5-15-2015

Educational Policies Committee Program Proposal, College of Engineering, May 15, 2015 - PhD Degree in Aerospace Engineering

Utah State University

Cover/Signature Page – Full Template

Institution Submitting Request: Utah State University
Proposed Title: PhD Degree in Aerospace Engineering
School or Division or Location: College of Engineering
Department(s) or Area(s) Location: Mechanical and Aerospace Engineering
Recommended Classification of Instructional Programs (CIP) Code[1] **:** 14.0201
Proposed Beginning Date: 08/01/2015
Institutional Board of Trustees' Approval Date: 01/09/2015

Proposal Type (check all that apply):

Regents' Agenda Items		
R401-4 and R401-5 Approval by Committee of the Whole		
SECTION NO.		**ITEM**
4.1.1	☐	(AAS) Associate of Applied Science Degree
4.1.2	☐	(AA) Associate of Arts Degree
	☐	(AS) Associate of Science Degree
4.1.3	☐	Specialized Associate Degree
4.1.4	☐	Baccalaureate Degree
4.1.5	☐	K-12 School Personnel Programs
4.1.6	☐	Master's Degree
4.1.7	X	Doctoral Degree
5.2.2	☐	(CER C) Certificate of Completion
5.2.4	☐	Fast Tracked Certificate

Chief Academic Officer (or Designee) Signature:
I certify that all required institutional approvals have been obtained prior to submitting this request to the Office of the Commissioner.

_____
Signature **Date:**

Printed Name: Laurens H. Smith, Jr., Executive Senior Vice Provost

R 401 Executive Summary
Utah State University
PhD Degree in Aerospace Engineering
Department of Mechanical and Aerospace Engineering

Program Description
The Department of Mechanical and Aerospace Engineering (MAE) at USU seeks to offer a new PhD (Doctor of Philosophy) degree program in Aerospace Engineering to complement the current MS in Aerospace Engineering and the current MS and PhD programs in Mechanical Engineering. Aerospace Engineering is the primary branch of engineering associated with design, construction, testing, and technology development for all types of flying vehicles including airplanes, rockets, missiles, and spacecraft. Currently, the PhD in Mechanical Engineering degree is being used to accommodate both mechanical and aerospace engineering graduate students who successfully complete the Mechanical Engineering doctoral program. The proposed new degree program will establish a separate degree path for aerospace engineering graduate students and attract new students that specifically desire a PhD graduate degree in Aerospace Engineering. This can be accomplished without any change to our current faculty, staff and coursework.

Role and Mission Fit
The proposed PhD graduate degree program in Aerospace Engineering is consistent with the role of USU as set forth in Regent's Policy R312. The PhD in Aerospace Engineering will support the Regent's mission for a doctoral granting institution "*through discovery, creation, and transmission of knowledge through a graduate educational program".* More specifically, Regent's Policy R312-4.1.2 states that "*the mission of Utah State University is to be one of the nation's premier student centered land grant and space grant universities by fostering the principle that academics come first; by cultivating diversity of thought and culture; and by serving the public through learning, discovery, and engagement*". Additionally, the proposed program is complementary to ongoing research at the Space Dynamics Lab (SDL). In a letter of support from the USU Research Foundation (USURF), President Scott Hinton states that *"USURF and SDL would welcome and encourage an Aerospace PhD at USU. We think that the program you are proposing would complement and support much of the work that is the core of SDL's business"*.

Faculty
The MAE department has 16 tenured and tenure-track faculty members, all with doctoral degrees. Eight faculty members, including four with doctoral degrees in Aerospace Engineering, have expertise directly related to the proposed aerospace engineering program as well as current research projects in aerospace that will support the proposed PhD degree program.

