Mechanical and Aerospace Engineering - Graduate Programs

Objective - Aerospace Engineering

The overall objective of the graduate program in Aerospace Engineering is to develop in a student the ability to define a technical problem, establish an appropriate mathematical or experimental model based on a firm understanding of the physical nature of the problem, analyze the problem by theoretical, numerical, or experimental techniques, and evaluate the results. Although this ability is developed in the context of aerospace problems, it is applicable to the engineering of any physical system. The program is designed for a student with any of the following specific objectives:

a. A sound foundation in advanced mathematics, science, and engineering which will equip the student well for research and development work or for further advanced study toward a doctoral degree in engineering.
b. A program of advanced study which allows specialization in one of the following areas:
   - Fluid dynamics, aerodynamics and propulsion (theoretical and applied aerodynamics, gas dynamics, viscous fluid mechanics, turbulence, computational and experimental fluid dynamics, bio-fluidics, hypersonic flow theory, high-temperature gas dynamics, V/STOL and rotorcraft aerodynamics, air-breathing and rocket propulsion);
   - Structural mechanics and structures (solid mechanics, aerospace structures, structural dynamics, composite structures and material characterization, damage tolerance and durability, smart structures, structure optimization, sensor technology, high-temperature structures and materials, aeroelasticity);
   - Flight mechanics and controls (atmospheric and space flight mechanics, orbital mechanics, guidance, navigation and control);
   - Vehicle design (conceptual aircraft design, atmospheric flight vehicle design, spacecraft design, computer-aided engineering).
c. A balanced but non-specialized program of advanced study in aerodynamics, astronautics, flight dynamics, structural analysis, propulsion, and fluid mechanics, with emphasis on experimental techniques and modern mathematical analysis.

Objective - Mechanical Engineering

The graduate program provides opportunities for professional development in such forms as: instructional courses to enhance technical competence in areas of mechanical engineering practice; training through a variety of experiences in design, development, research, experimentation, and/or analysis in joint efforts with faculty and peers; specialized courses of study required for entry into career fields allied to the mechanical engineering discipline; guided individual study under faculty supervision; and supportive coursework for programs leading to careers that require interdisciplinary competence.

A student with aid from a faculty advisor plans a program that will be consistent with his or her technical interests and the available facilities and course offerings. Typically, programs are classified as:

- Thermal Science
- Fluid Science
- Mechanical Design and Manufacturing
- Solid Mechanics and Structures
- Controls and Systems

Admission Requirements for Master's Program in Aerospace Engineering

Applicants for the master's degrees must have a baccalaureate degree in engineering or science. Applicants who have completed a bachelor's degree and wish to pursue a doctoral degree without completing a master's degree may apply for admission in the Bachelor of Science (B.S.) to Ph.D. Track. The minimum admission requirements to this highly competitive track are the same as those for all doctoral applicants. All applicants must meet the general requirements of the Graduate School as stated in the section of this catalog entitled "Admission Requirements and Procedures". Applicants not meeting all criteria may be admitted on a provisional or probationary basis.

For applicants with no prior training in engineering or with insufficient undergraduate Aerospace Engineering coursework, the same minimum criteria will apply. Additionally, their records will be reviewed in relation to their mathematics, engineering, and science backgrounds, and probationary status may be a basis for acceptance of such applicants, with specific undergraduate remedial work required.

The UT Arlington Aerospace Engineering Program uses the following guidelines in the admission review process:

Unconditional Admission for Master's Program in Aerospace Engineering

Unconditional admission into the Aerospace Engineering Program requires the submission of items 1 through 4 below for each degree program. To be unconditionally admitted, an applicant must meet the minimum requirements for 1, 2 and 4.

a. An overall GPA, as calculated by the Graduate School, of 3.0 or higher in undergraduate coursework is required for admission to the M.S. program. (For some international applicants where GPA calculations based on a 4.0 system are not performed, a minimum performance level of 65 percentile.

This minimum expectation may be higher for some countries, where less stringent grading criteria are used.) Performance in core Aerospace Engineering courses is of particular importance.

b. A GRE score of at least 146 (verbal) and 155 (quantitative). For those applicants whose GRE verbal score falls below 146, high TOEFL/IELTS scores may be considered to offset the GRE verbal score.

c. A Statement of Purpose detailing the applicant's background, education, professional goals, technical interests, and research interests.

d. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Probationary Admission for Master's Program in Aerospace Engineering

Probationary admission into the Aerospace Engineering Program may be permitted under the following conditions for each degree program:

a. If the applicant meets any two of the items 1, 2, and 3 above for the master's program.

b. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Provisional Admission For Master's Program in Aerospace Engineering

An applicant who is unable to supply all required documentation prior to the admission deadline, but who otherwise appears to meet admission requirements, may be granted provisional admission.

Deferred for Master's Program in Aerospace Engineering

If an applicant does not present adequate evidence of meeting admission requirements, the admission decision may be deferred until admission records are complete or the requirements are met.

Denial of Admission for Master's Program in Aerospace Engineering

A candidate may be denied admission if he/she has less than satisfactory performance in two out of the first three admission criteria.

Waiver of the graduate record exam for master's program in Aerospace Engineering

A waiver of the Graduate Record Examination may be considered for applicants with a GPA of 3.2 or higher from U.S. universities with an ABET accredited engineering program or other select U.S. universities subject to graduate advisor's approval. The waiver of the GRE applies only to applicants for the MENGR program. Interested applicants should contact the Aerospace Engineering Graduate Advisor. GRE is not waived for MS-Thesis and PhD programs.

Criteria for Award of Fellowships and Assistantships

Applicants who demonstrate skills, experience or interests that meet the needs of the AE Graduate Program will be considered for fellowships or assistantships.

Master's Degree Requirements

ALL GRADUATE DEGREES

- All entering students must be proficient in mathematics, engineering analysis, and computer programming. *(Students not meeting these requirements may be admitted on a probationary basis and given a plan of remedial undergraduate coursework).*
- No graduate credit will be granted for courses that are required in the undergraduate Aerospace Engineering curriculum.
- All Doctoral candidates in Aerospace Engineering shall enroll in AE 5101 GRADUATE SEMINAR course a minimum of three times.

All candidates are required to select a Supervising Professor and obtain an approved program of work in the second full semester or after 12 hours are completed.

Master of Science or Master of Engineering Degrees

The Department of Mechanical and Aerospace Engineering offers both the Master of Science and the Master of Engineering degrees in Aerospace Engineering.

Core Areas in the Aerospace Engineering Program

The four core areas in the Aerospace Engineering program along with the recommended courses in each core area are listed below:

Fluid Mechanics, Aerodynamics and Propulsion

AE 5342	GAS DYNAMICS	3
AE 5350	CLASSICAL AERODYNAMICS (This course is new for fall 2021)	3

AE 5381	BOUNDARY LAYERS	3
Solid Mechanics and Structures		
AE 5310	FINITE ELEMENT METHODS	3
AE 5311	STRUCTURAL DYNAMICS	3
AE 5312	CONTINUUM MECHANICS	3
AE 5339	INTERMEDIATE MECHANICS OF MATERIALS	3
Flight Mechanics and Controls		
AE 5302	ADVANCED FLIGHT MECHANICS	3
AE 5362	GUIDANCE, NAVIGATION, AND CONTROL OF AEROSPACE VEHICLES	3
Flight Vehicle Design		
AE 5368	FLIGHT VEHICLE SYNTHESIS AND SYSTEMS ENGINEERING	3

Requirements for the Master of Science Degree in Aerospace Engineering

The Master of Science (M.S.) Degree in Aerospace Engineering is a research-oriented program in which completion of a thesis is mandatory. A minimum of 30 credit hours is required as follows:

Two Core Courses (One course each from at least two core areas)	6
Two Math/Engineering Analysis courses	6
Four elective courses related to the student's areas of interest. At least 9-credit hours of coursework should be from Aerospace Engineering program.	12
Thesis	6
Total Hours	**30**

The student might enroll in AE 5398 or AE 5197, AE 5297 or AE 5397 every semester in which the student is actively involved in thesis preparation or research, respectively, except that the student must enroll in AE 5398 or AE 5698 in the semester of graduation.

Requirements for the Masters of Engineering Degree in Aerospace Engineering

The Master of Engineering (M.Engr.) Degree in Aerospace Engineering is an engineering practice-oriented program. A minimum of 30 credit hours is required as follows:

Three Core Courses (One course each from at least three core areas)	9
Two Math/Engineering Analysis courses	6
Five elective courses relating to the student's areas of interest. At least 12-credit hours of coursework should be from Aerospace Engineering program.	15
Total Hours	**30**

For both the M.S. and the M. Engr. degrees, the balance of the required coursework hours may be chosen in consultation with the Supervising Professor to meet the student's needs and interests. Courses taken outside the Aerospace Engineering program require approval of the student's Supervising Professor as well as the Graduate Advisor. The elective courses cannot include special project courses (for example, AE 5391 / 5291 / 5191 Advanced Studies in Aerospace Engineering) or research courses (for example, AE 5397 / 5297 / 5197 Research in Aerospace Engineering).

Admission Requirements for Master's Program in Mechanical Engineering

Admission to the graduate program in ME is based on equal weighting of the following five criteria:

a. An overall GPA, as calculated by the Graduate School, of 3.0 or higher in undergraduate coursework is required for admission to the M.S. program. (For some international applicants where GPA calculations based on a 4.0 system are not performed, a minimum performance level of 65 percentile. This minimum expectation may be higher for some countries, where less stringent grading criteria are used.) Performance in core Mechanical Engineering courses is of particular importance.

b. A GRE score of at least 146 (400 in old scaling) (verbal) and 155 (700 in old scaling) (quantitative) for M.S. applicants.

c. A written essay on the student's goals and reasons for pursuing graduate studies.

d. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

e. Students who are currently enrolled in either the Master of Engineering or Master of Science in Mechanical Engineering program, may be admitted to the BS-Ph.D program in Mechanical Engineering after completing 15 hours of graduate mechanical engineering lecture coursework with a GPA of 3.6 or higher in addition to satisfying the same admission requirements as the BS-Ph.D. program.

Admission Status for Master's program in Mechanical Engineering

a. Unconditional Admission: To be unconditionally admitted, an applicant must at least meet conditions 1, 2, and 3.

b. Probationary Admission: M.S. applicants who fail to meet the conditions for unconditional admission, but satisfy any three of items 1, 2, and 3, will be considered for probationary admission.

c. Provisionary Admission: Applicants who are unable to supply all of the required documentation prior to the admission deadline, but who otherwise appear to meet the admission criteria, may be granted provisional admission.

d. Denial: Applicants who fail to meet at least two of the first four admission criteria will normally be denied admission.

e. Deferral: A deferred decision may be granted when an application file is incomplete or when a denied decision is not appropriate.

Probationary Admission for Master's Program in Mechanical Engineering

Probationary admission into the Mechanical Engineering Program may be permitted under the following conditions for each degree program:

a. If the applicant meets any two of the items 1, 2, and 3 above for the master's program.

b. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Provisional Admission for Master's Program in Mechanical Engineering

An applicant who is unable to supply all required documentation prior to the admission deadline, but who otherwise appears to meet admission requirements, may be granted provisional admission.

Waiver of the Graduate Record Exam for Master's Program in Mechanical Engineering

A waiver of the Graduate Record Examination may be considered for a UT Arlington graduate who has completed a BSME degree within the past 3 years. The student's GPA must equal or exceed 3.0 in each of two calculations: (a) in the last 60 hours of study and (b) in all undergraduate coursework completed at UT Arlington. The GRE waiver may be extended to include non-UT Arlington candidates that have undergraduate degrees in mechanical engineering (with GPA of 3.25 or above) from U.S. universities with an ABET accredited engineering program or other select U.S. universities subject to graduate advisor's approval. The waiver of the GRE applies only to applicants for the master's degree programs. Interested applicants should contact the Mechanical Engineering Graduate Advisor.

