

Department of Mechanical and Aerospace Engineering

(www.mae.buffalo.edu)

GRADUATE MANUAL

(revised 1/15/2007)

**State University of New York at Buffalo
School of Engineering and Applied Sciences**

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The department offers separate programs in Mechanical and Aerospace Engineering. In each program, the Master of Science, M.S., the Master of Engineering, M.Eng., and the Doctor of Philosophy, Ph.D., degrees are granted. Students are accepted for Spring or Fall admission. Subject to certain limitations, students may undertake their program on a full- or part-time basis.

1. Admission Requirements

The B.S. in Mechanical or Aerospace Engineering, or the equivalent, with a quality point average of at least 3.0/4.0, is the normal background required for admission for all Masters programs. Prospective Ph.D. students may apply for either the M.S. or Ph.D. program, but those without an M.S. degree will initially be accepted as M.S. candidates. Full-time students admitted to the M.S. program who show research ability and are in good academic standing may apply for admission to the Ph.D. qualifying examination after two semesters. The procedure for applying is the same as for students who first complete the M.S. program. Students who complete the M.S. program and wish to continue must apply for admission to the Ph.D. program and qualifying examination as described in Sec. 11.

Students applying for admission with a quality point average less than 3.0 or without a B.S. in Mechanical or Aerospace Engineering may occasionally be admitted on a provisional basis, depending on the circumstances of their case and their letters of recommendation. Admission on a provisional basis requires that the student obtain a grade of B or higher in each of the first three graduate courses taken.

2. Student Classifications

- a) **Degree Student**: Graduate students who have been accepted by the department with an undergraduate quality point average of 3.0/4.0 or better.
- b) **Non-degree Student**: Students with appropriate academic qualifications who do not wish to pursue a degree program.
- c) **Non-Matriculated Student**:
 - i) Graduate credit earned by non-degree students may be applied toward a degree program by petition to the Director of Graduate Studies after acceptance as a degree student.
 - ii) Students who are admitted to a particular course on a no credit basis at the discretion of the Department and the instructor of the course. No transcripts or other supporting papers are required, but an online application must be completed.
 - iii) *Provisional Admission*: Students admitted on a provisional basis do not qualify as degree students and must demonstrate their ability to perform satisfactorily at the graduate level before being admitted to degree candidacy. As indicated above, a grade of B or higher is required in each of the first three graduate courses. Otherwise, the student will be dropped automatically from the program with no further probationary period possible.

3. Application Dates for Admission

These dates can be found at http://www.mae.buffalo.edu/explore-application_deadlines.shtml.

4. Student Status

- a) **Full-Time:** A student who carries 12 credit hours (equivalent to four approved courses) of work approved by the advisor is considered a full-time student by the department. The following students must be full time: *department fellows, teaching, research and graduate assistants* (TA's, RA's and GA's), *university fellows, veterans* (supported by the Veteran's Administration), and **all foreign students with a student visa**. RA's, TA's and GA's are considered full time at 9 or more credit hours.

Students who are within 12 credit hours of fulfilling their Master's or Ph.D. degree requirements (9 credit hours in the case of RA's, TA's and GA's) should petition the Graduate School for full-time status if registering for fewer than 12 (9 for RAs, GA and TAs) credits. Petition forms are available at www.grad.buffalo.edu/grad-docs. All supported students and all foreign students falling into this category must file the petition. Please note that an Application to Candidacy (ATC) form (see <http://www.grad.buffalo.edu/docs/index.html>) must be submitted and approved **before** a petition for full-time status will be approved by the Graduate School. Supported students should also be aware that the number of tuition scholarship credits that will be allowed will be limited to only those credit hours required for a particular degree (30 credit hours for the M.S. or 72 credit hours for the Ph.D., less any transfer credits).

- b) **Part-Time:** A student who carries less than the equivalent of four approved courses and has not filed a petition for full-time status is considered a part-time student by the department.

5. Advisement

As early as possible in their first semester, students should meet with the department faculty members working in their general area of research or technical interest with the purpose of deciding a preference for a thesis/dissertation advisor. On reaching mutual agreement with a faculty member on thesis advisement the student should so notify the department graduate office. The advisor must be a member of the Graduate School Faculty. Prior to selection of an advisor, the Director of Graduate Studies will serve as advisor.

Students are urged to select an advisor by the end of their first semester if at all possible. Students are encouraged to actively seek an advisor.

Students are required to confer regularly with their advisors, who must approve all course selections as well as provide thesis or project supervision. Students may change advisors only with permission of the Director of Graduate Studies.

Advisement by non-MAE faculty: Non-MAE faculty can serve as committee members, provided they have a Graduate School appointment. If a non-MAE faculty member is to serve as the principal advisor, this must be approved in advance by the Graduate Director according to MAE policy. In such a case, the other committee members must be MAE faculty. If appropriate to the research effort, additional members beyond the minimum number may be added.

6. Registration

Every student is required to register as early as possible at the beginning of each semester in which courses, research, thesis or dissertation work are planned. The latter may be undertaken only under the direct supervision of a member of the faculty. No credit will be allowed for work done without proper registration. Proper registration is important for determination of the residence requirement. "Residence" implies the pursuit of advanced study or research while registered at UB-SUNY under the supervision of the Graduate School Faculty.

A minimum registration period of one year on a full-time equivalent basis is required for the M.S. degree, and two years on a similar basis is required for the Ph.D. A Ph.D. candidate must also fulfill the Ph.D. residency requirement of at least two semesters as a full-time student.

Students are required to register continuously during their period of graduate study until all requirements for the degree are completed. Students who, for one reason or another, cannot maintain continuous registration must request a Leave of Absence (using the Graduate Student Petition Form available at <http://www.grad.buffalo.edu/docs/petition.pdf>) before the start of the semester for which the leave is being requested. For this purpose, the student must petition the Dean of the Graduate School and obtain the approval of the Director of Graduate Studies. A leave of absence will only be granted to students in good academic standing. If the student is enrolled for less than 12 credits (less than 9 credits for TA's, GA's or RA's), and for all international students, the Certification of Full-Time Status form should be completed; see the page <http://www.grad.buffalo.edu/docs/certfts.pdf> .

Leaves of absence will normally be granted for only one (1) semester at a time. Leaves of more than one (1) semester may require additional justification and documentation from the student and the student's advisor. Documented cases of financial hardship, illness, or compulsory military service constitute valid justification. Students who leave the program after completion of some graduate work, but have not been given an approved leave of absence, must reapply and be readmitted as a new student. Continued leaves of absence beyond two (2) semesters will not be granted.

