

Graduate Manual

Department of Mechanical and Aerospace Engineering
State University of New York at Buffalo
School of Engineering and Applied Sciences

Revised: August 26, 2016

Contents

1	General Academic Information	3
1.1	Admission Requirements	3
1.2	Student Classifications	3
1.3	Application Dates for Admission	4
1.4	Student Status	4
1.5	Advisement	5
1.6	Academic Grievances	6
1.7	Academic Integrity	6
1.8	Registration	7
1.9	Paperwork Deadlines for M.S. and Ph.D. Conferral	8
1.10	Transfer Credit	9
1.11	Graduate Credit	9
1.11.1	Informal Courses	10
1.11.2	Distance Learning for Part-time Students	10
1.11.3	Distance Learning for Full-time Students	10
1.11.4	Graduate Credit from Undergraduate Courses	10
1.11.5	Other	10
1.12	Scholastic Requirements (General)	11
1.13	Financial Assistance and Tuition Scholarships	12
1.14	Seminar Requirement	14
2	Masters Program Information	15
2.1	Master Degree Programs	16
2.1.1	Dual M.S. Degrees	18
2.1.2	Deadlines	18
3	Doctoral Program Information	19
3.1	Students Entering Ph.D. Program With M.S. degree	19
3.2	Students Entering Ph.D. Program Without M.S. degree	20

3.3	Ph.D. Program for Continuing Students	20
3.4	Qualifying Examination	20
3.4.1	Qualifying Exam Format	21
3.4.2	Summary of Qualifier Procedure	25
3.5	Other requirements	25
3.6	Dissertation	27
Appendix A Forms		29
Appendix B Regularly Offered Courses		30
B.1	Design and Optimization (Track 1)	30
B.2	Dynamics, Control and Mechatronics (Track 2)	31
B.3	Fluid and Thermal Sciences (Track 3)	32
B.4	Materials and Mechanics (Track 4)	33

Chapter 1

General Academic Information

The department offers separate programs in Mechanical and Aerospace Engineering. In each program, the Master of Science, M.S., 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.

1.1 Admission Requirements

The Department of Mechanical and Aerospace Engineering offers Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees. A B.S. in Mechanical or Aerospace Engineering, or the equivalent, with a quality point average of at least 3.0/4.0, is normally required for admission to all programs. Prospective students may apply for either the M.S. or the Ph.D. program. Students with B.S. degree (i.e., without a M.S. degree) can apply for Ph.D. program directly or may choose to first obtain M.S. degree and then enter the Ph.D. program. Students who complete UB's M.S. program and wish to continue for Ph.D. must re-apply for admission to the Ph.D. program.

All Ph.D. students are required to have GRE's taken before admission to the program. All M.S. students who have not obtained an undergraduate degree in the United States are also required to have GRE's taken before admission to the program.

1.2 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: A student who has enrolled but is not yet accepted into the academic program.
- d) Conditional Admission: Students admitted on a conditional 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. 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.
- e) Provisional Admission: Students admitted on a provisional basis must complete certain requirements before being allowed to enroll in MAE.

Graduate credit earned (4 courses or 12 credits) 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. An online application must be completed and an application fee is required. An official transcript must be supplied.

1.3 Application Dates for Admission

These dates can be found at <http://www.mae.buffalo.edu/admissions/graduate.php>.

1.4 Student Status

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

Students who are within 12 credit hours of fulfilling their Masters or Ph.D. degree requirements (9 credit hours in the case of RAs, TAs and GAs) should submit the Certification of Full-Time Status Form to the Graduate School for full-time status if registering for fewer than 12 (9 for RAs, GA and TAs) credits. All supported students and all foreign students falling into this category must file the petition. Note that an ATC form 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.

1.5 Advisement

- a) Initial Advisement and Registration: Students enrolling for graduate study for the first time should report to the Department office in 210 Bell Hall at least one week prior to the first day of classes. International students registering for the first time should report to the Office of International Education in Talbert Hall for assistance on housing, visa status, and orientation before coming to the department office.

Each student is assigned a preliminary advisor upon admission. The preliminary advisor will: (1) work with the student to decide course work that should be taken during the first year of graduate study; (2) help with any general questions a student may have about the program, opportunities for research, or funding; and (3) help the student find an academic advisor for their MS thesis or Ph.D. dissertation. The academic advisor may or may not be the same person as the preliminary advisor. The preliminary advisor also might be of assistance to provide counsel in non-curricular matters, such as health, housing, deficiencies in English comprehension, speaking or writing.

All incoming students must attend the department's orientation where they will be introduced to their preliminary advisor. This orientation typically is held the week before Fall Semester classes start. After consultation with their preliminary advisors, new students will register for their first semester's classes.