CORE COURSES

Thermal Science

ME 5316	THERMAL CONDUCTION	3
ME 5317	CONVECTION HEAT TRANSFER	3
ME 5318	RADIATIVE HEAT TRANSFER	3
ME 5321	ADVANCED CLASSICAL THERMODYNAMICS	3
Fluid Science		
ME 5313	FLUID DYNAMICS	3
ME 5342	GAS DYNAMICS	3
ME 5344	VISCOUS FLOWS	3
Design, Mechanics and Manufacturing		
ME 5310	FINITE ELEMENT METHODS	3
ME 5311	STRUCTURAL DYNAMICS	3
ME 5312	CONTINUUM MECHANICS	3
ME 5337	INTRODUCTION TO ROBOTICS	3
ME 5339	INTERMEDIATE MECHANICS OF MATERIALS	3
Controls and Systems		
ME 5303	CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS	3
ME 5305	DYNAMIC SYSTEMS MODELING	3
ME 5341	CONTROL SYSTEM COMPONENTS	3
Analysis Courses		
ME 5331	ANALYTIC METHODS IN ENGINEERING	3
ME 5332	ENGINEERING ANALYSIS	3

Approved Mathematics courses

Requirements for the Master of Science Degree in Mechanical Engineering

The Master of Science degree is a research-oriented program in which completion of a thesis is mandatory. A minimum of 30 credit hours is required as follows: three core courses (one course each in three of the four areas) and the two analysis courses listed above; three graduate courses (nine credit hours) related to a specialty in mechanical engineering (registration in elective courses outside the ME department requires prior approval of the ME graduate advisor and the students committee chair otherwise they will not count towards graduation requirements); and six credit hours of thesis. In addition, all GTA/GRA Master of Science students are required to enroll in ME 5101 course. The student must enroll in ME 5398 or ME 5397 every semester in which the student is actively involved in thesis preparation or research, except that the student must enroll in ME 5398 or ME 5698 in the semester of graduation.

Requirements for the Master of Engineering Degree in Mechanical Engineering

The Master of Engineering degree is an engineering practice-oriented program. A minimum of 30 credit hours is required as follows: three core courses (one in each area) and the two analysis courses listed above; five courses (15 credit hours) of elective graduate courses in engineering, mathematics, and/or science relating to the student's interest areas. The elective courses cannot include special project courses (for example, ME 5391 and ME 5359) or research courses (for example, ME 5397). Registration in elective courses outside the ME department requires prior approval of the ME graduate advisor; otherwise they will not count towards graduation requirements.

Admission Requirements for Ph.D. in Aerospace Engineering

Applicants for the doctoral degree must have either a baccalaureate or master's degree in engineering or science. Applicants who have completed a bachelor's degree and wish to pursue a doctoral degree without completing a master's degree may apply for admission in the Bachelor of Science (B.S.) to Ph.D. Track. The minimum admission requirements to this highly competitive track are the same as those for all doctoral applicants. Doctoral candidates shall also demonstrate through previous academic preparation the potential to carry out independent research in Aerospace Engineering. All applicants must meet the general requirements of the Graduate School as stated in the section of this catalog entitled "Admission Requirements and Procedures". Applicants not meeting all criteria may be admitted on a provisional or probationary basis.

For applicants with no prior training in engineering or with insufficient undergraduate Aerospace Engineering coursework, the same minimum criteria will apply. Additionally, their records will be reviewed in relation to their mathematics, engineering, and science backgrounds, and probationary status may be a basis for acceptance of such applicants, with specific undergraduate remedial work required.

The UT Arlington Aerospace Engineering Program uses the following guidelines in the admission review process:

Unconditional Admission for Ph.D. in Aerospace Engineering

Unconditional admission into the Aerospace Engineering Program requires the submission of items 1 through 5 below for each degree program. To be unconditionally admitted, an applicant must at least meet conditions 1, 2, 3, and 4.

a. Minimum GPA of 3.3 in the last 60 hours taken in the major field of study in an appropriate engineering or science discipline. (For some international applicants where GPA calculations based on a 4.0 system are not performed, a minimum performance level of 70 percentile is expected. This minimum expectation may be higher for some countries, where less stringent grading criteria are used.) Performance in core Aerospace Engineering courses is of particular importance.

b. A GRE scores of at least 150 on the Verbal and 159 on the Quantitative subtests. For those applicants whose GRE verbal score falls below 150, high TOEFL/IELTS scores may be considered to offset the GRE verbal score.

c. Three favorable recommendations via the university's recommendation form or via recommendation letter.

d. A Statement of Purpose detailing the applicant's background, education, professional goals, technical interests, and research interests.

e. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Probationary Admission for Ph.D. in Aerospace Engineering

Probationary admission into the Aerospace Engineering Program may be permitted under the following conditions for each degree program:

a. If an applicant meets any three of the items 1, 2, 3, and 4 above for the doctoral program.

b. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Provisional Admission for Ph.D. in Aerospace Engineering

An applicant who is unable to supply all required documentation prior to the admission deadline, but who otherwise appears to meet admission requirements, may be granted provisional admission.

Deferred for Ph.D. in Aerospace Engineering

If an applicant does not present adequate evidence of meeting admission requirements, the admission decision may be deferred until admission records are complete or the requirements are met.

Denial of Admission for Ph.D. in Aerospace Engineering

A candidate may be denied admission if he/she has less than satisfactory performance in two out of the first three admission criteria.

Criteria for Award of Fellowships and Assistantships

Applicants who demonstrate skills, experience or interests that meet the needs of the AE Graduate Program will be considered for fellowships or assistantships.

B.S. to Ph.D. Program

The B.S. to Ph.D. Program is an accelerated program in which the student bypasses the M.S. thesis and proceeds directly to the Ph.D. dissertation research. Requirements for unconditional admission to the B.S. to Ph.D. Degree Program include:

- An overall GPA, as calculated by the Graduate School, of 3.3 or higher in undergraduate coursework.
- Relevance of the student's previous degrees to the AE curriculum.
- Reputation of the universities or colleges the student has attended.
- A GRE scores of at least 153 on the Verbal and 159 on the Quantitative subtests.
- Three satisfactory written recommendation forms from prior professors or supervisors.
- A written essay on the student's goals and reasons for pursuing graduate studies.

Doctoral Degree Requirements

ALL GRADUATE DEGREES

- All entering students must be proficient in mathematics, engineering analysis, and computer programming. *(Students not meeting these requirements may be admitted on a probationary basis and given a plan of remedial undergraduate coursework).*
- No graduate credit will be granted for courses that are required in the undergraduate Aerospace Engineering curriculum.
- All Doctoral candidates in Aerospace Engineering shall enroll in AE 5101 GRADUATE SEMINAR course a minimum of three times.

All candidates are required to select a Supervising Professor and obtain an approved program of work in the second full semester or after 12 hours are completed.

Degree Requirements for Ph.D. in Aerospace Engineering

Doctor of Philosophy

- The Ph.D. degree requires a minimum of 24 hours of graduate-level course work beyond the Master's degree, and will include a scholarly dissertation that provides a significant original contribution to Aerospace Engineering.
- The Ph.D. degree course requirement can be tailored to satisfy the individual student's aspirations in choice of the area of specialization. However, to meet the educational goals of a broad-based technical background in Aerospace Engineering, it is expected that each student will take sufficient course work to obtain in-depth knowledge in at least two core areas of Aerospace Engineering.
- Students whose background is in a field other than Aerospace Engineering must satisfy the Master's degree core requirements.
- There is no foreign language requirement for the Ph.D.
- **Qualifying Exam:** All students entering the Ph.D. program are required to take the Ph.D. Qualifying Exam. Students admitted into AE Ph.D. program with MS degree in Aerospace Engineering or equivalent must take the Qualifying Exam at the end of the 1st semester. This exam is offered twice per year, during the week preceding the start of classes for the fall and spring semesters. Possible outcomes of this evaluation are:
  i. continuation in the doctoral program,
  ii. approval to continue with certain specified remedial work,
  iii. failure with approval to retake,
  iv. termination in the program.
- **Comprehensive Exam:** Students are eligible to take the comprehensive examination after satisfying all requirements stipulated by the Qualifying Exam Committee and giving evidence to their doctoral committee of adequate academic achievement by having completed all or most coursework requirements. The comprehensive examination is used to determine if the student has the necessary background and specialization required for the dissertation research and if the student can organize and conduct the research. *An applicant must pass this examination to be admitted to candidacy for the Ph.D. degree.*

B.S. to Ph.D. Track

- The Ph.D. degree requires a minimum of 42 credit hours of graduate-level course work beyond the bachelor's degree, and will include a scholarly dissertation that provides a significant original contribution to Aerospace Engineering
- A B.S.-Ph.D. Track student will be *required to enroll in at least three hours of research each semester during the student's first two years, receiving a pass/fail grade (no R grade) in these hours.*
- A student may be exempted from enrolling in research hours in the student's initial semester.
- A B.S.-Ph.D. Track student must have a faculty research (dissertation) advisor prior to the start of the student's second full semester.
- Students in the BS-Ph.D. program must take the Ph.D Qualifying Exam within the first year from the start of their Ph.D.

Admission Requirements for Ph.D. in Mechanical Engineering

Admission Status

a. Unconditional Admission: To be unconditionally admitted, an applicant must at least meet conditions 1, 2, 3, and 4.
b. Probationary Admission: Ph.D. applicants who fail to meet the conditions for unconditional admission, but satisfy any three of items 1, 2, 3 and 4, will be considered for probationary admission.
c. Provisional Admission: Applicants who are unable to supply all of the required documentation prior to the admission deadline, but who otherwise appear to meet the admission criteria, may be granted provisional admission.
d. Denial: Applicants who fail to meet at least two of the first four admission criteria will normally be denied admission.
e. Deferral: A deferred decision may be granted when an application file is incomplete or when a denied decision is not appropriate.

Admission Requirements for B.S. to Ph.D. Track

a. An overall GPA, as calculated by the Graduate School, of 3.3 or higher in undergraduate coursework.
b. A GRE scores of at least 150 on the Verbal and 159 on the Quantitative subtests.
c. Three satisfactory written recommendation forms from prior professors or supervisors.
d. A written essay on the student's goals and reasons for pursuing graduate studies.
e. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Probationary Admission

Probationary admission into the Mechanical Engineering Program may be permitted under the following conditions for each degree program:

Doctoral Program and BS to PhD track

a. If an applicant meets any three of the items 1, 2, 3, and 4 above for the doctoral program or BS to PhD track.
b. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Provisional Admission

An applicant who is unable to supply all required documentation prior to the admission deadline, but who otherwise appears to meet admission requirements, may be granted provisional admission.

Deferred Admission

If an applicant does not present adequate evidence of meeting admission requirements, the admission decision may be deferred until admission records are complete or the requirements are met.

Denial of Admission

A candidate may be denied admission if he/she has less than satisfactory performance in two out of the first three admission criteria.

Admission Requirements for B.S. to Ph.D. Track

The B.S. to Ph.D. program is an accelerated program in which a student proceeds directly to the Ph.D. dissertation research and bypasses the M.S. thesis. Requirements for unconditional admission to this program include the following:

a. Minimum GPA of 3.3 in the last 60 hours taken in the major field of study in an appropriate engineering or science discipline. (For some international applicants where GPA calculations based on a 4.0 system is not performed, a minimum performance level of 70 percentile is expected. This minimum expectation may be higher for some countries, where less stringent grading criteria are used.) Performance in core mechanical engineering courses is of particular importance.

b. A GRE scores of at least 150 on the Verbal and 159 on the Quantitative subtests.

c. Three favorable, veracious recommendations, via the university's recommendation form or via recommendation letter.

d. A Statement of Purpose detailing the applicant's background, education, professional goals, technical interests, and research interests.

e. For applicants whose native language is not English: All students admitted in the program must meet the minimum university English language requirements as detailed in the general admission requirements section of the catalog. However, meeting the minimum requirement does not guarantee admission. The program will give preference to students with IELTS score of 6.5, or TOEFL-iBT total score of 84.

Waiver of the Graduate Record Exam

There is no GRE waiver for Ph.D. applicants.