7. Transfer Credit

- a) **From Another School:** Transfer credit will be allowed only for graduate work with a grade of "B" or better. Graduate work done at other institutions may be offered in partial fulfillment of the requirements for a degree if the work is of acceptable quality and appropriate to the student's program. Credits earned in correspondence courses may not be transferred.

A student desiring to transfer graduate credits should consult with his advisor at the earliest opportunity after admission. When the student's Application to Candidacy is submitted, it must list the credits to be transferred.

For the M.S. or M.E. program, this transfer is limited to a maximum of 20% of the degree requirements (or 6 credit hours total).

A student entering the Ph.D. program may receive credit for up to 24 credit hours of previous graduate course work. Previous project or thesis work may **not** be transferred.

- b) **From another Department within SUNY/Buffalo:** Graduate work done in another department within SUNY/Buffalo may be offered in partial fulfillment of the degree requirements if the work is of acceptable quality and appropriate to the student's program.

8. **Graduate Credit**

Graduate credit is granted only to degree students who:

- i) have been accepted into the department prior to registration in any course, seminar, research program, or other type of study.
- ii) are seniors close to graduation with at least a 3.0/4.0 grade point average during their last three semesters and who do not need the course credit to complete the B.S. requirements. (Petition forms are available in the Student Advising Services office. Exception registration is done within the department, by the assistant to the chair, with instructor permission.)

Graduate credit is earned for "approved courses" consisting of a minimum of 3 semester hours (1 semester hour of credit is equivalent to 15 hours of class work per semester) and registration in thesis/dissertation which is under the direct supervision of the advisor.

Graduate credit is granted for 500, 600 and 700 level courses, provided the advisement and registration requirements are met. Graduate courses from outside the School of Engineering and Applied Sciences or Natural Sciences and Mathematics must receive prior approval from the student's advisor and the Director of Graduate Studies.

Informal Courses

Informal courses usually include Individual Problems and Special Topics courses, which are taught on an informal basis. These courses require a complete narrative description on a special form designed for this purpose, which includes the signatures of the student, instructor, and the Director of Graduate Studies. A copy of this form (available [on](http://www.mae.buffalo.edu/forms) the page <http://www.mae.buffalo.edu/forms>) should be submitted to the department graduate office during registration time, at the beginning of the semester, and is included along with the student's Application to Candidacy form.

A maximum of six (6) credit hours of individual problems may be applied toward the minimum 30 credit-hour requirement for the Master's degree.

Excluding those credits applied towards the Master's degree, a maximum of six (6) additional credit hours of informal course work may be applied towards the minimum 72 credit-hour requirement for the Ph.D. degree.

Graduate Credit for Undergraduate Courses

Students wishing to use an undergraduate course for graduate credit **must** submit a petition (<http://www.grad.buffalo.edu/docs/petition.pdf>) along with a statement or syllabus from the instructor showing the additional work required for graduate credit to the MAE graduate office during the first week of classes to receive approval. Copies of these petitions must be included along with the Application to Candidacy form. **Retroactive approval will not be granted.**

Such courses must be limited to a maximum of two (2) advanced undergraduate courses at the 400 level. This maximum limit applies to the entire M.S. or Ph.D. degree program. **Undergraduate courses may not be applied to the M.Eng. degree program.**

Undergraduate courses which carry four (4) or more semester hours of credit will receive a maximum of three (3) semester hours of graduate credit. Graduate students taking a 4 credit hour course must register and pay tuition for the full 4 credits.

Other

The following courses may **not** be employed to fulfill degree credit requirements:

- i) undergraduate courses in which a grade of C or lower is obtained. Credit for such courses will not be applied to the total program, but the grades will be counted in the overall average.
- ii) a graduate course already used to fulfill the requirements of an undergraduate degree program; repeat of graduate course already taken at undergraduate level
- iii) graduate courses in which a grade of D, F or U is obtained.

9. Scholastic Requirements (General)

- a) **Grades:** A minimum average of B (3.0/4.0) must be maintained during all graduate work. This requirement takes effect after 3 courses, and all work taken for graduate credit which could be applied to the degree is used in calculating the grade point average. Courses should not be taken using "S/U" grading unless approval is obtained ahead of time from the Director of Graduate Studies.

Accordingly, courses taken in excess of that applied toward the degree credit requirements will be included in the computation of grade point average. Students whose averages fall between 2.5 and 3.0 at the end of any grading period may be permitted, upon the recommendation of their advisors and approval of the Director of Graduate Studies, to make up the grade point deficiency within a specified period.

A student will be considered for dismissal from the program when:

- i) the grade of F is earned in any course;

- ii) more than two grades are earned from among, C, D, and U;
- iii) probation status has not been removed;
- iv) the grade point average falls below 2.5 at the end of any grading period;
- v) the student is found guilty of academic dishonesty according to existing regulations.

Incomplete grades (I) are not counted in the program average while they are on the student's record. However, after no more than two additional semesters, all requirements for such courses must be completed and a letter grade assigned. If this is not done, the I grade will **automatically** be changed to a U (unsatisfactory), which cannot be used to satisfy graduation requirements. The program average is not affected by grades received for thesis, dissertation and seminar.

The grade L is normally to be used for Thesis, Project, Dissertation or Departmental Seminar courses.

Graduate students are permitted to resign from a course without academic penalty if this is done prior to the last day for dropping a course without penalty. The student must resign officially by use of a Change of Registration slip which is available in the Student Response Center office. The student must consult with his advisor before returning the slip. Students who are required to keep full-time status must also receive approval of the Director of Graduate Studies prior to dropping a course.

It is important that the student resign officially from a course in the manner described, otherwise a grade of **F** will be recorded.

b) **Time limits for full-time degree students**

The time limit for the M.S. or M.Eng. degree is four years, measured from the first registration as a graduate degree student. For *part-time* students a time limit of six (6) years from the first registration in the graduate program may be permitted. At the end of four (4) years, a graduate student petition form must be submitted to request an extension beyond the fourth year. The limit for the Ph.D. degree is five years from the date of the first Ph.D. registration, and seven years from the date of first graduate registration. The time spent on an approved leave of absence is not included in these time limits.

Time limit extensions may be granted for adequate reasons by petition to the Executive Committee of the Graduate School. The petition must be forwarded with a recommendation from the Director of Graduate Studies. The extension of time limit is normally granted for a maximum period of one year.

c) **Other requirements**

Any general requirements of the Graduate School or SEAS (see <http://www.eng.buffalo.edu/policies.php>) must also be satisfied.

