Department of Mechanical Engineering

GRADUATE STUDENT HANDBOOK

This guidebook contains graduate school and mechanical engineering department graduation requirements as well as department policies. Although this guidebook is intended to be a common source for all information, it is ultimately student's responsibility to verify graduation requirements and necessary deadlines. Questions or suggestions on the guidebook's content should be directed to the Chair or Director of Graduate Program.

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1. ADMISSION REQUIREMENTS

Admission to the Mechanical Engineering MS and Ph.D. programs is subject to the requirements of the Texas Tech University Graduate School. Complete details regarding admission may be obtained from: *Graduate School, Texas Tech University, Box 41033, Lubbock, TX, 79409.* A brief summary of these requirements follows.

Initiating an Application

Application materials may be obtained by contacting the Graduate School at the above address. In addition to the application form, applicants must provide official transcripts which document the last two years of their undergraduate studies and any graduate studies which have been completed. Applicants must also provide scores from the aptitude portion of the Graduate Record Examination (GRE) which is administered by: Educational Testing Service, 20 Nassau Street, Princeton, NJ, 08540. The GRE is required for all students. Students who have not completed the GRE can be admitted as "special students" for up to two semesters in order to complete the GRE. Students admitted on a "special" basis will be dropped from the graduate program if their GRE scores do not meet departmental requirements.
Application materials are processed by several offices, and time must be allowed for transcripts and test scores to be received. Students in the United States should allow at least *three months* for the processing of their application. Students looking for financial support must apply much earlier.

Admission Requirements

Graduates of ABET---accredited mechanical engineering programs are required to have a cumulative grade point average of 3.0 or better for the last 60 hours of courses completed. In addition, a high score in GRE will increase the chances of admission with financial aid to the Ph.D. program. Graduates of programs other than mechanical engineering will be required to take leveling courses. Specific leveling programs are tailored to the background of the applicant. These courses are not applicable to the requirements of the MS or Ph.D. degrees.

International Students

In addition to the above requirements, international students are required to submit scores from the Test of English as a Foreign Language (TOEFL) as well as the GRE before admission will be granted. They must also provide evidence of financial support while in the United States prior to being admitted. A fee is required for processing applications from outside the United States. The Department is not able to waive the required fee nor can we make a preliminary assessment of the likelihood of admission. Nine or *more months* are normally required for the processing of international student applications.

2. UNIVERSITY ACADEMIC REGULATION

ME Department complies unconditionally with the university's regulations. The details of the

University Academic Regulation can be found at:

http://www.depts.ttu.edu/officialpublications/catalog/GradSchool.php

2.1. Outside-department course

Although there is a possibility that a graduate student can take courses outside the ME department, please be advised that you need pre-approval to do so. Otherwise the course may not be counted as effective and helpful in your degree plan. Please consult your advisor before you register for any outside department course.

2.2. Full-time study

The following table shows the allowed credit hours for each semester.

Semester/Session	MS Student (min - max)	Ph.D. Student (min - max)
Spring	9 – 16	9 – 13
Fall	9 – 16	9 – 13
Summer I	3 – 6	3 – 6
Summer II	3 – 6	3 – 6

Spring and fall semesters are two regular semesters which are required for all graduate students. If you are on fellowships, assistantships and/or other appointments (TA, RA, GA), you are required to keep your full-time study status in both summer sessions. That means you need to take at least 3 credit hours in EACH summer session of the two summer terms, which makes it at least 6 credit hours in total.

A Ph.D. student who is required to register solely for the purpose of satisfying a **continuous enrollment** requirement needs not register for more than 1 credit hour during each term. However, a doctoral student who is involved in internship, research, or another type of academic study should register for credit hours in proportion to the teaching effort required of the program faculty. Students supported by the department needs to take at least 9 credit hours during regular semesters and 3 credit hours for each summer semester.

2.3. Continuous enrollment

Students who have begun thesis or dissertation research must register for 6000 or 8000 courses in each regular semester and at least once each summer until all degree requirements have been completed, unless granted an official leave of absence from the program for medical or other exceptional reasons. Off-campus students may register for 1 hour of 6000 or 8000 with departmental approval until their final semester, at which time they must enroll for at least 3 hours. Students receiving financial assistance must register for the number of hours required by Financial Aid. Approval of a leave of absence will not extend the allowed time for completion of the degree.

2.4. Leave of absence

Any student who fails to register during a fall or spring semester and who does not have an official leave of absence from study is subject to review for readmission by the standards in effect at the time of reconsideration. Official leave of absence, which is granted by the dean of the Graduate School upon departmental recommendation, may be requested only in case of serious medical conditions and other exceptional reasons. Normally, leaves of absence will not exceed one year. Leaves of absence do not extend the maximum time allowed for completion of the degree.

2.5. Required thesis/dissertation hours

Registration for at least 6 hours of 6000 is required for the master's thesis and at least 12 hours of 8000 for a doctoral dissertation. Once the project is begun, a student must be enrolled in such courses every semester until completion. A student should enroll under the committee chairperson; however, in those instances in which other professors on the committee are making substantial contribution to the student's research, it is permissible for the student to enroll proportionally under those professors. Students certified as off-campus may enroll for as little as 1 hour until their final semester, at which time 3 hours minimum are required.

Students may not enroll in thesis or dissertation courses before formal admission to a degree program by the graduate dean.

Enrollment for thesis or dissertation courses is permitted only during a regular registration period. Students away from the campus may, however, register for such courses by mail, provided arrangements are made with the registrar's office by telephone or electronically prior to the beginning of a registration period.

Students are required to register for appropriate courses in every semester or summer term in which they expect to receive assistance, use the facilities of the university, or take comprehensive examinations.

The number of hours for which students must enroll in each semester depends on their level of involvement in research and their use of university facilities and faculty time. Students in residence who are devoting full time to research should enroll for 9 to 12 hours.

2.6. Registration in the semester of graduation

There are three official graduation dates: December, May, and August. Every candidate for a graduate degree must be registered in the Graduate School in the session of graduation. Students must be registered for at least 3 hours of coursework at the 6000 level (thesis option) or the 8000 level (doctoral students) or they must register for 1 hour of non---thesis coursework at the 7000 level (individual study) if all requirements are met. Failure to graduate at the expected time requires such additional registrations as may be necessary until graduation. A new "Statement of Intention to Graduate" is required for each semester.

2.7. Maximum allowable doctoral hours

Students not making timely progress toward completion of the doctoral degree are subject to termination by the graduate dean. The Texas Legislature has capped fundable graduate study at 99 doctoral hours for most programs and may impose sanctions upon universities permitting registration for excess hours. Graduate students with more than 99 doctoral hours will be required to pay out-of-state tuition, regardless of residence status. The maximum time allowed for completing the doctoral degree is EIGHT years from the first doctoral semester or FOUR years from admission to candidacy, whichever comes first. The graduate dean must approve exceptions or extensions in advance.

2.8. Maximum allowable graduate hours (except doctoral programs)

Students who are in programs other than doctoral programs and are not making timely progress toward completion of their degree are subject to termination by the graduate dean. Graduate students beyond the maximum allowable graduate hours as determined by the Texas Legislature may be required to pay out-of-state tuition, regardless of residence status. The maximum time allowed for completing a master's degree is six years. The graduate dean must approve exceptions or extensions in advance.

2.9. Change in schedule and withdraw

A graduate student who wishes to add or drop a course must initiate such action with the graduate advisor for his or her program. A student who quits a course without official withdrawal is likely to receive an ***F*** in that course.

3. ACADEMIC PROBATION AND SUSPENSION

Every student enrolled in the Graduate School, whether working toward a degree or not, is required to maintain a high level of performance and to comply fully with the policies of the institution. The Graduate School reserves the right to place on probation or to suspend any post---baccalaureate or graduate student who does not maintain satisfactory academic standing or who fails to conform to the regulations of the university.