Criteria for Award of Fellowships and Assistantships

Applicants who demonstrate skills, experience or interests that meet the needs of the ME Graduate Program will be considered for fellowships or assistantships.

Degree Requirements for Ph.D. in Mechanical Engineering

Doctor of Philosophy

There is no foreign language requirement for the Ph.D. degree.

B.S.-Ph.D. Track Students

To meet the educational goal of a broad-based technical background in Mechanical Engineering, it is expected that each student will take sufficient graduate coursework to obtain in-depth knowledge in at least two areas of Mechanical Engineering. Students whose background is in a field other than Mechanical Engineering must satisfy the BS core requirements. Note that registration in elective courses outside the ME department requires prior approval of the ME graduate advisor and student's committee chair. Otherwise they will not count towards the graduation requirements. The doctoral degree program consists of a minimum of 42 credit hours of coursework beyond the bachelor's degree level plus 9 hours of dissertation and 2 hours of seminar and requires the successful completion of the following requirements:

ME 5331	ANALYTIC METHODS IN ENGINEERING	3
ME 5332	ENGINEERING ANALYSIS	3

Or other approved mathematics courses

a. Three core courses (9 credit hours) from at least two different areas, as listed below:

Thermal Science

ME 5316	THERMAL CONDUCTION	3
ME 5317	CONVECTION HEAT TRANSFER	3
ME 5318	RADIATIVE HEAT TRANSFER	3
ME 5321	ADVANCED CLASSICAL THERMODYNAMICS	3

Fluid Science

ME 5313	FLUID DYNAMICS	3
ME 5342	GAS DYNAMICS	3
ME 5344	VISCOUS FLOWS	3

Design, Mechanics and Manufacturing

ME 5310	FINITE ELEMENT METHODS	3
ME 5311	STRUCTURAL DYNAMICS	3
ME 5312	CONTINUUM MECHANICS	3
ME 5337	INTRODUCTION TO ROBOTICS	3
ME 5339	INTERMEDIATE MECHANICS OF MATERIALS	3

Controls and Systems

ME 5303	CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS	3
ME 5305	DYNAMIC SYSTEMS MODELING	3
ME 5341	CONTROL SYSTEM COMPONENTS	3

b. One additional course (3 credit hours) at the graduate level in one of the broad areas of Mechanical Engineering outside the student's major area of specialization. A core course is also acceptable for meeting this requirement.

c. Eight additional courses (24 credit hours) in the student's major area of research

d. Two courses (6 credit hours) of engineering analysis:

e. Two credit hours of seminar

f. Nine credit hours for Dissertation

ME 6299	DISSERTATION	2
ME 6399	DISSERTATION	3
ME 6699	DISSERTATION	6
ME 6999	DISSERTATION	9

   i. Doctoral students must register for a minimum total of 9 hours of dissertation research over the course of their programs of work. These hours may be accumulated over several terms or completed in a single term. The course hours of ME 6299, ME 6399, ME 6699, ME 6699, and/or ME 7399 are all counted towards this nine-hour requirement.

   ii. Doctoral students must be enrolled in 9 hours while completing organized coursework and 6 hours while exclusively enrolled in dissertation research in order to be considered full time except in the term they designate as their "completion term." The completion term is typically the term in which a student successfully defends his or her dissertation, fully completes all degree requirements and graduates. Students may designate only one term as the completion term.

   iii. Doctoral students must enroll in a minimum of 3 dissertation hours (ME 7399) in the term designated as their completion term. Alternatively, students may complete and defend their dissertation while enrolled in 6 or 9-hour dissertation courses:

   iv. Doctoral students who do not graduate at the end of their completion term will receive a grade of R, W, or F and must enroll in a minimum of 6 hours of dissertation research (ME 6299, ME 6399, ME 6699 or ME 6999) every term until graduation.

   v. Students enrolled in the completion term meet enrollment requirements for holding fellowships awarded by the Office of Graduate Studies and GTA or GRA positions by enrolling in the required 3-hour completion term dissertation course.

   vi. Students who wish to remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours each term as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Students should consult with the Office of Financial Aid and other funding agencies to be certain they enroll in sufficient hours to retain support.

Final course requirements are determined by the student's supervising committee.

M.S.-Ph.D. Track Mechanical Students

To meet the educational goal of a broad-based technical background in Mechanical Engineering, it is expected that each student will take sufficient graduate coursework to obtain in-depth knowledge in at least two areas of Mechanical Engineering. Students whose background is in a field other than Mechanical Engineering must satisfy the Masters of Science core requirements. Note that registration in elective courses outside the ME department requires prior approval of the ME graduate advisor and student's committee chair. Otherwise they will not count towards the graduation requirements. The doctoral degree program consists of a minimum of 24 credit hours of coursework beyond the Master's degree level plus 9 hours of dissertation and 2 hours of seminar and requires the successful completion of the following requirements:

ME 5331	ANALYTIC METHODS IN ENGINEERING	3
ME 5332	ENGINEERING ANALYSIS	3

Or other approved mathematics courses

a. Three core courses (9 credit hours) from at least two different areas, as listed below:

Thermal Science

ME 5316	THERMAL CONDUCTION	3
ME 5317	CONVECTION HEAT TRANSFER	3
ME 5318	RADIATIVE HEAT TRANSFER	3
ME 5321	ADVANCED CLASSICAL THERMODYNAMICS	3

Fluid Science

ME 5313	FLUID DYNAMICS	3
ME 5342	GAS DYNAMICS	3
ME 5344	VISCOUS FLOWS	3

Design, Mechanics and Manufacturing

ME 5310	FINITE ELEMENT METHODS	3
ME 5311	STRUCTURAL DYNAMICS	3
ME 5312	CONTINUUM MECHANICS	3

| ME 5337 | INTRODUCTION TO ROBOTICS | 3 |
| ME 5339 | INTERMEDIATE MECHANICS OF MATERIALS | 3 |

Controls and Systems

ME 5303	CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS	3
ME 5305	DYNAMIC SYSTEMS MODELING	3
ME 5341	CONTROL SYSTEM COMPONENTS	3

b. One additional course (3 credit hours) at the graduate level in one of the broad areas of Mechanical Engineering outside the student's major area of specialization. A core course is also acceptable for meeting this requirement.

c. Three additional courses (9 credit hours) in the student's major area of research

d. One course (3 credit hours) of engineering analysis:

e. Two credit hours of seminar

f. Nine credit hours (ME 6999) for Dissertation.

ME 6299	DISSERTATION	2
ME 6399	DISSERTATION	3
ME 6699	DISSERTATION	6
ME 6999	DISSERTATION	9

   i. Doctoral students must register for a minimum total of 9 hours of dissertation research over the course of their programs of work. These hours may be accumulated over several terms or completed in a single term. The course hours of ME 6299, ME 6399, ME 6699, ME 6699, and/or ME 7399 are all counted towards this nine-hour requirement.

   ii. Doctoral students must be enrolled in 9 hours while completing organized coursework and 6 hours while exclusively enrolled in dissertation research in order to be considered full time except in the term they designate as their "completion term." The completion term is typically the term in which a student successfully defends his or her dissertation, fully completes all degree requirements and graduates. Students may designate only one term as the completion term.

   iii. Doctoral students must enroll in a minimum of 3 dissertation hours (ME 7399) in the term designated as their completion term. Alternatively, students may complete and defend their dissertation while enrolled in 6 or 9-hour dissertation courses:

   iv. Doctoral students who do not graduate at the end of their completion term will receive a grade of R, W, or F and must enroll in a minimum of 6 hours of dissertation research (ME 6299, ME 6399, ME 6699 or ME 6999) every term until graduation.

   v. Students enrolled in the completion term meet enrollment requirements for holding fellowships awarded by the Office of Graduate Studies and GTA or GRA positions by enrolling in the required 3-hour completion term dissertation course.

   vi. Students who wish to remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours each term as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Students should consult with the Office of Financial Aid and other funding agencies to be certain they enroll in sufficient hours to retain support

Final course requirements are determined by the student's supervising committee. In addition, a student must pass three examinations before being awarded the Ph.D. degree: the Qualifying Exam, the Comprehensive Exam, and the Final Exam (or Dissertation Examination).

A Qualifying Examination will be administered to the student prior to the start of the student's second long semester. The Qualifying Exam is a written test of the student's capability to pursue successfully the doctorate degree, and it aids in developing the program of study for the student. The Qualifying Examination tests fundamental knowledge in two technical areas of mechanical engineering. The student and the student's research advisor jointly choose the technical areas from the following five:

a. thermal science,

b. fluid science,

c. mechanical design and manufacturing,

d. solid mechanics and structures, and

e. controls and systems.

The exam topics for the technical areas are given in the ME Ph.D. Qualifying Exam handout. The Qualifying examination is normally offered twice a year the week prior to the beginning of the Fall and/or Spring semesters. A student should inform the ME graduate advisor in advance and no later than the middle of the long semester prior to the planned time of taking the exam and consult with the ME graduate advisor for the time and place of the Qualifying examination.

A comprehensive examination will be administered to the student after the successful completion of all phases of the Qualifying examination and before the student's research work for the dissertation. The comprehensive examination is used to determine if the student has the necessary background and

specialization required for the dissertation research and if the student can organize and conduct the research. An applicant must pass this examination to be admitted to candidacy for the Ph.D. degree.

The student must enroll in at least three hours of dissertation courses (ME 6399 - ME 6999) or research courses (ME 6397 - ME 6999) every semester in which the student is actively involved in dissertation preparation or research, except that the student must enroll in ME 6999 in the semester of graduation.

The student must submit the Application for Candidacy and Final Program of Work to the Mechanical Engineering Committee on Graduate Studies immediately after completion of the Comprehensive Examination. Coursework taken for the Master's degree at this institution may be used to meet these requirements; however, courses listed for the Master's degree or any other degree cannot be listed as the actual course requirement on the Final Program of Work. Transfer work is not accepted in doctoral programs; however, such courses may provide a basis for waiving some course requirements.

The student must file the Request for Dissertation Defense form with the Graduate School at least two weeks prior to the defense. At the same time of requesting the exam, the student must also announce the exam to the members of the university community by posting fliers on the departmental bulletin boards and by providing an electronic statement to the ME graduate advisor to be posted on the departmental web page indicating details (title, abstract, advisor, time and place) of the exam. Approval of the dissertation by the members of the Dissertation Committee is required.

Please see the section entitled General Graduate School Regulations and Information in this Catalog for further details.

The grade of R (research in progress) is a permanent grade; completing course requirements in a later semester cannot change it. To receive credit for an R-graded course, the student must continue to enroll in the course until a passing grade is received.

An incomplete grade (the grade of I) cannot be given in a course that is graded R, nor can the grade of R be given in a course that is graded I. To receive credit for a course in which the student earned an I, the student must complete the course requirements. Enrolling again in the course in which an I was earned cannot change a grade of I. At the discretion of the instructor, a final grade can be assigned through a change of grade form.

Three-hour thesis courses and three- and six-hour dissertation courses are graded R/F/W only. The grade of P (required for degree completion for students enrolled in thesis or dissertation programs) can be earned only in six-hour thesis or nine-hour dissertation courses. In the course listings below, R-graded courses are designated either "Graded P/F/R" or "Graded R." Occasionally, the valid grades for a course change. Students should consult the appropriate Graduate Advisor or instructor for valid grade information for particular courses. (See also the sections titled "R" Grade, Credit for Research, Internship, Thesis or Dissertation Courses and Incomplete Grade in this catalog.)

B.S. to Ph.D. Track

In addition to the requirements listed below for the Ph.D. degree, a B.S.-Ph.D. Track student will be required to enroll in at least three hours of research each semester during the student's first two years, receiving a pass/fail grade (no R grade) in these hours. A B.S.-Ph.D. student must have a faculty research (dissertation) advisor prior to the start of the student's second full semester. A B.S.-Ph.D. student must take the Ph.D. Qualifying examination prior to the start of the student's third long semester.

