POLICY ON RESEARCH ETHICS
SCHOOL OF MATERIALS SCIENCE AND ENGINEERING

The effectiveness of the research infrastructure throughout the world is based on the personal and professional integrity of the people involved. The basic assumption that is central to all research endeavors is that researchers have done what they say that they have done. The School of Materials Science and Engineering is part of that infrastructure, and the research conducted here must withstand the highest scrutiny. Consequently, we must all ensure that our scholarly work is conducted and reported with the highest ethical standards. We must be careful in our record keeping and diligent in our efforts to always attribute credit where it belongs. In particular, we must guard against any activity that would bring the integrity of the department or the individuals within it into question. Among the activities to be avoided are:

- Falsification of Data – ranging from fabrication to deceptively selective reporting of results or methods, including the purposeful omission of conflicting data with intent to falsify results;

- Misappropriation of other’s Ideas – the unauthorized use of privileged information, however obtained; and

- Plagiarism – representation of another’s work as one’s own; the following website link has a great deal of information in defining and giving examples of plagiarism: www.plagiarism.org/learning_center/what_is_plagiarism.html

In the Clemson University graduate announcements plagiarism is described “as a form of academic dishonesty that includes copying of language, structure or ideas of another, and attributing the work to ones own efforts.”

**Note:** there is no mention of intent or deceitful intent. This means that if you submit plagiarized work, **even if this is unintentional**, it is still plagiarism. Ignorance of the rules is no excuse for breaking them.
It is the responsibility of every member of Clemson University to enforce the academic policy (see Graduate Announcements).

**Examples of plagiarism**

- To use ideas (i.e., to steal them) from someone else and pass them off as if the ideas were your own is plagiarism.

- To take a source of material, words, diagrams or results and pass them off as your own is plagiarism.

- To copy someone else’s work and submit it as your own is plagiarism.

- To copy words and ideas without giving appropriate credit is plagiarism.

- If you quote someone but do not use quotation marks this is regarded as plagiarism.

- If you change the words in a sentence but do not change the structure this is regarded as plagiarism.

- If you take or copy a vast number of words or sentences or paragraphs from a paper, book, journal or any other literary source so that it makes up a large amount of your work whether you give credit or not is still plagiarism because this goes against United States government guidelines of “fair use”. Basically, if you have copied a text or diagram exactly as in the original source then this is unlikely to be considered fair use. If in some way you have creatively rewritten the material then this more than likely will be considered fair use. However, the more you use or borrow from other sources the less likely it is to be considered fair use.

- Anything directly taken from copyrighted material is plagiarism unless permission is granted to use those materials from the author/publisher.

The undersigned attests that s/he acknowledges receipt of this manual, has read and understood pages 2 and 3 of the manual and recognizes the importance of maintaining the highest ethical standards in research and covenants with the other members of the department to conduct his/her research and professional life in a manner consistent with those details.

**NAME**
__________________________________________

**SIGNATURE**
__________________________________________

**DATE**
__________________________________________
STATEMENT OF AGREEMENT

SCHOOL OF MATERIALS SCIENCE AND ENGINEERING

I, the undersigned, have reviewed the *MS&E Graduate Student Manual* and agree to abide by all of the procedures and guidelines discussed therein.

__________________________  ________________
(Printed Name)     (Date)

__________________________
(Signature)
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5
INTRODUCTION

WELCOME to the School of Materials Science and Engineering (MS&E). This manual is intended to familiarize Graduate Students with the operational aspects of the School of Materials Science and Engineering at Clemson University. As such, it serves as an informational source and a catalog of School procedures and requirements that affect graduate students. The requirements specified here are in addition to those described in the “Graduate School Announcements,” which may be found on the Clemson Graduate School Web Site at www.grad.clemson.edu.

All new students are required to attend orientations held by the School of Materials Science and Engineering and the Graduate School. Information from these orientations helps students to select specific research areas and allows them to choose their advisory committee members more responsibly. Dates and times of orientation meetings are announced each semester.

We hope this manual is useful both to graduate students and their faculty advisors. Any inconsistencies or omissions should be brought to the attention of the Program Coordinator.

Jurisdiction/Authority

This document is subject to periodic review and revision by the MS&E faculty. Each graduate student is subject to the policies in effect at the time of beginning their program. If policies change, a student may petition, in writing, the MS&E faculty for approval, or disapproval, of changing to the new policies.
BUILDING KEYS
   Student Services Coordinator, 160 Sirrine Hall

COURSE SELECTION (1st semester only, students without major advisor)
   Graduate Program Coordinator, 161 Sirrine Hall

GRADUATE ASSISTANTSHIPS
   Graduate Program Coordinator (students without advisor), 161 Sirrine Hall
   Administrative Assistant (in charge of assistantship forms), 161 Sirrine Hall

GRADUATE STUDENT FORMS
   Student Services Coordinator, 160 Sirrine Hall

PAYROLL
   Administrative Assistant (in charge of finance), 161 Sirrine Hall

PURCHASING
   Administrative Assistant (dependant on type of order), 161 Sirrine Hall
   Order types include: NTC, Grant, General orders, etc.

STUDENT RECORDS
   Student Services Coordinator, 160 Sirrine Hall

TRAVEL
   Administrative Assistant (in charge of travel), 161 Sirrine Hall
GRADUATE PROGRAM PERSONNEL

Dr. Kathleen Richardson (161 Sirrine, richar3@clemson.edu)
*Director of the School of Materials Science and Engineering* – decides matters involving resources available to graduate students; has final approval on assistantship and fellowship offers; has the authority on regulations and procedures pertinent to the Graduate Program.

Graduate Program Coordinators and Committee

Dr. Michael Ellison (271A Sirrine Hall, 656-5956, ellisom@clemson.edu)
*Chairperson of MS&E Graduate Standards Committee* – makes recommendations to the School Director regarding graduate admissions offers along with other members of the Graduate Standards Committee; interacts with the Graduate School on other matters including student status, assistantships, and fellowships; coordinates graduate student recruitment activities.

Dr. Gary Lickfield (161 Sirrine Hall, 656-5964, lgary@clemson.edu)
*Graduate Program Coordinator* – works with students that have been accepted and have officially entered the MS&E graduate program; acts as the initial advisor in first semester course selection for those graduate students who have not yet selected a major advisor.

Program Assistance

Kathy Bolton (160 Sirrine Hall, 656-1512, boltonk@clemson.edu)
*Student Services Coordinator* – distributes graduate student forms and building keys; maintains student records; coordinates conference room/classroom reservations in MS&E buildings; sends email alerts for student meetings, fellowships and job opportunities.

Shelby Sheriff (161 Sirrine Hall, 656-3187, sshelby@clemson.edu)
*Office Manager, Administrative Assistant* – assists the Director of MS&E with her duties; coordinates fellow Administrative Assistants.

Tonya Bledsoe (161 Sirrine Hall, 656-6900, bledsoe@clemson.edu)
*Administrative Assistant* – in charge of assistantship forms, Payroll, Travel Vouchers and car rental, Purchase Orders/Requisitions for general orders and other graduate student financial matters; receives Research Proposals, accident reports and requests for military leave.

Nancy Belanger (161 Sirrine Hall, 656-1116, nbelang@clemson.edu)
*Administrative Assistant* – receives packages for MS&E and National Textile Center (NTC); processes departmental charges for MS&E and NTC; facilitates travel transportation (car rental) with Tonya Bledsoe.
Technical Assistance

Kim Ivey (Lab 68, 656-5968, ikimber@clemson.edu)  
Analytical Lab Manager

Robbie Nicholson (Lab 272, 656-5972, nrobbie@clemson.edu)  
Technical Services Manager

Greg Schlock (B19 Olin, 656-1658, gschloc@clemson.edu)  
Laboratory Technologist

David White (160 Sirrine, 656-1135, wdavid@clemson.edu)  
Systems Programmer
**REGISTRATION**

**Registration for New Students**

Prior to registration for the first semester of study, beginning graduate students must report to the Graduate Program Coordinator. S/he will be their initial advisor and will help them plan their initial program of study. See “Graduate Program Personnel” for current Coordinator.

**Registration Procedures**

The Office of Registration Services provides an online guide:
www.registrar.clemson.edu/

**Enrollment Limits Maximum/Minimum Credit Hours**

<table>
<thead>
<tr>
<th>Student Category</th>
<th>Semester</th>
<th>6-week Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time students</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Graduate assistants ((\frac{1}{4}) time)</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Graduate Assistants ((\frac{1}{2}) time)</td>
<td>12/9</td>
<td>4/3</td>
</tr>
<tr>
<td>Graduate Assistants ((\frac{3}{4}) time)</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Full-time Employees</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

**Financial Support**

Graduate students are eligible for financial support if they are (1) enrolled in full-time graduate studies and (2) in good academic standing, i.e., not on probation. Tuition and fees for students receiving support is a flat fee. To receive the reduced tuition and fees for a particular semester, a qualified student must be on the University payroll prior to the beginning of that semester.

Financial support is awarded based on several factors, which include academic merit and the availability of funds. If a student changes his/her subject area after support has been extended, support eligibility will be reviewed and may be terminated.
POLICIES AND PROCEDURES FOR MASTER’S DEGREES

Introduction

The faculty of MS&E adopted these policies. These policies supersede any policies written prior to the current semester. Academic regulations pertaining to the various degree programs are published in the “Graduate School Announcements”.

Selecting a Research Advisor

All beginning M.S. students are asked to confer with each MS&E faculty member in whose general area they may have an interest. Upon having done so, the student selects a research advisor subject to the consent of the selected faculty member. The student subsequently begins to formulate research plans with the advice of their advisor.