Labor Market Demand
Nearly 80,000 engineers are currently employed in aerospace, significantly higher than the number employed in computer hardware, nuclear engineering, biomedical engineering or chemical engineering, among other fields. (IEEE, http://www.todaysengineer.org/2012/may/career-focus.asp) Over the decade from 2012 to 2022, the Bureau of Labor Statistics projects a 7% growth in employment for aerospace engineers. Overall, Utah is one of the top ten states in the nation in the concentration of aerospace employment. Given the large concentration of aerospace industries in Utah, USU graduates with a PhD in aerospace engineering will clearly be "first in line" to fill these available high-paying positions; keeping "home-grown" talent "close to home."

Student Demand
Presently the MAE department supports a PhD in Mechanical Engineering. A new PhD in Aerospace Engineering will provide graduate students with an option that is more focused on the specialized topics that are central to aerospace engineering. Graduates with a PhD in aerospace engineering will be better prepared and more competitive in the aerospace industry. Students wanting a PhD degree in aerospace engineering will be able to stay in Utah rather than go out of state. As stated previously, this change will help to keep home-grown talent close to home.

When the PhD in Aerospace Engineering program is approved, there exists a potential for an initial small decrease in the number of students pursuing a PhD in Mechanical Engineering. However, because of the previously-described market demand and the desire of many students to choose a program with a PhD in Aerospace Engineering, overall enrollment is in MAE's PhD programs is projected to increase during the next five years.

Statement of Financial Support
Indicate from which of the following the funding for this new degree program will be generated:

Legislative Appropriation ..... ☐
Grants ..... ☒
Reallocated Funds..... ☒
Tuition dedicated to the program..... ☐
Other ..... ☒

The MAE's full-time PhD graduate students receive graduate research or graduate teaching assistantships to help finance their education. All of the research assistantships are supported by grants and contracts initiated by the faculty. These grants and contracts also provide research equipment, materials, and supplies used by the students in their courses and research associated with the PhD degree.

Similar Programs Already Offered in the USHE
Currently, there no Aerospace Engineering PhD degree within the Utah System of Higher Education. Thus, offering the Aerospace PhD degree better positions USU to capture regional talent that would otherwise leave the state. A flourishing PhD program in aerospace engineering will likely attract students who would not have previously considered USU.

R 401 Proposal
PhD Degree in Aerospace Engineering
Department of Mechanical and Aerospace Engineering
Utah State University

Section I: The Request

Utah State University (USU) requests approval to offer the Doctor of Philosophy degree in Aerospace Engineering effective Fall Semester 2015. The program has been approved by the institutional Board of Trustees 01/09/2015.

Section II: Program Description

Overview

The Department of Mechanical and Aerospace Engineering (MAE) at USU seeks to offer a new PhD (Doctor of Philosophy) degree program in Aerospace Engineering to complement the current MS in Aerospace Engineering and the current MS and PhD programs in Mechanical Engineering. Aerospace Engineering is the primary branch of engineering associated with design, construction, testing, and technology development for all types of flying vehicles including airplanes, rockets, missiles, and spacecraft. Currently, the PhD in Mechanical Engineering degree is being used to accommodate both mechanical and aerospace engineering graduate students who successfully complete the Mechanical Engineering doctoral program. The proposed new degree program will establish a separate degree path for aerospace engineering graduate students and attract new students that specifically desire a PhD graduate degree in Aerospace Engineering. MAE offers sufficient foundation and aerospace courses that provide the breadth and depth needed for a quality aerospace PhD degree program without the need to develop any new courses.

PhD Degree Requirements

The PhD degree requires 72 credit hours beyond the bachelor's degree and 42 credit hours beyond the Master's degree and will comply with all Graduate School requirements for PhD programs of study including a formal dissertation. All students must pass 3 PhD Qualifier Exams, a dissertation proposal defense, and a final dissertation defense. PhD degree requirements also consists of core courses (5000-, 6000-, and 7000-level) in aerospace engineering, advanced mathematics, technical electives, and quality aerospace research. A summary of PhD degree requirements is provided below.