10. Masters Degree Programs

For Master of Science degrees in Mechanical Engineering or Aerospace Engineering the overall credit requirement is a minimum of 30 semester credit hours. Three options exist in each program: a six-credit

Thesis plus at least eight courses of three credits each; a three-credit Project plus at least nine courses of three credits each; or, the all-course option which consists of at least ten approved graduate courses of three credits each, plus a final comprehensive examination. Students receiving financial support (TA, RA or GA) through the department are **required** to do the Thesis option, except if they enter the Ph.D. program by passing the Ph.D. qualifying exam.

The Mechanical Engineering and Aerospace Engineering Master of Science program has no core course requirements. However, at least five courses of the student's program must be MAE courses. Aerospace Engineering Masters students are also required to select at least three courses from the Aerospace Engineering program courses listed in Sec. 20 at the end of this manual. Exceptions to this require the permission of the Department Chair or the Director of Graduate Studies.

Although the M.S. programs have no formal core course requirements, students specializing in: **Fluid and Thermal Sciences** are normally expected to take the two-semester sequence in both Fluid Mechanics (MAE 515, 516) and Heat Transfer (MAE 545, 546); students in **Mechanics and Materials** are encouraged to take Elasticity Theory (MAE 524), and at least one basic course in both Applied Mathematics and Advanced Materials Science; students in **Dynamics and Control** are encouraged to take Systems Analysis (MAE 571) and Vibration and Shock (MAE 567); and students in **Design** are encouraged to take Optimization in Engineering Design (MAE 550) and Computer Aided Design (MAE 577).

Subject to the foregoing requirements, graduate courses may be taken from other departments in Engineering or the School of Arts and Sciences (e.g. Physics, Chemistry, Geology, Biology, Mathematics, etc.).

Graduate courses from other Faculties, such as Health Sciences, for example, may also be taken. However, students should have the **explicit approval** of their academic advisor and the Director of Graduate Studies **before** taking such courses.

As described in Section 8, above, M.S. students may undertake a maximum of two informal courses under faculty supervision, each study counting a maximum of three credit hours. These courses **cannot** be applied to the Master of Engineering degree program. Also, as noted previously in Sec. 8, a maximum of two advanced undergraduate (400-level) courses may be taken for graduate credit for M.S. and Ph.D. degrees upon petition to and approval by the Graduate School at the time of registration. Failure to petition at the time of registration will result in no credit being granted.

Students who have previously completed graduate courses at other universities may, at the discretion of the department, receive transfer credit for a maximum of two three-credit-hour courses or six credit hours. The student should have received a grade of "B" or better to transfer the course(s).

- a) **Master of Science Degree with Thesis**: The minimum requirements consist of at least eight approved graduate courses (24 to 27 credit hours) and 3 to 6 credit hours of thesis registration, for a total of 30 credit hours. One semester before the degree is to be conferred, the student must submit an Application to Candidacy form. Informal courses listed in the Application to Candidacy must be accompanied by complete narrative descriptions signed by the instructors. The Application to Candidacy is then approved by the Director of Graduate Studies and submitted to the Graduate School for approval by the Executive Committee of the Graduate School.

The department must approve and notify the Graduate School in writing when major changes in the program, such as a change in Thesis title, are made.

The thesis may cover a variety of activities, including theoretical and experimental investigations, practical design projects, comprehensive reviews of engineering areas, and the like. The nature of these activities may vary greatly, but no essential difference should exist in equality and significance as a contribution to engineering. The thesis should be carefully prepared, and must be typed and bound as indicated below. Three people, qualified to render judgment in the area involved, constitute the thesis examination committee: the advisor plus two other faculty members. The candidate makes an oral presentation at which the examination committee is present in addition to other interested faculty and students. Advance notice of the oral defense must be sent to all department members at least one week prior to the presentation.

Following a successful oral defense, the examination committee certifies approval of the thesis by signing the Graduate School "M" form, and the advisor reports the thesis grade (if it needs to be changed).

The typing and detailed format and arrangement of the M.S. thesis as well as the hard-cover binding are to be the same as prescribed for the Ph.D. dissertation in Sec. 11. After final corrections have been made, the student submits **one** spiral-bound copy of the thesis to the department and usually at least one bound copy to the advisor. The student also submits the thesis electronically; see <http://www.grad.buffalo.edu/etd/> for details. Costs of thesis typing, copying, and binding are paid by the student. The department sends the signed "M" form to the Graduate School. **All materials must be in the Graduate School Office on or before the degree conferral deadlines established each year by the Graduate School.** (See Section 13).

- b) **Master of Science Degree with Project**: The minimum requirements consist of nine approved graduate courses (27 credit hours) and 3 credit hours of project registration (under MAE 560) for a total of 30 credit hours. One semester before the degree is to be conferred, the student must submit an Application to Candidacy form (see Section 13) which includes a summary of courses to be applied toward the degree. Informal courses listed in the Application to Candidacy must be accompanied by complete narrative descriptions signed by the instructor. The Application to Candidacy is then approved by the department Director of Graduate Studies and submitted to the Graduate School for approval by the Executive Committee of the Graduate School.

The project should be carefully prepared, and must be typed and bound as indicated below. Two people, qualified to render judgment in the area involved, constitute the project examination committee: the advisor plus one other faculty member. The candidate makes an oral presentation at which the examination committee is present in addition to other interested faculty and students. Advance notice of the oral defense must be sent to all department members at least one week prior to the presentation.

The requirements and procedures for the three-credit Project are as follows:

1. The Project must be done under the supervision or advisement of a Mechanical and Aerospace Engineering Department graduate faculty member, although it can be initiated by a student.

2. A typed report of substantial length is required, written to a satisfactory standard as judged by the faculty advisor, with one spiral-bound copy to be submitted to the MAE department (for retention). The detailed format and arrangement of the report should be the same as prescribed for the M.S. thesis.

Following a successful oral presentation, the advisor certifies approval of the project by signing the Graduate School "M" form.

- c) **All-Course Master of Science Degree with Comprehensive Examination**: The requirements of this option are at least ten approved graduate courses of three credits each, plus a final comprehensive examination. The general regulations and guidelines governing program course content are the same as for the M.S. Thesis and Project options.

The comprehensive exam for the All-Course option is an oral exam in the area of the student's specialization conducted by a committee of at least two faculty members of the department. Upon approval from the Director of Graduate Studies the student forms the examination committee, and arranges for notice of the exam to be sent to all faculty members of the department at least one week in advance. Any faculty member may attend the exam. The result of the exam is to be communicated by the examination committee to the Director of Graduate Studies.