Students who are admitted to a degree program on condition of maintaining a required GPA are automatically on academic notice. Failure to fulfill the conditions stipulated at the time of admissions will result in termination from the program.

Student's whose cumulative GPA falls below 3.0 are placed on academic probation and have two consecutive semesters to raise their cumulative GPA to at least 3.0. If their semester GPA drops below 3.0 during the two---semester period, students are subject to suspension. Students placed on suspension are required to remain out of the Graduate School for one semester. Summer sessions and/or trimester count as one semester. In accordance with OP 64.07, any student who has been suspended must appeal

to the Graduate School if reinstatement is desired. A student who is suspended twice will not be allowed to return to the Graduate School.

Students may be suspended for unprofessional conduct such as cheating or plagiarism. Any appeal of such action is subject to the provisions of the Code of Student Conduct. See the *Student Handbook* for further information.

4. DEPARTMENTAL SAFETY PROTOCOLS

The safety protocols can be viewed and downloaded at:

https://www.depts.ttu.edu/me/safetyplan.php

5. A LIST OF GRADUATE LEVEL COURSES

ME department class website:

https://www.depts.ttu.edu/me/grad/ms/index.php

https://www.depts.ttu.edu/me/grad/phd/index.php

ME 5120 Graduate Seminar

ME 5301 Analysis of Engineering Systems

ME 5302 Numerical Analysis of Engineering Systems

ME 5311 Advanced Dynamics

ME 5312 Control Theory

ME 5313 Control Theory II

ME 5314 Nonlinear Dynamics

ME 5316 Advanced Vibrations

ME 5317 Robot and Machine Dynamics

ME 5321 Advanced Thermodynamics

ME 5322 Conduction Heat Transfer

ME 5323 Two---Phase Flow and Heat Transfer

ME 5325 Convection Heat Transfer

ME 5326 Combustion

ME 5327 Advanced Heat Transfer

ME 5330 Boundary Layer Theory

ME 5332 Potential Flow
ME 5334 Gas Dynamics
ME 5335 Mathematical Models of Turbulence ME 5336 Computational Fluid Dynamics
ME 5338 Advanced Fluid Mechanics
ME 5339 Transmission Electron Microscopy

ME 5340 Elasticity
ME 5341 Plasticity
ME 5342 Fracture and Failure Analysis
ME 5343 Contact Mechanics of Engineering Materials
ME 5344 Introduction to High Pressure Science and Technology
ME 5345 Computational Mechanics I
ME 5346 Computational Mechanics II
ME 5347 Phase Transformation I
ME 5349 Nonlinear Mechanics of Materials
ME 5350 Mechanics of Composite Material
ME 5351 Advanced Engineering Design
ME 5352 Probabilistic Design
ME 5353 Fundamental of Transdisciplinary Design and Process
ME 5354 System Engineering Principles
ME 5355 Complexity Theory for Design and Process
ME 5356 Digital Human Modeling for Human-Centric Design
ME 5357 Transdisciplinary Discovery and Innovation
ME 5360 BioFluid Mechanics
ME 5362 Orthopedic Biomechanics
ME 5385 MEMS I
ME 5386 MEMS II
ME 5387 MEMS III

ME 6000 Master's Thesis
ME 6301 Master's Report
ME 6330 Advanced Topics in Mechanical Engineering (Lecture)
ME 6331 Theoretical Studies (Self-study)

ME 7000 Research

ME 8000 Doctor's Dissertation

Note:

a) Elasticity is a required course for Mechanics major.

b) ME 6331 and ME 7000 can be repeated both three times, but maximum credit hours enrolled under same professor is 9 hours counting all lecture, individual studies & research courses (this does not include ME 6000, ME 6301 or ME 8000). ME 7000 is not allowed for MS program thesis option. 3 credit hours of ME 7000 is allowed for MS program report/course only options; additional hours may be approved if the student participates in Co OP/internship.

c) The title of ME 6330, ME 6331 and ME 7000 depends on the course instructor. If you register for ME 6330, ME 6331, or ME 7000, you have to ask the course advisor for a specific title for this course.

d) All courses are NOT offered in every semester but in a rolling base, depending on the availability of professors, classrooms and other resources.

6. SOFTWARE PACKAGES SUPPORTED BY ME DEPARTMENT

Currently, the ME department supports MATLAB, ANSYS, Inventor 11, NI Labview, Solidworks and MathCAD. These software packages are available on all computers in the open computer laboratory. More detailed information of available software will be found at:

http://www.depts.ttu.edu/itts/software/

7. COMMON REQUIREMENTS FOR GRADUATE DEGREES

There are two common requirements for both MS and Ph.D. students.

A. Graduate Seminar

One credit hour of graduate seminar (ME 5120) is required for all graduate students. Students register for this course in their first full-time graduate semester, but must attend seminars throughout their entire academic career, until completion of the requirement. This may include any of the Mechanical Engineering departmental seminars, as well as any external seminars approved in advance by the ME Graduate Advisor.

To find information about Mechanical Engineering seminars, please see the schedule by checking:

https://www.depts.ttu.edu/me/department/seminars.php

To find external seminars, please see the Advising Office for a list of approved presentations. Alternatively, you may find a seminar yourself and bring an abstract to the Advising Office IN ADVANCE for approval. In either case, a feedback sheet must be picked up from the Advising Office before attending any external seminars and it must be turned in to the Advising Office as soon as possible afterwards.

PLEASE NOTE: For MS students that graduate in less than the average amount of time, the attendance requirement will be 80% of the number of ME seminars offered during your tenure in the department as a graduate student.

B. Academic regulations

Dept. of Mechanical Engineering complies with the graduate school's code: Academic Probation and Suspension of Graduate Studies (OP64.04), and furthermore, the department will permit only a single grade of C for courses listed on the Official Degree Plan. If a student earns two or more C's or any single grade less than C, he or she must meet with a group consisting of the Faculty Advisor, Advisory Committee, and the Department Graduate Advisor. This group will recommend appropriate action, which may include probation or suspension by the Department.

General information of graduate degree requirements is found at:

https://www.depts.ttu.edu/gradschool/academic/ThesesDissertation.php

8. M.S. DEGREE REQUIREMENTS

The Graduate School of Texas Tech University sets the policies and regulations regarding admission, minimum grade requirements, final examinations, and other such items of interest to the student. Students should obtain and study the current Graduate Catalog in order to be familiar with these regulations. This Procedures Manual presents information specifically concerning the Master of Science in Mechanical Engineering (MSME).

8.1. Leveling Requirements

Most students will have a Bachelor's degree in Mechanical Engineering upon entering the program. Some students, however will have undergraduate or graduate degrees from other technical disciplines and will be required to take leveling courses in preparation for graduate studies in mechanical engineering. The courses listed below, or their equivalents are minimum leveling requirement for students who have not graduated from a mechanical engineering program. Additional courses may be required depending upon the background of the student and will be assigned on a case by case by the Department Director of Graduate Program or the student's Advisory Committee. Leveling courses do not apply toward the requirements of the MSME degree.