Aerospace Engineering (PhD) Degree Requirements	
Beyond the BS - 72 credits	**Beyond the MS** - 42 credits
Coursework*: 24 credits (minimum) Aerospace Core • must include MAE 5500 and 5560 if not previously completed 21 credits (minimum) Aerospace Electives/Other • No more than 6 credits MAE 7930 Doctoral Publications • No more than 6 credits MAE 5930/6930/7930 Independent Study courses. 6 credits advanced math **Dissertation Research** 21 credits MAE 7970 **Dissertation Proposal & Final Defense** *No more than 21 credits of 5000- level coursework	**Coursework*:** 12 credits (minimum) Aerospace Core • must include MAE 5500 and 5560 if not previously completed 6 credits (minimum) Aerospace Electives/Other • No more than 6 credits MAE 7930 Doctoral Publications • No more than 6 credit MAE 5930/6930/7930 Independent Study courses. 3 credits advanced math **Dissertation Research** 21 credits MAE 7970 **Dissertation Proposal & Final Defense** *No more than 15 credits of 5000- level coursework

Purpose of the Degree

The new degree program will attract new PhD students to the MAE graduate studies and research program and provide graduate students with the opportunity to receive a degree more directly aligned with the academic and research skills that are critical to the aerospace industry. Students completing this degree program will possess skills sought by research organizations in industry, government, and academia requiring advanced design, research, and technical management in aerospace engineering. The PhD in Aerospace Engineering will support the Utah-based aerospace industry, as well as other prominent regional and national aerospace companies and research laboratories.

Institutional Readiness

The new degree program will be administered by the MAE Department, which has in place the administrative infrastructure necessary to manage the program. There is a graduate committee that oversees the graduate programs and a full-time staff member assigned to the graduate program. Presently, the MAE department supports a PhD program in Mechanical Engineering. The PhD program in Aerospace Engineering will place more emphasis on core aerospace engineering coursework, but will not require additional institutional resources or the development of new courses. In a very real sense, the level of effort and cost to administer this degree program will be the same as that already being accomplished for the Mechanical Engineering PhD degree.

Faculty

Eight faculty members in MAE have appropriate backgrounds and research interests in aerospace engineering to support the program. In the past, these faculty members have supported the MS program in Aerospace Engineering and a degree specialization in aerospace under the MS program in mechanical engineering.

Professors:
Christine Hailey - PhD Mechanical Engineering, University of Oklahoma, 1985 (aerodynamics and flight mechanics)

Associate Professors:
Rees Fullmer – PhD Mechanics Engineering, University of Utah, 1985 (guidance, navigation and control)
Steven Folkman - PhD Mechanical Engineering, Utah State University, 1990 (aerospace structures)
David Geller - PhD Space Physics and Astronomy, Rice University, 1999 (guidance, navigation and control)
Steven Whitmore - PhD Aerospace Engineering, University of California, Los Angeles, 1989 (flight mechanics and propulsion)

Assistant Professors:
Aaron Katz - PhD Aeronautics and Astronautics, Stanford University, 2009 (computational fluid dynamics)
Currently two additional faculty positions are being filled at the assistant professor level to support the needs of the Aerospace Engineering curriculum.

Staff
Additional staff lines will not be required. The current resources within the Department of Mechanical and Aerospace Engineering will be able to accommodate this new program.

Library and Information Resources
Two major library resources needed for the new program are the IEEE Xplore database and a series of journals produced by the American Institute of Aeronautics and Astronautics. The Merrill-Cazier library presently subscribes to these resources. See attached letter from the Merrill-Cazier Library.

Admission Requirements
Applicants with a bachelor's or master's degree in Aerospace Engineering or Mechanical Engineering from an ABET-accredited program can apply. For unrestricted admission to the program, students are required to have a minimum 3.3 GPA and successfully pass the GRE exam. The subject GRE is not required. Additional coursework in aerospace engineering fundamentals may be required in individual cases. All graduate students are expected to have a working knowledge of a computer programming language.