Fast Track Program for Master's Degree in Aerospace Engineering

The Fast Track Program enables outstanding UT Arlington senior undergraduate students in Aerospace Engineering to satisfy degree requirements leading to a master's degree in Aerospace Engineering while completing their undergraduate studies.

For additional information, see Undergraduate Catalog. (https://catalog.uta.edu/engineering/mechanical/undergraduate/#fasttracktext)

Fast Track Program for Master's Degree in Mechanical Engineering

The Fast Track Program enables outstanding UT Arlington senior undergraduate students in Mechanical Engineering to satisfy degree requirements leading to a master's degree in Mechanical Engineering while completing their undergraduate studies.

For additional information, see Undergraduate Catalog. (https://catalog.uta.edu/engineering/mechanical/undergraduate/#fasttracktext)

Graduate Certificate in Automotive Engineering

Program Objective

The University of Texas at Arlington is pleased to offer a Graduate Certificate in Automotive Engineering through the Arnold E. Petsche Center for Automotive Engineering. This certificate confirms the student's commitment to automotive engineering and the learning experience gained from being a contributing team member of a student design competition. Students shall be awarded the Graduate Certificate for Automotive Engineering by the College of Engineering and the Graduate School upon satisfactory completion of the certificate requirements with an overall grade point average of 3.0.

Admission Requirements

Students wishing to enroll only in the Graduate Certificate in Automotive Engineering but NOT a graduate degree program may apply for admission to UT Arlington as a non-degree seeking student. The GRE is not necessary. Admission to the certificate program allows participants to take the specific courses approved for the certificate program. Student are not allowed to take courses in excess of those required for the certificate. A Bachelor's degree

in engineering with a GPA of 2.8 is required for admission through the Graduate School. Students with GPAs lower than 2.8 may be recommended for admission as special student by the Director of the Arnold E. Petsche Center for Automotive Engineering, based on the following admission enhancing factors:

a. the applicant's work experience and level of responsibility;

b. two letters of recommendation.

Students already enrolled in a Master's degree program at TU Arlington may enroll by submitting the appropriate application form to the certificate program director and his or her academic graduate advisor. Students who have completed a Master's degree may apply for admission to UT Arlington as a non-degree seeking student. In either case, a minimum GPA of 3.0 in Master's degree work is required.

Academic Requirements

Participants must satisfactorily complete 12 hours of required courses according to the following criteria:

9 hours from the following list:		9
ME 5340	AUTOMOTIVE ENGINEERING	
ME 5358	RACECAR ENGINEERING	
ME 5359	APPLIED AUTOMOTIVE ENGINEERING [1]	
No more than 3 hours from the following list: [2]		3
ME 5341	CONTROL SYSTEM COMPONENTS	
EE 5313	MICROPROCESSOR SYSTEMS	
Total Hours		**12**

[1] May be taken twice for credit toward the certificate.

[2]   Or other graduate level engineering course approved by the Director of the Arnold E. Petsche Center for Automotive Engineering.

Students can take ME 5010 (no credit hours) to be recognized as full team members on a competition team such as Formula SAE.

Graduate Certificate in Electronic Packaging

Program Objective and Requirements

The Certificate in Electronic Packaging program provides graduate-level knowledge in the field of electronic packaging, with a concentration on numerical and experimental characterization of thermo/mechanical issues. Courses are taught by faculty of the departments of Mechanical and Aerospace Engineering and Materials Science and Engineering, plus other UT Arlington faculty and adjunct faculty as needed. Technical material covered in the classroom will be complemented by a number of seminars by industry leaders in the packaging field. Completion of the certificate program will provide a head start for UT Arlington students when joining industry and skills-enhancement opportunities for current industry employees.

There are two enrollment options: as a student pursuing a graduate degree or as a non-degree-seeking special student. The special student avenue is tailored for individuals currently employed in an electronics-related industry. Students will receive the certificate after completing 12 credit hours of packaging courses, as advised by the certificate program director, and must have a cumulative GPA of 3.0 in the four selected courses. The time limit for completion of the Certificate in Electronic Packaging program is six years.

Applicants on a degree track must be admitted to the Master's degree program. Non-degree students must have a BS degree and a minimum GPA of 2.5. Special students who decide that they want to pursue a graduate degree after starting as a special student may transfer up to 12 credit hours of graduate level courses.

ME 5317	CONVECTION HEAT TRANSFER	3
ME 5352	FUNDAMENTALS IN ELECTRONIC PACKAGING	3
ME 5353	COMPUTATIONAL TECHNIQUES FOR ELECTRONIC PACKAGING	3
ME 5390	SPECIAL TOPICS IN MECHANICAL ENGINEERING	3
EE 5343	SILICON INTEGRATED CIRCUIT FABRICATION TECHNOLOGY	3
EE 5344	INTRODUCTION TO MICROELECTROMECHANICAL SYSTEMS (MEMS) AND DEVICES	3
ME 6314	FRACTURE MECHANICS	3

Graduate Certificate in Manufacturing

Program Objective

The Graduate Certificate in Manufacturing provides students with advanced manufacturing knowledge and skills required for professional careers in manufacturing engineering while meeting the requirements for a master's degree in mechanical engineering. The program is accomplished by augmenting core engineering classes with classes and research in specific disciplines relevant to manufacturing. The certificate program recognizes the

broad base of engineering sciences that supports manufacturing processes as well as specialized concepts, theories, and enabling technologies used in modern manufacturing operations.   Students completing this program will gain knowledge in key disciplines required in manufacturing engineering ranging from the unit process level up to the operational systems level.

Admission Requirements

(1) A Bachelor's degree in an engineering discipline with a minimum GPA of 3.0 or a current enrollment in an engineering Master's program at UTA with a minimum GPA of 3.0.

If enrolled in a UTA graduate degree program, complete requirement (2):

(2) Application to the certificate administrator

If not enrolled in a UTA graduate degree program, complete requirements (3)-(5):

(3) Those who desire to complete the certificate program without enrolling must be admitted to UTA as a non-degree seeking student.

(4) An essay detailing the applicant's background and skills as pertaining to manufacturing, his/her interest in a specific domain, and his/her expected benefit from completing this program.

(5) Two recommendation letters explaining how the applicant will contribute to the certificate program and how he/she will benefit by completing the program.

Academic Requirements

To earn the Graduate Certificate in Manufacturing, students must complete 12 hours with grades of B or better from the list below.

Required:		6
ME 5326	MANUFACTURING PROCESSES AND SYSTEMS	
ME 5327	DESIGN FOR MANUFACTURING	
At least 3 hours from the following:		6
ME 5329	ADDITIVE MANUFACTURING	
ME 5337	INTRODUCTION TO ROBOTICS	
ME 5339	INTERMEDIATE MECHANICS OF MATERIALS	
ME 5341	CONTROL SYSTEM COMPONENTS	
ME 6316	COMPUTER AIDED DESIGN	
ME 6337	ADVANCED ROBOTICS	
ME 5390	SPECIAL TOPICS IN MECHANICAL ENGINEERING	
With approval of the certificate director. Examples of acceptable topics are Robotics for Manufacturing, Micro/nano-scale manufacturing, Composite Structures: Manufacturing & Repair, Computer-aided Design and Manufacturing.		
No more than 3 hours from the following:		
IE 5301	INTRODUCTION TO OPERATIONS RESEARCH	
IE 5302	INTRODUCTION TO INDUSTRIAL ENGINEERING	
IE 5303	QUALITY SYSTEMS	
IE 5310	PRODUCTION SYSTEMS DESIGN	
IE 5317	INTRODUCTION TO PROBABILITY AND STATISTICS	
IE 5319	ADVANCED STATISTICAL PROCESS CONTROL AND TIME SERIES ANALYSIS	
IE 5329	PRODUCTION AND INVENTORY CONTROL SYSTEMS	
IE 5330	AUTOMATION AND ADVANCED MANUFACTURING	
IE 5342	METRICS AND MEASUREMENT	
Total Hours		**12**

Graduate Certificate in Unmanned Vehicle Systems

Program Objective

The Certificate in UVS (Unmanned Vehicle Systems) is offered through the Mechanical and Aerospace Engineering Department and will educate graduate students and train practicing engineers in selected areas required for the design, development and operation of UVS including UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground Systems) and UMS (Unmanned Maritime Systems). The certificate program will emphasize the common aspects of UVS including sensors, actuators, communications and more importantly decision-making capabilities (autonomy), while also covering development of domain-specific mobile platforms such as airplane, rotorcraft, Ackerman steering car and boat. A student after completing this program will be familiar with the UVS-related concepts, theories and enabling technologies, and their interrelations while at the same time gaining a

focused experience in specific areas of his/her choice. This program will also give students the opportunity to gain practical experience contributing to a larger system by working in a multidisciplinary environment. This program aims at the dual goal of providing the UVS industry with a knowledgeable, locally available workforce and developing career opportunities for its participants.

Admission Requirements

a. A Bachelor's degree in an engineering discipline with a minimum GPA of 3.0 or a current enrollment in an engineering graduate program at UTA with a minimum GPA of 3.0.

b. An essay detailing the applicant's background and skills as pertaining to UVS, his/her interest in a specific domain and his/her expected benefit from completing this program.

c. Two recommendation letters explaining how the applicant will contribute to the certificate program and how he/she will benefit by completing the program.

Those who desire to complete the certificate program without enrolling in graduate degree program must be admitted to UTA as a non-degree seeking student.

Academic Requirements

Students must complete 15 hours of coursework with a 3.0 grade point average or better. A grade of C or better is required in all courses counted towards the completion of the certificate.

The recommended progression in the program is (1) start with AE 5378 or ME 5378, which will raise awareness with UVS-related subjects in the following coursework, (2) take 9 credit hours of coursework and any prerequisite if applicable for the elective course selected, and (3) complete the certificate program with AE 5379 or ME 5379. Prerequisite to the elective courses will not be counted towards the 15 hour requirement.

3 credit hours from the following list:		**3**
AE 5378	INTRODUCTION TO UNMANNED VEHICLE SYSTEMS [1]	
ME 5378	INTRODUCTION TO UNMANNED VEHICLE SYSTEMS [2]	
3 credit hours from the following list:		**3**
AE 5379	UNMANNED VEHICLE SYSTEM DEVELOPMENT	
ME 5379	UNMANNED VEHICLE SYSTEM DEVELOPMENT	
9 credit hours from the following lists: [3]		**9**
At least 6 credit hours from the following AE and ME lists:		
AE (Aerospace Engineering) Courses:		
AE 5301	ADVANCED TOPICS IN AEROSPACE ENGINEERING	
AE 5302	ADVANCED FLIGHT MECHANICS	
AE 5303	CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS	
AE 5336	OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS	
AE 5337	INTRODUCTION TO ROBOTICS	
AE 5341	CONTROL SYSTEM COMPONENTS	
AE 5362	GUIDANCE, NAVIGATION, AND CONTROL OF AEROSPACE VEHICLES	
AE 5368	FLIGHT VEHICLE SYNTHESIS AND SYSTEMS ENGINEERING	
AE 5374	NONLINEAR SYSTEMS ANALYSIS AND CONTROLS	
AE 5380	DESIGN OF DIGITAL CONTROL SYSTEMS	
ME (Mechanical Engineering) Courses:		
ME 5303	CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS	
ME 5305	DYNAMIC SYSTEMS MODELING	
ME 5335	OPTIMAL CONTROL OF DYNAMIC SYSTEMS	
ME 5336	OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS	
ME 5337	INTRODUCTION TO ROBOTICS	
ME 5341	CONTROL SYSTEM COMPONENTS	
ME 5374	NONLINEAR SYSTEMS ANALYSIS AND CONTROLS	
ME 5380	DESIGN OF DIGITAL CONTROL SYSTEMS	
ME 5390	SPECIAL TOPICS IN MECHANICAL ENGINEERING	
No more than 3 credit hours from the following EE, CSE, IE, ENGR lists:		
EE (Electrical Engineering) Courses:		
EE 5322	INTELLIGENT CONTROL SYSTEMS	
EE 5313	MICROPROCESSOR SYSTEMS	

EE 5314	EMBEDDED MICROCONTROLLER SYSTEMS	
CSE (Computer Science and Engineering) Courses:		
CSE 5326	REAL-TIME SOFTWARE DESIGN	
CSE 5360	ARTIFICIAL INTELLIGENCE I	
CSE 5361	ARTIFICIAL INTELLIGENCE II	
CSE 5364	ROBOTICS	
IE (Industrial Engineering) Courses:		
IE 5330	AUTOMATION AND ADVANCED MANUFACTURING	
IE 5339	PRODUCT DESIGN, DEVELOPMENT, PRODUCIBILITY, AND RELIABILITY DESIGN	
IE 5351	INTRODUCTION TO SYSTEMS ENGINEERING	
ENGR (Engineering) Courses:		
ENGR 4302	ENGINEERING ENTREPRENEURSHIP	
Total Hours		**15**

1   New Course.
2   New Course.
3   Advanced and special topics courses must be approved by the certificate advisor.

Graduate Certificate in Vertical Lift/Rotorcraft

Program Objective

The Certificate in Vertical Lift/Rotorcraft is offered by the Mechanical and Aerospace Engineering Department to provide formal recognition to students who acquire knowledge and understanding required for the analysis, design, development, and operations of vertical lift air vehicles via 15 credit hours of focused, specialized coursework selected from a curriculum that emphasizes core aspects of vertical lift such as rotor aerodynamics, rotor dynamics, flying qualities, simulation and control law development, structures, structural dynamics, materials (i.e. composites), transmission and drive systems design, and most importantly the conceptual and preliminary design and synthesis of advanced concepts. The Certificate in Vertical Lift/Rotorcraft prepares students for careers in the rotorcraft industry.