8.2. Minimum Leveling Requirements

Six hours of thermal science courses (e. g. ME 3322, ME 3370, ME 3371)

Six hours of mechanical science courses (e. g. ME 2311, ME 3331, ME 3433, ME 3464)

Computational Methods (ME 2315)

All undergraduate math courses in the BSME curriculum

8.3. MSME Options

The MSME is a graduate degree requiring an additional 18 to 24 months of study beyond the undergraduate degree, BSME. Currently, the Department offers the three master's program options: thesis option, report option and coursework option. Students in pursuing each program option must select and designate a major area of study from the four streams available: 1 - Solid Mechanics, 2 – Thermo/Fluids and Heat Transfer, 3 - Dynamics and Controls, and 4 - Design. Students are required to submit a degree plan during their first semester. For information about degree plans as well as the form, please visit:

https://www.depts.ttu.edu/me/grad/ms/index.php

In order to obtain the MS degree, you need to satisfy the Graduate Seminar requirements as well as the academic regulations mentioned above, and:

A. Faculty advisor and advisory committee

Each graduate student must have a Faculty Advisor from the Graduate Faculty of the Mechanical Engineering Department to advise them on academic, thesis, or report matters. The Department Graduate Advisor will temporarily serve as the Faculty Advisor for each student during the student's first semester in the master's degree program. Each student should choose a permanent Faculty Advisor by the end of the first semester of attendance and report this advisor to the Department Graduate Advisor. The Faculty Advisor will assist the student with the selection of a thesis or report topic and the courses needed to satisfy the requirements of the MSME degree.

Students pursuing an MSME degree with a thesis or report option must have an Advisory Committee to assist with academic and thesis matters. This committee is chaired by the Faculty Advisor and consists of the Faculty Advisor and a minimum of TWO additional graduate faculty members for the thesis option and a minimum of ONE additional graduate faculty member for the report option. This committee is responsible for approval of the student's thesis/report. This committee should be selected as soon as possible after the student has selected a Faculty Advisor and before the second semester of enrollment. Committee membership is formalized when the student files the Official Degree Program and Admission to Candidacy.

B. Final exam

All MS students must pass a final examination before graduating. The final examination requires a synthesis and application of knowledge acquired during the course of study and research leading to the master's degree; no student should expect the evaluation to be based solely on performance

in the classroom. A student who fails the final examination may repeat it after a period of two months or more.

C. Thesis option

(a) The thesis option requires a minimum total of 30 credit hours, consisting of a minimum of 24 hours of course work, and six hours of ME 6000 Master's Thesis.

(b) Nine hours of course work must be selected from the designated courses in the students' selected major area.

(c) At least six hours of course---work must be in the designated breadth areas (breadth areas are areas outside the students' major area, but within Mechanical Engineering).

(d) All thesis students are required to take 6 hours of advanced mathematics.

(e) In addition to the core and breadth courses, students must take an additional 3 hours of graduate level course work designated as graduate free elective. This free elective could be selected from any of the areas inside the ME department, other engineering departments, and/or sciences (independent study or special topics are also acceptable). Also, if a student participates in a graduate internship/Co-op, an ME 7000 may be included on their official degree plan to replace/satisfy the free elective requirement.

(f) No ME 7000 is allowed on the official degree plan without internship/Co-op.

(g) In situations where the students' thesis is highly interdisciplinary and requires extensive course work outside the department, the two breadth courses and the additional free elective may all be taken in other departments or colleges as needed. The faculty advisor must notify the graduate advisor of this necessity in written.

(h) Time required to complete the thesis option Master's degree is usually between 18 and 24 months.

(i) F-1 international students may not use a graduate internship/coop as graduate research, ME 7000, unless it is an integral part of the student's academic program and is stated so in writing by the student's academic advisor (per United States immigration regulations).

(j) Students pursuing a MS degree in Mechanical Engineering with a thesis option must submit to the graduate school a written thesis that is approved by the students' Advisor and Advisory Committee. The Master's thesis represents the results of original and significant research work in Mechanical Engineering conducted by the student under the supervision of the Faculty Advisor and Advisory Committee. The thesis must be prepared in strict conformance with the requirements described in the booklet Instructions for Preparing and Submitting Thesis and Dissertations available at the Texas Tech University Bookstore. As stated in the booklet, it is the student's responsibility to be sure that English usage is proper and that the physical form (margins, spacing, etc.) is acceptable. Students are encouraged to employ assistance (typically students majoring in English) in correcting their thesis or report manuscripts prior to submittal to their Faculty Advisors. Masters candidates are required to defend their thesis in an oral presentation to their Advisory Committees. A draft of the thesis must be provided to the Advisory Committee at least one week prior to the defense. The date and place of the defense presentation must be advertised two weeks

in advance of the defense and the presentation must be open to the public. Failure to follow these guidelines may delay graduation.

(k) Thesis defense is the final examination for the MS program with thesis option in Mechanical Engineering.

D. Report option

(a) The report option requires a minimum of 36 hours consisting of 33 hours of course work and three hours of ME 6301, Master's report.

(b) Nine hours of course work must be selected from the designated courses in the students' major area.

(c) At least six hours of course-work must be in the designated breadth areas (breadth areas are areas outside the students' core area, but within Mechanical Engineering).

(d) All report students are required to take 6 hours of advanced mathematics.

(e) In addition to the core and breadth courses, students must take an additional 12 hours of graduate level course work designated as graduate free elective. These free electives could be selected from any of the areas inside the ME department, other engineering departments, and/or sciences (up to three hours may be independent study or special topics).

(f) Up to three hours of free elective courses may be substituted by graduate research, ME 7000, on the official degree plan. If a student participates in a graduate internship/coop, an additional 3 hours of ME 7000 may be included on their official degree plan to replace three additional hours of free elective.

(g) Time required to complete the report option Master's degree is usually between 15 and 18 months.

(h) F-1 international students may not use a graduate internship/coop as graduate research, ME 7000, unless it is an integral part of the student's academic program and is stated so in writing by the student's academic advisor (per United States immigration regulations).

(i) The master's report is not as extensive as a thesis and may represent work other than original research, but the quality of the work and the level of activity will still be expected to meet the high standards required for a master's degree in mechanical engineering. A final approved copy of the report must be supplied to the Mechanical Engineering Department for archival purposes.

The report need not conform strictly to the Graduate School booklet, but rather to the individual requirements of the student's Faculty Advisor. The student must satisfy their report committee by giving a formal report presentation that is open to faculty and students. Students are required to present a draft of the report one week prior to the presentation. An announcement of the presentation must be given to the Department two weeks in advance of the presentation.

(j) Report defense is the final examination for the MS program with report option in Mechanical Engineering.

E. Coursework option

(a) The coursework option requires a minimum of 36 hours consisting entirely of coursework.

(b) Nine hours of course work must be selected from the designated courses in the students' selected major area.

(c) At least six hours of course work must be in the designated breadth areas (breadth areas are areas outside the students' core area, but within Mechanical Engineering).

(d) All coursework option students are required to take 6 hours of advanced mathematics.

(e) In addition to the core and breadth courses, students must take an additional 15 hours of graduate level course work designated as graduate free elective. These free electives could be selected from any of the areas inside the ME department, other engineering departments, and/or sciences (up to three hours may be independent study or special topics).

(f) Up to three hours of free elective courses may be substituted by graduate research, ME 7000, on the official degree plan. If a student participates in a graduate internship/coop, an additional 3 hours of ME 7000 may be included on their official degree plan to replace three additional hours of free elective.

(g) Time required to complete the coursework option Master's degree is usually between 15 and 18 months.

(h) F-1 international students may not use a graduate internship/Co-op as graduate research, ME 7000, unless it is an integral part of the student's academic program and is stated so in writing by the student's academic advisor (per United States immigration regulations).

(i) The MS course work only option requires a final examination to be administered by the ME departmental Graduate Advisor. The exam will be geared on courses taken by the student toward the student's selected program. Coursework students should check with the Graduate Advisor regarding the format of the exam.

9. Ph. D. Degree Requirements

In order to obtain the Ph.D. degree, you need to satisfy the Graduate Seminar requirements as well as the academic regulations mentioned above, and:

9.1. Faculty advisor and advisory committee

When a student first begins a graduate studies program he/she is assigned to the Departmental Graduate Student Advisor. During the first semester of attendance, students should seek a Faculty Advisor. This advisor assists the student with the selection of a dissertation research topic and the courses needed to earn the Ph. D. degree. A Faculty Advisor should be selected by the student and reported to the Department Graduate Student Advisor by the end of the first semester of attendance.