Student Advisement
The mechanics of admission to the programs and fulfilling program requirements are handled by our full-time staff graduate advisor. As students are admitted to the program, they are assigned a temporary faculty advisor who guides them on which courses to take the first semester and how to prepare for the PhD Qualification Exams. During the first semester, students select a graduate committee and a major professor who advise them throughout the rest of their program.

Justification for the Number of Credits
The number of credits required for this program is the same as the currently offered PhD in Mechanical Engineering which is overseen by the Graduate School.

External Review and Accreditation
As with the current PhD program in Mechanical Engineering and practice throughout the United States, no accreditation will be sought.

Projected Enrollment

Table 1. Projected enrollment for the PhD Aerospace Engineering Degree.

Year	Student FTE	Student Headcount	# of Faculty	Mean FTE-to-Faculty Ratio
1	0	0	8	0.0
4	2	2	8	0.25
3	4	4	8	0.50
4	6	6	8	0.75
5	8	8	8	1.00

Section III: Need

Program Need
Within the intermountain region, only Arizona State University, University of Arizona, and the University of Colorado at Boulder offer PhD programs in Aerospace Engineering. There are no Aerospace Engineering PhD degree programs in Wyoming, Nevada or Idaho, or within the Utah System of Higher Education (USHE). Thus, offering the Aerospace PhD degree better positions USU to capture regional talent that would otherwise leave the state. A flourishing PhD program in aerospace engineering will likely attract students who would not have previously considered USU.

Labor Market Demand
Nearly 80,000 engineers are currently employed in aerospace, significantly higher than the number employed in computer hardware, nuclear engineering, biomedical engineering or chemical engineering, among other fields. (IEEE, http://www.todaysengineer.org/2012/may/career-focus.asp) According to the U.S. Department of Labor, Bureau of Labor Statistics, aerospace engineers are expected to have a 7% growth in employment during the decade of 2012 to 2022.

Overall, Utah is one of the top ten states in the nation in the concentration of aerospace employment. In 2011, the Economic Development Corporation of Utah listed the leading aerospace organizations in Northern Utah. Largest amongst these organizations is Hill Air Force Base (HAFB) located just south of the city of Ogden, and near the towns of Clearfield, Riverdale, Roy, Sunset, and Layton. HAFB is the host unit for the USAF Material Command's 75th Air Base Wing. This unit provides support for the Ogden Air Logistics Complex (OALC) and its subordinate organizations. The OALC is the worldwide manager for a wide range of aircraft, engines, missiles, software, avionics, and accessories components. The largest private employer is Alliant Technology Systems (ATK) with the Space Systems Division groups located in Magna and Promontory, and its Aerospace Structures Division in Clearfield.
These large-scale employers are supported by a significant group of medium-sized employers including Aircraft and Space Defense Groups of Moog Inc., the Parker-Hannifin Corporation, Boeing Utah Company, and the Northrop Grumman Space and Missile Systems Group, all of Layton Utah.

The Space Dynamics Laboratory, North Logan, Utah is a University Affiliated Research and Development Center (UARC) and a sub-unit of the Utah State University Research Foundation (USURF). It is a medium-sized non-commercial employer of aerospace engineers. SDL expects to continue to hire new PhD aerospace engineers as they have done for the past 50 years, and it would be to SDL's advantage if these PhD engineers were "home-grown" right in their own backyard.

Multiple small private supplier and integration organizations provide to this network of large-to medium scale employers. Examples of these small support vendors include Compositex, Inc. Sandy Utah, a manufacturer of rocketry cases and nozzles; Groen Brothers Aviation Global, Inc., Salt lake City Utah, a designer of high-performance rotorcraft for both civil and military applications; Borsight, Inc, Ogden Utah, an aerospace systems integrator; and Hypercomp, Inc., Brigham City Utah, a manufacturer of composite pressure vessels.