Admission Requirements

a. A Bachelor's degree in an engineering discipline with a minimum GPA of 3.0, or current enrollment in an engineering graduate program at UTA with a minimum GPA of 3.0
b. Two recommendation letters describing the applicant's abilities as relevant and applicable to the Vertical Lift/Rotorcraft program of study

Those who desire to complete the certificate program without enrolling in graduate degree program must be admitted to UTA as a non-degree seeking student.

Academic Requirements

Students must complete 15 hours of coursework selected from the certificate program's courses listed below, with a grade of C or higher in each course, and a minimum 3.0 grade point average. All courses must be taken and completed within a time window of 6 consecutive years. With advisor approval, students may transfer up to nine hours toward a Master's Program. An overall 3.0 GPA is required to earn the Certificate.

3 Hours Required (entry point course):		**3**
AE 5363	INTRODUCTION TO ROTORCRAFT ANALYSIS	
ME 5363	INTRODUCTION TO ROTORCRAFT ANALYSIS	
12 hours from the following list:		**12**
AE 5322	AEROELASTICITY	
AE 5364	INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT	
ME 5364	INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT	
AE 5365	INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION	
ME 5365	INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION	
AE 5301	ADVANCED TOPICS IN AEROSPACE ENGINEERING	
With approval of the certificate director. Examples of acceptable topics are Rotor Aeromechanics, Performance/ S&C/ HQ of V/STOL Air Vehicles, Mechanical Systems of V/STOL Air Vehicles.		
ME 5390	SPECIAL TOPICS IN MECHANICAL ENGINEERING	

With approval of the certificate director. Examples of acceptable topics are Rotor Aeromechanics, Performance/ S&C/ HQ of V/STOL Air Vehicles, Mechanical Systems of V/STOL Air Vehicles.

Total Hours	**15**

COURSES

AE 5100. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 1 Hour.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5101. GRADUATE SEMINAR. 1 Hour.
The purpose is to acquaint graduate students with ongoing research at UTA, and outside in academia and industry. Seminars are given by graduate students of the department based on their ongoing research. Seminars are also given by external speakers from academia, industry and government.

AE 5191. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 1 Hour.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5197. RESEARCH IN AEROSPACE ENGINEERING. 1 Hour.
Research in masters programs.

AE 5200. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 2 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5291. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 2 Hours.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5297. RESEARCH IN AEROSPACE ENGINEERING. 2 Hours.
Research in masters programs.

AE 5300. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 3 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the student has to earn at least a B grade in aggregate based on all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5301. ADVANCED TOPICS IN AEROSPACE ENGINEERING. 3 Hours.
To provide formal instruction in special topics pertinent to Aerospace Engineering from semester to semester depending on the availability of faculty. May be repeated for credit as provided topics change.

AE 5302. ADVANCED FLIGHT MECHANICS. 3 Hours.
Rigid body motion. Kinematics and dynamics of aerospace vehicles. Linear and nonlinear control of aircraft and spacecraft. Advanced aircraft and spacecraft modeling and control issues. Prerequisite: MAE 3405 and MAE 4310.

AE 5303. CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS. 3 Hours.
Equip the student with familiarity of significant tools of the control engineer. Topics covered include controllers and their effect on system performance and stability, block diagram algebra, stability and analysis, system performance definition, root locus, frequency techniques, and state variable methods. Digital simulation tools for design and simulation of control systems. Demonstration of controller design and performance in the laboratory. Also offered as ME 5303.

AE 5305. DYNAMIC SYSTEMS MODELING. 3 Hours.
To equip the student with the capability of determining the necessary equations for distributed and lumped parameter modeling of mixed physical system types including mechanical, fluid, electrical, and thermal components. Models are formulated for computer simulation and analysis for systems with deterministic and stochastic inputs. Topics of random vibration and system identification are included. Offered as AE 5305 and ME 5305. Credit will be granted only once.

AE 5310. FINITE ELEMENT METHODS. 3 Hours.
Finite element method in the study of the static response of complex structures and of continua applications to field problems; analytical methods emphasized and digital computer application undertaken. Offered as AE 5310 and ME 5310. Credit will be granted only once.

AE 5311. STRUCTURAL DYNAMICS. 3 Hours.
Natural frequencies; forced response of complex structural systems studied through the use of the finite element method; computational aspects of these problems discussed, and digital computer applications undertaken. Offered as AE 5311 and ME 5311. Credit will be granted only once.

AE 5312. CONTINUUM MECHANICS. 3 Hours.
Study of the underlying physical and mathematical principles relating to the behavior of continuous media; interrelationships between fluid and solid mechanics. Offered as AE 5312 and ME 5312. Credit will be granted only once.

AE 5313. FLUID DYNAMICS. 3 Hours.
Basic conservation laws, flow kinematics, special forms of the governing equations, two-dimensional potential flows, surface waves and some exact solutions of viscous incompressible flows. Offered as AE 5313 and ME 5313. Credit will be granted only once.

AE 5315. FUNDAMENTALS OF COMPOSITES. 3 Hours.
This fundamental course will introduce students to mechanics of composites at various scales, including analysis, characterization, and manufacturing methods. Emphasis is on constitutive relations; mechanical and hygrothermal behavior; stress analysis; and simple applications. Offered as AE 5315 and ME 5315. Credit will be granted only once.

AE 5320. DESIGN OPTIMIZATION. 3 Hours.
The purpose of this course is to present modern concepts of optimal design of structures. Basic ideas from optimization theory are developed with simple design examples. Analytical and numerical methods are developed and their applications discussed. Use of numerical simulation methods in the design process is described. Concepts of structural design sensitivity analysis and approximation methods will be discussed. The emphasis is made on the application of modern optimization techniques linked to the numerical methods of structural analysis, particularly, the finite element method. Prerequisite: AE 5310 or ME 5310.

AE 5322. AEROELASTICITY. 3 Hours.
A fundamental course addressing phenomena related to the time-independent interactions between structural flexibility and aerodynamic loads as relevant to flying vehicles. Emphasis is placed upon the development and use of simple analytical and/or interactive computational models that capture the essential aspects of the static aeroelastic phenomena investigated and provide insight into the response, including i) aeroelastic divergence; ii) aeroelastic change in control effectiveness; iii) aeroelastic distribution of lift; and iv) aeroelastic change in longitudinal static stability.

AE 5323. ENGINEERING RESEARCH METHODS. 3 Hours.
This hands-on course will teach the tools that are essential for conducting graduate research, with an aim to prepare the students for project-based graduate research. The course will be focused on the integration of engineering concepts to complete course projects that imitate mini research projects. Prerequisite: Undergraduate education in engineering or science.

AE 5325. COMBUSTION. 3 Hours.
Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Offered as AE 5325 and ME 5325. Credit will be granted only once.

AE 5326. AIR-BREATHING PROPULSION. 3 Hours.
Development of thrust and efficiency equations, thermodynamic cycle analysis, cycle design methods of aerospace propulsion systems, component performance analysis methods, component matching and dynamic interactions, and vehicle/propulsion-system integration.

AE 5327. COMPUTATIONAL AERODYNAMICS I. 3 Hours.
Solution of engineering problems by finite-difference methods, emphasis on aerodynamic problems characterized by single linear and non-linear equations, introduction to and application of major algorithms used in solving aerodynamics problems by computational methods.

AE 5328. COMPUTATIONAL AERODYNAMICS II. 3 Hours.
Review of the fundamental equations of aerodynamics, development of methods for solving Euler, boundary-layer, Navier-Stokes, and parabolized Navier-Stokes equations, application to practical aerodynamic analysis and design problems.

AE 5329. ADDITIVE MANUFACTURING. 3 Hours.
The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for additive manufacturing are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacturing. Offered as AE 5329 and ME 5329. Credit will be granted only once. Prerequisite: Graduate standing.

AE 5331. ANALYTIC METHODS IN ENGINEERING. 3 Hours.
Introduction to advanced analytic methods in engineering. Methods include multivariable calculus and field theory, Fourier series, Fourier and Laplace Transforms. Offered as AE 5331 and ME 5331. Credit will be granted only once. Prerequisite: Undergraduate degree in engineering, physics, or mathematics.

AE 5332. ENGINEERING ANALYSIS. 3 Hours.
Introduction to partial differential equations and complex variable theory with application to modeling of physical systems. Offered as AE 5332 and ME 5332. Credit will be granted only once.

AE 5333. THERMAL PHENOMENA IN MICROSYSTEMS. 3 Hours.
Introduction to experimental methods for microscale thermal transport, including experimental measurement techniques, design of experiments, data acquisition and analysis tools. Significant emphasis on carrying out mini-projects on related topics. Course learning outcomes are directly relevant for engineering jobs in semiconductors, energy conversion and other related industries. Offered as AE 5333 and ME 5333. Credit will be granted only once.

AE 5335. OPTIMAL CONTROL OF DYNAMIC SYS. 3 Hours.
Linear and nonlinear optimization methods; optimal control; continuous time Ricatti equation; bang-bang control; singular arcs; differential inclusions; collocation techniques; design of optimal dynamic system trajectories. Offered as AE 5335 and ME 5335. Credit will be granted only once.

AE 5336. OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS. 3 Hours.
Kalman filter design and implementation. Optimal filtering for discrete-time and continuous-time dynamical systems with noise. Wiener filtering. State-space determination. Offered as EE 6327, AE 5336 and ME 5336. Credit will be granted only once. Prerequisite: Prior introductory systems or identification course is desirable.

AE 5337. INTRODUCTION TO ROBOTICS. 3 Hours.
An overview of industrial robots and their application to traditional and emerging applications. Coordinate systems and homogeneous transformations, kinematics of manipulators; motion characteristics and trajectories; dynamics and control of manipulators; actuation and design issues. Programming of industrial robotic manipulators in the laboratory. Offered as AE 5337 and ME 5337. Credit will be granted only once.

AE 5338. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.
The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Offered as AE 5338 and ME 5338. Credit will be granted only once.

AE 5339. INTERMEDIATE MECHANICS OF MATERIALS. 3 Hours.
This fundamental mechanics course covers the concepts of deriving stress formulas from deformation and the stress-strain relationship, stress and failure analysis, 2D elasticity, energy methods, and elastic stability. Offered as AE 5339 and ME 5339. Credit will be granted only once.