- d) **Master of Engineering Degree**: Effective Fall 2006, no new students will be admitted to the M. Eng. program. It has been found that the MS degree offers sufficient flexibility for research-oriented and for generalist Master's degree students. Details for current M.Eng students can be found in Appendix at the end of this Graduate Manual.
- e) **Dual M.S. Degrees**: It is possible for a student to complete a program leading to two M.S. degrees, for example, the Mechanical Engineering and Aerospace Engineering degrees described, or one of those and a second degree from another engineering discipline and department. The guideline governing such a program is that the integrity of each degree must be observed. This will usually mean that a minimum of 24 semester hours of credit must be completed for each degree and that 6 semester hours may be applied to both programs. In some cases the curriculum will contain prescribed courses which are common to both programs. Such common courses may be counted for both degree programs. See also information on the Graduate School site at <http://www.grad.buffalo.edu/academics/combined.php>.
- f) **Deadlines**: In order that students receive their degrees when expected it is necessary that certain deadlines be met in their programs. See Sec. 13 below. It is the student's responsibility to be cognizant of these deadlines and ensure that they are met.

11. **Ph.D. Degree Programs**

The minimum requirements for both the Mechanical Engineering and the Aerospace Engineering Ph.D. programs consist of a minimum of 48 credit hours of graduate course work and 12-24 credit hours of dissertation work, for a total of 72 credit hours. A maximum of six credit hours of the 48 credit hour course requirement may be fulfilled by M.S. Thesis (six (6) credit hours) or M.S. Project (three (3) credit hours) completed at the University at Buffalo. Master of Engineering degree project work cannot be applied toward the 72 credit hour Ph.D. requirement. Transfer credit policy for students entering with an

M.S. degree from outside the Department was stated previously in Sec. 7. Effective Fall 2007, all PhD students must have taken the GRE tests.

Normally, at least three academic years of full-time graduate study, beyond the baccalaureate degree, are required to complete the Ph.D. degree requirements. The first two years usually emphasize formal course work, while subsequent years usually concentrate on completing the dissertation research. The selection of the program of courses and the student's dissertation research are under the supervision of a Ph.D. program committee chaired by the student's advisor. There is no foreign language requirement for the Ph.D. degree.

Ph.D. Program for Continuing Students

Students completing an M.S. program in the department who wish to proceed to a Ph.D. program in the department must first request approval to do so in a letter to the Director of Graduate Studies. This letter should summarize completely the student's graduate record (all courses and grades) and identify the Ph.D. dissertation advisor. A letter to the Director of Graduate Studies is also required from the student's M.S. Thesis or Project advisor giving an opinion as to the student's suitability for entering a Ph.D. program and discussing how the student will be funded. The student will be advised in writing as to whether he is admitted to the Ph.D. program and therefore eligible to take the Ph.D. qualifying examination. **Effective Fall 2007, all applicants to the PhD program must take the Graduate Record Exam (GRE), preferably before their application to the program. This requirement holds even if the applicant previously earned an M.S. degree or equivalent at UB or elsewhere and had not taken the GRE.**

Qualification for the Ph.D. programs is through a qualifying examination. Details of this examination, the Ph.D. program committee, and the final dissertation examination (oral defense by the student) are described below.

- a) **Qualifying Examination:** Each student desiring to become a Ph.D. candidate in the department must pass a Ph.D. qualifying examination. This exam is given only once yearly immediately before the beginning of the spring semester. Students should take the exam at their first opportunity to do so after having been accepted by the department into the Ph.D. program. Thus students entering with the M.S. degree completed should take the qualifying exam in the spring semester first following their entrance. Students who begin their graduate studies in the department without the M.S. degree should be admitted to the Ph.D. program and take the exam at the first opportunity to do so after completion of 24 credit hours of graduate courses.

The qualifying exam is organized and administered by an ad hoc examination committee of department faculty members appointed each year by the Department Chair. The committee consists of a chair, who has overall responsibility for the exam, and at least two faculty members for each area in which a specialty exam will be given.

The qualifying examination is the same for Mechanical Engineering and Aerospace Engineering students. It consists of three separate written exams from the following list, each of which may be followed by an oral exam. The written exams are typically about 2 hours each.

The areas of the exams are:

- Fluid Mechanics and Heat Transfer
- Thermodynamics
- Solid Mechanics

Mathematics
 Dynamics and Control
 Design and Optimization
 Materials
 Materials Science
 Bioengineering (bio-fluids, biomechanics, biomaterials)

The subject level of the exams may include undergraduate and introductory graduate level material. Students will be asked to declare their exam areas. Students are strongly advised to review the exam contents (courses, topics, references) provided below. All details involving the written and oral exams will be decided by the examination committee.

Following completion of the written and oral exams the examination committee reaches a decision as to whether each candidate has passed or failed overall. In the case of a failure, the committee decides whether or not the candidate should be permitted a second opportunity, which is limited to retaking the entire exam, both written and oral. Candidates who fail without being granted a second try, or those who fail twice, must necessarily be dropped from the program.

b) **Qualifying Examination Details:**

Fluid Mechanics and Heat Transfer: (rev. 7/1/04)

Suggested texts/chapters-

I Shames, "Mechanics of Fluids"
 I.G. Currie, "Fundamental Mechanics of Fluids", 2nd edition
 Incropera and Dewitt, "Fundamentals of Heat and Mass Transfer", Chapters 1-13
 S. Kakac and Y. Yener, "Heat Conduction", 3rd edition, 1993
 S. Kakac and Y. Yener, "Convective Heat Transfer", 2nd edition, 1995
 Alexander J. Smits, "A Physical Introduction to Fluid Mechanics"

Suggested courses-

MAE 335, MAE 336, MAE 515, MAE 516, MAE 545, MAE 546

Topics/subtopics-

Fluid Mechanics

-Fundamentals: flow kinematics, conservation equations
 -Ideal flow: basic theory, elementary solutions, superposition, complex potential
 -Viscous flow: Navier Stokes equations, exact solutions, low-Reynolds number flows, boundary layer flows
 -Compressible flow: shock waves, one dimensional flows
 -Turbulent flow: basic properties, transition

Heat Transfer

-Fundamentals: physical origins, rate equations, energy conservation, control volume analysis
 -Conduction: steady, transient, multidimensional, approximate techniques
 -Convection: natural, forced, laminar, turbulent, dimensionless groups, correlations
 -Radiation: blackbody, view factor, spectral intensity, properties, diffuse-gray enclosures
 -Phase change: latent heat, condensation, boiling, physics of various regimes

Thermodynamics: (rev. 10/2/02)(Currently being reviewed, 7/19/04)

Suggested texts/chapters-

Moran and Shapiro, "Fundamentals of Engineering Thermodynamics"

Van Wylen and Sonntag, "Fundamentals of Classical Thermodynamics"

Suggested courses-

EAS 204, MAE 431

Topics/subtopics-

-Energy forms: potential, kinetic and internal; energy transfer - work and heat, equivalence; properties of ideal gases - concept; equation of state; pressure, temperature, internal energy specific heat

-Energy conservation: first law for closed and open systems (control volume); enthalpy and flow work; unsteady and steady state

-First law for ideal gas-closed systems: constant T, p or v processes; adiabatic reversible processes; polytropic processes; Carnot cycle; open system steady flow processes; unsteady or transient flow processes

-Entropy and second law: definition of entropy; entropy change of ideal gases; isentropic processes of ideal gases; the TdS relations; irreversible effects and entropy production; statement of the second law of thermodynamics; availability

-Gas power and refrigeration systems

Solid Mechanics: (rev. 7/1/04)**Suggested texts/chapters-**

I. Shames, F. Cozzarelli, "Elastic and Inelastic Stress Analysis" (1992)

A.C. Ugural, S.K. Fenster, "Advanced Strength and Applied Elasticity" 2nd ed. (1995)

J.R. Vinson, The Behavior of Thin Walled Structures - Chapter 9 (1989).