Despite the changing environment of the aerospace industry, where NASA's operations have scaled back significantly, demand for aerospace engineers by private, commercial, and national defense employers is still strong. Over the decade from 2012 to 2022, the Bureau of Labor Statistics projects a 7% growth in employment for aerospace engineers. This growth is primarily driven by two emerging markets 1) unmanned aerial vehicle (UAV) and their integration into civil airspace, and 2) commercial space ventures both crewed and robotic. These emerging markets will require the creation and development of a wide swath of highly specialized technologies in order to become viable, and will clearly support a large pool of employees with advanced aerospace engineering degrees. Given the large concentration of aerospace industries in Utah, USU graduates with a PhD in aerospace engineering will clearly be "first in line" to fill these high-paying positions; keeping "home-grown" talent "close to home." USU and SDL already host the annual "SmallSAT" international conference on small spacecraft technologies; and the introduction of the PhD degree in Aerospace Engineering will better position Utah State to become the de facto leader of small spacecraft world.

In addition to the need for aerospace engineering PhDs in industry and government, we have identified 64 academic aerospace engineering programs within the United States. With an estimated average of 15 faculty per program, this indicates a total of approximately 960 aerospace engineering faculty positions. Assuming a retirement rate of approximately 5%, we estimate 48 openings per year. In addition, a PhD degree in aerospace engineering will also qualify graduates for many of the annual openings within mechanical engineering departments.

Student Demand

Presently the MAE department supports a PhD in Mechanical Engineering. A new PhD in Aerospace Engineering will provide graduate students with an option that is more focused on the specialized topics that are central to aerospace engineering. Graduates with a PhD in aerospace engineering will be better prepared and more competitive in the aerospace industry. Students wanting a PhD degree in aerospace engineering will be able to stay in Utah rather than go out of state. As stated previously, this change will help to keep home-grown talent close to home.

When the PhD in Aerospace Engineering program is approved, there exists a potential for an initial small decrease in the number of students pursuing a PhD in Mechanical Engineering. However, because of the previously-described market demand and the desire of many students to choose a program with a PhD in

Aerospace Engineering, overall enrollment is in MAE's PhD programs is projected to increase during the next five years.

Section IV: Impact and Benefits

Collaborations with and Impact on Other USHE Institutions
There will be no impact on other USHE institutions.

Benefits
The PhD in Aerospace Engineering will directly impact the goals of the USHE to prepare a workforce and develop advanced aerospace technologies that will directly impact Utah's economy. This proposed degree will make USU graduates more competitive for aerospace engineering positions within Utah as well as elsewhere in the aerospace industry. By having more engineers educated and trained for their needs, the Utah aerospace companies are, presumably, going to be more competitive in competing for new contracts and developing new aerospace technologies.

Consistency with Institutional Mission
The mission of USU is to be one of the nation's premier student-centered land-grant and space-grant universities by fostering the principle that academics come first, by cultivating diversity of thought and culture, and by serving the public through learning, discovery, and engagement.

The proposed PhD in Aerospace Engineering enhances the University's reputation as a space-grant institution through both its graduates and research productivity. It supports the University Mission Statement in the following ways:

1. The department becomes more student-centered by providing a program to meet the needs of the students.
2. The doctoral program will improve academics in aerospace engineering by fostering research in the forefront of the field, consistent with the USU mission to be one of the nation's premier space-grant universities.

The doctoral program will serve the public by application of the research produced. It will also serve the growing aerospace industry in Utah with a better-prepared work force.

Section V: Program and Student Assessment

Program Assessment
The major goal for the program is to graduate PhD students with expertise in aerospace engineering and who are prepared to meet the needs of research organizations in industry and academia. Attainment of this goal will be measured by the placement rate of graduates within local and national research laboratories in industry, government, and academia.