AE 5341. CONTROL SYSTEM COMPONENTS. 3 Hours.
The components and hardware used in electronic, hydraulic, and pneumatic control systems; techniques of amplification, computation, compensation, actuation, and sensing; modeling of multiport systems as well as servo systems analysis. Pulse modulated systems. Offered as AE 5341 and ME 5341. Credit will be granted only once. Prerequisite: Undergraduate introductory control course in Mechanical Engineering or equivalent or ME 5303 or equivalent.

AE 5342. GAS DYNAMICS. 3 Hours.
Review of fundamental compressible flow theory, method of characteristics for perfect gases, the Rankine-Hugoniot conditions, linearized flow theory. Offered as AE 5342 and ME 5342. Credit will be granted only once. Prerequisite: MAE 3303 or equivalent.

AE 5345. NUMERICAL HEAT TRANSFER AND FLUID FLOW. 3 Hours.
Introduction to numerical solutions for problems in heat transfer and fluid flow by the finite-volume method. The focus will be on numerical aspects pertaining to incompressible fluids. It provides the background training towards the use of commercial software. Offered as AE 5345 and ME 5345. Credit will be granted only once.

AE 5347. ROCKET PROPULSION. 3 Hours.
Thrust and efficiency relations, trajectory analysis, introduction to design and performance analysis of chemical (liquid and solid), electrical and nuclear rocket systems, combined cycle propulsion systems, and pulse detonation rockets.

AE 5348. HYPERSONIC PROPULSION. 3 Hours.
Design and performance analysis of propulsion systems for sustained flight at hypersonic speeds, airframe/propulsion system integration, supersonic combustion, finite-rate chemistry effects, radiative cooling.

AE 5350. CLASSICAL AERODYNAMICS. 3 Hours.
To present a classical treatment of incompressible and compressible aerodynamics. Kinematics of fluid flow. Potential flow theory applied to non-lifting and lifting wings and bodies. Subsonic and supersonic wings and bodies. Familiarity with advanced engineering mathematics is recommended.

AE 5362. GUIDANCE, NAVIGATION, AND CONTROL OF AEROSPACE VEHICLES. 3 Hours.
Basics of flight dynamics and control. Autopilot structures for aerospace vehicles (aircraft, missiles, launch vehicles). Equilibrium glide trajectories for atmospheric flight. Discussion of the various guidance algorithms used in aircraft/missiles/launch vehicles. Basics of Kalman filtering, sensor and data fusion. Selection and trade-off between various navigation components such as the IMU, GPS and other navigation components. Integration of the guidance, navigation and control components in aerospace vehicles.

AE 5363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.
History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects. Offered as AE 5363 and ME 5363. Credit will be granted only once.

AE 5364. INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT. 3 Hours.
Practical aerodynamics of rotors and other components of rotorcraft. Introduction to performance, handling qualities, and general flight mechanics related to rotorcraft design, test, and certification requirements. Emphasis is on real rotorcraft mission capabilities as defined by the customer. Offered as AE 5364 and ME 5364. Credit will be granted only once.

AE 5365. INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION. 3 Hours.
Dynamic and aerodynamic modeling of rotorcraft elements using vector mechanics, linear algebra, calculus and numerical methods. Special emphasis on rotors, aerodynamic interference, proper axis system representation, model assembly methods and trimming. Offered as AE 5365 and ME 5365. Credit will be granted only once.

AE 5367. HIGH-SPEED AIRCRAFT AND SPACE ACCESS VEHICLE DESIGN. 3 Hours.
An introductory course on high-speed aircraft and space access vehicle design. The course concentrates on reusable flight vehicles. Topics covered are historical case studies, design disciplines, design space visualization and proof of design convergence. Prerequisite: consent of the instructor.

AE 5368. FLIGHT VEHICLE SYNTHESIS AND SYSTEMS ENGINEERING. 3 Hours.
An introductory course on multi-disciplinary design decision-making applied to flight vehicle design. The course introduces decision-making techniques leading to efficient aerospace product design. The following main topics are covered: a) management domain, b) operational domain, c) engineering domain. Prerequisite: MAE 4350, MAE 4351 or equivalent.

AE 5372. PARAMETRIC SIZING OF HIGH-SPEED AIRCRAFT. 3 Hours.
An introductory course on high-speed aircraft design. Aimed to develop insight into basic concepts underlying the analysis and design of supersonic and hypersonic aircraft. Topics covered are historical case studies, design disciplines, and design methodologies. Prerequisite: MAE 4350, MAE 4351 or equivalent.

AE 5374. NONLINEAR SYSTEMS ANALYSIS AND CONTROLS. 3 Hours.
Nonlinear systems; phase plane analysis; Poincare-Bendixon theorems; nonlinear system stability; limit cycles and oscillations; center manifold theorem, Lyapunov methods in control; variable structure control; feedback linearization; backstepping techniques. Offered as AE 5374 and ME 5374. Credit will be granted only once.

AE 5378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.
Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Offered as AE 5378 and ME 5378. Credit will be granted only once.

AE 5379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.
Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Offered as AE 5379 and ME 5379. Credit will be granted only once. Prerequisite: B or better in MAE 4378 or AE 5378 or ME 5378 and admission to the UVS certificate program.

AE 5380. DESIGN OF DIGITAL CONTROL SYSTEMS. 3 Hours.
Difference equations, Z- and w-transforms, discrete TF (Transfer Function). Discrete equivalence (DE) to continuous TF. Aliasing & Nyquist sampling theorem. Design by DE, root locus in z-plane & Youla parameterization. Discrete state-space model, minimality after sampling, pole placement, Moore-Kimura method, linear quadratic regulator, asymptotic observer. Computer simulation and/or lab implementation. Offered as EE 5324, AE 5380 and ME 5380. Credit will be granted only once. Prerequisite: MAE 4310 or equivalent.

AE 5381. BOUNDARY LAYERS. 3 Hours.
An introductory course on boundary layers. The coverage emphasizes the physical understanding and the mathematical foundations of boundary layers, including applications. Topics covered include laminar and turbulent incompressible and compressible layers, and an introduction to boundary layer transition. Offered as AE 5381 and ME 5381. Credit will be granted only once.

AE 5382. ADVANCED ASTRONAUTICS. 3 Hours.
Topics include orbital mechanics, orbital maneuvering, relative motion, orbit determination and estimation, three body problem, perturbations and numerical techniques.

AE 5383. HYPERSONIC FLOW. 3 Hours.
A study of the basic principles of hypersonic flows. Inviscid and viscous hypersonic flows. The course focuses on the effects of high temperature on the gas properties and associated effects on canonical gas dynamics processes. Applications in aerodynamic heating and atmospheric entry. Application of numerical methods.

AE 5385. HIGH TEMPERATURE GASDYNAMICS. 3 Hours.
Surveys kinetic theory, statistical mechanics, and chemical reaction rate theory. Application to the prediction of thermodynamic properties of gasses and the analysis of problems in high-temperature gasdynamics.

AE 5386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.
A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses.

AE 5391. ADVANCED STUDIES IN AEROSPACE ENGINEERING. 3 Hours.
Individual research or design project performed for fulfilling the requirements of the Master of Engineering degree option. Prior approval of the AE Graduate Advisor is required for enrollment. A written and/or oral report is required.

AE 5397. RESEARCH IN AEROSPACE ENGINEERING. 3 Hours.
Research in masters programs.

AE 5398. THESIS. 3 Hours.
Thesis.

AE 5400. PREPARATORY COURSE FOR AEROSPACE ENGINEERING. 4 Hours.
The course may be offered with multiple sections, wherein each section is paired with a corresponding UG course being offered that semester. The purpose of this course is to strengthen academic preparation of students who were found inadequately prepared for a graduate degree in Aerospace Engineering. Students can concurrently enroll in multiple sections and may need to enroll in this course multiple times until their academic preparation is deemed complete. In order to pass this class, the students has to earn at least a B grade in aggregate based all the assignments and exams. The student will earn an R grade if the class aggregate is a C/D and will need to repeat the course until the student passes the class. The student will Fail the class if the aggregate is an F. The course may be repeated as often as required.

AE 5698. THESIS. 6 Hours.
Thesis.

AE 6196. AEROSPACE ENGINEERING INTERNSHIP. 1 Hour.
For students participating in internship programs. Requires prior approval of Graduate Advisor.

AE 6197. RESEARCH IN AEROSPACE ENGINEERING. 1 Hour.
Research in doctoral programs.

AE 6297. RESEARCH IN AEROSPACE ENGINEERING. 2 Hours.
Research in doctoral programs.

AE 6299. DISSERTATION. 2 Hours.
Dissertation Prerequisite: Admission to candidacy for the Doctoral of Philosophy degree.

AE 6304. ADVANCED MECHANICS OF MATERIALS. 3 Hours.
This graduate level course will cover the calculation of stresses and strains in a body that experiences hyperelastic, viscoelastic and plastic deformation. Offered as AE 6304 and ME 6304. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

AE 6310. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Offered as AE 6310 and ME 6310. Credit will be granted only once. Prerequisite: AE 5310, ME 5310, or instructor consent.

AE 6311. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Offered as AE 6311 and ME 6311. Credit will be granted only once. Prerequisite: AE 5311, ME 5311, or instructor consent.

AE 6314. FRACTURE MECHANICS. 3 Hours.
Linear elastic fracture mechanics, energy of fracture, mixed mode crack propagation, fatigue crack growth, numerical methods for stress intensity factor determination, damage tolerance and durability design. Offered as AE 6314 and ME 6314. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

AE 6315. ADVANCED COMPOSITES. 3 Hours.
This course introduces students to advanced mechanics of composites at various scales, including analysis and characterization methods. Emphasis is on advanced methods for material characterization; nonlinear constitutive relations; structural and microstructural analysis; and advanced materials and structures applications. Offered as AE 6315 and ME 6315. Credit will be granted only once. Prerequisite: AE 5315, ME 5315, or instructor consent.

AE 6337. ADVANCED ROBOTICS. 3 Hours.
Advanced robotic design concepts considering structural statics, dynamics and control strategies for both rigid and flexible manipulators will be studied using optimization techniques and analytical approaches and introduction to micro- and mobile robotic devices. Study of emerging applications of robotics will be explored. Digital simulation of robotic devices and programming and demonstration of robotic devices in the laboratory. Prerequisites: AE 5337 or ME 5337 or equivalent.

AE 6397. RESEARCH IN AEROSPACE ENGINEERING. 3 Hours.
Research in doctoral programs.

AE 6399. DISSERTATION. 3 Hours.
Dissertation Prerequisite: admission to candidacy for the Doctor of Philosophy degree.

AE 6697. RESEARCH IN AEROSPACE ENGINEERING. 6 Hours.
Research in doctoral programs.

AE 6699. DISSERTATION. 6 Hours.
Dissertation. Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

AE 6999. DISSERTATION. 9 Hours.
Dissertation. Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

AE 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.

COURSES

ME 5010. AUTOMOTIVE ENGINEERING PRACTICUM. 0 Hours.
Practical design experience as full member of automotive design competition team. Prerequisite: Permission of Director for the Arnold E. Petsche Center for Automotive Engineering.

ME 5101. GRADUATE SEMINAR. 1 Hour.
The purpose is to acquaint graduate students with ongoing research at UTA, and outside in academia and industry. Seminars are given by graduate students of the department based on their ongoing research. Seminars are also given by external speakers from academia, industry and government.

ME 5191. PROJECT STUDIES IN MECHANICAL ENGINEERING. 1 Hour.
May be repeated for credit as topics change. Project work performed under a non-thesis degree will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies. May be graded pass/fail.

ME 5197. RESEARCH IN MECHANICAL ENGINEERING. 1 Hour.
Research in master's programs.

ME 5291. PROJECT STUDIES IN MECHANICAL ENGINEERING. 2 Hours.
May be repeated for credit as topics change. Work performed as a thesis substitute will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies. Maybe graded P/F.

ME 5297. RESEARCH IN MECHANICAL ENGINEERING. 2 Hours.
Research in master's programs.