THG Megson, Aircraft Structures, 3rd ed. (1999), Chaps. 1-4, 6, (9)

Suggested courses-

MAE 524, MAE 415

Topics/subtopics-

-Cartesian Tensors - operations; integral theorems; invariants

-Stress - transformation, equilibrium, traction (Cauchy)

-Strain - infinitesimal displacement gradient, rotation, and strain; compatibility (simply connected); transformation

-Hooke's Law - isotropic, anisotropic; relation of constants; engineering constants; thermal effects

-Yield surfaces (von Mises, Tresca)

-Boundary Value Problems - posing and solving basic problems (exact solutions)

-Structural Elements (approximate solutions) - Euler Bernoulli beam theory, plane strain/plane stress, buckling

-Energy Methods - Castigliano 2nd; virtual work; approximate (minimum potential energy) methods (Rayleigh-Ritz); derivation of differential equation and admissible boundary conditions from minimum potential energy

Mathematics: (rev. 9/17/02)**Suggested texts/chapters-**

R. Haberman, "Elementary Applied Partial Differential Equations" 2nd ed. (1994) Chapters 1-9, 11

C.R. Wylie, L.C. Barrett, "Advanced Engineering Mathematics" (1982) Chapters 7-10

Suggested courses-

MAE 428, MAE 507

Topics/subtopics-

- Ordinary differential equations (equivalent Math 242 or 306)
- Separation of variables and eigenfunction expansion methods
- Laplace and Fourier transform methods
- Sturm-Liouville systems - eigenvalues, applications, orthogonality, self-adjoint operators
- Inhomogeneous problems - homogeneous & inhomogeneous boundary conditions, Poisson equation
- Green's functions
- Method of Characteristics
- Bessel function

Dynamics and Control: (rev. 7/1/04)

Suggested texts/chapters-

C.M. Close and D.K. Frederick, "Modeling and Analysis of Dynamic Systems"

Thomas & Dahleh, "Theory of Vibration with Applications"

Ogata, "Modern Control Engineering"

C.-T. Chen, "Linear System Theory and Design"

A.G. Erdman and G.N. Sandor, "Mechanism Design: Analysis & Synthesis"

Suggested courses-

MAE 340, 443, 571, MAE 412

Topics/subtopics-

- Fundamentals - system modeling, ordinary differential equations: stability, step response, frequency domain analysis
- State Space - formulation, eigenvalues, transfer function matrix
- Control - PID, block diagrams, step response; stability, phase margin, gain margin
- Systems Theory - linear vector spaces, bases, similarity, Jordan Canonical Form, generalized eigenvectors
- Machines & Mechanisms - kinematic and dynamics of mechanisms, cams, gears

Design and Optimization: (rev. 9/10/02)

Suggested texts/chapters-

Anand, V.B., Computer Graphics and Geometric Modeling for Engineers (John Wiley 1993)

Vanderplaats, G., Numerical Optimization Techniques for Engineering Design: With Applications (McGraw-Hill 1984)

Bickford, W.B., A First Course in the Finite Element Method (Irwin 1994)

Suggested courses:

MAE 477/577, MAE 473/573, MAE 550

Topics/subtopics:

- Fundamentals of 2-D and 3-D Graphics: translations and rotations (including rotations about arbitrary axes), representation of solids, coordinate system transformations, viewing operations

(projection techniques, the eye coordinate system, vanishing points), curve and surface generation (Bezier and B-Spline approaches)

-Concepts of FEM: stiffness matrices for elements and systems, basics of variational approach, solution concepts for deflections, stress, etc., von Mises failure concepts

-Concepts for Optimal Design: problem formulation, conditions for unconstrained and constrained optimality, unconstrained methods (direct, first order, second order), constrained methods (sequentially unconstrained minimization techniques, methods dealing directly with constraints such as SLP, MOC, MFD, GRG, SQP, etc.), Optimum Sensitivity Analysis

Materials: (rev. 7/1/04)

Suggested texts/chapters-

W.D. Callister, Jr., "Materials Science and Engineering", Van Nostrand Reinhold, Materials Science for Engineers (1970), or other introductory to intermediate level texts

T.H. Courtney, "Mechanical Behavior of Materials"

References (advanced reading): R.E. Reed-Hill, R. Abbaschian, "Physical Metallurgy Principles", 3rd ed.

Suggested courses-

MAE 381, 485 (optional)

Topics/subtopics-

-Atomic/molecular structure and bonding of metals, ceramics, polymers, and composites; defects; diffusion

-Typical mechanical behavior of metals, ceramics, polymers and composites, including elastic, plastic, fracture and fracture toughness, creep and creep rupture, fatigue; the dependence of behavior on microstructure, defects, grains and grain boundaries, and bonding ("structure - property relations")

-Phase diagrams, phase transformations - equilibrium and non-equilibrium;

-Manufacturing processes including casting, forming, cutting & joining, heat treatments, surface modifications

-Strengthening mechanisms

-Corrosion

-Electronic properties (electrical, magnetic, optical)

-Thermal properties

Materials Science: (rev. 7/1/04)

Suggested texts/chapters-

R.E. Reed-Hill, R. Abbaschian, "Physical Metallurgy Principles", 3rd ed., Chaps. 4-13

D. Gaskell, "Introduction to the Thermodynamics of Materials", 3rd ed.

C. Barrett, T.B. Massalski, "Structure of Metals", 3rd ed., Chaps. 1-15, 22.

C. Kittel, Intro to Solid State Physics, 4th ed., Chaps. 1-3

R.T. DeHoff, Thermodynamics in Materials Science, Chaps. 1-5, 7-9.

Suggested courses-

MAE 581, 570, 589

Topics/subtopics-

-Ordered alloys; solid state diffusion; defects, dislocations, grain boundaries.