Advisory Committee

The student, working with his/her advisor, selects an advisory committee. The advisory committee should be chosen during the student’s first semester. A Master’s advisory committee shall consist of a minimum of three (3) members who hold faculty appointments at Clemson University. A majority of the committee shall hold tenure track faculty appointments in the School of Materials Science and Engineering. If the student has declared a minor, at least one of the committee must be from the faculty of the program offering the minor. The chairperson of the committee is usually the research advisor and must hold a full time faculty appointment at Clemson University.

The student’s advisory committee will perform the following functions:

- Assist in the selection of course work and approve course work;
- Assist in supervision of research program;
- Administer the final oral examination;
- Approve the Master’s thesis; and
- Initiate recommendation to the graduate school for awarding the degree.
# MS&E Course Schedule

<table>
<thead>
<tr>
<th><strong>FALL SEMESTER</strong></th>
<th><strong>UNDERGRADUATE PRE-REQUISITES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MSE 826</strong> Phase Equilibria in Materials Science</td>
<td><strong>CME 326</strong> Thermodynamics</td>
</tr>
<tr>
<td><strong>MSE 827</strong> Kinetics in Materials I</td>
<td><strong>CME 327</strong> Transport Phenomena</td>
</tr>
<tr>
<td><strong>MSE 820</strong> Deformation Mechanisms in Solids</td>
<td><strong>CME 422</strong> Mechanical Properties of Materials</td>
</tr>
<tr>
<td><strong>PFC 811</strong> Polymer Science I</td>
<td><strong>PFC 415/615</strong> Introduction to Polymer Science &amp; Engineering</td>
</tr>
<tr>
<td><strong>PFC 657</strong> Dyeing and Finishing</td>
<td><strong>PFC 303</strong> Textile Chemistry (Organic Chemistry)</td>
</tr>
<tr>
<td><strong>TEXT 821</strong> Fiber Physics I</td>
<td><strong>PFC 304</strong> Textile Chemistry (Physical Chemistry)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SPRING SEMESTER</strong></th>
<th><strong>UNDERGRADUATE PRE-REQUISITES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MSE 828</strong> Kinetics in Materials II</td>
<td><strong>CME 402</strong> Solid State Materials</td>
</tr>
<tr>
<td><strong>MSE 821</strong> Fracture and Fatigue</td>
<td></td>
</tr>
<tr>
<td><strong>MSE 825</strong> Solid-State Science</td>
<td></td>
</tr>
<tr>
<td><strong>PFC 812</strong> Polymer Science II</td>
<td></td>
</tr>
<tr>
<td><strong>TEXT 835</strong> Textile Structures I</td>
<td></td>
</tr>
<tr>
<td><strong>TEXT 866</strong> Fiber Formation</td>
<td></td>
</tr>
</tbody>
</table>
MINIMUM DEGREE REQUIREMENTS FOR M.S. IN MS&E AND PFS

<table>
<thead>
<tr>
<th>Course Credit Hours</th>
<th>24 Hours*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core + Other courses required</td>
<td>4 core + 4 other = 8</td>
</tr>
<tr>
<td>Thesis Research 891</td>
<td>6-hour thesis (Grad School)</td>
</tr>
<tr>
<td>Exams</td>
<td>Thesis Defense</td>
</tr>
</tbody>
</table>

* Does not include MS&E 800 Materials Research Seminar

COURSE DEFICIENCIES

The MS&E Graduate Program is not designed to be a “remedial or entry-level” program; therefore, students are expected to have the appropriate technical background prior to entering these programs. If course deficiencies are specified as a condition of a student’s admission, it is important that these be taken early in the program in order to provide the student with background for graduate level courses. Normally, these deficiencies are removed by taking and passing the required courses during a normally scheduled course offering. These courses do not count toward the total number of semester hours of graduate credit (exclusive of the MATE 800) required for graduation.

Pre-requisite courses must be completed before admission as a graduate student, whereas co-requisite courses must be completed before receipt of the advanced degree.

REQUIRED CORE

All students must enroll in MS&E 800 Materials Research Seminar every semester.

Core Courses

Students pursuing a M.S. in MS&E, with a metals and/or ceramics specialization, require four (4) from the following six (6) courses, chosen by the student in consultation with their supervisor and research committee.

- MS&E 820 Deformation Mechanisms in Solids
- MS&E 826 Phase Equilibria in Materials Science
- MS&E 827 Kinetics in Materials Science I
- MS&E 821 Fracture and Fatigue
- MS&E 825 Solid-State Science
- MS&E 828 Kinetics in Materials Science II
Four (4) other courses are selected by the student and his/her advisor. A student has to maintain a minimum 3.0 overall GPA order to graduate with a M.S. degree.

Students pursuing a M.S. in MS&E, with a polymer specialization, will require four (4) core courses from the following, chosen by the student in consultation with the supervisor and research committee.

TWO FROM:
- PFC 811 Polymer Science I
- PFC 812 Polymer Science II
- TEXT 821 Fiber Physics I
- TEXT 822 Fiber Physics II
- TEXT 866 Fiber Formation
- PFC 840 Analytical Methods in Polymer and Fiber Science

AND TWO FROM:
- MS&E 820 Deformation Mechanisms in Solids
- MS&E 826 Phase Equilibria in Materials Science
- MS&E 827 Kinetics in Materials Science I
- MS&E 821 Fracture and Fatigue
- MS&E 825 Solid-State Science
- MS&E 828 Kinetics in Materials Science II

Four (4) other courses are selected by the student and his/her advisor. A student has to maintain a minimum 3.0 overall GPA order to graduate with a M.S. degree.

Students pursuing a M.S. in MS&E with specialization in Polymer and Fiber Science and M.S. in Polymer and Fiber Science, require four (4) from the following six (6) courses, chosen by the student in consultation with the supervisor and research committee.

- PFC 811 Polymer Science I
- PFC 812 Polymer Science II
- TEXT 821 Fiber Physics I
- TEXT 822 Fiber Physics II
- TEXT 866 Fiber Formation
- PFC 840 Analytical Methods in Polymer and Fiber Science

Four (4) other courses should be selected by the student and his/her advisor. A student has to maintain a minimum 3.0 overall GPA order to graduate with a M.S. degree.

The student’s advisory committee must approve all the courses by signing off on the student’s GS2 form.
CURRICULUM DEVELOPMENT – GS2 FORM

All students are expected to develop an area of study with the advice and consent of their advisory committee.

The planned course of study, once approved, must be presented to the Graduate School via the completion of the GS2 Form. The GS2 Form must be completed as soon as the student talks with his/her advisor and determines the course of study s/he will pursue; but no later than the end of the first semester.

The GS2 is a form that serves to appoint the graduate advisory committee and notifies the Graduate School of all the classes the student will take to fulfill the degree requirements. **It is important to note that any class listed on one’s GS2 must be completed before graduation. If changes are necessary, a revised GS2 must be filed.** This form may be found at [www.grad.clemson.edu/forms.php](http://www.grad.clemson.edu/forms.php).
MASTER’S THESIS

Purpose

The purpose of the M.S. thesis is to demonstrate the capability of the student to:

- Formulate a research problem;
- Demonstrate knowledge relevant to a meaningful resolution of a specific problem;
- Effectively plan the work leading to the completion of the problem; and
- Report the results of the problem in a concise, precise professional style.

Selecting a Research Topic

Major advisors will assist students in the selection of an appropriate topic for their thesis. Students are expected to have selected a thesis topic by the end of their first semester of graduate study. By the end of second semester they must have prepared and presented to their advisory committee a typewritten proposal containing a definition of the problem, the objective(s) of the problem, and a plan and schedule for the completion of the problem. Proposals should also indicate any instruments, equipment, and materials that may be required. Each student’s advisory committee will review his/her initial proposal and make appropriate recommendations. Copies of the approved written proposal must be filed with the MS&E Administrative Assistant before the end of the second semester of enrollment. Failure of the graduate student to complete this requirement within the specified time frame will be ground for dismissal from the MS&E graduate program.

Thesis Proposal

A student’s thesis proposal is a persuasive document intended to document the worthiness of his/her research. It should be a brief, concise document that is 5 to 30 pages when double-spaced, not including references. An M.S. student should complete the final draft of the proposal by the end of the second semester of enrollment in the M.S. degree program.

Students develop their proposal with the help of their advisor and committee. The purpose of the proposal is to create a research plan. The student’s actual activities may vary as conditions and initial results dictate. The research proposed should be worthwhile and tractable. At the center of the proposal, there should be a clear hypothesis to be tested and/or a set of objectives. The material discussed before the objectives should give the necessary background and lead to why the objectives are worth pursuing. After the objectives are stated, a research plan should be presented aimed at attaining the objectives. The student should go over the central parts of the proposal, especially the objectives, with his/her advisor and then produce an initial draft.
The student’s advisor will review the first draft and offer suggestions or changes. Upon approval of the advisor, copies will be distributed to the student’s committee members for comments. Students may be required to orally defend their proposal before their committee. The signed original is kept in the student’s original departmental file, which is maintained by the student coordinator.

**Proposal Text – Introduction**

The introduction to the thesis should include some brief introductory remarks and a review of the literature that is relevant to the stated objectives. The literature review should be current and organized to support the research objectives.

**Research Objective**

This section should be written first. This section should contain a paragraph summarizing the major objective of the research. The major objective, whenever possible, should be stated as a hypothesis with tasks outlined for testing the hypothesis.

**Experimental Plan and Methodology**

This section should outline the experimental approach that will be used to accomplish the tasks listed in the objectives section. The approach should include the experimental design and a matrix of experiments to be conducted. The methodology should include procedures and analytical protocol or information about the development of those procedures. Information about the data to be collected and the use of the data should be provided, as well as final evaluation approaches.