Expected Standards of Performance
The standard of performance for all students is a grade of C or better in all classes required for the degree and to maintain an overall program GPA of 3.0 or higher in order to graduate with a PhD degree. In addition, all PhD students must satisfactorily pass a set of qualification exams within 3 semesters of being admitted to the aerospace engineering PhD program, and pass a dissertation defense upon completion of their dissertation research. PhD students are also expected to publish in peer-reviewed journals before

completing their PhD program of study. These standards are already well established in the Graduate School as well as for the existing Mechanical Engineering PhD degree program.

Section VI: Finance

Funding Sources
The proposed PhD in Aerospace Engineering builds on MAE's MS in Aerospace Engineering Program and the aerospace specialization in place within MAE's undergraduate program. Additional funding is not required.

Reallocation
No budget transfers or reallocations will be requested or needed to offer a quality program as explained in the next section.

Impact on Existing Budget
A new aerospace PhD degree will enhance the MAE graduate program with virtually no impact on existing budgets.

Faculty: This new degree will have no impact on faculty salaries since new faculty positions are not needed to offer the degree. In reality, each professor is constantly managing his/her time to maintain a research program that includes preparing proposals, contract management, student mentoring, teaching courses, publishing research results, and providing University and professional service. Experience has shown that even though the required student contact time increases with the number of graduate advisees, the overall workload may not increase but actually decrease because there is more graduate student support for developing and maintaining the research productivity. The MAE Faculty feels that the benefits of the projected enrollment offset the time costs to manage the program.

Staff: This new degree program will have no impact on staff work load and staff salaries.

Facilities: During the past five years, the MAE department has been planning for and working toward increased graduate enrollment and has sufficient office/study space to accommodate the expected small enrollment increase. Most of the incidental cost associated with graduate students is already covered by the research grants/contracts and F&A return such that the impact on E&G funds is essentially zero.

Operating Costs: Increase in enrollment results in increased copy service charges and other miscellaneous expenses. MAE has already been using electronic communications more and more to curb paper and copy expenses. This will continue such that these costs will be minimal for this degree program. In summary, the additional work load imposed by this degree is minimal and will have no impact on tasks that would normally be done by current faculty and staff.

Budget Explanation: Salaries, wages, and benefits are estimates of the marginal costs of offering PhD level instruction based on the USHE cost study. Since these courses are already being taught, the revenue to pay for these expenses is simply a reallocation within current department funds. Thus, the difference, revenue less expenses, is zero. The teaching expenses are based on eight faculty members with an approximately 50% teaching role assignment, and with a 50/50 split between mechanical engineering courses and

Commented [JoeV1]: I'm using the estimated costs of PhD instruction calculated in the associated spreadsheet.

aerospace engineering courses. The expenses are thus approximately 25% of our current salaries, wages, and benefits for these faculty members. Note that any additional expenses associated with research will be externally funded. Additional comments for Table 2:

- FTE = 10 credits
- Tuition increase is estimated at 8%.
- Salary and Wages increase is estimated at 3%.
- Benefit increase follows the Sponsored Programs rates
- No new funding is required for this program.

Table 2. Projected Aerospace PhD Program Revenue and Expenses

		Year 1	Year 2	Year 3	Year 4	Year 5
Students						
	Projected FTE	4	6	8	9	10
	Cost Per FTE	12,173	10,843	9,811	9,455	9,1
	Student/Faculty Ratio	0.50	0.75	1.00	1.13	1.
Projected Tuition						
	Gross Tuition	21,897	35,473	51,081	62,063	74,4
	Tuition to Program	0	0	0	0	0
5 Year Budget Projection						
		Year 1	Year 2	Year 3	Year 4	Year 5
Expenses						
	Salaries & Wages	93,727	96,539	99,435	102,418	105,491
	Benefits	40,303	40,303	40,303	40,303	40,303
	Total Personnel	134,030	136,841	139,738	142,721	145,793
	Current Expense	38,820	38,820	38,820	38,820	38,820
	Travel					
	Capital					
	Library Expense					
Total Expense		172,850	175,662	178,558	181,541	184,614
Revenue						
	Legislative Appropriation					
	Grants					
	Reallocation	172,850	175,662	178,558	181,541	184,614
	Tuition to Program					
	Fees					
Total Revenue		172,850	175,662	178,558	181,541	184,614
Difference	Revenue-Expense	0	0	0	0	0