- b) Academic Advisor: As early as possible in their first semester students should meet with MAE department faculty members to find a common area of research or technical interest with the purpose of deciding a preference for a thesis/dissertation topic and advisor. Upon 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 academic advisor, student should consult with their preliminary advisor for any advisement concerning their study.

Students should discuss regularly with their advisors, who must approve all course selections as well as provide thesis or project supervision. In unusual circumstances, students may change advisors only with permission of the Director of Graduate Studies.

- c) Advisement by Non-MAE faculty: Non-MAE faculty can serve as a co-advisor or as project, thesis, and dissertation committee members, provided they have a Graduate

School appointment. If appropriate to the research effort, additional members beyond the minimum number may be added.

1.6 Academic Grievances

All academic grievances should first be brought to the attention of the current Director of Graduate Studies. If the grievance is with the Director of Graduate Studies, the issue should be brought to the attention of the MAE Chair.

A listing of policies and procedures regarding of academic grievances can be found at the following website: <https://www.grad.buffalo.edu/study/progress/policies.html>.

1.7 Academic Integrity

Academic integrity is a fundamental university value. Through the honest completion of academic work, students sustain the integrity of the university while facilitating the university's imperative for the transmission of knowledge and culture based upon the generation of new and innovative ideas. When an instance of suspected or alleged academic dishonesty by a student arises, it shall be resolved according to the procedures set by the Graduate School. These procedures assume that many questions of academic dishonesty will be resolved through consultative resolution between the student and the instructor. It is recommended that the instructor and student each consult with the department chair, School or College dean, or the Graduate School if there are any questions regarding these procedures.

Examples of academic dishonesty include:

1. Previously submitted work. Submitting academically required material that has been previously submitted – in whole or in substantial part – in another course, without prior and expressed consent of the instructor.
2. Plagiarism. Copying or receiving material from any source and submitting that material as one's own, without acknowledging and citing the particular debts to the source (quotations, paraphrases, basic ideas), or in any other manner representing the work of another as one's own.
3. Cheating. Soliciting and/or receiving information from, or providing information to, another student or any other unauthorized source (including electronic sources such as cellular phones and PDAs), with the intent to deceive while completing an examination or individual assignment.
4. Falsification of academic materials. Fabricating laboratory materials, notes, reports, or any forms of computer data; forging an instructor's name or initials; resubmitting

an examination or assignment for reevaluation which has been altered without the instructor's authorization; or submitting a report, paper, materials, computer data, or examination (or any considerable part thereof) prepared by any person other than the student responsible for the assignment.

5. Misrepresentation of documents. Forgery, alteration, or misuse of any University or Official document, record, or instrument of identification.
6. Confidential academic materials. Procurement, distribution or acceptance of examinations or laboratory results without prior and expressed consent of the instructor.
7. Selling academic assignments. No person shall sell or offer for sale to any person enrolled at the University at Buffalo any academic assignment, or any inappropriate assistance in the preparation, research, or writing of any assignment, which the seller knows, or has reason to believe, is intended for submission in fulfillment of any course or academic program requirement.
8. Purchasing academic assignments. No person shall purchase an academic assignment intended for submission in fulfillment of any course or academic program requirement.

Complete policies and procedures regarding academic integrity issues can be found at the following website: <https://www.grad.buffalo.edu/study/progress/policies.html>.

1.8 Registration

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

Normally, a minimum registration period of one year on a full-time equivalent basis is expected for the M.S. degree, and two years on a similar basis is expected 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.

It is important for all international students to maintain full-time status during their entire graduate study at the University at Buffalo. As per immigration regulations, international students must maintain full time status.

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 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 TAs, GAs or RAs, and for all international students), the Certification of Full-Time Status form should also be completed.

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.

1.9 Paperwork Deadlines for M.S. and Ph.D. Conferral

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://grad.buffalo.edu/Academics/Policies-Procedures.html>) 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.

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

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.

IMPORTANT NOTE ON APPLICATION TO CANDIDACY (ATC) FORM: To be in compliance with University policies all full-time students must submit their ATC forms at least one semester before the degree is to be conferred. Students in the M.S. program should submit their ATC form in their second semester of full time study. Students in the Ph.D. program should submit their ATC form as soon as possible after passing the Ph.D. qualifier exam but no later than the fourth semester of full-time study.

1.10 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/her advisor before the end of the first semester in the program. When the student’s Application to Candidacy is submitted, it must list the credits to be transferred.

For the M.S. 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 transfer up to 30 total credit hours of previous graduate course work. Previous project or thesis work may not be transferred.