**Significance of the Proposed Work**

This section should be a brief summary of why it is important to conduct the proposed research. What are the expected results and how will they benefit the Materials Science and Engineering community?

**Helpful Hints**

Students should use the recommended Graduate School format desired for references, font and other formatting items.

Whenever possible, use the active voice as the use of the first person is generally discouraged in technical writing.

Avoid starting sentences with numbers. Numbers less than or equal to ten should be spelled out. Numbers of 11 or more can be represented by Arabic numerals. However, if referring to an exact amount such as 1.0 ml, use numerals.
For additional information on technical writing, the following are recommended:

- *How to Publish a Scientific Paper* by Robert A. Day;
- *Scientific English: A Guide for Scientists and Other Professionals* by Robert A. Day; and
- *The ACS Style Guides: a Manual for Authors and Editors* edited by Janet S. Dodd.

**Approval of Research Proposal**

Master’s students should have a research proposal approved before the end of their second semester. The proposal is developed with and approved by the research advisor and the advisory committee.

**Graduate Diploma Application – GS-4 Form**

The GS-4 form informs students of how to apply for graduation and order their diplomas. The form is downloadable from the following web link: www.grad.clemson.edu/forms/forms_graduating.php

**Thesis Deadline**

The first draft of the thesis should be completed at least twelve weeks before the date of the final oral examination.

**Final Oral Examination**

The final oral examination is given at least three weeks before the date on which the degree is to be conferred. This is given under the authority of the student’s advisory committee in accordance with Graduate School deadlines. The committee will have been given final draft copies of the thesis a minimum of two weeks prior to the exam.

The chair of the student’s advisory committee will schedule the examination that is administered by the committee. During the examination, the student will be expected to orally present the findings of the research, support various aspects thereof, and be questioned on integrated knowledge of related coursework. The Graduate School will be notified of the time and place of the examination at least ten days prior to the time scheduled. At that time, members of the MS&E faculty, the Graduate Standards Committee, the Deans of the College of Engineering and Science and the Graduate School, and MS&E students are invited to attend the examination. Procedurally, the examination consists of a 30-45 minute presentation made by the student followed by questions posed, first, by non-members of the student’s graduate advisory committee and, second, by the members.
The results of the oral defense are submitted to the graduate school via the GS7 form. This form must be filled out and taken to the defense by the student and signed by the Committee.

Unsatisfactory performance on the final examination, as determined by the advisory committee, will result in at least one of the following actions to be taken:

1. Additional work on the thesis and resubmission of the thesis to the advisory committee for further review; or
2. Additional study in their area of specialty.

In case of failure, the advisory committee is required to submit a written report to the Dean of the College of Engineering and Science and the Graduate School stating that the student failed the final examination. A second failure on the final examination shall result in the student being declared ineligible for a Master's Degree in MS&E or PFS at Clemson University.
Master’s Student Checklist

Table 1.0 provides a checklist for milestones in the Master Degree Program.

Table 1.0 – Checklist for Master’s Students

<table>
<thead>
<tr>
<th>WHAT</th>
<th>WHEN</th>
<th>HOW/WHO</th>
<th>DATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of major advisor</td>
<td>Before the end of the 1st semester</td>
<td>Notify Graduate program coordinator and Admin. Assistant</td>
<td></td>
</tr>
<tr>
<td>Appointment of advisory committee</td>
<td>Before the end of the 1st semester</td>
<td>In consultation with advisor</td>
<td></td>
</tr>
<tr>
<td>Preparation of study program</td>
<td>Before the end of the 1st semester</td>
<td>In consultation with advisor and committee</td>
<td></td>
</tr>
<tr>
<td>Filing of study plan</td>
<td>Before the beginning of the 2nd semester</td>
<td>GS2 Form by student</td>
<td></td>
</tr>
<tr>
<td>Approval of thesis proposal</td>
<td>Before the end of the 2nd semester</td>
<td>Signed thesis proposal submitted to graduate student file</td>
<td></td>
</tr>
<tr>
<td>Apply for Graduation and Diploma</td>
<td>(Current deadlines can be found on the Graduate School website)*</td>
<td>GS4 Form by student</td>
<td></td>
</tr>
<tr>
<td>Submittal of thesis</td>
<td>1st draft at least 12 weeks before date of final examination; final (approved) drafts at least 2 weeks before final examination</td>
<td>By student</td>
<td></td>
</tr>
<tr>
<td>Final examination (Oral)</td>
<td>At least 3 weeks prior to date on which degree is expected (see website)*</td>
<td>GS7 Form to be filed by advisor after examination is completed</td>
<td></td>
</tr>
<tr>
<td>Cap and Gown Rental</td>
<td>Early during semester in which degree is to be conferred (see website)*</td>
<td>By student</td>
<td></td>
</tr>
</tbody>
</table>

* Graduate School Deadlines website: [www.grad.clemson.edu/Deadlines.php](http://www.grad.clemson.edu/Deadlines.php)
POLICIES AND PROCEDURES FOR Ph.D. DEGREES

Introduction

The faculty of MS&E adopted these policies. These policies supersede any policies written prior to the current semester. Academic regulations pertaining to the various degree programs are published in the Graduate School Announcements.

Selecting a Research Advisor

All beginning Ph.D. students should confer with each MS&E faculty member in whose general area they may have an interest. Upon doing so, the student should select a research advisor subject to the consent of the selected faculty member. The student subsequently begins to formulate research plans with the advice of his/her advisor.

Advisory Committee

The student, working with his/her advisor, selects an advisory committee. The Ph.D. advisory committee shall consist of a minimum of four (4) members who hold faculty appointments at Clemson University. A majority of the committee shall hold tenure track faculty appointments in the School of Materials Science and Engineering. If the student has declared a minor, at least one of the committee must be from the faculty of the program offering the minor. The chairperson of the committee is usually the research advisor and must hold a full time faculty appointment in Clemson University.

The student’s advisory committee will perform the following functions:

- Approve the student’s plan of study;
- Supervise his/her graduate program and dissertation research;
- Administer the comprehensive and final oral examination;
- Initiate recommendation to the graduate school for awarding the degree.

Curriculum Development – GS2 Form

The student develops a plan of coursework with the assistance of the research advisor and input from the advisory committee. This should be done before the end of the first semester after beginning the program. This plan is formally submitted to the Graduate School on the GS2 Form (www.grad.clemson.edu/forms/forms_current.php). Work in a minor field, if declared, normally requires a minimum of 12 hours in courses carrying a graduate credit (See “Policies and Procedures for the Master’s Degree”).
Minimum Degree Requirements for Ph.D. in MS&E and PFS

<table>
<thead>
<tr>
<th>Total Hours of Courses</th>
<th>12 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses Required</td>
<td>4</td>
</tr>
<tr>
<td>Doctoral Research Dissertation 991</td>
<td>18 hours (Grad School)</td>
</tr>
<tr>
<td>Exams</td>
<td>Comprehensive and Dissertation Defense (Final Examination)</td>
</tr>
</tbody>
</table>

Ph.D. comprehensive examination

Qualifications of students to take exam and criteria for eligibility:

Doctoral students are required to have a minimum GPA score of 3.2 in the core course work in order to be eligible to take the candidacy/comprehensive examination. Students may repeat up to two courses from the core in order to obtain the GPA of 3.2. Students who do not make a GPA of 3.2 after completion of the core coursework may not take the comprehensive examination and will be dismissed from the Ph.D. program. If the GPA score is above or equal 3.2, then the students will have TWELVE (12) MONTHS to prepare themselves and pass candidacy/comprehensive examination. The 12 months period will start on the first day of the semester following the semester in which the GPA requirement was satisfied.

Those students not meeting this time deadline will be:

1. Dismissed from Ph.D. program and dismissed from the School if they have a prior graduate degree in MS&E or PFS;

2. Required to complete M.S. degree in MS&E or PFS prior to seeking re-admission to the Ph.D. program.

Students failing the Ph.D. Comprehensive Examination and completing a M.S. degree as outlined herein will not be considered for admission to the School of Materials Science Ph.D. program.
**Core Courses**

Students pursuing a Ph.D. in MS&E, with a metals and/or ceramics specialization, will require four (4) from the following six (6) courses, chosen by the student in consultation with his/her supervisor and research committee.

- MS&E 820 Deformation Mechanisms in Solids
- MS&E 826 Phase Equilibria in Materials Science
- MS&E 827 Kinetics in Materials Science I
- MS&E 821 Fracture and Fatigue
- MS&E 825 Solid-State Science
- MS&E 828 Kinetics in Materials Science II

Other courses, which the supervisor/committee recommends to the student, may be taken; however, these will not count for the “GPA cut-off” score. The student must maintain a minimum 3.0 overall GPA upon completion of all classes taken during his/her graduate study to be eligible for the Ph.D. degree.

Students pursuing a Ph.D. in MS&E, with a polymer specialization, will require four (4) core courses from the following, chosen by the student in consultation with the supervisor and research committee.

**TWO FROM:**

- PFC 811 Polymer Science I
- PFC 812 Polymer Science II
- TEXT 821 Fiber Physics I
- TEXT 822 Fiber Physics II
- TEXT 866 Fiber Formation
- PFC 840 Analytical Methods in Polymer and Fiber Science

**AND TWO FROM:**

- MS&E 820 Deformation Mechanisms in Solids
- MS&E 826 Phase Equilibria in Materials Science
- MS&E 827 Kinetics in Materials Science I
- MS&E 821 Fracture and Fatigue
- MS&E 825 Solid-State Science
- MS&E 828 Kinetics in Materials Science II

Other courses, which the supervisor/committee recommends to the student, may be taken; however, these will not count for the “GPA cut-off” score. The student must maintain a minimum 3.0 overall GPA upon completion of all classes taken during his/her graduate study to be eligible for the Ph.D. degree.
Students pursuing a Ph.D. in MS&E with Polymer and Fiber Science specialization and a Ph.D. in Polymer and Fiber Science will require four (4) from the following six (6) courses, chosen by the student in consultation with the supervisor and research committee.