Each student pursuing the Ph. D. program must also have an Advisory Committee to assist with academic and dissertation matters. This committee is chaired by the Faculty Advisor and consists of the Faculty Advisor plus a minimum of THREE additional graduate faculty members (TWO ME faculties & ONE external TTU graduate faculty), excluding the Graduate Dean's representative. Students are strongly encouraged to have at least one member from outside the Department. This committee is responsible for the comprehensive examination and approval of

the dissertation. This committee should be selected shortly after the student has selected a Faculty Advisor and prior to the end of the first year of attendance. Committee membership is formalized when the student files for admission to candidacy.

9.2. Course work requirements

The Doctor of Philosophy program in Mechanical Engineering (Ph. D.) is a graduate degree requiring a minimum of three years of graduate study beyond the undergraduate degree. It is awarded to students who have completed a program of graduate courses, a final examination, and a dissertation.

The doctorate requires at least 60 semester hours of graduate work, exclusive of the dissertation. No more than 30 semester credit hours of an earned Master's degree from another institution may be transferred. A student will be required to take two math courses and two other courses from the courses listed below. The remaining 18 hours may consist of ME 7000, ME 6331, or additional graduate courses. A student may not include more than 9 hours each of ME 7000 or ME 6331 courses. Each of the ME 7000 and ME 6331 courses should have a unique prefix identifying the class name. The Graduate School's custom and practice is to reject all degree plans when a student is taking more than 9 hours with a single professor because this is not consistent with the guidelines of Southern Association of Colleges and Schools (SACS).

The balance of the graduate courses required for a degree program may be selected from mathematics, science, and engineering with the approval of the Faculty Advisor and Advisory Committee. All courses must carry graduate credit. Students should obtain the approval of the offering department when taking courses outside of Mechanical Engineering to be sure that they have the appropriate prerequisites. All students are required to submit a degree plan during their first semester.

Students enrolled in the Ph.D. program are required to complete two math courses and two core courses from two different groups, totaling 4 courses, listed below. However, with the approval of his/her advisory committee, core course requirements can be exempted.

Math Course 1

ME 5301 Analysis of Engineering Systems, MATH 5310, or MATH 5311

Math Course 2

ME 5302 Numerical Analysis of Engineering Systems, MATH 5334, Math 5335, Math 5384, Math 5385 or CE 5310

Course 3

ME 5311 Advanced Dynamics or ME 5316 Mechanical Vibrations I

Course 4

ME 5321 Thermodynamics, ME 5319 Advanced Heat Transfer, or ME 5320 Advanced Fluid Mechanics

Course 5

ME 5340 Elasticity, ME 5342 Fracture and Failure Analysis, ME 5345 Computational Mechanics I, ME 6330 Mechanics of Nanomaterials

Course 6

ME 5353 Transdisciplinary Design & Process, ME 6330 Automotive Systems, ME 5351 Advanced Engineering Design, ME 5352 Probabilistic Design, ME 5355 Complexity Theory for Design & Process, ME 6330 Digital Human Modeling

9.2. Journal publication requirement

The department of Mechanical Engineering requires, as part of its PhD degree requirements, that all its PhD degree candidates have at least two journal publications prior to the defense of their PhD thesis.

9.3. Qualifying exam

The purpose of the qualifying exam is to ensure thorough understanding of fundamental engineering concepts by all Ph.D. students in the ME Program at TTU. The exam will evaluate students' core ME knowledge and provide an early assessment of their potential for successful completion of their Ph.D. studies.

- All Ph.D. students must complete their qualifying exam within the first 18 months of matriculation into the graduate program.
- Students must complete at least one semester in the Mechanical Engineering Ph. D. (or prior MS) Graduate Program before taking the Qualifying Exam. Student must be enrolled during the semester they take the Qualifying Exam.
- The qualifying exam is composed of 3 subject tests: Math (mandatory) + one primary + one secondary. The second exam attempt for each of the failed subjects is allowed, which must be taken in the following semester. It is noted that failure to pass the exam for the second time will cause dismissal from the Ph.D. Program.
- The details of Qualifying Exam are found in **Appendix.**
- The Graduate Advisor then notifies the Graduate School that the candidate successfully passed the PhD Qualifying Examination and is officially a PhD candidate graduation date.

9.4. Research Proposal

The intent of the PhD Proposal is to demonstrate that the candidate understands the relevant scientific background, how the proposed research fits into the general field, and has original ideas for research to expand the 'state-of-the-art', bring in new information, or provide an original perspective on the central problem. An adequate search of the relevant literature is expected.

- The deadline for Research Proposal is one year after passing the Qualifying Exam. A student's Research Advisor may request an extension in writing to the Graduate Advisor providing an appropriate justification for a delay.

- The candidate prepares a Research Proposal covering the PhD project and defends it orally before the PhD Committee. The Proposal should outline work already accomplished as well as present details of the proposed project.
- The oral presentation by the candidate is followed by questions from the Committee. Immediately following the presentation, the Committee deliberates and decides whether the candidate has successfully defended the proposal. If not, at the discretion the committee, the candidate may repeat the defense one additional time within one semester.
- The written research proposal must first be approved by the Research Advisor, and then submitted to each Committee member not less than ten (10) days before the date of the presentation.

9.5. Dissertation

A dissertation is required of every candidate for a doctoral degree. This requirement is separate and apart from other requirements in doctoral programs; consequently, successful performance in other areas does not necessarily guarantee the acceptance of a dissertation. The dissertation work must earn a grade of at least B in order to qualify the student for graduation.

The doctoral dissertation represents the results of original and significant research work in mechanical engineering conducted by the student under the supervision of the Faculty Advisor and Advisory Committee. The dissertation must be prepared in strict conformance with the requirements described in the Graduate School booklet, "Instructions for Preparing and Submitting Reports, Thesis, and. Dissertations." As stated in the booklet, it is the student's responsibility to be sure that English usage is proper and that physical form (margins, spacing, etc.) is acceptable. Students who have difficulty with writing proper English are encouraged to employ assistance (typically students majoring in English) in correcting their dissertation or report prior to submittal to their Faculty Advisor. Students must defend their dissertation to their Advisory Committee. A draft of the thesis must be provided to the Advisory Committee three weeks prior to the defense. An announcement of the defense must be given to the Department three weeks in advance of the defense.

9.6. Final Oral Examination

A final public oral examination, usually over the general field of the dissertation, is required of every candidate for the doctorate. The oral examination must be scheduled by the student and the advisory committee after the committee has read the completed dissertation and prior to the defense deadline during the semester of graduation. Students should present their dissertation to all committee members at least three weeks before the defense date. In addition, the Graduate School requires three weeks notification prior to the oral examination. The required Defense Notification Form noting the time, place, and other information concerning the examination is available on the web site: https://www.depts.ttu.edu/me/grad/phd/index.php

The advisory committee and the graduate dean or a professor designated to act in place of the graduate dean conduct the examination. All members of the committee participate fully in the examination and cast a vote. Professors other than members of the committee, including the graduate dean’s representative who is expected to come from outside the academic department,

may participate in the examination but have no vote in determining the outcome. At the conclusion of the examination, the chairperson of the advisory committee will send a written notice to the Graduate School giving the result of the examination.

9.7. Minimum residence and time limit

The minimum residence time for a Ph. D. is one full academic year of graduate study beyond the master's degree or beyond the equivalent of this degree if the student proceeds to doctoral work without getting a master's degree. All work for the doctorate must be completed within four years after the applicant has been admitted to candidacy. Students whose graduate study is interrupted by military service will be granted an extension of time for the period of their military service, not to exceed five years.