- b) From another Department within UB: Graduate work done in another department within UB may be offered in partial fulfillment of the degree requirements if the work is of acceptable quality and appropriate to the student’s program and to the satisfaction of the advisor.

1.11 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’s 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. A form for this purpose is available with the department office of graduate studies.

1.11.1 Informal Courses

Informal courses usually include Individual Problems, Special Topics courses, and Graduate Internship, 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, and should be submitted to the MAE graduate secretary during registration time (the beginning of the semester).

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

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

1.11.2 Distance Learning for Part-time Students

Part-time students can take 4 courses through distance learning (e.g. EngiNet).

1.11.3 Distance Learning for Full-time Students

Full time Domestic Students can take 2 courses through distance learning (e.g. EngiNet). Full time International Students can take 1 course through distance learning. In such a case, both domestic and international students must discuss this with their advisor and the Director of Graduate Studies. International students must also contact ISSS.

1.11.4 Graduate Credit from Undergraduate Courses

Students wishing to use an undergraduate course for graduate credit must submit a petition form 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 2 advanced undergraduate courses at the 400 level. This maximum limit applies to the entire M.S. or Ph.D. degree program.

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

1.11.5 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.

1.12 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 which is applied toward the degree credit requirements will be included in the computation of the student’s 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) multiple semesters with a GPA lower than 3.0 occur;
- vi) 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/her 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. degree is four years, measured from the first registration as a graduate degree student. For part-time students a time limit of 6 years from the first registration in the graduate program may be permitted. At the end of 4 years, a graduate student petition form must be submitted to request an extension beyond the fourth year.

For students entering the Ph.D. program with a M.S. degree the limit is five years from the date of the first Ph.D. registration and seven years from the date of first graduate registration. For students entering the Ph.D. program with a B.S. degree the limit is seven years from the date of the first Ph.D. 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 must also be satisfied. See <http://grad.buffalo.edu/Academics/Policies-Procedures.html>

1.13 Financial Assistance and Tuition Scholarships

All students are automatically considered for financial aid upon application for admission to graduate studies. There are three main types 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. In addition to Research Assistantships, potential new graduate students applying for admission are also eligible for Teaching Assistantships on which the decisions are made by the Graduate Studies Committee of the department. For TAs, the general policy of the department is to limit them to two semesters. Ph.D. students as TAs are eligible for support beyond the first

two semesters; however the expectation is that the bulk of the support of Ph.D. students is to be provided by Research Assistantships and Graduate Fellowships based on satisfactory performance. The University has imposed a two-year limit on support (TA and GA) of Masters students on a state line; the limit for Ph.D. students is four years.

The duties of TAs, 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 RAs are decided by the Principal Investigator or grant holder. Usually the work of RAs 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 Masters students, it is unusual for the time limit to be extended. For Ph.D. 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 before the beginning of the Fall semester each year.

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

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. 3.4 and complete the annual review form every year. 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 in completing the objectives and requirements of the degree program. It is mutually advantageous for the student to complete his/her 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 following websites:

- a) <http://gse.buffalo.edu/lis/scholarships>
- b) <http://fellowships.buffalo.edu/>
- c) http://www.mae.buffalo.edu/graduate/graduate_scholarships.php

Students are also encouraged to search for competitive awards available from sources outside the department or outside the University.

1.14 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. Students who enter the M.S. program are required to register for two semesters of seminar during their M.S. degree program. Students who enter the Ph.D. program with a M.S. degree are required to register for two semesters of seminar while those entering with a B.S. degree are required to register for four semester of seminar during their Ph.D. program. All students are encouraged to attend seminars, whether registered or not.

Chapter 2

Masters Program Information

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 and do a dissertation.

The Mechanical Engineering and Aerospace Engineering Master of Science program requires that at least 21 credits, including research credits, be from within the MAE department. All MAE classes have been split into four main specialization tracks:

- Design and Optimization (DO)
- Dynamics, Control & Mechatronics (DCM)
- Fluid and Thermal Sciences (FTS)
- Materials and Mechanics (M&M)

Appendix B provide a list of classes in each area and a full list of currently offered classes can be found at the following link:

http://www.mae.buffalo.edu/graduate/course_descriptions.php

The remaining 9 credits (3 courses) must be taken from MAE, another engineering department, or hard-science department such as Chemistry, Physics, Mathematics, Geology, MDI, or Biology. Requests to use credits from any other department must be made to the Graduate Director before the semester in which that course will be taken.

It is suggested that students should take 9 MAE credits from three of the four different tracks to broaden his/her knowledge in the general area of MAE. The remaining 12 MAE credits will be free electives and can be chosen among any combination of tracks. However, students are advised to take these 12 credits among one particular track to get specialization in one particular area. For example, a student could take 5 courses within Materials and Mechanics to get specialization in M&M and can take one course in FTS and one course in DO to broaden his/her knowledge scope in MAE. Students are not required to declare their specialization track.