ME 5302. INTRODUCTION TO BEARING DESIGN AND LUBRICATION. 3 Hours.
The course introduces 1) selection principles and design guidelines for various rolling element bearings, 2) theory of liquid and gas lubrication, 3) various novel fluid film bearings used in modern high speed turbomachinery and energy systems, and 4) fundamental principles of rotordynamics.

ME 5303. CLASSICAL METHODS OF CONTROL SYSTEMS ANALYSIS AND SYNTHESIS. 3 Hours.
Equip the student with familiarity of significant tools of the control engineer. Topics covered include controllers and their effect on system performance and stability, block diagram algebra, stability and analysis, system performance definition, root locus, frequency techniques, and state variable methods. Digital simulation tools for design and simulation of control systems. Demonstration of controller design and performance in the laboratory. Also offered as AE 5303. Credit will be granted only once.

ME 5305. DYNAMIC SYSTEMS MODELING. 3 Hours.
To equip the student with the capability of determining the necessary equations for distributed and lumped parameter modeling of mixed physical system types including mechanical, fluid, electrical, and thermal components. Models are formulated for computer simulation and analysis for systems with deterministic and stochastic inputs. Topics of random vibration and system identification are included. Offered as AE 5305 and ME 5305. Credit will be granted only once.

ME 5306. FLUID POWER CONTROL. 3 Hours.
Mathematical models for hydraulic and pneumatic control components and systems including hydraulic pumps, motors, and spool valves. The application of electrohydraulic and hydromechanical servomechanisms for position and velocity control are treated. Theory supported by laboratory demonstrations and experiments.

ME 5310. FINITE ELEMENT METHODS. 3 Hours.
Finite element method in the study of the static response of complex structures and of continua; applications to field problems; analytical methods emphasized, and digital computer application undertaken. Offered as AE 5310 and ME 5310. Credit will be granted only once.

ME 5311. STRUCTURAL DYNAMICS. 3 Hours.
Natural frequencies; forced response of complex structural systems studied through the use of the finite element method; computational aspects of these problems discussed, and digital computer applications undertaken. Offered as AE 5311 and ME 5311. Credit will be granted only once.

ME 5312. CONTINUUM MECHANICS. 3 Hours.
Study of the underlying physical and mathematical principles relating to the behavior of continuous media; interrelationships between fluid and solid mechanics. Offered as AE 5312 and ME 5312. Credit will be granted only once.

ME 5313. FLUID DYNAMICS. 3 Hours.
Basic conservation laws, flow kinematics, special forms of the governing equations, two-dimensional potential flows, surface waves and some exact solutions of viscous incompressible flows. Offered as AE 5313 and ME 5313. Credit will be granted only once.

ME 5315. FUNDAMENTALS OF COMPOSITES. 3 Hours.
This fundamental course will introduce students to mechanics of composites at various scales, including analysis, characterization, and manufacturing methods. Emphasis is on constitutive relations; mechanical and hygrothermal behavior; stress analysis; and simple applications. Offered as AE 5315 and ME 5315. Credit will be granted only once.

ME 5316. THERMAL CONDUCTION. 3 Hours.
Fundamental laws, initial and boundary conditions, basic equations for isotropic and anisotropic media, related physical problems and steady and transient temperature distributions in solid structures.

ME 5317. CONVECTION HEAT TRANSFER. 3 Hours.
Equations of motion of viscous fluids are reviewed and the energy equations are introduced. Exact and approximate solutions are made for forced convective problems with non-isothermal and unsteady boundaries. Free convection and combined free- and forced-convection problems are solved.

ME 5318. RADIATIVE HEAT TRANSFER. 3 Hours.
General equations of radiative transfer derived and solved for special problems, and the elements of atomic, molecular, and continuum radiation are introduced.

ME 5319. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Continuation of ME 5310. Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Prerequisite: ME 5310 or equivalent.

ME 5320. DESIGN OPTIMIZATION. 3 Hours.
The purpose of this course is to present modern concepts of optimal design of structures. Basic ideas from optimization theory are developed with simple design examples. Analytical and numerical methods are developed and their applications discussed. Use of numerical simulation methods in the design process is described. Concepts of structural design sensitivity analysis and approximation methods will be discussed. The emphasis is made on the application of modern optimization techniques linked to the numerical methods of structural analysis, particularly, the finite element method. Prerequisite: AE 5310 or ME 5310.

ME 5321. ADVANCED CLASSICAL THERMODYNAMICS. 3 Hours.
Fundamentals of thermodynamics reviewed. Different treatments of principles studied, compared and formal relationships developed and applied to chemical, magnetic, electric and elastic systems.

ME 5322. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Prerequisite: ME 5311 or equivalent.

ME 5323. ENGINEERING RESEARCH METHODS. 3 Hours.
This hands-on course will teach the tools that are essential for conducting graduate research, with an aim to prepare the students for project-based graduate research. The course will be focused on the integration of engineering concepts to complete course projects that imitate mini research projects. Prerequisite: Undergraduate education in engineering or science.

ME 5324. POWER PLANT ENGINEERING. 3 Hours.
Fundamental thermodynamics and heat transfer principles behind design and optimization of power generation systems with significant emphasis on component and system design. This class will cover a number of power plant types, including coal/gas fired, hydroelectric, nuclear, and solar. Concepts learnt in this class prepare students for an engineering career in power plants, oil, gas and related industries.

ME 5325. COMBUSTION. 3 Hours.
Fundamental treatment of problems involving simultaneous occurrence of chemical reaction and transfer of heat, mass and momentum. Topics include kinetically controlled combustion phenomena; diffusion flames in liquid fuel combustion; combustion of solids; combustion of gaseous fuel jets; flames in premixed gasses. Offered as AE 5325 and ME 5325. Credit will be granted only once.

ME 5326. MANUFACTURING PROCESSES AND SYSTEMS. 3 Hours.
Survey and modeling of manufacturing, assembly, surface treatment, automation, and integration processes. Prerequisite: Graduate standing.

ME 5327. DESIGN FOR MANUFACTURING. 3 Hours.
The interaction between design and manufacturing stressed in terms of the design process, customer-focused quality, design specifications versus process capability and tolerances, and redesign for producibility. Topics include material and manufacturing process selection, tolerancing, quality function deployment (QFD), design for assembly (DFA), quality control techniques, reliability, and robust design. Prerequisite: ME 5326.

ME 5328. METAL ADDITIVE MANUFACTURING. 3 Hours.
This course will provide students with essential knowledge and technical skills for metal additive manufacturing (AM), providing a solid foundation for a future career in the field. Primary areas of focus include: metal AM processes and their capabilities, process fundamentals, part design and analysis, build preparation and machine set-up, fabrication and post-processing, inspection and monitoring, microstructure analysis and mechanical testing, and process optimization.

ME 5329. ADDITIVE MANUFACTURING. 3 Hours.
The range of technologies and processes, both physical and digital, used to translate virtual solid model data into physical models using additive layering methods. Emphasis is given to application of these technologies to manufacture end use components and assemblies but rapid prototyping is also discussed. Metal, polymer, ceramic, and composite material applications of additive manufacturing are included. Discussion includes advantages and limitations of additive methods with respect to subtractive methods and to each other. Principles of design for additive manufacturing are covered along with discussion of applications. Students complete a project to design and build an engineering component or assembly for additive manufacturing. Offered as AE 5329 and ME 5329. Credit will be granted only once. Prerequisite: Graduate standing.

ME 5331. ANALYTIC METHODS IN ENGINEERING. 3 Hours.
Introduction to advanced analytic methods in engineering. Methods include multivariable calculus and field theory, Fourier series, Fourier and Laplace Transforms. Offered as AE 5331 and ME 5331. Credit will be granted only once. Prerequisite: Undergraduate degree in engineering, physics, or mathematics.

ME 5332. ENGINEERING ANALYSIS. 3 Hours.
Introduction to partial differential equations and complex variable theory with application to modeling of physical systems. Offered as AE 5332 and ME 5332. Credit will be granted only once.

ME 5333. THERMAL PHENOMENA IN MICROSYSTEMS. 3 Hours.
Introduction to experimental methods for microscale thermal transport, including experimental measurement techniques, design of experiments, data acquisition and analysis tools. Significant emphasis on carrying out mini-projects on related topics. Course learning outcomes are directly relevant for engineering jobs in semiconductors, energy conversion and other related industries. Offered as AE 5333 and ME 5333. Credit will be granted only once.

ME 5335. OPTIMAL CONTROL OF DYNAMIC SYSTEMS. 3 Hours.
Linear and nonlinear optimization methods; optimal control; continuous time Ricatti equation; bang-bang control; singular arcs; differential inclusions; collocation techniques; design of optimal dynamic system trajectories. Offered as AE 5335 and ME 5335. Credit will be granted only once.

ME 5336. OPTIMAL ESTIMATION OF DYNAMIC SYSTEMS. 3 Hours.
Kalman filter design and implementation. Optimal filtering for discrete-time and continuous-time dynamical systems with noise. Wiener filtering. State-space determination. Offered as EE 6327, AE 5336 and ME 5336. Credit will be granted only once. Prerequisite: introductory systems or identification course is desirable. Also offered as AE 5336 and EE 6327. Credit will be granted only once.

ME 5337. INTRODUCTION TO ROBOTICS. 3 Hours.
An overview of industrial robots and applications to traditional and emerging applications. Coordinate systems and homogeneous transformations, kinematics of manipulators; motion characteristics and trajectories; dynamics and control of manipulators; actuation and design issues. Programming of industrial robotic manipulators in the laboratory. Offered as AE 5337 and ME 5337. Credit will be granted only once.

ME 5338. ANALYTICAL & COMPUTATIONAL DYNAMICS. 3 Hours.
The course focuses on developing the equations of motion for dynamic systems composed of multiple, connected and unconnected, rigid bodies using Kane's method and the Lagrangian approach. The resulting model is used to simulate and visualize the predicted motion. Topics include: kinematics, Euler parameters, kinematic constraints, virtual work, the calculus of variations, energy, momentum, contact, impact, and checking functions. Offered as AE 5338 and ME 5338. Credit will be granted only once.

ME 5339. INTERMEDIATE MECHANICS OF MATERIALS. 3 Hours.
This fundamental mechanics course covers the concepts of deriving stress formulas from deformation and the stress-strain relationship, stress and failure analysis, 2D elasticity, energy methods, and elastic stability. Offered as AE 5339 and ME 5339. Credit will be granted only once.

ME 5340. AUTOMOTIVE ENGINEERING. 3 Hours.
Introduction to automotive engine types and performance, drive train modeling and vehicle loading characteristics, fueling requirements, fuel injection systems, tire characteristics and modeling, suspension characteristics and handling, braking systems and requirements. Course taught through lecture, student presentations and student design projects.

ME 5341. CONTROL SYSTEM COMPONENTS. 3 Hours.
The components and hardware used in electronic, hydraulic, and pneumatic control systems; techniques of amplification, computation, compensation, actuation, and sensing; modeling of multiport systems as well as servo systems analysis. Pulse modulated systems. Offered as AE 5341 and ME 5341. Credit will be granted only once. Prerequisite:Undergraduate introductory control course in Mechanical Engineering or equivalent or ME 5303 or equivalent.

ME 5342. GAS DYNAMICS. 3 Hours.
Review of fundamental compressible flow theory, method of characteristics for perfect gases, the Rankine-Hugoniot conditions, linearized flow theory. Offered as AE 5342 and ME 5342. Credit will be granted only once. Prerequisite: MAE 3303 or equivalent.

ME 5344. VISCOUS FLOWS. 3 Hours.
Navier-Stokes equations and Prandtl's boundary layer approximations; laminar and turbulent boundary layers including internal and external flows.

ME 5345. NUMERICAL HEAT TRANSFER AND FLUID FLOW. 3 Hours.
Introduction to numerical solutions for problems in heat transfer and fluid flow by the finite-volume method. The focus will be on numerical aspects pertaining to incompressible fluids. It provides the background training towards the use of commercial software. Offered as AE 5345 and ME 5345. Credit will be granted only once.