- PFC 811 Polymer Science I
- PFC 812 Polymer Science II
- TEXT 821 Fiber Physics I
- TEXT 822 Fiber Physics II
- TEXT 866 Fiber Formation
- PFC 840 Analytical Methods in Polymer and Fiber Science

Other courses, which the supervisor/committee recommends to the student, may be taken; however, these will not count for the “GPA cut-off” score. The student must maintain a minimum 3.0 overall GPA upon completion of all classes taken during his/her graduate study to be eligible for Ph.D. degree.

If a student has completed comparable course work at other Institutions, s/he still must complete the four (4) core classes at the School of MS&E (Clemson University). If student has taken the courses from the School for his/her M.S. degree, the student automatically proceeds to comprehensive examination.

**Content of Comprehensive Examination and Expectations**

The candidacy/comprehensive examination will consist of: (1) a written dissertation proposal and (2) an oral exam. The oral exam will be conducted and administered by the research advising committee of the student (excluding the major dissertation advisor) plus one extra examiner appointed by the graduate standards committee following review and acceptance of the written proposal. If the proposal is not accepted after a second attempt, the student will be removed from the Ph.D. program. The supervisor can advise the student on topic and general content of the proposal but has no say in the pass/fail outcome of either the written proposal or oral examination. It is expected that the written document will be solely the work of the student.

Students will be expected to have an in-depth knowledge in their selected research area including relevant literature, experimental methods, and fundamental assumptions and limitations. In addition, students are expected to be ready to answer all pertinent questions in this topic area based on the courses taken at the time of the examination that the examining committee deems relevant to the area of proposed research. Students must also be prepared to answer basic questions about materials science and engineering or polymer and fiber science, which are representative of a senior undergraduate major in the area. Suitable texts that cover these concepts will be recommended to students when necessary. The students must also be able to critique approaches and methodologies used by them and others cited in the literature. If the
outcome of the candidacy/comprehensive examination results in a “fail” the student will have one chance to retake the candidacy/comprehensive examination.

The Guidelines for the Research Proposal

The proposal is graded on a “pass/fail” basis by the student’s research advising committee (excluding the major research advisor) and an additional faculty examiner appointed by the MS&E Graduate Committee. A majority vote by the committee is required to pass.

ONLY TWO ATTEMPTS TO PASS THE RESEARCH PROPOSAL STEP ARE GRANTED.

The written document should reflect an effort by the student and not by the research advisor. The advisor may work on points of clarification improving the structure of the document.

The proposal has a basic format and should be no more than 5,000 words as determined by Microsoft Word (approx. 15 pages long), excluding appendices, graphs, charts and tables. Proposals longer than this limit indicate that the student is unable/incapable of fulfilling a given brief to provide a proposal of a specified length. Proposals longer than those specified may be penalized, especially if content is judged to be 'padding' which could have been shortened or omitted.

The proposal must be typed, using standard typeface, with double spacing on standard paper, leaving a margin of at least 25mm (1 inch) on the left side, 20mm (0.75 inches) on the right side and 25mm (1 inch) top and bottom of the sheet using 12 point Times New Roman font.

Enough copies should be produced so that the student has one (1) for himself/herself and one (1) for each committee member who will examine the proposal including the student’s supervisor. The proposal should be logically expressed and written in clear, unambiguous English. Any acronyms used should be initially fully written out with the acronym in brackets following the text, e.g. General Skewed Data (GSD). If several such abbreviations are to be used in the text, the student should also include a page with a glossary of terms.

Diagrams, graphs, charts, etc. should be numbered consecutively throughout the proposal, or, better still, numbered consecutively within each section, e.g. Figure. 2.3 (denotes the third figure in section 2). Whenever possible, charts, tables etc. should be included in an appendix with only summary versions in the text.
The Research Proposal is intended to provide the students with the opportunity to:

1. Show they are capable of undertaking a specific Research Project on a chosen topic with minimum supervision in the area of specialization;
2. Demonstrate their ability and initiative to organize and plan such investigative work;
3. Undertake a literature survey and critically apply their findings;
4. Develop their ability to analyze and solve problems and produce or suggest rational solutions to such problems;
5. Interpret the data produced from their investigations and draw conclusions;
6. Present a concise written research proposal;
7. Use appropriate information from the research proposal for the oral defense of said proposal; and
8. Communicate to faculty the basic problem and the experimental, practical or theoretical work undertaken, and to discuss the results and conclusions to date.

While the Research Proposals will vary to some extent in quantity and type of information, the various sections of the proposal should be structured as close as possible in the following way:

1. Introduction (motivation, objects, hypothesis and literature review)
2. Experimental and/or Theoretical Approaches
3. Results and Discussion
4. Conclusions to date
5. Future work (to contain anticipated results and potential scientific merit and impact)
6. References

1. **Introduction.** It is essential that the first thing presented in this section deals with the problem which one is addressing. The problem should be clearly stated followed by an outline of how one intends to research this problem and what one hopes to prove (i.e. a set of objectives for the research).

The introduction should also explain why the project is considered to be of importance, be it from a financial, technological, environmental or academic viewpoint. The introduction should then describe, critically, the various ways of examining the problem which were considered and explain the reasons for the choice of method or approach adopted. This section also includes the literature survey (where appropriate). The section should give background to the area, outlining any previous work on the subject and commenting critically on this previous work. The introduction should show evidence of reading around the subject and an understanding of the subject area. The way in which the research extends or fits in to this previous work must be clearly explained.
2. **Experimental and/or Approaches.** The work carried out (or to be carried out) must be described briefly. This section should describe accurately the research or work that was actually carried out by the student. The section should not include any results, except for brief statements in cases where the results required a change in direction of the research. Whatever the research proposal is, this section should be discussed carefully with the supervisor to ensure that the plan of work adopted will be capable of providing reliable and meaningful results.

3. **Results and Discussion.** All relevant results to date should be presented and should follow a logical pattern, reflecting the order of the work carried out in the methodology section.

Where possible, the results should be presented in an easily understood format such as graphs or bar charts. The mean of several results, the error involved or the spread of the results should be indicated on the graphs/charts/tables.

All the graphs/charts/tables must be presented with adequate titles, legends, captions and units.

Any limitations of the results should be mentioned and discussed. Depending on the proposal type, this discussion may be included along with the results section to provide a better understanding of the outcome of the research, or it may be a stand alone section, or it could be included in the conclusions section.

The discussion element of the work involves the critical appraisal of the results obtained and suggestions or explanations as to why such results were obtained, i.e.:

- Were the results expected or unexpected?
- What problems were encountered?
- What are the limitations of the results?
- What are the shortcomings of the results? Etc.

4. **Conclusions.** This section should state what conclusions may be drawn from the results obtained. These conclusions *must* refer back to the *purpose* of the research as detailed in the **Introduction.** Where specific objectives have been outlined in the Introduction, each objective should have its own conclusion in this section. The student should also indicate what the limitations are to drawing such conclusions and comment on general feasibility of the research proposed. The student should take care in drawing too firm a conclusion if it cannot be fully justified from the results. Tentative or suggestive conclusions are perfectly acceptable as long as it is made clear that they are tentative.

5. **Future work.** It should contain anticipated results and potential scientific merit and impact. The proposal should recommend the direction of the coming work
and how further work may be advantageous in terms of generating an original contribution to the field.

6 References. They should be numbered consecutively in the proposal using Arabic numbers in brackets immediately following the author's name or the text words referred to:
e.g. Latham¹ or Latham [1]

References to journal articles or book chapters should include:
Authors (surname then initials)
Title of the article/ chapter
Journal title (abbreviated)
Volume number (underlined)
Issue number (if any)
Year (in brackets)
Page number

References to text books should include:
Author
Title (in quotes)
Publisher
Place of publication
Year of publication
Chapter or Page number

IMPORTANT NOTE - Plagiarism and Inadequate Referencing

Plagiarism is where students copy large sections of other people's work and presents it as their own work. Inadequate referencing is where students have indicated that they are quoting another person's work but fail to reference it adequately in the discussion, resulting in confusion as to where their own work began and the cited work ended. The penalties for plagiarism and inadequate referencing are severe. Normally, it is a failed Project and possible expulsion from the MS&E program and Clemson University. No further warnings on violation of this type will be provided to the student.

PLEASE BE FULLY AWARE OF THESE PENALTIES.
Oral Examination

The oral examination will be conducted by the qualifying committee consisting of the research advising committee (excluding the major research advisor, who can be present) and one extra examiner appointed by the MS&E Graduate Committee. The exam is graded on a "pass/fail" basis. A majority is needed to pass. The major research advisor attends the oral examination for observation and clarification purposes only.

ONLY TWO ATTEMPTS TO PASS THE ORAL EXAM ARE GRANTED

The oral examination is based on:

1. An oral defense of a written dissertation proposal and questions related to the proposal;

2. General questions in MS&E or PFS as related to the proposed research. Students must also be prepared to answer basic questions (BEYOND THEIR AREA OF SPECIALIZATION) about materials science and engineering or polymer and fiber science.

Students will be expected to have an in-depth knowledge in their selected research area. In addition, students are expected to be ready to answer all pertinent questions based on the courses taken at the time of the examination that the examining committee deems relevant to the proposed area of research. Students should approach their examiners well before the exam to seek a list of specific topics. Examples of topics are in appendix to this manual.