-Recovery, recrystallization, grain growth.

-Crystal structure, reciprocal lattice.

-State functions, process variables, thermodynamic potentials, Maxwell relations; equilibrium of thermal, mechanical, chemical systems; statistical thermodynamics; application to reacting and nonreacting unary, and binary systems, equilibrium & stability.

-Materials characterization methods including diffraction, spectroscopy, microscopy.

Bioengineering: (Students are expected to be knowledgeable in two of the three areas)(rev. 7/1/04)

1. BIOMATERIALS

Suggested text-

Handbook of Biomaterials Evaluation, Editor, Andreas von Recum, Macmillan, 1986 Edition preferred (copies available in UB Libraries and ON LOAN from Dr. R.E. Baier)

Suggested courses-

MAE514/BMA 520 Evaluation of Biomedical Materials

MAE 607/BMA 501 Biomaterials Science of Cell-Surface Phenomena

MAE 608/BMA 513 Polymeric Biomaterials

Topics-

Polymers, Absorbable and Nonabsorbable Sutures, Surface Analysis, Corrosion and Biodegradation, Reference Materials, In-Use Testing of Biomaterials in Biomedical Devices, Hemocompatibility Assessment, Preclinical Testing Evaluation of Biomaterials

2. CARDIOVASCULAR AND CEREBROVASCULAR BIOMECHANICS

Suggested texts-

Y.C. Fung, 1984, Biodynamics Circulation.

Y.C. Fung, 1981, Biomechanics Mechanical Properties of Living Tissues.

D.O. Cooney, 1976 biomedical Engineering Principles, An Introduction to Fluid, Heat, and Mass Transport Processes, Vol. 2.

W.R. Milnor, 1989. Hemodynamics, 2nd Ed.

K.B. Chandran, 1992. Cardiovascular Biomechanics

Suggested courses-

MAE 478/578, [Cardiovascular Biomechanics](#)

MAE 579, [Cerebrovascular Hemodynamics](#)

Topics-

Cardiac physiology, Rheology of blood, Blood flow in the heart and circulation, [Physical principles of circulation](#), [Mechanical properties of blood vessel](#), [Steady and unsteady flow models](#), [Hemodynamic effects on cardiovascular pathology](#).

3. MUSCULOSKELETAL BIOMECHANICS

Suggested texts-

Mow & Hayes, 1997, Basic Orthopaedic Biomechanics OR

Nordin & Frankel, Basic Biomechanics of the Musculoskeletal System, 3rd ed. AND

Hollinshead & Jenkins, 1999, Functional Anatomy of the Limbs and Back (Overview)

Burstein & Wright, 1994, Fundamentals of Orthopaedic Biomechanics

Suggested courses-

MAE 420/520, [Biomechanics of the Musculoskeletal System](#)

MAE 417/517, [Applied Orthopaedic Biomechanics](#)

Topics-

Musculoskeletal anatomy, Joint forces, kinematics of joints, Gait analysis, Dynamics of simple motions, Stresses and strains in bone and soft tissue, Implant materials, Structure and function of cortical and cancellous bone, Electrical phenomena and mechanical adaptation.

- c) **Program Details:** After successful completion of the qualifying examination, a Ph.D. program committee is formed consisting of three members and chaired by the dissertation advisor. The selection of the program committee members is primarily the responsibility of the candidates and their dissertation advisors.

The student shall prepare a presentation to his/her program committee which will include a literature review, research plan, and any preliminary results. This presentation will be given within 6 months after the student successfully passes the Qualifying Exam or within 2 years of being admitted to the Ph.D. program, whichever comes first. The committee will offer written and/or oral comments on the presentation.

The Ph.D. program committee has formal responsibility for the program and guidance of the candidate. During the course of the student's program, one or more progress evaluations should be carried out by the program committee. In the progress evaluation the candidate's course performance will be considered as well as progress made on the candidate's dissertation research. If the committee finds the candidate's progress unsatisfactory, it may recommend corrective action. If the candidate's progress continues to be unsatisfactory, the committee may recommend withdrawal from the University to the Department Chair.

Within one year of passing the qualifying examination, before the completion of eight semesters of graduate study (beyond the B.S.) and no fewer than two semesters (see Section 13) before the degree conferral date, the student's Ph.D. program must be approved by the program committee and submitted to the department for approval by the Director of Graduate Studies. The student's Application to Candidacy must include the dissertation title, a 300-400 word dissertation proposal abstract, evidence of full-time residency for at least two semesters, and itemization of at least 72 semester hours beyond the baccalaureate. Courses for transfer credit must be indicated as such on the Application for Candidacy. The approved program is then filed for approval by the Executive Committee of the Graduate School. Approval by the Executive Committee constitutes admission to candidacy. The student notifies the Graduate School by petition when minor changes in the program, such as changes in the dissertation title, or deletion/addition of one or two courses, occur. Major changes in the program, such as research abstract revision, adding or deleting more than two courses or change in major advisor require a petition to be filed through the department graduate office.

- d) **Dissertation:** Each Ph.D. student is required to complete an original dissertation and orally defend his work before the program committee and any other interested parties. Upon completion of the dissertation a draft is submitted to the advisor for comments, corrections, and approval. Graduate School approval of the selection of an outside reader must be obtained before a copy is provided to the outside reader for review. Upon the advisor's approval the student submits copies of the dissertation to the remaining two members of the program committee for their approval and also submits one copy to the outside reader for his/her approval. The outside reader (outside of the department) is selected by the student and his advisor. The outside reader is required to submit his/her approval in writing to the Dean of the Graduate School.

The oral defense consists of a presentation during which the candidates outline the highlights of their work, followed by questions from the program committee or any other interested persons present. Following a successful dissertation defense, the program committee certifies approval of the dissertation by signing the Graduate School M form. The M form must be signed by the Director of Graduate Studies or the Department Chair before being forwarded to the Graduate School.

After the student has made final corrections to the dissertation, the student submits **one** spiral-bound copy to the department and usually at least one bound copy to the advisor. . In addition, the dissertation is submitted electronically; see <http://www.grad.buffalo.edu/etd/> for details. This must be done prior to your designated conferral date. **All materials must be in the Graduate School office on or before the degree conferral deadlines established each year by the Graduate School; see <http://www.grad.buffalo.edu/deadlines> for details.**

The typing and arrangement of Ph.D. dissertations and M.S. theses must meet the requirements of the Graduate School. The Graduate School will accept any self-consistent format which follows the conventions of a recognized discipline. Uniformity is desirable and will be required in the following details:

Pagination: Pages should be numbered consecutively, including not only the principal text but also all plates, tables, figures, etc.