10. GUIDELINE FOR STUDENTS

10.1. Teaching Assistants

TA's will be assigned to specific undergraduate courses on a semester by semester basis. The TA should report to the professor in charge of their assigned course one week before the course begins. TA duties will include such tasks as: assisting the faculty in the conduction of courses, grading laboratory reports, homework assignments, and exams, and running discussion sessions. Occasionally, TA's may be asked to conduct a lecture in the absence of the faculty member in charge. It is a Departmental practice that TA's will not be used on a regular basis to teach classes other than laboratory classes. A TA appointment at the Master's level is given for a maximum of 4 regular semesters and at the PH. D. level for a maximum of 8 regular semesters. However, for students coming directly in the PH. D. program with a BS degree can have a TA appointment for a maximum of 10 regular semesters.

It is the responsibility of the TA to be familiar with the course material and with the operation of the course. This will, at a minimum, require close communication with the professor in charge, and may require that the TA attend some or all the lectures/problem sessions. It is the responsibility of the faculty to inform the TA of their specific duties in a timely fashion so that they may be adequately prepared.

All TA's are expected to be available to students of the class to which they are assigned as a TA. Establishing office hours is recommended.

A TA's load is 20 hours/week spent assisting classroom learning. Some courses will require significant preparation when school is not in session. All TAs are expected to work on their research during semester breaks. All TAs are expected to attend department's seminar on a regular basis. TAs at the MS level are expected to have one journal publication submitted. TAs at the Ph. D. level are expected to have 2 to 3 journal publications submitted.

10.2. Research Assistants

RA's will report to their faculty advisors on the first day of their assignment. RA's will be responsible for conducting research related to the project to which they are assigned. The specifics of these duties will be communicated to the student by the faculty advisor. As with TA's, the RA's load is 20 hours/week of responsibilities that may or may not be directly related to their thesis research.

10.3. Graduate Scholarship Recipients

Graduate students who are given departmental scholarships are expected to attend department's seminar on a regular basis. Department's graduate scholarships are given for a maximum of 4 regular semesters to MS students and a maximum of 8 regular semesters to Ph. D. students. Students with a TA or a RA position do not receive a departmental scholarship.

10.4. General

All funded students (TA, RA, fellowship, etc.) are expected to be present during undergraduate school vacations and semester breaks to work on their research. Absences will be handled by the Department Chair and Graduate Coordinator for unassigned TA's and by the specific research advisor for RA's and TA's.

Continuation of support for all funded students depends upon the satisfactory performance of their assigned duties as well as their academic progress including both course work and research. Graduate students are expected to do their part in creating a scholarly environment which enhances effective learning and professional growth. Example actions include but are not limited to:

a) taking responsibility for laboratory safety, maintenance, and training of new personnel,

b) academically challenging and stretching fellow graduate students and faculty by discussing their own work and other's work for the personal growth of themselves and others,

c) seeking expertise within and beyond the Department to achieve research goals,

d) continuously pursuing research goals and a deep understanding of both general mechanical engineering principles and their specific research area, and

e) writing conference papers and journal publications. For the MS thesis option candidates at least one journal publication is expected. For a Doctoral Candidate, 2 to 3 journal papers are expected.

10.5. Expectations of Faculty

Students should expect the faculty to be committed to creating a scholarly environment where effective learning and professional growth are enhanced. Actions toward this goal include but are not limited to the following:

a) providing opportunities in core courses for students to develop a graduate---level understanding of mechanical engineering principles,

b) challenging and stretching students to achieve high standards of excellence,

c) encouraging students to broaden their knowledge of mechanical engineering as well as to develop expertise in an area of research, and

d) including new technology areas in elective and core courses.

11. FINANCIAL SUPPORT

11.1. Departmental support

The ME department provides Teaching Assistantship (TA), Research Assistantship, (RA), Graduate Assistantship (GA), Student Assistantship (SA), and scholarship to support qualified students. Talk with your supervisor about the availability and other detailed information.

11.2. Graduate School Support and Scholarships

Graduate school has various scholarships and fellowships which may help you financially.

Go and check: https://www.depts.ttu.edu/gradschool/financial/GeneralFellowships.php

or send an E-mail to gradfellowships@ttu.edu for detailed information.

12. STUDENT ADVISING

Changdong Yeo, PhD. Associate Chair of Research and Graduate Affairs changdong.yeo@ttu.edu 806-834-5452	Rene Fuentes Graduate Advisor/Coordinator rene.fuentes@ttu.edu 806-834-2335

13. REEARCH OVERVIEW in ME DEPARTMENT

https://www.depts.ttu.edu/me/research/researchareas/index.php

APPENDIX I. A FORMAT OF PHD QUALIFYING EXAM

A. PURPOSE

The purpose of the exam is to ensure thorough understanding of fundamental engineering concepts by all Ph.D. students in the ME Program at TTU. The exam will evaluate students' core ME knowledge and provide an early assessment of their potential for successful completion of their Ph.D. studies.

B. ELIGIBILITY

(a) All Ph.D. students must complete their qualifying exam within the first 18 months of matriculation into the graduate program.
(b) Students must complete at least one semester in the Mechanical Engineering Ph. D. (or prior MS) Graduate Program before taking the Qualifying Exam.
(c) Student must be enrolled during the semester they take the Qualifying Exam.

C. TIMELINE

(a) The Qualifying Exam is offered on September and February every year; this schedule can be changed by a joint decision of the Graduate Director and Graduate Committee.
(b) Students apply by April 1 for the September exam and by October 1 for the February exam.
(c) The specific information of Qualifying Exam (Date & Time) will be announced several weeks before the exam.

D. REGISTRATION

Eligible student must submit the application form of Qualifying exam to Graduate Academic Advisor. The deadline is:

(a) April 1 for 'Qualifying Exam on September'
(b) October 1 for 'Qualifying Exam on February'

E. FORMAT OF QUALIFYING EXAM

(a) Students choose one primary area and one secondary subject from the following list:
- MATH (**Mandatory**)
- DYNAMICS & VIBRATIONS
- SYSTEMS & CONTROLS
- FLUID MECHANICS
- THERMODYNAMICS
- MECHANICS OF MATERIALS

(b) Qualifying Exam is composed of 3 subject tests: Math (mandatory) + one primary + one secondary
- Primary & Secondary subject: written (50%) + oral (50%)
- Math: written only

- Coverage of tests:
  - ✓ Written test covers upper level undergraduate materials (100 min test)
  - ✓ Oral test can cover from UG to introductory graduate level materials
    - Introductory graduate level materials are based on the core courses offered every semester or year.

(c) Criteria for Pass & Fail

- A passing grade of over 70% is required for each subject.
- Second exam attempt for each of the failed subjects is allowed; the failed exam must be retaken in the following semester.
- Failure to pass the exam for the second time will cause dismissal from the Ph.D. Program.

F. PREPARATION OF QUALIFYING EXAM

(a) Check and read carefully the instruction and guideline of each subject (Appendix).

(b) Make study groups if possible.

(c) If necessary, speak with a faculty in the interesting area.

APPENDIX II. APPLICATION FORM OF PHD QUALIFYING EXAM

Application form of PHD Qualifying Exam

Check Eligibility:

- Students who have completed at least one semester in the PHD program.
- Student must be enrolled during the semester they take the Qualifying Exam.