The scope of the general questions will be within the topics and level as covered in the following undergraduate textbooks:

- For Metal, Ceramics, and Polymer emphasis areas in MS&E: 
- For Ph.D. in MS&E with Polymer and Fiber Science specialization and Ph.D. in Polymer and Fiber Science: 
  J. R. Fried, “Polymer Science and Technology”

The students must also be able to critique/defend approaches and methodologies used by them and others cited in the literature.

Satisfactory performance on the comprehensive examination will result in a recommendation to the Graduate School of acceptance of the student’s application for admission to candidacy.

Unsatisfactory performance on the oral part of the comprehensive examination shall require additional work and complete re-examination. A second failure shall result in the student being declared ineligible for the Ph.D. degree in MS&E or PFS at Clemson
University. Satisfactory completion of the comprehensive examination must occur no less than six (6) months and no more than five (5) years prior to the date of graduation.

If the student disputes the results of the comprehensive exam, s/he may appeal. The appeal procedure is to write to the chair of the Graduate Standards Committee, asking for a hearing in front of the School Director and the Graduate Standards Committee. The chair will schedule a hearing. The student will present his/her case and give the chair a written brief of his/her grievance. The combined committee will judge the case and give the student the results of their judgment within two weeks of the hearing. The judgment of the committee is final.

**Results of the Doctoral Comprehensive Examination – GS5 Form**

The GS5 Form is filed after successful completion of the comprehensive examinations. Satisfactory completion of the comprehensive examination will result in a change of status from a Ph.D. student to a Ph.D. candidate.

[www.grad.clemson.edu/forms/forms_current.php](http://www.grad.clemson.edu/forms/forms_current.php)

**APPLICATION FOR GRADUATION AND DIPLOMA**

Early in the semester that the student plans to defend his/her dissertation and expects to graduate, the GS4 form (Application for Graduation and Diploma) must be submitted to the Graduate School.

**Dissertation**

The first draft of the dissertation should be completed at least twelve (12) weeks before the date of the final oral examination.

**Final Oral Examination**

An oral examination, to be given at least three weeks before graduation, will serve to examine the student on his/her dissertation research. A broad and penetrating interpretation of the research project and conclusions is required of the student. The committee will have already received final draft copies of the dissertation prior to the examination. This examination will be conducted under the authority of the Ph.D. advisory committee. All MS&E faculty members will be invited to participate in the examination and to provide advisory comments to the committee.

Successful completion of this examination will result in a recommendation (GS7 Form, [www.grad.clemson.edu/forms/forms_graduating.php](http://www.grad.clemson.edu/forms/forms_graduating.php)) by the advisory committee to the Graduate School that the Ph.D. degree be awarded.

Unsatisfactory performance on the final examination will require either complete re-examination (with or without recommendations for additional work) or dismissal.
**Ph.D. Student Checklist**

Table 2.0 provides a checklist of milestones for the Ph.D. program. *These are guidelines and may change for students who enter the doctoral program without completing the Master’s Degree.*

<table>
<thead>
<tr>
<th>WHAT</th>
<th>WHEN</th>
<th>HOW/WHO</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Selection of major advisor</td>
<td>Before the end of the 1st semester</td>
<td>Notify Graduate program coordinator and Admin. Assistant</td>
<td></td>
</tr>
<tr>
<td>2 Appointment of advisory committee</td>
<td>Before the end of the 1st semester</td>
<td>In consultation with advisor and committee</td>
<td></td>
</tr>
<tr>
<td>3 Preparation of curriculum</td>
<td>Before the end of the 1st semester</td>
<td>In consultation with advisor and committee</td>
<td></td>
</tr>
<tr>
<td>4 Filing of curriculum</td>
<td>Before the beginning of the 2nd semester</td>
<td>GS2 Form by student</td>
<td></td>
</tr>
<tr>
<td>6 Comprehensive exam: written proposal</td>
<td>After completion of core classes</td>
<td>Advising and graduate committee</td>
<td></td>
</tr>
<tr>
<td>7 Comprehensive exam: oral exam</td>
<td>After written proposal is accepted. Not later than 12 months after completion of core classes</td>
<td>Advising and graduate committee</td>
<td></td>
</tr>
<tr>
<td>8 Admission to Doctoral Candidacy</td>
<td>After completion of Comprehensive Exam</td>
<td>Research Advisor, GS5 Form to be completed by graduate committee</td>
<td></td>
</tr>
<tr>
<td>9 Application for Graduation and Diploma</td>
<td>(Current deadlines can be found on the Graduate School website)*</td>
<td>GS4 Form by student</td>
<td></td>
</tr>
<tr>
<td>10 Cap and Gown</td>
<td>Early in semester during which degree is expected to be awarded (see website)*</td>
<td>By student</td>
<td></td>
</tr>
<tr>
<td>11 Completion of draft of dissertation</td>
<td>1st draft at least 8 weeks before date of final examination; final (approved) copies at least 2 weeks before final examination</td>
<td>By student with review by research advisor</td>
<td></td>
</tr>
<tr>
<td>12 Final oral examination</td>
<td>At least 3 weeks prior to date on which degree is expected (see website)*</td>
<td>GS7 Form to be filed by major advisor after examination is completed</td>
<td></td>
</tr>
<tr>
<td>13 Approval of dissertation by Graduate School</td>
<td>About 2 weeks before graduation (see website)*</td>
<td>By student</td>
<td></td>
</tr>
<tr>
<td>14 Duplication of dissertation</td>
<td>At least 2 weeks before graduation (see website)*</td>
<td>By student</td>
<td></td>
</tr>
</tbody>
</table>

* Graduate School Deadlines website: [www.grad.clemson.edu/Deadlines.php](http://www.grad.clemson.edu/Deadlines.php)
**PREPARATION OF THESIS OR DISSERTATION**

**Planning**

The deadlines for the tasks depend on the date of anticipated graduation and are posted at the Graduate School website (www.grad.clemson.edu/deadlines.php). A list of the deadlines also can be obtained by contacting the Graduate School. **Failure to meet any of these deadlines will result in postponement of graduation.**

Sufficient time must be allotted for writing the thesis or dissertation. It is required that the student fully complete his/her thesis before leaving the university. Experience shows it is very difficult to complete a thesis or dissertation after leaving the university.

**Writing the Thesis or Dissertation**

The writing process usually begins toward the end of the research period. The document must be written in a format that is acceptable to the Graduate School (M.S. or Ph.D.) The formatting rules that should be followed are outlined at the following website: www.grad.clemson.edu/manuscript

**Review and Approval**

As a result of the final oral examination and review of the written document by the advisory committee, the student may be required to do more work. After a successful final oral examination, the committee members will provide any comments or corrections that must be made to the thesis or dissertation.

**Duplication**

The student must decide how many copies of the dissertation s/he wants. A minimum of three copies must be made: one hardbound copy and one soft unbound copy each for the School of MS&E; and one hardbound copy for the major advisor. It is courteous to offer each committee member the opportunity to obtain a hardbound copy. Additional copies can be made for the student’s personal use. Once the student determines the number of copies needed, s/he should call to schedule an appointment with the Printing Service Center. Unbound copies are produced at the Printing Services Center, but the student must pay for the binding of hardbound copies at the Bursar's Office, located in Sikes Hall. At the appointment, the student will need to pay the duplication fees and describe any special services required (offset printing, photos, etc.). The student can pay for duplication by personal check either directly to the Printing Services Center or at the Bursar's Office and then present a receipt for that payment to the Printing Services Center. The cost for duplication depends on the length and the number of copies requested. Duplication usually takes no longer than one week.

For all current policies, procedures, deadlines, and regulations regarding theses and dissertations, consult the Graduate School website: www.grad.clemson.edu
GRADUATE ASSISTANTSHIP AND FINANCES

Assistantship Award Policy

Assistantships are awarded based on many factors, including but not limited to: GPR, GRE scores, recommendations, previous schools, discipline, Statement of Purpose, and English language ability.

Assistantship Funding

The School of MS&E uses two different sources for funding graduate students: State of South Carolina monies and funds from contracts, grants and donations. Students supported by state funds normally are assigned teaching assistant duties while those supported by research contract funds are assigned research duties. All assistantships may be subject to time limits as described below (depending upon the degree being pursued) and are contingent upon satisfactory performance and progress toward the degree by the student.

- Assistantships for M.S. students will normally last for a maximum of two years. The same time limit applies to fellowships awarded by the School of MS&E. Assistantships for Ph.D. students will normally last for three years beyond the M.S. degree. The same applies to fellowships awarded by the School.

- Continuation of assistantships and fellowships is contingent upon satisfactory academic performance, as well as satisfactory performance of assigned duties associated with the assistantship.

- All research contract and grant supported graduate assistantships are subject to continued funding by the contracting agency. If a research contract or grant is terminated before a student has completed his/her degree program, the School will endeavor (on an individual basis) to provide financial support to allow completion of the student’s program. The foregoing statement should not be construed as an assurance of funding. The student is expected to complete his/her degree program in a timely fashion.

Work Load

The normal half-time graduate assistantship workload is 20 hours per week (average). Students are sometimes hired for 12.5% (5 hrs), 25% (10 hrs), 37.5% (15 hrs) and 75% (30 hrs) of full-time work, under appropriate circumstances. Students should be aware of both their academic and work obligations and are encouraged to discuss any problems with faculty.
**Vacations**

In addition to days off when the University is closed, students are allowed up to two weeks of vacation time each year. These days should be scheduled with approval of their advisor.

**Start of Pay**

Students are appointed to a graduate assistantship at the beginning of the first semester if the student is present and available for a work assignment at that time. Otherwise, pay will begin when the student is available for work. Students with research assignments should report to their research advisor. All other students should report to the Graduate Program Coordinator.