Commented [JoeV2]: There are many definitions of FTE, but the Regents use 10 credit hours at the graduate level per FTE, so that is probably what we should use

Commented [JoeV3]: This just makes it extremely clear that there are NOT any new costs, but existing appropriations within the department that will be shifted to the new program.

Commented [JoeV4]: See attached spreadsheet for details. This is the average Cost per FTE of Doctoral students only

Commented [JoeV5]: See attached spreadsheet for details.

Commented [JoeV6]: When a proposed program doesn't require any additional funds, we usually included some generic language like "N/A – All costs are currently covered in existing programs. There are no additional faculty or staff FTE, library or other operational funds required". By putting numbers in there it implies that the faculty support this program exclusively, which we know is not the case.
We can definitely estimate numbers to go in this section, as contained in the attached spreadsheet, but we traditionally haven't had to.

Commented [JoeV7]: When a proposed program doesn't require any additional funds, we usually included some generic language like "N/A – Funded through existing resources".

Appendix A: Program Curriculum

All Program Courses

PhD Beyond BS	
Course Requirements	**Credit Hours (minimum)**
Core Courses	24
Math Courses	6
Dissertation Research	21
Technical electives/other credits	21
Total Credits	72

PhD Beyond MS	
Course Requirements	**Credit Hours (minimum)**
Core Courses	12
Math Course	3
Dissertation Research	21
Technical electives/other credits	6
Total Credits	42

Existing Aerospace Core Courses

Fall Semester

MAE 5500 Aerodynamics
MAE 5560 Dynamics of Space Flight
MAE 6500 Potential Flow
MAE 6510 Aircraft Dynamics and Flight Simulation
MAE 6540 Advanced Astrodynamics
MAE 7540 Advanced Astrodynamics Techniques/Applications

Spring Semester

MAE 6340 Spacecraft Attitude Control
MAE 6560 Spacecraft Navigation
MAE 6930 Advanced Control of Aero Vehicles

Summer Semester

MAE 6530 Advanced Propulsion
MAE 6570 Optimal Space Guidance
MAE 6930 Monte Carlo and Linear Covariance Techniques
MAE 7560 Optimal Estimation/Aerospace

Aerospace Technical Electives

Fall Semester

MAE 5310 Dynamic Systems and Controls
MAE 5420 Compressible Fluid Flow
MAE 6180 Dynamics & Vibrations

MAE 6410 Fluid Dynamics
MAE 7360 Optimal and Robust Control
MAE 6320 Linear Multivariable Control
ECE 5230 Space Systems Engineering
ECE 6240 Space Environment Engineering
ECE 6650 Optics I

Spring Semester

MAE 5440 Computational Fluid Dynamics
MAE 5510 Dynamics of Atmospheric Flight
MAE 5540 Propulsion Systems
MAE 6440 Advanced Computational Fluid Dynamics
MAE 6490 Turbulence*
MAE 6550 Advanced Structural Analysis
MAE 7330 Nonlinear and Adaptive Control
MAE 7350 Intelligent Control Systems

All Semesters (Fall, Spring, and Summer)

MAE 5930, 6930, 7930 Special Topics (must be Aero focused)