2.1 Master Degree Programs

There are three Master Degree programs available to students:

- 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. The student must submit an application to the candidacy form one semester before the degree is to be conferred and no later than the second semester of full-time graduate study. One semester before the degree is to be conferred, the student must submit an Application to Candidacy form. Informal courses (Sec. 1.11) 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, 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 as indicated below. Three people, qualified to render judgment in the area involved, constitute the thesis examination committee: the advisor plus two other graduate faculty members. Non-MAE faculty can serve as a co-advisor or committee members, provided they have a Graduate School appointment. 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. Any changes in the thesis examination committee should be approved by the graduate committee.

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 are to be the same as prescribed for the Ph.D. dissertation in Sec. 3.6. After final corrections have been made, the student must submit the thesis electronically to the graduate school; see <http://www.grad.buffalo.edu/etd/> for details. 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.

- 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, 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 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. Non-MAE faculty can serve as committee member, provided they have a Graduate School appointment. 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:

- i) 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.
- ii) A typed report of substantial length is required, written to a satisfactory standard as judged by the faculty advisor. An electronic copy of the report must be submitted to the MAE graduate office (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. The comprehensive examination is designed to evaluate the student's mastery of their program of study and their ability to integrate knowledge acquired through their program. The comprehensive examination date will be established by the Director of Graduate Studies and will be held within one week of the conclusion of each semester. The result of the exam is to be communicated by the examination committee to the Director of Graduate Studies.

2.1.1 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://grad.buffalo.edu/Academics/Policies-Procedures/General-Graduate-Degree-Requirements.html#dual-list>.

2.1.2 Deadlines

In order that students receive their degrees when expected it is necessary that certain deadlines be met in their programs. It is the student's responsibility to be cognizant of these deadlines and ensure that they are met. See <http://grad.buffalo.edu/Academics/Academic-Deadlines.html> for more details.

A summary of different requirements for each Master's degree are shown in the following Table.

M.S. Degree Option	Minimum Course work Credits	Culminating Experience	Expected Time to Completion
All-Course	30	Comprehensive Exam	2 to 3 semesters
Project	27	3 credit project and presentation	3 to 4 semesters
Thesis	24 to 27	3 to 6 credits M.S. Thesis and defense	3 to 4 semesters

Chapter 3

Doctoral Program Information

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. Transfer credit policy for students entering with an M.S. degree from outside the Department was stated previously in Sec. 1.10. Effective Fall 2007, all PhD students must have taken the Graduate Record Exam (GRE).

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 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.

3.1 Students Entering Ph.D. Program With M.S. degree

Students who already have a Masters degree, an outstanding academic background and highly interested in research can pursue their Ph.D. degree by entering the Ph.D. program. All applicants to the Ph.D. program must take the GRE before their application to the program can be assessed.

3.2 Students Entering Ph.D. Program Without M.S. degree

Students with outstanding undergraduate studies and a high level of interest in research can pursue their Ph.D. degree by directly entering the Ph.D. program. During this pursuit, if the student wishes to take M.S. instead of Ph.D. for special reasons, they need to first seek for the approval from their advisor. The request needs to be submitted by the advisor to Graduate Studies Committee for final approval.

3.3 Ph.D. Program for Continuing Students

Students completing the M.S. program in UB's MAE department who wish to proceed to the Ph.D. program must re-apply following the standard admission procedure. All applicants to the Ph.D. program must take the GRE 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.

3.4 Qualifying Examination

Each student desiring to become a Ph.D. candidate in the department must pass a Ph.D. qualifying examination. Part 1 of the qualifier will be given at the end of the Fall Semester while Part 2 of the qualifier will be given at the end of the Spring Semester. The exact date for each will be given at the beginning of the semester in which they will take place. Qualifier tests normally last 5-6 hours, and details depend on the core and specific focus areas, as described in detail below.

To remain in the Ph.D. program a student must pass the Qualifying Examination within the first three years of the Ph.D. program if they enter with a B.S. degree and within two years of the Ph.D. program if they entered with a M.S. degree. The academic advisor of a student may require, at the advisor's discretion, that a student pass the Qualifying Examination within the first two years of the Ph.D. program, regardless if they entered with a B.S. or M.S. degree.

All students will have two opportunities to pass the Qualifying Examination. Failure to take the examination during the second year for students who enter with a B.S. degree or during the first year for students with a M.S. degree will be counted as a failed attempt. For any students whose academic advisor requires that they pass the Qualifying Examination

during the first two years of the Ph.D. program, failure to take the examination during the first year will be considered a failure.