New graduate assistants must report to the departmental staff and complete the following: information sheet, tax forms (federal and state), and I-9 form. Students will need to provide proof of nationality, social security number, age, etc.

International students should have their offer letter with them upon arrival. They should then go to the Social Security Administration in Anderson, SC for a Social Security Number or meet with the Social Security Administration representative in Martin Hall on the dates indicated by the Graduate School. The student should then see the appropriate Administrative Assistant in 161 Sirrine Hall. The Administrative Assistant will provide them with the paperwork that they must take with their signed Social Security card to the Foreign National Payments Coordinator (call for appointment: 656-5589, E-208 Martin) who will complete the necessary paperwork to assist them with getting on the payroll. When making the appointment, students should ask what forms they should complete prior to the appointment.

For complete information on employment requirements for international students, make an appointment at the Office of International Affairs (656-3614, E-301 Martin Hall) or visit their website: www.clemson.edu/ia/. Electronic forms are available under the “Forms and Documents” tab in the sidebar.

**Termination of Pay**

Pay for any session will end when the student leaves Clemson or is no longer available for work assignments. Normal termination dates for the Spring and Fall semesters for students not continuing into the next session is graduation day. The student’s research advisor or the School Director must approve any deviations from these dates.

**Reduction of Pay**

Normally, 20 hours per week will be submitted on each payroll for each half-time graduate assistant. However, less than 20 hours may be submitted for a student, with the pay reduced accordingly, if the amount of time worked by the student consistently
deviates from the required 20 hours per week average. Due to the procedure in which
time sheets are currently used, it may be necessary to implement any pay reductions in
the pay period following the one in which the work deficiency actually occurred. Pay
also may be withheld from students who violate the vacation policy, as stated above in
the section on "Vacations."

**Summer Enrollment**

Students receiving any assistantship or fellowship must enroll in three credit hours for
the first and three credit hours for the second Summer Session. Any student not on an
assistantship but using faculty time and/or university facilities (including any student
actively working on a thesis or dissertation) must register for a minimum of one credit
hour each session. Only students not active and not physically present at Clemson
need not register.

**Students without Assistantships**

Students who enter a graduate program in the School of MS&E without an assistantship
can apply for future consideration with the Director.

**Financial Assistance**

Graduate students are eligible for financial assistance if they are: (a) enrolled in full-time
graduate studies and (b) in good academic standing; i.e., not on probation. Tuition and
fees for students receiving financial assistance is a flat reduced fee. To receive the
reduced tuition and fees for a particular semester, a qualified student must be on the
department payroll at the beginning of that semester.

Financial support is awarded based on academic merit, educational and employment
discipline as well as on the research interests of the student. If a student changes
his/her interest area after support has been extended, support eligibility will be
reviewed. Only Ph.D. students and Master's students pursuing research are eligible for
financial support.

**Deferment of Graduate Fees**

Graduate assistants may choose to defer tuition and fees. This is accomplished easily
on the day of registration. Persons in the fee assessment area will have a list of all
graduate assistants. Anyone listed may sign a note to defer these costs and these
costs will be deducted from the first six full paychecks of the semester. It is not possible
to defer fees for summer sessions. The student must pay these for each summer
session. The School of MS&E is not permitted to pay tuition and fees directly to the
university; therefore, return of tuition and fees to graduate assistants is spread over the
entire year and included in stipend checks.
**GENERAL DEPARTMENTAL INFORMATION**

**Information**

Students should not hesitate to ask questions concerning MS&E policies and procedures. The Graduate Program Coordinators’ task is to assist students with such questions.

**Notices**

Notices of interest to graduate students will be placed on the MS&E bulletin boards in Sirrine and Olin Halls and, on occasion, mailed directly to students. To ensure receipt of MS&E mailings, each student should have a current address and telephone and cell phone number on file with the School. MS&E also maintains a mail slot for each graduate student, the location of which will be shown to him or her upon beginning with the School.

**Paychecks**

Students must set up a direct deposit for stipend checks through the University system. **This action is mandatory!** Please obtain an “Authorization for Deposit of Net Pay” Form from the Administrative Assistant located in 161 Sirrine. New students going on the payroll for the first time will have a two-week lag before they will be paid. This will be paid out after their termination from the University.

**Keys**

The key(s) issued to students are for their use only. Keys must never be loaned to anyone else, even another graduate student. Failure to observe this rule may result in withdrawal key privilege. See the “Quick Reference Guide" for the current key distributor.

**Building Security**

It is necessary to maintain the security of the buildings at all times. During normal working hours all entrances will be kept unlocked. At all other times all outside doors will remain locked and should not be propped open. All students entering or leaving the building should ensure that the outside doors remain locked. The computer rooms and labs should always be locked when unoccupied.

**Parking**

Ample parking is available. Parking on campus requires a permit that can be purchased at Parking Services (656-2270).
Emergencies

The Clemson University Police Department (656-2222) is to be called for all major emergencies: fire, medical, police. They will ensure that the proper authorities are dispatched.

- In case of tornado warning, take appropriate shelter. Use stairwells; do not use the elevators.
- In case of fire, exit the building immediately. Use stairwells; do not use the elevators.

Desks

It is the goal of the School of MS&E to provide a desk for each graduate student. However, due to the limited available space, it may not be possible to accommodate each student. Therefore, a priority system is used that first assigns a desk to each graduate assistant and graduate fellow, then to each unsupported M.S. thesis student. Remaining desks are allocated to all other students on a temporary use basis.

**NOTE:** Study facilities for graduate students are intended solely for studying and interacting with students. They are not to be used for socializing or temporary housing. Students abusing these privileges will forfeit them.

Room Use Policies

Certain rooms are to be used by reservation only: classrooms and conference rooms. Reservations may be made via the Graduate Assistant Coordinator.

Computer Laboratory

The School maintains a well-equipped computer laboratory for student use in Olin Hall. This allows access to the Clemson University mainframe computer and a local area network that hosts many software packages. The door should be closed and locked when unoccupied after normal business hours.

Computer Center Account Number

Each graduate student is automatically assigned a unique computer ID providing access to the centralized computer facilities upon acceptance to the University. Notification of this assignment should have been received prior to orientation via the Graduate School through the U.S. postal service. This User ID is also published in the university telephone directory. Clemson Computing and Information Technology offers numerous instructional short courses. Visit their website for details: [www.clemson.edu/ccit](http://www.clemson.edu/ccit)
Office Supplies

The School does not furnish office supplies to graduate students for personal use. The faculty advisor must authorize all research contract-related use of office supplies, including letterhead stationery.

Mail

All personal mail is to be directed to a student's home address. The School is not to be used as one's mailing address. Outgoing mail, both U.S. and campus mail, can be placed in the appropriate receptacle in the reception areas.

MS&E Copy Machines

Teaching assistants required to make copies for class may use this machine with an account number specific to the course provided by the instructor. Otherwise, School copy machines may not be used for personal copies.

MS&E Seminars

During the fall and spring semesters, the School of MS&E sponsors a weekly seminar. Students and faculty give presentations about their research or other topics of interest to the department. Invited speakers from industry, government, and other academic departments are also included. All students are required to attend the seminars and faculty is expected to attend. If a student cannot attend a particular seminar, s/he should inform his/her advisor ahead of time. The MS&E curriculum requires that all students enroll for this seminar each semester.

Fax Machines

Students may use School facsimile machines for official MS&E business purposes with authorization from their advisor.

Telephones

Graduate students making research-related long distance calls at the request of an advisor should use the advisor's nine-digit authorization code. Students are authorized to place long distance telephone calls only with the permission of the appropriate advisor or with their own personal calling card.

Telephone Numbers to Know

<table>
<thead>
<tr>
<th>Service</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration Services (E-205 Martin Hall)</td>
<td>656-2305</td>
</tr>
<tr>
<td>Graduate School Office</td>
<td></td>
</tr>
<tr>
<td>Admissions (Sikes Hall)</td>
<td>656-3195</td>
</tr>
<tr>
<td>Enrolled Student Services (104 Sikes Hall)</td>
<td>656-5339</td>
</tr>
</tbody>
</table>
Files

Graduate students should not access school files. Students should contact the Student Services Coordinator if they need information from an MS&E file.

Photos

At the start of each semester, photos of beginning students are taken for the MS&E directory, and also, more importantly, for the potential recommendations later in life.

MS&E Library

The School libraries in 152 Sirrine and 202 Olin Hall are available for use by all students, staff and faculty of the School of MS&E.

Receiving Supplies

Supplies will normally be delivered to 161 Sirrine. When they are checked in, the student’s name will be indicated on the outside of the package. It is helpful to the staff receiving supplies if students let them know they are expecting a package(s).

Note: Do not pick up any box that has not been checked in.

Recycling and Resource Recovery

MS&E faculty, staff, and students, out of a spirit of environmental sensitivity, collect and recycle white paper and cardboard. All recycle containers are located in various areas of both facilities. White paper waste is stored in marked containers. The recycling containers will be checked several times monthly to ensure that all is well and to determine whether the storage containers have filled faster than normal.

Professional Memberships

Application forms for membership in various Materials Science & Engineering professional organizations may be obtained from appropriate faculty.
Policy on Alcohol

Alcoholic beverages are prohibited for any activity held in any of the School of Materials Science & Engineering facilities.

Student travel

School-specific travel information and guidelines from the Clemson University Travel Policy and Guidelines have been incorporated into this section. The complete Policy and Guidelines, including authority references and guidelines specific to university administration, is available at virtual.clemson.edu/groups/procurement/buy_4_cu.htm, under the “Travel” tab in the sidebar. Any questions regarding travel should be directed to the Administrative Assistant in charge of travel in 161 Sirrine. Summarized MS&E procedures are as follows:

1. Complete Request to Travel form, obtain appropriate signatures (faculty member responsible for the account number to which it will be charged) and submit to the Administrative Assistant.