Applicant's Information

Last Name:	First Name:	R#:

Subject Selection (v-check):

(a) Choose one primary and one secondary topics (Math is mandatory)
(b) Indicate if primary or secondary

- ☑ **(Mandatory) MATH**
- ☐ **(Primary , Secondary) DYNAMICS & VIBRATIONS**
- ☐ **(Primary , Secondary) SYSTEMS & CONTROLS**
- ☐ **(Primary , Secondary) FLUID MECHANICS**
- ☐ **(Primary , Secondary) THERMODYNAMICS**
- ☐ **(Primary , Secondary) MECHANICS OF MATERIALS**

Exam Date (term & year)	Term: (v-check) September / February	Year:

Advisor's Approval

Print Name:	Signature	Date

APPENDIX III. INSTRUCTION AND GUIDELINE OF QUALYFING EXAM

A. MECHANICS OF MATERIALS

(1) Expected Knowledge and Exam Contents

- Strength of materials
- Linear deformation under axial loading
- Angular displacement under torque
- Combined loadings
- Deflection of beam
- Buckling
- Allowable design: dimension and load
- Failure theories
- Elasticity (Plane stress and plane strain, 2-D elastic body)

(2) ME Courses to be covered

- ME3403 Mechanics of Solids
- ME5340 Elasticity

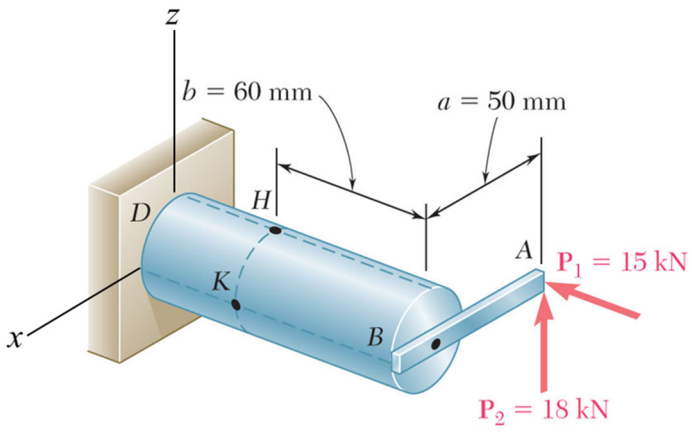
(3) Reference Textbooks

- "Mechanics of Materials", 9th Ed. by R.C. Hibbeler, Pearson – Prentice Hall Pub
- "Theory of Elasticity", S. P. Timoshenko and J. N. Goodier, 3rd edition, McGRAW-HILL

(4) Examples

Problem #1

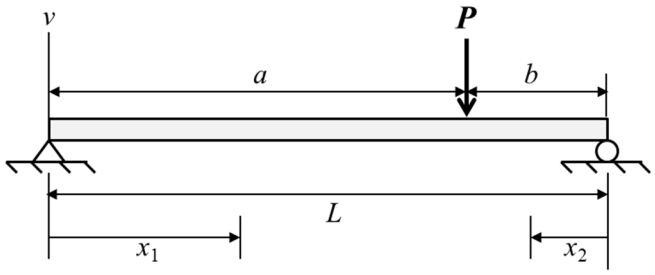
Two forces are applied as shown to end A of bar AB, which is welded to a cylindrical member BD of 20 mm radius. Distance from A to the longitudinal axis of member BD is 50 mm. Using Mohr's circle, determine the principal stresses and the maximum in-plane shear stress at point H. Show your results on 2D stress elements.



Problem #2:

For the beam and the loading shown below, and assuming $EI = 1$:

a) Write down the equations for the elastic curve.
b) Write down the equations to solve for integration constants for the elastic curve.
c) Determine the integration constants.



Problem #3:

For a specified elastic body in a Cartesian coordinate system (x, y, z), the stress components are given by:

$\sigma_x = x^2 + y^2, \quad \sigma_z = x^2 + z^2, \quad \tau_{xy} = xy, \quad \sigma_y = \tau_{xz} = \tau_{yz} = 0$

If the body is in equilibrium state, determine the body forces acting on this body.

B. DYNAMICS AND VIBRATIONS

(1) Expected Knowledge and Exam Contents

- Kinematics
- Degrees of freedom
- Dynamics of particles and rigid bodies
- Newtonian mechanics (vectorial mechanics)
- Work and energy
- Impulse and momentum
- Solution methods for linear first and second order ODEs
- Stability
- Linearization about equilibrium
- Transient and steady state response
- Frequency response
- Modal analysis
- *Analytical mechanics (variational approach to mechanics)
- *Continuous systems

*denotes topics covered on major area exams

(2) ME Courses to be covered

- ME2302 Dynamics
- ME3333 Dynamic Systems and Vibrations
- ME 5311 Advanced Dynamics
- ME 5316 Advanced Vibrations

(3) Reference Textbooks

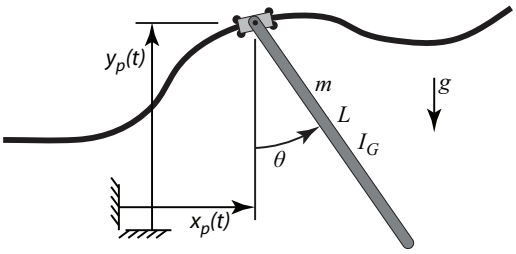
- "Engineering Mechanics: Dynamics" 14th edition, Russell C. Hibbeler, Pearson.
- "System Dynamics" third edition, William Palm III, McGraw-Hill.
- Graduate dynamics textbook
- "Fundamentals of Vibrations", Leonard Meirovitch, 2010, Waveland Press, Inc.

(4) Examples

Problem #1

A rod is driven along a track with prescribed displacements x_p(t) and y_p(t). Assume the mass center of the rod is at its midpoint and that the motion is planar.

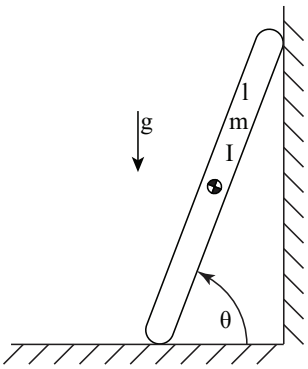
d) How many degrees of freedom does the system have? Justify your answer.
e) Find the equation(s) of motion for the system.



Problem #2:

For the following system, assume the bar remains in contact with the wall and floor, the wall and floor are frictionless, I=ml^2/12, the angle remains within the range $0<\theta<\pi/2$.

a) If the system starts at rest with the angle θ just less than 90°, find the angular velocity of the rod immediately before it hits the floor (θ=0°)



Problem #3:

When the mass (M) spring (K) system below (Before) is forced by a harmonic force f(t)=Acos(ωt) the mass (M) vibrates with an unacceptably large amplitude.

a) Design a mass (m) spring (k) system to attach to mass M such that its amplitude at steady state minimized; see below (After). (Note, M, K, A, and ω are known constants; find m and k.) Assume damping is present in the system, although very small.
b) The additional mass and spring change the natural frequency of the system. Write the characteristic equation that must be solved to determine the system's natural frequencies.

Problem #4:

The following state variable model can be used to determine the stability of a satellite rotating about its body-fixed z axis with constant angular velocity Ω. Characterize the stability of the system. Assume I_1, I_2, I_3, and Ω are positive real constants.

$$\begin{bmatrix} \dot{\omega}_1 \\ \dot{\omega}_2 \\ \dot{\omega}_3 \end{bmatrix} = \begin{bmatrix} 0 & \frac{I_2-I_3}{I_1}\Omega & 0 \\ \frac{I_3-I_1}{I_2}\Omega & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix}$$

C. FLUID MECHANICS

A general knowledge of fluid mechanics including dimensionless analysis, control volume analysis, differential analysis, internal flow, external flow, boundary layer theory, potential flow, and turbomachinery.