Any requests for deferment of a qualifying exam must be provided in writing by the Ph.D. advisor of the student at least two weeks prior to the scheduled exam date. These will be considered by the Graduate Studies Committee on a case-by-case basis. If a student is not able to take the examination on the scheduled date due to medical reasons, documentation must be provided to the Graduate Studies Committee regarding the medical condition.

The qualifier exam is made up of two parts. The qualifying examination is the same for Mechanical Engineering and Aerospace Engineering students and all students are required to take both parts. The first part tests the student's knowledge in four (4) basic areas of MAE: 1) statics/dynamics, 2) thermodynamics, 3) continuum mechanics, and 4) materials. The material for each is based on undergraduate level courses found in most Mechanical and Aerospace Engineering programs.

The second part tests the student's knowledge in his/her specific focus area. The qualifying exam in each focus area is organized and administered by an ad hoc examination committee of department faculty members. The focus area committee consists of a chair, who has overall responsibility for the exam, and at least two faculty members from that focus area in which a specialty exam is given. The subject level of the focus area exam may include undergraduate and introductory graduate level material. Students will be asked to declare their focus area prior to the qualifying exam. Students are strongly advised to review the exam contents (courses, topics, references) provided below.

3.4.1 Qualifying Exam Format

a) Part I Core MAE Requirement: Each student will be required to take the core MAE requirement part of the qualifier exam, which consists of four (4) basic areas: 1) statics/dynamics, 2) thermodynamics, 3) continuum mechanics, and 4) materials. Two questions will be asked from each area and students will be asked to do five questions. It is highly suggested that students prepare for all four basic areas. Students must obtain a B or higher to pass Part I. At the discretion of the Graduate Studies Committee, additional work, including but not limited to an oral exam or class work, may be required for passage of the Core MAE exam.

Specific topics for each area are listed below.

i) Statics/Dynamics

- Statics:
 - Elements of Vector Algebra
 - Equivalent Force Systems
 - Equations of Equilibrium

- Introduction to Structural Mechanics
 - Friction Forces
 - Properties of Surfaces
 - Moments and Products of Inertia
 - Axially Loaded Members
 - Torsion of Rods, Bending Moments in Beams
 - Dynamics:
 - Kinematics of a Particle
 - Particle Dynamics
 - Energy Methods for Particles
 - Methods of Momentum for Particles
 - Kinematics of Rigid Bodies
 - Kinetics of Plane Motion of Rigid Bodies
 - Energy and Impulse-momentum Methods for Rigid Bodies
 - Dynamics of General Rigid-Body Motion
 - Vibrations
 - Suggested Texts:
 - Engineering Mechanics: Dynamics, Meriam and Kraige
 - Principles of Dynamics, Donald T. Greenwood, Prentice Hall, 1987
 - Vector Mechanics for Engineers: Statics and Dynamics, Beer and Johnston
 - Engineering Mechanics: Statics and Dynamics, Hibbeler
- ii) Thermodynamics
- First and Second Law of Thermodynamics:
 - Mass, Energy, and Entropy Balance
 - Kelvin-Planck and Clausius Statements of Second Law of Thermodynamics
 - Carnot Heat Pump, Refrigerator, and Heat Engine
 - Determination of Properties of a Pure Substance:
 - Using a Table
 - Equations of State
 - Analysis of Open and Closed Systems:
 - Boundary Work
 - Efficiency
 - Isentropic Relationships
 - Analysis of Cycles:

- Power Cycles: Carnot, Otto, Diesel, Gas-Turbine (Brayton)
- Net Work
- Thermal Efficiency
- Suggested texts/chapters:
 - Thermodynamics: An Engineering Approach by Cengel and Boles, Chapters 1-7 and 9
 - Fundamentals of Engineering Thermodynamics by Moran, Shapiro, Boettner, and Bailey

iii) Continuum Mechanics

- Conservation of momentum
- Solid Mechanics:
 - Stresses and Deflections in Homogeneous Beams, both Statically Determinate and Indeterminate, Under Thermal and Mechanical Loads
 - The Shear Center Concept
 - Analysis of Stress and Strain: principal values and directions, constitutive equations
 - Plane Stress vs Plane Strain Concepts
 - Lamé Solution for Axisymmetric Thick Shell
 - Yield Theories
- Fluid Mechanics:
 - Fluid statics
 - Control volume analysis
 - Integral form of conservation laws (Reynolds Transport Theorem)
 - Stresses in fluids
 - Dimensional Analysis
 - Laminar and turbulent pipe flow
 - Compressible flow
 - Potential flow
- Suggested texts/chapters:
 - Mechanics of Materials, Beer, Johnston, DeWolf, Mazurek, 6th ed, McGraw-Hill (2011) entire text, except for sections dealing with plasticity or energy methods (Chapter 11).
 - Advanced Mechanics of Materials and Applied Elasticity, AC Ugural, SK Fenster, 5th ed., Prentice-Hall (2011), (Chapters 1-2, 3.3-3.4, 4.6-4.7, 5.6-5.12, 8.2)