2. Enter travel status according to guidelines outlined herein.

3. Upon completion of travel, complete Travel Worksheet, obtain appropriate signatures, and submit to the Administrative Assistant for reimbursement.

Note: Hardcopies of all travel forms are located in the copy/work room in 161 Sirrine. If students have trouble using the electronic forms, please see one of the staff for assistance.

Traveler's Responsibilities

When individuals file for reimbursement of travel expenses they are stating:

- They have followed the University's travel policies;
- They have not nor will not receive reimbursement for these expenses from any other entity outside the University;
- None of the expenses are of a personal nature; and,
- All supporting documentation is on file with the School.

Under the Progressive Discipline Policy of the University, any employee who falsifies records or documents or willfully violates written rules, regulations or policies can be suspended or terminated from his/her job.

Reimbursement will be made upon completion of the travel. All travel vouchers must be submitted within the same fiscal year (July 1-June 30) in which the trip occurred.
All travel vouchers submitted for reimbursement are required to have the signature of the traveler and one other person authorized to spend funds from the account numbers that appear on the travel voucher. All signatures must be original. No stamped signatures will be accepted.

Travelers are expected to exercise the same judgment when making travel arrangements and expenditures that a prudent person would exercise if traveling on personal business and expending personal funds. Excess costs, circuitous routes, delays or luxury accommodations unnecessary or unjustified in the performance of an assignment are not considered exercising prudence.

Travel by commercial airlines will be in coach or tourist class.

Transportation to or from points of arrival and departure will be by the most economical method.

**Expenses for Spouses or Other Individuals**

Reimbursements to an individual may cover only those expenses pertaining to that individual. It may not include expenses pertaining to other individuals, regardless of who paid the expense. Travel expenses for spouses, friends, or other individuals not traveling on official University business are not reimbursable.

**Unauthorized Costs**

Employees will be responsible for unauthorized costs and any additional expenses incurred for personal preference or convenience. No reimbursement for reduced fare advance purchase tickets charged on a personal credit card will be made to employees prior to the completion of travel since direct payment by the University is available using the School Purchase Card.

**Meals**

Maximum expense reimbursement rates are variable. There are two maximums: first, for official travel within the State of South Carolina; second, for official travel outside of the State of South Carolina. See the Administrative Assistant for current, applicable maximums.

When the daily limit for meals is exceeded due to the cost of an official banquet, the excess will be allowed provided that a receipt and proper explanation for the banquet charge accompanies the travel voucher.

If an individual on non-overnight travel receives reimbursements for meals, this amount could be considered income and be reported on their W-2 tax form. For instance, meals on day trips are subject to tax withholding except when a business purpose for the meal
can be documented. If claiming reimbursement for such business meals, documentation should include the name and affiliation of the person sharing the meal and the nature of the business discussed.

An individual must be in travel status (more than 10 miles from their residence or official headquarters) to be eligible for reimbursement of meals.

**Lodging**

Lodging expenses will be allowed subject to the following limitations, provided an original, itemized receipt is furnished. Lodging arrangements and any required deposits are the responsibility of the traveler and will be reimbursed as part of the travel expenses upon completion of the trip.

Actual lodging expenses will be reimbursed; however, the more moderately priced accommodations must be requested when a choice is available. Employees should request a state or government rate when available.

No reimbursement will be made for overnight lodging within 50 miles of the employee's official headquarters or residence.

The expense for shared lodging may be reimbursed to one employee if only one original itemized receipt is obtained. If the room is shared with other than a University employee, the single room rate will apply.

All necessary and reasonable tips for baggage handling will be reimbursed.

**Miscellaneous Expenses**

Movies, bar bills, laundry, room service, safes and security insurance, health or spa fees, etc. will not be subject to reimbursement on the travel expense report. These are considered personal in nature and should be paid by the traveler.

**Foreign Travel**

Travel outside the continental United States, Alaska, Hawaii, Canada, Puerto Rico or the Virgin Islands requires approval prior to departure. Foreign travel funded from sponsored program activities must be approved in advance by Sponsored Programs Accounting.

While on foreign travel, actual lodging expenses will be reimbursed. Fees for the purchase of traveler's checks, passports and visas will be reimbursed provided a receipt is furnished. All expenses claimed must be converted to U.S. dollars and the conversion rate and computation should be shown on each receipt.
When an employee is on foreign travel, meal expenses not exceeding federal rates will be reimbursed. These rates are listed by country under the “Per Diems” tab at: www.state.gov/travelandbusiness/

**Travel by Automobile**

Automobile transportation may be used when common carrier transportation cannot be arranged satisfactorily, or to reduce expenses when two or more University employees are traveling together.

When planning to travel by car, see the Administrative Assistant. S/he will then contact Transportation Services in advance to reserve a Motor Pool vehicle via the Internet.

University employees may use their own automobile for official travel provided the University would incur no added expenses above that of other forms of transportation available. Rates will change based on whether or not a University-owned vehicle was available to the employee at the time. If no vehicle was available, the employees must attach a statement from Transportation Services confirming non-availability to Travel Reimbursement Voucher. See the Administrative Assistant for current mileage rates for personal vehicles.

Taxi fares and reasonable tolls will be reimbursed to the individual. Receipts must be furnished if claiming airport, hotel or parking garage parking of more than $5.00.

**No reimbursement will be made to operators of state owned vehicles who must pay fines for moving or non-moving violations.**

**Rental Cars**

The contract for Rental Cars varies from year to year. Please check with the Administrative Assistant in charge of travel before renting a car. If there is no rental agency on state contract, students are encouraged to shop cost efficiently for a rental car just like for anything else. Charges for automobile rental are allowed when it is more economical than alternative methods of transportation or is the only practical means of transportation.

If it is necessary to rent an automobile while in travel status outside the United States, it is recommended the collision damage waiver insurance be obtained. The charge and the applicable tax will be included on the automobile rental statement submitted with the request for reimbursement. **DO NOT obtain additional coverage while in travel status inside the United States.**

**Conference/Convention Registration Fees**

Registration fees in the amount necessary to qualify individuals to attend conventions, meetings, conferences, etc. are allowed. These fees can be paid using the School
Purchase Card or by completing a Direct Purchase Voucher and sending it to Accounts Payable ten days to two weeks before the deadline of the meeting. If registration fees are not prepaid, and rather are paid at the time of the meeting registration, reimbursement will be made after the trip is completed.

**Receipts**

Students must submit a receipt per expenditure of $5 or more, except for meals, tolls and portage. All receipts and paid bills should be originals. If originals are not available, a memorandum, approved at the next level in the approval process, must accompany the travel voucher when it is submitted.

**Final Checkout**

Graduate students leaving for any reason should do as follows:

- Turn in all keys to current key manager (see “Quick Reference Guide”)
- Return all equipment and supplies to appropriate locations
- Clean assigned laboratory space
- Submit an unbound copy of the thesis or dissertation
- Return all books and journals to the department library
- Inform the School Director of the impending departure and schedule an exit interview

No student will be cleared to leave until these procedures have been completed.
GENERAL SAFETY AND HEALTH POLICIES

Chemical Hygiene Plan

The Chemical Hygiene Plan details MS&E policy and regulations concerning health and safety. This plan is required reading for all laboratory personnel. After reading the plan all laboratory personnel must sign a copy of the Chemical Hygiene Plan Awareness Certification form. In addition, all personnel must fill out the employee/student safety checklist. Direct any questions on safety to the research advisor. New students will attend a safety seminar at the beginning of the fall semester each year. This will be conducted by MS&E faculty and staff.

Laboratory Operating Policies

The following laboratory operating policies are designed to ensure a safe and secure working environment, and to provide a research environment that nurtures the acquisition of experimental results of the highest quality:

- No food or drink is to be brought into or consumed in any laboratory.
- To facilitate cleaning, nothing is to be stored on laboratory floors.
- Only scientific charts and similar educational or reference materials are to be hung from laboratory ceilings or walls.
- Suitably sized posters or photos may be affixed to walls using non-damaging tape or hangers.
- Nothing is to be affixed to the laboratory doors.
- No laboratory doors including the exterior doors are to be propped open.
- Nothing, including carts, is to be stored or left in the hallways.
- All laboratory chairs are to be cleaned weekly, more frequently if required.
- All laboratories are to be left clean and orderly prior to departing for the day.
- When conducting wet research in the laboratories, plastic containment trays are to be used, insofar as possible, to capture spills.
- All samples, bottles, standards, etc. are to be dated and identified as to contents and person responsible. The contents are to be properly disposed of and the bottles cleaned when no longer needed.
- Material Safety Data Sheets should be requested from chemical vendors. These need to be kept in the lab where the chemical is stored.
- Chemicals in the laboratory should be segregated and safely stored.
- A record of use is to be maintained for all hazardous chemicals in laboratory.
- All analytical balances are to be left clean after each use.
- Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous.
- Lights are to be turned off whenever vacating a room.
- All memos, notices, etc. are to be posted on the official bulletin boards.
- All areas are to be maintained clean and free of refuse.
• All refuse that cannot easily be placed in a trash receptacle is to be carried to and placed in the appropriate dumpster.
• Any key codes to the exterior doors are to be kept strictly confidential within the MS&E community. Any hint of a breach in confidentiality is to be reported immediately.
• Recycled paper and cans are to be placed in the appropriate containers.

PERSONAL PROTECTIVE EQUIPMENT

Eye and Face Protection

Eye and face protection devices which meet OSHA requirements and American National Standards for industrial eye protection should be the minimum eye protection used for activities where there may be flying or falling particles or chemical splashes. Either safety or prescription glasses with side shields must be worn in any laboratory at all times, unless the departmental representative has made an exception. Visitors to any laboratory must wear safety or prescription glasses, preferably with side shields.