(1) Expected Knowledge and Exam Contents

- Basic understanding of surface tension, viscosity, and fluid properties
- Hydrostatic pressure distribution and force on plane and curved surfaces
- Dimensional homogeneity and analysis
- Reynolds transport theorem
- Navier-Stokes equation
- Analyze systems involving viscous internal flow through conservation of energy
- Analyze and design turbomachinery applications for performance and efficiency requirements.
- Characterize External Flows

(2) ME Courses to be covered

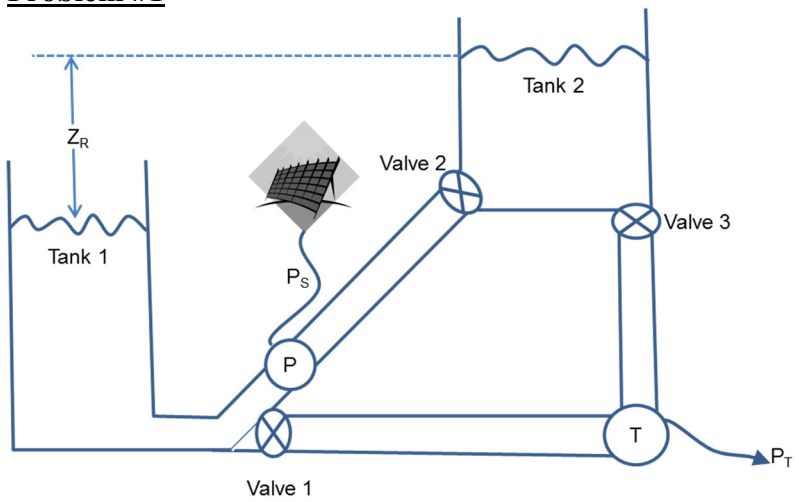
- Fluid Mechanics ME 3370 (Fundamental)
- Advanced Fluid Mechanics ME 5320 (Advantageous)
- Boundary Layer Theory ME 5330 (Advantageous)
- Potential Flow ME 5332 (Advantageous)

(3) Reference Textbooks

- White, "Fluid Mechanics" 7th Edition
    - Fluid statics: surface tension and pressure distributions on submerged surfaces (Chapter 2)
    - Introduction to Fluid Mechanics: basic concepts and definitions (Chapter 1)
    - Dimensional analysis: dimensional homogeneity and non-dimensional variables (Chapter 5)
    - Integral Relations (Chapter 3)
    - Differential Relations (Chapter 4)
    - Viscous flow in ducts (Chapter 6) and Turbomachinery (Chapter 11)
    - Viscous external flow (Chapter 7)

(4) Examples

Problem #1



Shown above is a schematic for a system used to store solar energy generated by solar panels so the energy is available when the sun is not shining. There are 2 large tanks opened to the atmosphere and connected by a series of pipes. When excess energy is generated with a power, P_s, it is used to run a pump that moves water from tank1 to tank2 (valve 2 is opened and valves 1 and 3 are closed). When the sun is not shining, water is moved from tank 2 to tank1 through a turbine to generate power, P_T (valve 2 is closed and valve 1 and 3 are opened). All pipes in the system are round and have a diameter, D.

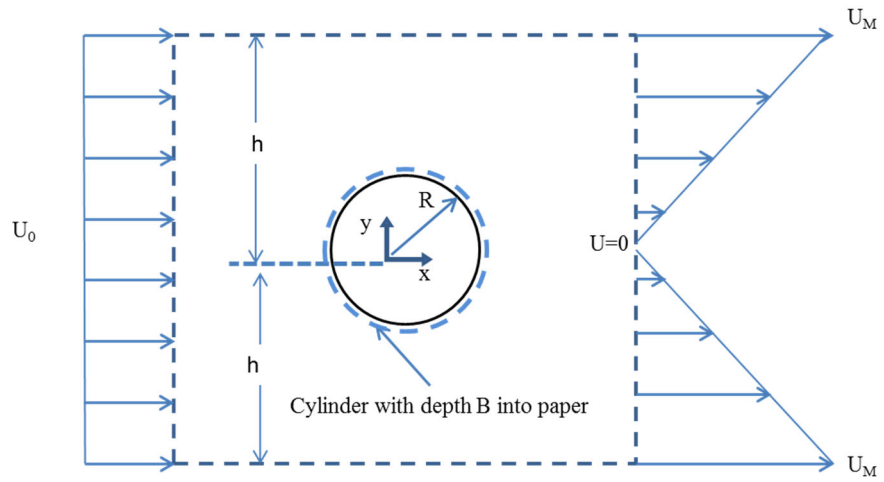
A) Assuming all the power from the solar generator makes it to the pump (i.e. $P_s = bhp$) and the pump efficiency at a flow rate, Q_P, is η_p find the head added by the pump, h_p, in terms of P_s, Q_P, η_p, ρ and g.

B) Assuming the total length of the pipe from tank 1 to 2 is L_p, use the energy equation to find Z_R in terms of known variables for the situation when tank 2 is being filled. Use the equation found for h_p in part A. You may assume that Q_P, ρ, g and D are known. Since geometry, flow rate, and fluid properties are known, you may use f_p for the friction factor. Ignore all minor losses.

C) Assuming the total length of the pipe from tank 2 to 1 is L_T, use the energy equation to find h_t in terms of known variables for the situation when tank 2 is being drained. Use the equation found for Z_R in part B. You may assume that Q_t, ρ, g and D are known. Since geometry, flow rate, and fluid properties are known, you may use f_t for the friction factor. Ignore all minor losses.

D) Assuming the turbine is completely efficient (i.e. all the water energy of the turbine is turned into P_T) find an overall efficiency for the system, $\eta = P_T / P_S$.

Problem #2



Above is a picture of a cylinder that is suspended in an air flow. Due to the cylinder, the velocity profile changes, which we have estimated to fit a linear profile. **ASSUMING** no flow leaves from the top or the bottom of the drawn control volume and U_0 is known as well as all fluid properties, answer the following questions.

A) The momentum of the fluid is reduced due to the drag force on the sphere. Find the drag force on the sphere using conservation of linear momentum and the control volume drawn above. Please have the answer in terms of known geometry and $\boldsymbol{U_0}$.

B) Using the drag force found above, find and equation for the drag coefficient on the cylinder. Be clear what area you are using for the area in drag coefficient.

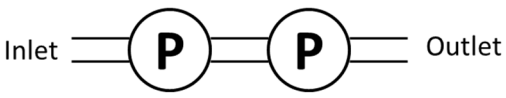
C) Based on your answer to C, do you think the proposed control volume and linear velocity profile accurately represent drag on a cylinder? Why?

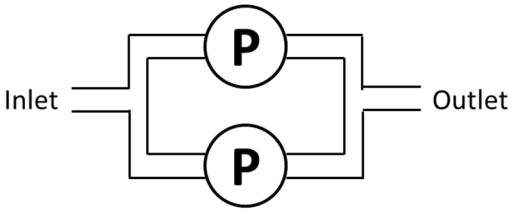
D) Propose a more accurate velocity profile.

E) If this were a real cylinder in flow, explain how the boundary layer would change when going from creeping flow, to laminar flow, to turbulent flow. Use pictures and words. How do these flow changes affect drag?

Problem #3

To the right is pictured 2 pipe systems, 2 pumps in series and 2 pumps in parallel. In each system you may assume the pumps are identical. Assume for the pumps in parallel that the system is symmetric, i.e. the line on top and bottom have identical conditions throughout.