- Fluid Mechanics by Dale B. Taulbee (Can be purchased from Great Lakes Copying in the Commons)
- Fox and McDonald’s Introduction to Fluid Mechanics
- Egor Popov, Engineering Mechanics of Solids 2nd ed (1998) all chapters except 17-20 (except energy methods and plasticity).

iv) Materials

- Crystal Structures
- Imperfections in Crystalline Solids
- Diffusion
- Phase Diagrams and Phase Transformations
- Mechanical Properties and Failures
- Corrosion
- Metals, Ceramics, and Polymers
- Suggested texts/chapters:
 - Materials Science and Engineering: An Introduction by William D. Callister, David G. Rethwisch, Wiley, 9th edition

b) Part II Focus Area Requirement: The student, in advisement with his/her advisor, will select the focus area. Students will be asked to identify their focus area at the start of their Ph.D. program. There are six focus areas as listed below:

- Bioengineering (BIO)
- Computational and Applied Mechanics (CAM)
- Design and Optimization (DO)
- Dynamics and Control (DC)
- Fluid and Thermal Sciences (FTS)
- Materials (MAT)

The focus area examination format and topics will be chosen by the area’s research group. The format and topics will be declared at the beginning of the Fall Semester before the exam. Each area will determine the criteria needed for a student to pass the Focus Area Examination. At the discretion of the Graduate Studies Committee, additional work, including but not limited to additional oral exams or class work, may be required for passage of the Focus MAE exam.

3.4.2 Summary of Qualifier Procedure

Following completion of each part of the examination the committee reaches a decision as to whether each candidate has passed or failed. In the case of a failure, the committee decides whether or not the candidate should be permitted a second opportunity for each part. Candidates who fail without being granted a second try, or those who fail twice, must necessarily be dropped from the program.

All students take Part I and Part II of the qualifier exam. To pass Part I a student must obtain an average grade of B or higher. If this is accomplished then the student is done with Part I. Otherwise, if the student has taken Part I during the first year in the Ph.D. program then he/she must retake Part I again the following year. If the student takes Part I during the second year of their Ph.D. program and he/she did not obtain an average grade of B or higher on Part I exam, then the student will be dismissed from the program.

The Part II (Focus Exam) will be given by each research area. It is up to an ad hoc committee composed of faculty from your research area to determine if you pass Part II. Should the student not pass the Part II exam and is taking it during the first year of their Ph.D. program then they will be allowed to take it again the following year. If a student is taking the Part II exam during their second year and do not pass they will be dismissed from the program.

Note that a student does not need to pass both parts in the same year. For example, if a student passes Part I but fails Part II during their first year in the Ph.D program, then only Part II needs to be retaken the following year.

The working of the qualifier can be summarized by the Fig. [3.1](#).

3.5 Other requirements

After successful completion of the qualifying examination, a Ph.D. program committee is formed consisting of three members and chaired by the dissertation advisor. Non-MAE faculty can serve as a co-advisor or committee members, provided they have a Graduate School appointment. Any changes in the Ph.D. program committee should be approved by the graduate committee. The selection of the program committee members is primarily the responsibility of the candidates and their dissertation advisors. Any changes in the Ph.D. program committee should be approved by the graduate committee.

The student shall prepare a pre-defense presentation to his/her program committee which will include a literature review, research plan, and any preliminary results. This presentation will be given by the end of the third year in the Ph.D. program. 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, annual progress evaluations