Typing and reproduction: The original of the dissertation must be laser printed, double-spaced, on 8-1/2" x 11", 20-lb. plain white (unlined in any way) bond paper. To allow for binding, the left hand margin must be 1-1/2". Other margins should be 1". Diagrams, photographs, or facsimiles in any form should be a standard page size, or, if large, folded so that a free left-hand margin of 1-1/2" remains and the folded sheet is not larger than the standard page.

The dissertation must conform to permanent record standards. The document submitted to the Graduate School can be either the original or a high quality photocopy. ***Please note: it is illegal to duplicate the University logo/emblem, and therefore, it should not appear anywhere in your body of work.***

The format of the title page (the first page) should be according to the Graduate School web page: <http://www.grad.buffalo.edu/etd/etdguide.pdf> , p.6.

The dissertation must contain an Abstract, not to exceed 600 words, and a complete table of contents. Bound copies should be bound in hard boards covered with black imitation leather. The title and author's name should be imprinted on the front in gold. The author's last name, his degree, and the year of conferral of the degree should be imprinted on the spine in gold. The department can provide names of local companies which do satisfactory and economical binding.

Since theses and dissertations represent the joint effort of students and their advisors (if not also other members of the faculty), the student should make no arrangements for publication without consulting his/her advisor. Electronic submission of Ph.D. dissertations ,as required by the Graduate School, does not preclude publication by other methods later.

It should be noted that the primary responsibility for the quality of the presentation, organization, grammar and readability of the dissertation, thesis or project lies with the student. Extra effort and

outside editorial assistance may be required when the student does not write fluently in the English language.

- e) **Deadlines**: In order that students receive their degrees when expected, it is necessary that certain deadlines be met in their programs. A summary of these deadlines is given in Sec. 13.

12. Seminar Requirement

All full-time students should register for, and attend, the departmental seminar series (MAE 503-504). In cases where courses or formal assignments preclude regular attendance at the seminar, students may be excused. It is suggested that full-time M.S. and M.Eng. students sign up for two semesters of seminar during their degree programs and that Ph.D. students take an additional two semesters. All students are encouraged to attend seminars, whether registered or not.

13. Paperwork Deadlines for M.S., M.Eng. or Ph.D. Conferral

Degree conferral deadlines are available at <http://www.grad.buffalo.edu/deadlines> and are subject to change. Check at least three months before expected conferral. Allow time for internal processing.

- * **IMPORTANT NOTE ON APPLICATION TO CANDIDACY FORM**: In order to be in compliance with tuition verification policies of the University and other requirements, all full-time students should submit their Application to Candidacy forms before the end of the second semester of full-time graduate study in the case of M.S. and M.Eng. students and before the end of the sixth semester (beyond the B.S. degree) in the case of the Ph.D. students. Students transferring to the University with an M.S. degree should submit the Application to Candidacy form no later than the end of the fourth semester of full-time study for the Ph.D.

It is the **responsibility of the student** to check with the Graduate School prior to the various deadline dates to be sure that all the requirements and paperwork for the degree have been completed.

14. Financial Assistance and Tuition Scholarships

On application for admission to graduate studies each student who so indicates is considered for financial aid. There are three main forms of financial support: Teaching or Graduate Assistantships, provided by state funds for lines allotted to the department, Research Assistantships provided by research grants held by individual faculty members, and Graduate Fellowships provided by state funds administered by the Graduate School. Potential new graduate students applying for admission are mainly eligible for Teaching Assistantships on which the decisions are made by the Graduate Studies Committee of the department. The general policy of the department is to limit Teaching Assistantship support to two semesters in most cases. Ph.D. students are eligible for support beyond the first two semesters; however the bulk of the support of Ph.D. students is expected to be provided by Research Assistantships and

Graduate Fellowships. The University has imposed a two-year limit on support of Masters students on a state line; the limit for Ph.D. students is four years.

The duties of Teaching Assistants, which are assigned by the Department Chair, typically require 15 hours per week and consist of conducting undergraduate laboratories or assisting faculty in recitations or the grading of problems. The stipend and duties of Research Assistants are decided by the Principal Investigator or grant holder; the stipend is subject to the same maximum limitation as Teaching Assistantships. Usually the work of Research Assistants contributes directly to their thesis study or at least is closely related. Graduate or University Fellowships are awarded annually, to new students, by the Graduate School on a University-wide competitive basis. The department proposes several of its most promising candidates for these Fellowships every February when applications are solicited by the Graduate School.

Assistantships and fellowships normally include a full or partial tuition scholarship. However, the University has imposed a four semester limit on tuition scholarships for all Masters students and an eight semester limit (beyond the B.S. degree) for Ph.D. students. Extensions of these limits are approved only by petition. For master's students, it is unusual for the time limit to be extended. For PhD students, no tuition scholarship or remission will be awarded beyond the tenth semester of graduate study. . Tuition Scholarship credit hours will generally be limited only to those credits required for the degree (M.S. or Ph.D.) being pursued. Continuing students who are eligible for tuition scholarships must complete and submit the necessary forms by the end of May each year for the Fall semester. Entering students should submit tuition scholarship verification forms before the end of the first week of classes. For exact due dates for these forms please go to <http://src.buffalo.edu/office/officeforms/graduatetuitionsscholarship.shtml> . In cases of late appointments, tuition scholarship forms may be filed until the middle of the **second week of classes each semester.** **Failure to do this could result in the loss of the tuition scholarship regardless of the initial appointment terms.** Students should also note that **tuition scholarships are not granted for courses or thesis/dissertation work undertaken during the summer months.** It is therefore necessary that all graduate students register for adequate thesis or project credit during the fall and/or spring semesters in order that tuition scholarships are received for such study. This should be done even though most of the thesis or project work might actually be delayed until a later period. Registration for up to 19 credit hours per semester is permitted without petition.

Supported students in the Ph.D. program must take the Ph.D. qualifying exam, at the first opportunity as described in Sec. 11. Failure to observe these requirements may result in the termination of financial support.

In the department's view the main purpose of assistantship or fellowship support is to assist the student to complete the objectives and requirements of a degree program. It is mutually advantageous for the student to complete his program in the shortest period of time consistent with high academic performance. All assistantship appointments are subject to continuous departmental review and require satisfactory progress towards the program objectives as well as satisfactory performance of any assigned assistantship duties.

The granting of a teaching assistantship to a continuing student first requires a nomination by the student's faculty advisor. Students are not permitted to nominate themselves.

Teaching and research assistants, as well as Fellows, are expected to pursue their programs vigorously and as a continuing full-time commitment. During the various recesses and periods without classes which

occur in the 10-month academic year (September through June) all Teaching and Research Assistants are expected to be present and actively engaged in thesis, project work, or assigned duties. Leaves of absence for time away from the campus must have the prior approval of the student's advisor.