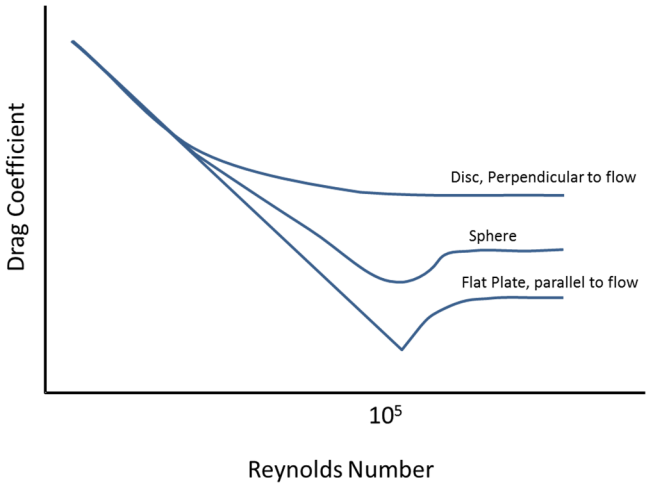




A) Find an equation for the head created by both systems. You may ignore minor losses to the system and frictional losses.

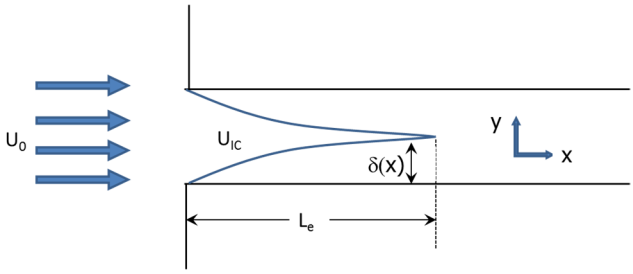
B) What would be the required head for the pumps in each system in order to create the same head increase between the inlet and the outlet for the same overall flow rate.

Problem #4



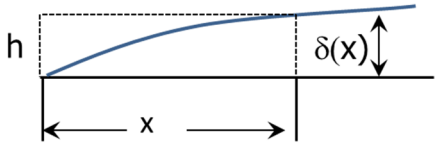
1) Using the graph above, explain the relationship of drag coefficient to Reynolds number for a sphere. What is the role of the boundary layer? Why does the curve take the shape it does in terms of fluid phenomenon?. You may use pictures to help make your point.
2) Explain the difference in the drag coefficient curves for the disc, sphere and flat plate in terms of relevant fluid flow phenomenon.
3) How could drag on a sphere be reduced through control of boundary layers? In general how does streamlining reduce drag?

Problem #5



Above is pictured an entry flow into planar pipe. The flow is 2D, with a depth into the paper of , *b*. The height of the channels is, *H*. Assuming that the flow in the developing boundary layer is linear, $u(y) = U_{IC}\frac{y}{\delta}$, answer the following questions.

1) Using a control volume and the integral relations, find an equation for the velocity in the inviscid core in terms of x, U_{IC} (X), in terms of U_o, *H*, and δ.
2) If the velocity of the inviscid core is accelerating, what does that tell you about the Pressure gradient in the X direction inside the boundary layer?
3) What is entry length of a pipe mean? After the entry length, a pipe flow is said to be fully developed, what does that mean?
4) Using conservation of mass, conservation of momentum, and the provided velocity profile, find the drag on a flat plat. Consider a wall to be a flat plate and use a control volume from the entry point to an arbitrary position x:



D. SYSTEMS AND CONTROL

(1) Expected Knowledge and Exam Contents

- Find a transfer function from mechanical, electrical, electromechanical and thermal system.
- Understand the characteristics of dynamic system
- System responses from various inputs
- Understanding time responses and frequency responses.
- System stability
- Loop shaping and frequency shaping: Design lead, lag and PID controller using root locus, bode plot and nyquist

(2) ME Courses to be covered

- ME3333 Dynamic Systems and Vibration
- ME4334 Control of Dynamic Systems

(3) Reference Textbooks

- Control System Engineering, Norman S. Nice, Wiley.
- Feedback Control of Dynamic Systems, G. F. Franklin, Pearson/Prentice-Hall

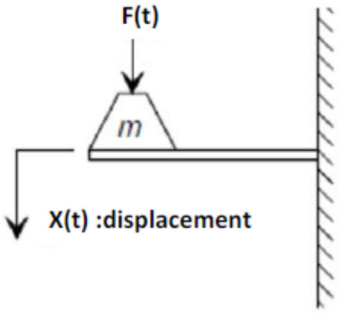
(4) Examples

Problem #1

A mass m supported on a cantilever beam and subjected to a prescribed force F(t) is shown in right figure.

A force source F(t) to represent the system input. A mass element m to represent the mass. The beam is assumed to be massless, and is represented by a spring element K.

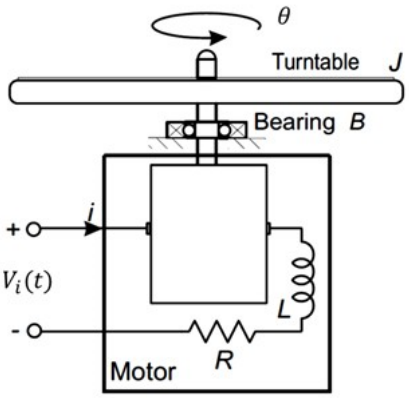
Find a transfer function X(s)/F(s). From the transfer function, find the damping ratio, natural frequency and unit step response.



Problem #2

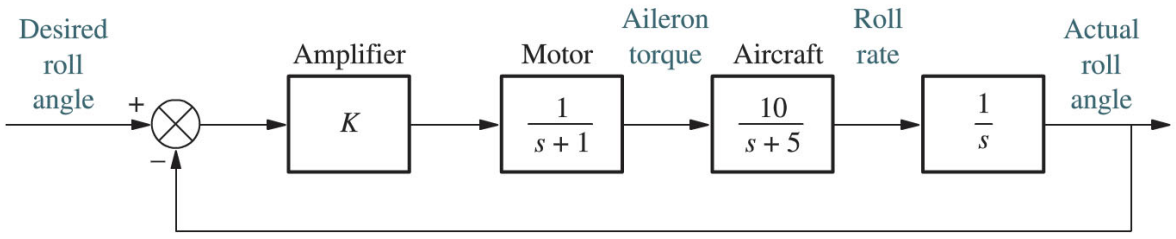
A typical electromechanical system is shown in figure below. The motor has electrical constant (k_V), torque constant (k_t), resistor(R) and inductor (L). The load has an inertia (J) and friction (B).

Derive the transfer function $\Theta(s)/V_i(s)$ for the electromechanical system using a linear graph technique. Draw the block diagram of DC motor system with input $V_i(s)$ and output Θ (s) with the equations of motion (Feedback System).



Problem #3

An aircraft roll control system is show in figure below. The torque on the aileron generates a roll rate. The resulting roll angle is then controlled through a feedback system as shown.



Determine the gain K to be marginally stable. Design a lead compensator for a 45° phase margin and K_v=2. (Correction factor=15°, Indicate all the critical values on the plot.)

E. ENGINEERING MATHEMATICS

(1) Expected Knowledge and Exam Contents

- Linear algebra: matrix, determinants, inversion techniques, eigen vectors
- Basic differential calculus: limit, continuity, product rule, chain rule etc.
- Basic integral calculus: fundamental definition, integration by-parts, rational fraction etc.
- Common ODEs: 1st order linear, 2nd order linear with constant coefficients etc.
- Separation of variables for second order PDEs: parabolic, wave, Laplace equations
- Functional transformations: Laplace, Fourier, Hankel
- Spatial fields and operators: coordinates, basis vectors, grad, div, curl, Laplacian

(2) ME Courses to be covered

- Calculus I, II and III in undergraduate
- ME5301 Engineering Analysis
- ME6331 Vector-Tensor and Linear algebra

(3) Reference Textbooks

- "Advanced Engineering Mathematics" 7th or 8th edition, Erwin Kreyszig, Wiley.

(4) Examples

I. Find Grad$[(y+z)*\tan^{-1}(x^y)]$, where x, y, z are Cartesian coordinates.

II. Your friend is using Laplace transform to solve the following ODE: $(1+x^2)y''+2xy'+6y=0$. What would be your advice to him, and why?