420 Finite Element Analysis  credit: 3 or 4 Hours.
Same as CSE 451 and ME 471. See ME 471.

AE 421 Aerospace Systems Design I  credit: 3 Hours.
Continuation of AE 442. Conceptual design project of either an aircraft or spacecraft flight system to satisfy a given set of requirements. Project team organization. Emphasis on sizing, trade studies and design optimization, subsystem integration, and technical communication skills. 3 undergraduate hours. No graduate credit. AE 442 and AE 443 taken in sequence fulfill the Advanced Composition Requirement. Prerequisite: Credit or concurrent registration in AE 311, AE 323, and AE 352.

AE 422 Aerospace Systems Design II  credit: 3 Hours.
Principles of systems engineering as they apply to the design process for aerospace flight systems; general design methodology; application of these concepts to the initial sizing of both aircraft and spacecraft systems. Intensive technical writing. 3 undergraduate hours. No graduate credit. AE 442 and AE 443 taken in sequence fulfill the Advanced Composition Requirement. Prerequisite: Consent of instructor.

AE 435 Electric Propulsion  credit: 3 or 4 Hours.
Elements of electric propulsion as applied to near-earth and deep-space missions; impact on spacecraft design; physics of ionized gases; plasmadynamics; electrothermal, electromagnetic, and electrostatic acceleration of gases to high velocity; high-impulse thruster design and performance; the resistojet, arcjet, ion engine, Hall thruster, MPD arc thruster, and plasma gun. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 433.

AE 442 Aerospace Propulsion  credit: 3 or 4 Hours.
Fundamentals of rocket and airbreathing jet propulsion devices electric propulsion; prediction of thrust, combustion reactions, specific fuel consumption, and operating performance; ramjets; turbojets; turbofans; turboprops; aerothermodynamics of inlets, combustors, and nozzles; compressors, turbines; component matching, fundamentals of electrothermal, electromagnetic elastostatistics thrusters, and solar sails. 3 undergraduate hours. 4 graduate hours. Prerequisite: AE 312 and PHYS 212.

AE 443 Electric Propulsion  credit: 3 or 4 Hours.
Principles of aerothermodynamics and dynamic structural phenomena associated with flexible airplanes and missiles; divergence of linear and nonlinear elastic lifting surfaces; effect of elastic and inelastic deformations on lift distributions and stability; elastic flutter of straight and swept wings; equations of disturbed motion of elastic and inelastic aircraft; dynamic response to forces, gusts, and continuous atmospheric turbulence; creep divergence of lifting surfaces; flutter in the presence of creep; effect of temperature on inelastic divergence and flutter. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: AE 352 or TAM 412; TAM 251.
AE 454  Systems Dynamics & Control  credit: 3 or 4 Hours.
Examination of the common core of dynamics and control theory.
Fundamental concepts of Lagrangian dynamics, state space
representations, Hamiltonian and modern dynamics, stability theory, and
control of dynamical systems. 3 undergraduate hours. 4 graduate hours.
Prerequisite: AE 353.

AE 456  Global Nav Satellite Systems  credit: 4 Hours.
Same as ECE 456. See ECE 456.

AE 460  Aerodynamics & Propulsion Lab  credit: 2 Hours.
Theory and application of experimental techniques in aerospace
engineering with emphasis on fluid dynamic, aerodynamic, thermal,
combustion, and propulsion phenomena. 2 undergraduate hours. No
graduate credit. Prerequisite: AE 311; credit or concurrent registration in
AE 433.

AE 461  Structures & Control Lab  credit: 2 Hours.
Theory and application of experimental techniques in aerospace
engineering with emphasis on structural mechanics, vibrations,
dynamics, and control systems. 2 undergraduate hours. No graduate
credit. Prerequisite: AE 321 and AE 352. Credit or concurrent registration
in AE 323 and AE 353.

AE 468  Optical Remote Sensing  credit: 3 Hours.
Same as ECE 468. See ECE 468.

AE 482  Introduction to Robotics  credit: 4 Hours.
Same as ECE 470 and ME 445. See ECE 470.

AE 483  Unmanned Aerial Vehicle (UAV) Navigation and Control  credit:
3 Hours.
Design, analysis, and application of decision algorithms to modern
aerospace systems: global positioning systems, air traffic control
systems, unmanned aerial vehicles, imaging and communication
satellites, and planetary ground vehicles. 3 undergraduate hours. No
graduate credit. Prerequisite: AE 202, AE 352, AE 353, AE 370, IE 300, and
PHYS 212.

AE 497  Independent Study  credit: 1 to 4 Hours.
Independent theoretical and experimental projects in aerospace
engineering. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be
repeated. Prerequisite: Consent of instructor.

AE 498  Special Topics  credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in aerospace
engineering intended to augment the existing curriculum. See Class
Schedule or department course information for topics and prerequisite. 1
to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the
same or separate terms if topics vary to a maximum of 9 undergraduate
hours or 12 graduate hours.