Unfortunately, the department does not have sufficient financial resources to assist all students deserving of support. In fact, only a fraction can be supported. For this reason students should consult the websites including (grad) to search for competitive awards available from sources outside the department or outside the University.

15. Information for International Students

The foreign graduate student should contact the *International Student and Scholar Services Office* (<http://wings.buffalo.edu/intlservices/>) immediately upon arrival on campus and should keep in touch with that office during their entire stay at the University. The office assists international students seeking general information concerning the University and its many educational programs, and also coordinates the various services generally needed by international students such as admission, housing, counseling, health services, TOEFL testing and placement. It arranges for reception and orientation of international students and faculty members and cooperates with other university offices to provide necessary counseling, financial aid, and special programming. It is also responsible for relations with Bureau of Citizenship & Immigration Services, Internal Revenue Service, and other governmental and private agencies and community groups concerned with international student exchange.

As previously mentioned, foreign students on visa status must register for a full-time program of at least 12 credit hours each semester whether or not they are receiving financial support. (See also the Student Status Section 4).

16. Student Services

All supported students are assigned desk locations by the Department Chair during the first week of each semester. Use of duplication equipment, laboratory space, computers, technician services, etc., must be arranged on an individual basis through the advisor with approval by the Department Chair. Departmental funds are not available for student travel.

17. Grievance Procedure

In the event a student has a grievance with respect to department matters associated with the graduate program, the student should discuss this matter with his/her advisor. If a satisfactory solution cannot be reached at this level or if the student does not have an advisor, the grievance should be brought to the Department Chair. Again, if a satisfactory solution cannot be achieved at this level, the Department Chair will convene a special Grievance Committee which includes department faculty and graduate students. If the committee and the Department Chair together cannot resolve the grievance it will be referred to the Divisional Committee of the Graduate School and the chair of that committee will decide whether a new faculty-wide committee should be convened to investigate the grievance. At this point, the grievance procedure is no longer within the jurisdiction of the department.

18. Student Membership in ASME and AIAA

All full-time graduate students are eligible for student membership in the Buffalo Student Chapters of the American Society of Mechanical Engineers and/or the American Institute of Aeronautics and Astronautics. In addition, graduate students, regardless of society memberships, are eligible to compete in student paper competitions sponsored by the ASME and the AIAA. The ASME award is sponsored by the Mechanical Engineering Department Heads Committee and requires endorsement by the Department Chair. Information on these items is available from the respective student chapter presidents, and the faculty advisors for the student chapters.

19. Graduate Representative

A representative of the full-time Mechanical and Aerospace Engineering graduate students is invited to attend departmental faculty meetings, except during deliberations on personnel cases. This representative has partial voting privileges and should be elected during the fall semester of each year at a meeting of the full-time graduate students. Normally the representative is a department assistant or fellow.

20. Aerospace Engineering Program Courses

MAE 519 Turbulent Flow
MAE 523 Theory of Turbomachinery
MAE 529 Finite Element Structural Analysis
MAE 534 Combustion
MAE 542 Engineering Applications of Computational Fluid Dynamics
MAE 572 Guidance, Navigation & Control
MAE 582 Intro to Composite Materials
MAE 672 Optimal Control Systems
MAE 674 Optimal Estimation Methods

The above list of courses was last reviewed in August 2005. In addition to the requirement that Aerospace Engineering Masters students select at least three courses from this list, basic courses have been recommended in Section 10 in accordance with the chosen area of concentration.

21. Deadlines and Rules

It is the responsibility of the student to meet all deadlines specified by the Department and by the Graduate School. Students should consult the **Graduate School Policies and Procedures** (<http://www.grad.buffalo.edu/docs/polpro.pdf>) and the **Graduate Newsletter** published each Fall and Spring semester as a supplement to **The Reporter**, for the most up-to-date information on these matters.

Appendix—The Master’s of Engineering program

The Master of Engineering Program in Mechanical and Aerospace Engineering provides graduate study beyond the baccalaureate degree for those with initial degrees in appropriate areas as approved by the Director of Graduate Studies. It is intended to provide an emphasis on applications and design in contrast to the research emphasis of the Master of Science program. The program is intended to be completed within one year for full-time students, although that time period may be extended under exceptional circumstances. In general, the M.Eng. degree is not research oriented and does not lead to entry into the Ph.D. program.

This program emphasizes computer-based design and analysis methods. The student will choose three Core courses which emphasize computation methods and design, three Fundamental Courses, and two Program Electives. The program is intended to be flexible; students can petition the Director of Graduate Studies to substitute other courses dealing with practical applications in Mechanical and Aerospace Engineering or in other Departments. The student is thus free to construct a program consisting of courses consistent with the program requirements.

The Master of Engineering Program requires a total of 30 credit hours, which consists of a minimum of 24 credit hours of approved graduate level courses and 6 hours of Engineering Project (MAE 591). In addition, any general requirement of the Graduate School or the SEAS must be met.

Before completion of their first three graduate courses, Master of Engineering degree candidates, in collaboration with their academic advisor, should submit a proposed program of coursework to the Director of Graduate Studies for his approval. Other procedural and reporting requirements for the degree are identical to those for the Master of Science Degree with project, described previously.

| | Core courses | Fundamental courses |
|----------------------------|---|---|
| Fluid/Thermal | MAE 542 Engineering Applications of Computational Fluid Dynamics MAE 539 Heating, Ventilation and Air-Conditioning | MAE 515 Fluid Mechanics 1 MAE 531 Advanced Thermodynamics-Materials Science MAE 545 Heat Transfer 1 |
| Mechanics/Materials | MAE 582 Introduction to Composite Materials MAE 583 Mechanics and Design Using Composite Materials MAE 608 Polymeric Biomaterials | MAE 514 Evaluation of Biomedical Materials MAE 524 Elasticity MAE 531 Advanced Thermodynamics-Materials Science MAE 581 Advanced Materials Science |
| Systems/Design | MAE 574 Virtual Reality Applications | MAE 550 Optimization in Engineering |

| | | |
|--|---|---|
| | MAE 577 Computer-Aided Design Applications MAE 529 Finite Element Structural Analysis MAE 561 Stability and Vibrations of Lumped Parameter Systems MAE 567 Vibration and Shock I | Design MAE 571 Systems Analysis 1 MAE 543 Continuous control MAE 572 Guidance Navigation and Control |
|--|---|---|

| | | |
|-------------|---|--|
| | Program Electives | |
| SEAS | EAS 580 Technical Writing EAS 583 Engr. Procedure Writing EAS 521 Principles of Engineering Management I EAS 522 Principles of Engineering Management II | |