ME 5347. HEAT EXCHANGER DESIGN. 3 Hours.
Design procedures, system evaluations and design parameters in heat exchangers. Heat exchanger configurations; student design projects.

ME 5352. FUNDAMENTALS IN ELECTRONIC PACKAGING. 3 Hours.
An introductory treatment of electronic packaging, from single chip to multichip, including materials, electrical design, thermal design, mechanical design, package modeling and simulation, processing considerations, reliability, and testing.

ME 5353. COMPUTATIONAL TECHNIQUES FOR ELECTRONIC PACKAGING. 3 Hours.
Characterization of the thermo/mechanical reliability of microelectronics devices using commercial computational heat transfer codes (Icepack, Flotherm, and ANSYS). Industry related problems ranging from first level packages through system level packages analyzed. Formulate and model contemporary problems using commercial CFD codes.

ME 5358. RACECAR ENGINEERING. 3 Hours.
This course intended for Formula SAE team members and other interested students to develop new systems or analyze concepts for the Formula SAE or Formula Electric racecar and related equipment. The students will form teams and perform research and development on projects related to automotive or racecar engineering.

ME 5359. APPLIED AUTOMOTIVE ENGINEERING. 3 Hours.
The purpose of this course is to gain practical experience in the design and fabrication of parts or systems for automotive applications. The student must write a proposal, give a public oral presentation, and prepare a formal final report. The student must have attained full team member status in a student design competition team. Prerequisites: permission of Director of the Arnold E. Petsche Center for Automotive Engineering.

ME 5362. INTRODUCTION TO MICRO AND NANOFLUIDICS. 3 Hours.
As going down to micro scales, the basic hypothesis in the macro scale fluid mechanics may not be applicable in such scales. The objectives of this course are: to identify dominant forces and their effects in micro scale fluid systems that are different from those in the macro scales; to understand the fundamentals of micro fluidic phenomena; to discuss various microfluidic applications in research and commercial levels; and to explore new possible microfluidic applications in the emerging fields. Topics include overview of microfluidics, scaling laws, violation limit of the Navier-Stokes equations, surface force, surface tension, electrowetting, electrokinetics, dielectrophoresis, and soft lithography. Prerequisite: MAE 2314 and MAE 3310 or equivalents.

ME 5363. INTRODUCTION TO ROTORCRAFT ANALYSIS. 3 Hours.
History of rotorcraft. Behavior of the rotor blade in hover and forward flight. Rotor configurations, dynamic coupling with the fuselage, elastic and aeroelastic effects. Offered as AE 5363 and ME 5363. Credit will be granted only once.

ME 5364. INTRODUCTION TO AERODYNAMICS OF ROTORCRAFT. 3 Hours.
Practical aerodynamics of rotors and other components of rotorcraft. Introduction to performance, handling qualities, and general flight mechanics related to rotorcraft design, test, and certification requirements. Emphasis is on rotorcraft mission capabilities as defined by the customer. Offered as AE 5364 and ME 5364. Credit will be granted only once.

ME 5365. INTRODUCTION TO HELICOPTER AND TILTROTOR SIMULATION. 3 Hours.
Dynamic and aerodynamic modeling of rotorcraft elements using vector mechanics, linear algebra, calculus and numerical methods. Special emphasis on rotors, aerodynamic interference, proper axis system representation, model assembly methods and trimming. Offered as AE 5365 and ME 5365. Credit will be granted only once.

ME 5366. FUEL CELLS AND APPLICATIONS. 3 Hours.
The course introduces: Principles and thermodynamics applied to fuel cell-based power generation systems; materials and manufacturing methods of two common fuel cells and their stacks; modeling, analysis, and design of fuel cells and various reformers; and design issue of balance of plants such as steam management systems.

ME 5374. NONLINEAR SYSTEMS ANALYSIS AND CONTROLS. 3 Hours.
Nonlinear systems; phase plane analysis; Poincare-Bendixon theorems; nonlinear system stability; limit cycles and oscillations; center manifold theorem, Lyapunov methods in control; variable structure control; feedback linearization; backstepping techniques. Offered as AE 5374 and ME 5374. Credit will be granted only once.

ME 5378. INTRODUCTION TO UNMANNED VEHICLE SYSTEMS. 3 Hours.
Introduction to UVS (Unmanned Vehicle Systems) such as UAS (Unmanned Aircraft Systems), UGS (Unmanned Ground System) and UMS (Unmanned Maritime System), their history, missions, capabilities, types, configurations, subsystems, and the disciplines needed for UVS development and operation. UVS missions could include student competitions sponsored by various technical organizations. This course is team-taught by engineering faculty. Offered as AE 5378 and ME 5378. Credit will be granted only once.

ME 5379. UNMANNED VEHICLE SYSTEM DEVELOPMENT. 3 Hours.
Introduction to the technologies needed to create an UVS (Unmanned Vehicle System). Integration of these technologies (embodied as a set of sensors, actuators, computing and mobility platform sub-systems) into a functioning UVS through team work. UVS could be designed to compete in a student competition sponsored by various technical organizations or to support a specific mission or function defined by the instructors. This course is team-taught by engineering faculty. Offered as AE 5379 and ME 5379. Credit will be granted only once. Prerequisite: B or better in MAE 4378 or AE 5378 or ME 5378 and admission to the UVS certificate program.

ME 5380. DESIGN OF DIGITAL CONTROL SYSTEMS. 3 Hours.
Difference equations, z- and w- transforms, discrete TF (Transfer Function). Discrete equivalence (DE) to continuous TF. Aliasing & Nyquist sampling theorem. Design by DE, root locus in z- plane & Youla parameterization. Discrete state- space model, minimality after sampling, pole placement, Moore-Kimura method, linear quadratic regulator, asymptotic observer. Computer simulation and/or laboratory implementation. Offered as EE 5324, AE 5380 and ME 5380. Credit will be granted only once. Prerequisite: undergraduate level controls course or equivalent. Also offered as AE 5380, EE 5324. Credit will be granted only once.

ME 5381. BOUNDARY LAYERS. 3 Hours.
An introductory course on boundary layers. The coverage emphasizes the physical understanding and the mathematical foundations of boundary layers, including applications. Topics covered include laminar and turbulent incompressible and compressible boundary layers, and an introduction to boundary layer transition. Offered as AE 5381 and ME 5381. Credit will be granted only once.

ME 5382. RESEARCH TRENDS IN RENEWABLE ENERGY TECHNOLOGIES. 3 Hours.
This course is offered to graduate and senior level undergraduate students with engineering and science background to introduce them to micro/nano research and development for energy conversion and storage. The course will cover topics such as Scaling laws, MEMS fabrication, Nanomaterial synthesis, Electrochemical energy storage/conversion (Batteries, Fuel Cells & Supercapacitors), Solar energy (photovoltaics and solar thermal energy), Energy harvesting and Solar water splitting and electrocatalysis.

ME 5386. WIND & OCEAN CURRENT ENERGY HARVESTING FUNDAMENTALS. 3 Hours.
A broad senior/graduate first course in wind/wave/ocean current energy harvesting systems, focused on fundamentals, and serving as the basis for subsequent MAE specialized follow-on graduate course offerings focused on structures (conventional and composite), aero/hydro-mechanical response and control, and tailoring and smart material actuation, respectively, as well as for non-MAE, specialized graduate courses. (also taught as AE 5386).

ME 5390. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 3 Hours.
To provide formal instruction in special topics pertinent to Mechanical Engineering from semester to semester depending on the availability of faculty. May be repeated provided topics differ.

ME 5391. ADVANCED STUDIES IN MECHANICAL ENGINEERING. 3 Hours.
May be repeated for credit as topics change. Project work performed under a non-thesis degree will normally be accomplished under this course number, with prior approval of the Committee on Graduate Studies.

ME 5397. RESEARCH IN MECHANICAL ENGINEERING. 3 Hours.
Research in master's programs.

ME 5398. THESIS. 3 Hours.
Thesis.

ME 5698. THESIS. 6 Hours.
Thesis Prerequisite: GRAD ME thesis major.

ME 5998. THESIS. 9 Hours.
Thesis Prerequisite: GRAD ME thesis major.

ME 6196. MECHANICAL ENGINEERING INTERNSHIP. 1 Hour.
For students participating in internship programs. May be repeated for credit. Requires prior approval of ME Graduate Advisor.

ME 6197. RESEARCH IN MECHANICAL ENGINEERING. 1 Hour.
May be repeated for credit.

ME 6297. RESEARCH IN MECHANICAL ENGINEERING. 2 Hours.
May be repeated for credit.

ME 6299. DISSERTATION. 2 Hours.
Prerequisite: Admission to candidacy for the Doctoral of Philosophy degree.

ME 6304. ADVANCED MECHANICS OF MATERIALS. 3 Hours.
This graduate level course will cover the calculation of stresses and strains in a body that experiences hyperelastic, viscoelastic and plastic deformation. Offered as AE 6304 and ME 6304. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

ME 6310. ADVANCED FINITE ELEMENT METHODS. 3 Hours.
Modeling of large systems, composite and incompressible materials, substructuring, mesh generation, solids applications, nonlinear problems. Offered as AE 6310 and ME 6310. Credit will be granted only once. Prerequisite: AE 5310, ME 5310, or instructor consent.

ME 6311. ADVANCED STRUCTURAL DYNAMICS. 3 Hours.
Normal mode method for undamped and proportionally damped systems, component mode synthesis, generally damped systems, complex modes, effect of design modification on system response. Offered as AE 6311 and ME 6311. Credit will be granted only once. Prerequisite: AE 5311, ME 5311, or instructor consent.

ME 6314. FRACTURE MECHANICS. 3 Hours.
Linear elastic fracture mechanics, energy of fracture, mixed mode crack propagation, fatigue crack growth, numerical methods for stress intensity factor determination, damage tolerance and durability design. Offered as AE 6314 and ME 6314. Credit will be granted only once. Prerequisite: AE 5339, ME 5339, or instructor consent.

ME 6315. ADVANCED COMPOSITES. 3 Hours.
This course introduces students to advanced mechanics of composites at various scales, including analysis and characterization methods. Emphasis is on advanced methods for material characterization; nonlinear constitutive relations; structural and microstructural analysis; and advanced materials and structures applications. Offered as AE 6315 and ME 6315. Credit will be granted only once. Prerequisite: AE 5315, ME 5315, or instructor consent.

ME 6316. COMPUTER AIDED DESIGN. 3 Hours.
Role of graphics; image representation, batch and interactive computing, methods of automated mathematical model generation in engineering design. Application in mechanical, structural, thermal, controls areas of mechanical engineering.

ME 6337. ADVANCED ROBOTICS. 3 Hours.
Advanced robotic design concepts considering structural statics, dynamics and control strategies for both rigid and flexible manipulators will be studied using optimization techniques and analytical approaches and introduction to micro- and mobile robotic devices. Study of emerging applications of robotics will be explored. Digital simulation of robotic devices and programming and demonstration of robotic devices in the laboratory. Prerequisites: AE 5337 or ME 5337 or equivalent.

ME 6344. HEAT TRANSFER IN TURBULENT FLOW. 3 Hours.
Introduction to heat transfer in turbulent boundary layers including internal and external flows, turbulence structure, the Reynolds analogy, van Driest hypothesis, high and low Prandtl number two equation model, effects of surface roughness on heat transfer. Also offered as AE 6344. Credit will be granted only once.

ME 6397. RESEARCH IN MECHANICAL ENGINEERING. 3 Hours.
May be repeated for credit.

ME 6399. DISSERTATION. 3 Hours.
May be repeated for credit.

ME 6697. RESEARCH IN MECHANICAL ENGINEERING. 6 Hours.
May be repeated for credit.

ME 6699. DISSERTATION. 6 Hours.
Prerequisite: Admission to candidacy for the Doctor of Philosophy degree.

ME 6997. RESEARCH IN MECHANICAL ENGINEERING. 9 Hours.
May be repeated for credit.

ME 6999. DISSERTATION. 9 Hours.
Admission to candidacy for the Doctor of Philosophy degree.

ME 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.
This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.