Approved Mathematics Courses

a. MATH 5270: Complex Variables
b. MATH 5410: Methods of Applied Mathematics
c. MATH 5420: Partial Differential Equations
d. MATH 5460: Introduction to Theory and Application of Nonlinear Dynamics Systems
e. MATH 5760: Stochastic Processes
f. MATH 6270: Complex Variables
g. MATH 6410: Ordinary Differential Equations I
h. MATH 6420: Partial Differential Equations I
i. MATH 6440: Ordinary Differential Equations II
j. MATH 6450: Partial Differential Equations II
k. MATH 6470: Advanced Asymptotic Methods
l. MATH 6610: Numerical Analysis
m. MATH 6620: Numerical Analysis
n. MATH 6640: Optimization
o. ECE 6010: Stochastic Processes in Electronic Systems
p. ECE 6030: Mathematical Methods for Signals and Systems
q. STAT 5200 Design of Experiments
r. MAE 7560 Optimal Estimation for Aerospace Systems

New Courses to be Added in the Next Five Years

No new courses are currently planned. However, to enhance the program and continually strengthen its relevance, it is expected that new courses will be integrated over time into the program using well established practices.

Appendix B: Program Schedule

The following is a sample program of study for the Aerospace Engineering PhD beyond the BS.

PhD Aerospace Engineering (Year 1)			**Yr 1 Credits**
Fall 1	**Spring 1**	**Summer 1**	
MAE 5500	MAE 6340	MAE 6530	
MAE 5560	MAE 5540[1]		
MAE 5420[1]	MAE 5440[1]		
9 hours	9 hours	3	21

[1] Technical Elective

PhD Aerospace Engineering (Year 2)			**Yr 2 Credits**
Fall 2	**Spring 2**	**Summer 2**	
MAE 6500	MAE 6560	MAE 6570	
MAE 6540	Math 5420		
MAE 5310[1]	MAE 6440[1]		
9 hours	9 hours	3 hours	21

[1] Technical Elective

PhD Aerospace Engineering (Year 3)			**Yr 3 Credits**
Fall 3	**Spring 3**	**Summer 3**	
MAE 6410[1]	MAE 7970	MAE 7560[m]	
ECE 5230[1]			
6 hours	9 hours	3 hours	18

[1] Technical Elective [m] Math Course

PhD Aerospace Engineering (Year 4)			**Yr 4 Credits**
Fall 4	**Spring 4**	**Summer 4**	
MAE 7970	MAE 7970		
6 hours	6 hours		12

Total Credits	72

The following is a sample program of study for the Aerospace Engineering PhD beyond the MS.

PhD Aerospace Engineering (Year 1)			**Yr 1 Credits**
Fall 1	**Spring 1**	**Summer 1**	
MAE 5500	MAE 6340	MAE 6530	
MAE 5560	MAE 5540[1]		
MAE 5420[1]	MATH 5420		
9 hours	9 hours	3	21

[1] Technical Elective

PhD Aerospace Engineering (Year 2)			**Yr 2 Credits**
Fall 2	**Spring 2**	**Summer 2**	
MAE 7970	MAE 7970		
6 hours	6 hours		12

[1] Technical Elective

PhD Aerospace Engineering (Year 3)			**Yr 3 Credits**
Fall 3	**Spring 3**	**Summer 3**	
MAE 7970	MAE 7970		
6 hours	3 hours		9

Total Credits	42

Appendix C: Faculty

Professors:
Christine Hailey - PhD Mechanical Engineering, University of Oklahoma, 1985 (aerodynamics and flight mechanics)

Associate Professors:
Rees Fullmer – PhD Mechanics Engineering, University of Utah, 1985 (guidance, navigation and control)
Steven Folkman - PhD Mechanical Engineering, Utah State University, 1990 (aerospace structures)
David Geller - PhD Space Physics and Astronomy, Rice University, 1999 (guidance, navigation and control)
Steven Whitmore - PhD Aerospace Engineering, University of California, Los Angeles, 1989 (propulsion)

Assistant Professors:
Aaron Katz - PhD Aeronautics and Astronautics, Stanford University, 2009 (computational fluid dynamics)
Currently two additional faculty positions are being filled at the assistant professor level to support the needs of the Aerospace Engineering curriculum.