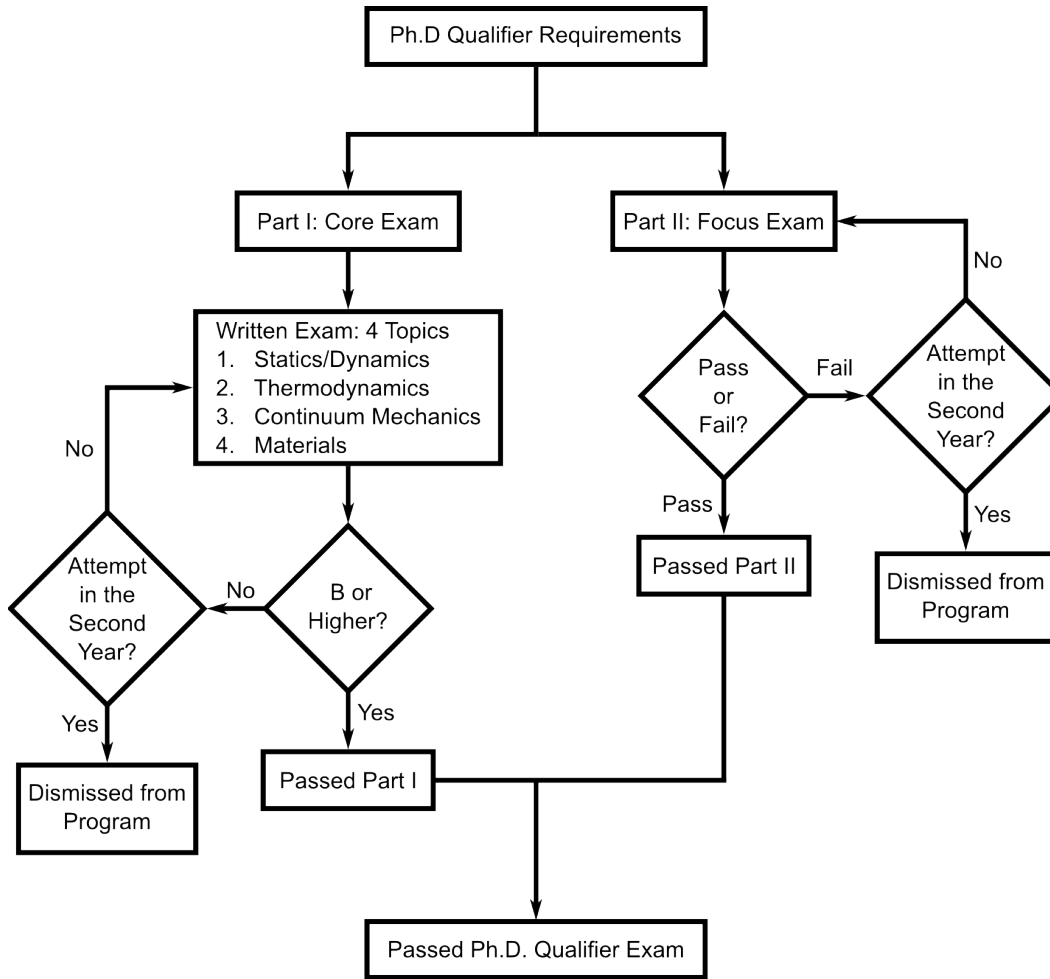


Figure 3.1: Summary of Qualifying Exam procedure.

should be carried out by the program committee and should be reported to the director of graduate studies. A review form for this purpose is available with the office of the MAE graduate studies. This annual review will take place in mid-October. 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.

As soon as after passing the qualifying examination and before the completion of four semesters of graduate study, 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.

All students initially admitted to a Ph.D. program for the Fall 2009 semester or thereafter are required to document successful completion of "Responsible Conduct of Research" (RCR) training when they submit their Application to Candidacy (ATC) for their Ph.D. degree. This training requirement may be fulfilled by either (1.) enrolling in and passing PHI 640 Graduate Research Ethics or RPN 541 Ethics and Conduct of Research or (2.) completing the Collaborative Institutional Training Initiative (CITI) online Responsible Conduct of Research course with an average score of 80% or higher. Students opting to complete the CITI online course must supply documentation of its successful completion with their Application to Candidacy.

3.6 Dissertation

Each Ph.D. student is required to complete an original dissertation and orally defend his/her 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. 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 MAE graduate director.

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 must submit

dissertation electronically to the graduate school; 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://grad.buffalo.edu/Academics/Academic-Deadlines.html> 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. More details regarding the formatting of the dissertation can be found at <http://grad.buffalo.edu/Academics/ETD.html>.

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.

Appendix A

Forms

a) Certification of Full-Time Status:

<http://grad.buffalo.edu/content/dam/www/graduate/documents/students/certfts.pdf>

b) Application to Candidacy (ATC):

<http://grad.buffalo.edu/content/dam/www/graduate/documents/students/atc.pdf>

c) Leave of Absence Graduate Student Petition:

http://grad.buffalo.edu/content/dam/www/graduate/documents/students/pet_loa.pdf

d) Informal Course (Individual Problems or Independent Study):

http://www.mae.buffalo.edu/files/special_topic.pdf

e) Petition for Course Credit Outside Your Primary Academic Career:

<http://registrar.buffalo.edu/pdfs/OutsideofCareerPetition.pdf>

f) Graduate Tuition Remission/Scholarship Verification:

<http://sarfs.buffalo.edu/office/pdfs/general/waiverInstructions.pdf>

Appendix B

Regularly Offered Courses

A sample of regularly offered classes in different research areas. Courses with * are offered every other year. The semester that a course is offered may change yearly. Note that some courses may be in multiple areas. A current listing of courses can be found at http://www.mae.buffalo.edu/graduate/course_descriptions.php. **It is highly suggested that all students take MAE 507: Engineering Analysis 1 and MAE 508: Engineering Analysis 2.**

The courses can be split into four major tracks:

1. Design and Optimization: Design and Optimization
2. Dynamics, Control and Mechatronics: Dynamics, Control and Mechatronics
3. Fluid and Thermal Sciences: Fluid and Thermal Sciences
4. Materials and Mechanics: Bioengineering, Computational and Applied Mechanics, and Materials

B.1 Design and Optimization (Track 1)

Fall:

- MAE 510: SP TP: Wind Turbine Modeling
- MAE 550: Optimization in Engineering Design
- MAE 526: SP TP: Decision based System Design
- MAE 564: Manufacturing Automation
- MAE 600: SP TP: Shape Synergy and Machine Learning*

Spring:

- MAE 509: SP TP: Sustainable Manufacturing
- MAE 527: Intelligent CAD Interface*
- MAE 551: Advanced Design Theory
- MAE 576: Mechatronics
- MAE 577: CAD Applications

B.2 Dynamics, Control and Mechatronics (Track 2)

Fall:

- MAE 509: SP TP: Introduction to Probability for Engineers
- MAE 536: Random Vibrations and Stochastic Structures*
- MAE 543: Continuous Control Systems
- MAE 554: Road Vehicle Dynamics 1
- MAE 571: System Analysis
- MAE 593: Math Methods in Robotics*
- MAE 600: SP TP: Data Assimilation*
- MAE 673: Vibration Control of Structures*
- MAE 674: Optimal Estimation Methods
- MAE 700: SP TP: Adaptive Control*
- MAE 701: SP TP: Celestial Mechanics*

Spring:

- MAE 513: Mobility and Manipulation*
- MAE 525: Spacecraft Dynamics and Control
- MAE 562: Analytical Dynamics
- MAE 566: System Identification*
- MAE 567: Vibration and Shock*

- MAE 576: Mechatronics
- MAE 670: Nonlinear Control*
- MAE 671: Nonlinear Systems*
- MAE 672: Optimal Control Systems*
- MAE 680: Stochastic Filtering and Control Theory
- MAE 698: SP TP: Random Matrix Theory and Its Applications
- MAE 700: SP TP: Dynamic Programming*

B.3 Fluid and Thermal Sciences (Track 3)

Fall:

- MAE 502: SP TP: Physical Fluid Dynamics*
- MAE 515: Fluid Mechanics 1
- MAE 534: Combustion 1
- MAE 542: Engineering Applications of Computational Fluid Mechanics
- MAE 545: Heat Transfer 1

Spring:

- MAE 510: SP TP: Moving Interfaces*
- MAE 516: Fluid Mechanics 2
- MAE 519: Turbulent Flow
- MAE 540: Computational Fluid Mechanics
- MAE 546: Heat Transfer 2
- MAE 547: Radiation Heat Transfer
- MAE 578: Cardiovascular Biomechanics
- MAE 703: SP TP: Introduction to Combustion Diagnosis*
- MAE 509: Direct Energy Conversion

B.4 Materials and Mechanics (Track 4)

Fall:

- MAE 509: SP TP: Introduction to Probability for Engineers
- MAE 507: Engineering Analysis 1
- MAE 529: Finite Element Structural Analysis
- MAE 536: Random Vibrations and Stochastic Structures*
- MAE 570: Thermodynamics of Materials
- MAE 582: Composite Materials
- MAE 587: Modern Theory of Materials
- MAE 607: Biomaterials Science of Cell-Surface Phenomena
- MAE 608: Polymeric Biomaterials
- MAE 609: High Performance Computing 1
- MAE 673: Vibration Control of Structures*

Spring:

- MAE 505 SP TP: Mechanical Aspects of Additive Manufacturing
- MAE 508: Engineering Analysis 2
- MAE 514: Evaluation of Biomedical Materials
- MAE 526 SP TP: Mechanics of Laminated Composites
- MAE 538: Smart Materials
- MAE 567: Vibration and Shock
- MAE 575: Kinetics of Materials
- MAE 578: Cardiovascular Biomechanics
- MAE 581: Advanced Materials Science
- MAE 584: Principles and Materials for MEMS and BioMEMS
- MAE 589: Experimental Methods in Materials and Engineering

- MAE 610: High Performance Computing 2
- MAE 698: SP TP: Random Matrix Theory and Its Applications*

Summer:

- MAE 509: Direct Energy Conversion