The wearing of contact lenses is strongly discouraged. Soft contact lenses are susceptible to absorption of vapors and may aggravate some chemical exposures, particularly if they are worn for extended periods. Manufacturers of soft lenses generally recommend they not be used in certain atmospheres.

Body Protection

Protection of the body from contact with solid and liquid contaminants requires some protective clothing. Such protective clothing may include boots, gloves, pants, coats, and head covers. Complete protection of the skin from contact with gases and vapors requires full-body protection such as an encapsulating suit.

Whenever in a laboratory, all MS&E students, faculty, and staff must ensure that arms, legs, and torso are covered at all times. For example, one can wear: long pants and a long-sleeved shirt; a knee-length, long-sleeved laboratory coat; or long pants and a waist-length laboratory coat. In addition, rubber and plastic aprons must be used whenever corrosive or irritating chemicals are handled. Because plastic aprons can accumulate static electricity, their use must be avoided in areas where flammable solvents could be ignited. Protective clothing will have to be discarded and replaced if it cannot be effectively decontaminated.

Clothing materials should be selected for resistance to the chemicals to which they will be exposed and for appropriate resistance to permeation.

Footwear

Closed-toed shoes must be worn at all times. Sandals, thongs, and bare feet are not permitted. Shoes made of impermeable material such as leather are strongly
recommended. Sneakers offer little protection against falling objects or chemical spills. High-heeled shoes pose a hazard and shall not be worn when working in laboratories.

**Hazardous Waste Management**

The concern for safe disposal of chemical wastes has increased dramatically in recent years. Legal and regulatory requirements, reinforced by public opinion, spurred the handling of hazardous wastes in a responsible way. Even laboratory personnel who work with relatively small amounts of chemicals have begun to recognize that the chemical wastes generated during their experiments are their responsibility and that waste management systems are necessary.

The Resource Conservation and Recovery Act (RCRA) of 1976 mandated a system for managing hazardous waste. Regulations adopted by the Environmental Protection Agency (EPA) carry out that mandate and now extend through South Carolina State Law to those who generate, store, transport, treat, and dispose of hazardous waste. The Department of Health and Environmental Control (DHEC) is the South Carolina agency responsible for enforcing EPA regulations.

The MS&E labs, like most research laboratories, generate and store small quantities of hazardous waste. MS&E has a Hazardous Waste Management Plan to ensure that laboratory wastes are properly managed to prevent harm to public health and the environment and to conform to the public's expectations and the government's requirements for proper waste management. All laboratory students are required to adhere to the regulations. Direct any questions concerning this to the faculty advisor.

**Emergency and accident procedures**

**Redfern Health Center** offers comprehensive preventive and basic health care services, primarily to the students of Clemson University. Redfern is open Monday through Friday from 8:00 - 5:00 PM. Four physicians, three nurse practitioners, and eleven registered nurses are available to provide continuous, quality medical care. Students are encouraged to make appointments to be seen for illness and injuries as they occur throughout their stay at Clemson. Although Redfern Health Center is not an emergency room or urgent care clinic, they offer acute and/or urgent care for minor illnesses and injuries via the nurse's clinic. In the nurse's clinic, a registered nurse sees the patient, assesses the problem, and takes appropriate action. If immediate physician intervention is needed, patients are referred to CU Now provider.

The following procedures should be followed in case of any accident or emergency that happens in our laboratories or anywhere on Clemson University's campus:

1. For all emergencies or accidents involving students, faculty, and/or visitors, that happen anywhere on campus (laboratories, offices, sidewalks, parking lots,
streets) at any time, any day of the week, dial either 911 or 656-2222 for University Police/Fire/EMS. Clemson University FIRE & EMS stands ready to respond and assist in handling any emergency medical needs and they are staffed with Emergency Medical Technicians (EMTs) 24 hours a day, 365 days per year. Their primary response area is the main campus of Clemson University and they can be on site within minutes of an emergency or accident. Anderson County EMS will respond to our other center locations (AMRL, CAR, NBRC) if the victim calls 911. They will treat the injury and determine whether or not further treatment is necessary at Redfern or at one of the following facilities: Clemson's Urgent Care (Urgent Care will not accept patients requiring ambulance transport to their facility), Oconee Memorial Hospital, Easley Baptist Hospital, Anderson Memorial Hospital, or Greenville Memorial Hospital. The officials at Redfern do not encourage walk-ins for these types of emergencies or accidents.

2. For all emergencies or accidents involving chemicals, it is imperative that a copy of the MSDS on the chemical is available for the EMS personnel immediately upon their arrival to the site and that they are informed of any potential chemical contamination. Our EHS guidelines stipulate MSDS sheets be located in or immediately outside the laboratory.

3. As soon as possible, report any accident referred to above first to your supervisor and then to the Administrative Assistant in the main office. The Administrative Assistant will report the accident to CU Risk Management Department and Compendium Insurance Company (workman's compensation insurance carrier for Clemson University) who will determine whether or not the claim should be covered under workman's compensation. Should any accident occur outside of normal working hours, an accident report should be given to all parties concerned at the beginning of the next working day.

If you ever feel uncomfortable about a situation, contact EMS (911) or 656-2222 immediately for campus emergency services. Small problems can quickly turn into larger problems, so it’s important to recognize when help is needed. CU EMS can provide a quick response and is able to assist in almost any emergency situation.
PURCHASING

All students will follow this procedure for purchasing chemicals and supplies.

Introduction

Advisors must approve orders for all research supplies and equipment required by MS&E. Administrative staff in 161 Sirrine orders general office supplies, books, etc. Students may contact vendors in order to obtain prices, availability, technical help, or other information but may not place the order. Purchase orders (telephone orders) are limited to $2,500 and under including freight and special handling, but excluding tax. Any order that exceeds $2,500 (Purchase Requisitions) must be put on a Purchase Order and sent to the University Purchasing Department. All chemicals or supplies are to be ordered from primary vendors, if possible.

Primary Vendors

The State of South Carolina has awarded contracts for laboratory equipment and supplies to the following: VWR Scientific Products; and Fisher Scientific Company (limited items).

Purchase Orders and Purchase Requisitions

Any student wishing to order laboratory supplies, equipment, etc. must first obtain an MS&E Purchase Order form from the Administrative Assistant in charge of purchasing. The PO form is to be completed in full by the student prior to obtaining the signature of the appropriate faculty member. Several items have an asterisk next to them. These items will be filled out when the order is placed. The following information must be provided on the form:

- Prices - Prices in catalogs are often incorrect. A call to the vendor or a website search can clarify the cost. The "total amount" column will suffice to provide an approximate cost if clarification is not available.

- Signature - The MS&E PO form will be retained as the official document authorizing the purchase of any item. As such, the Principal Investigator or his authorized representative must sign the form. No copied or rubber stamp signatures will be accepted.

- Quantity and Size - It is necessary to determine how the item being ordered has been packaged. This will usually be designated as each (ea), pack (pk), etc. If you want ten (10) of an item and it comes "each", then you order 10 "ea." If, however, it comes in a "pack" of five (5), then you order two "pks." It is confusing when forms are filled out to order twelve (12) packs and the individual only wanted 12 each.
• Catalog Number and Description - Put the catalog number and a short description in this column.

• Catalog Date and Catalog Page Number - Include this information in case a discrepancy arises.

ALL PURCHASE ORDERS MUST BE APPROVED FIRST.

After approval, orders will be processed the student himself/herself. The procedure for a purchase requisition is the same as for a purchase order, except that the Administrative Assistant will process the order after approval instead of the student. After the PO form has been completed and turned in, the necessary information will be transferred to a University Purchase Order by administrative staff and submitted through the proper channels. If the purchase requisition is being sent to one of the primary vendors, there will be no delay in processing the order.
GENERAL UNIVERSITY INFORMATION

Graduate Student Association (GSA)

The Graduate Student Association is a university-wide organization of all graduate students for promoting graduate student interests. At the start of the fall semester, GSA representatives are elected. The biweekly senate meetings are open to all graduate students. See the Graduate Student Handbook for more information or contact the GSA office at 656-2697.

Main Library

Located on campus adjacent to the reflecting pool, the main library (R.M. Cooper Library) is replete with MS&E related books and journals. Periodicals can be checked out for a maximum of three days while books can be checked out for a maximum of six weeks. Late fees do apply; ask at the Circulation Desk for current fees. The card catalog is on-line and can be accessed via any departmental computer. Gratis on-line literature searches can be conducted at the main library. An appointment must be made to complete the on-line search.

Fike Recreation Center

Graduate assistants can use these facilities. Lockers are available at the recreation center.

Sporting Events

Graduate students may purchase season tickets for Clemson football and basketball games. If interested, students should report to the ticket office in IPTAY/ticket office complex (Gate 9, Memorial Stadium) to complete an application. Further information can be obtained from the ticket office, 656-2118. Baseball games are free with university ID. Tickets for soccer games may be purchased at the gate (discounts with university ID).

Military Leave

The Graduate School has ruled that a graduate student on military leave (e.g. summer camp) will not receive a stipend for the period of that leave. Students planning to take military leave should notify the Administrative Assistant of the inclusive dates. Short periods of approximately one week can be taken as regular vacation with no interruption in pay. Students leaving the campus for six weeks to attend summer camp must obtain written permission from the Dean of the Graduate School to be excused from the continuous enrollment provision.
**Campus Parking**

Parking on campus is restricted and requires a permit that can be purchased at Parking Services, located in G-01 Edgar Brown University Union (656-2270).

**ETHICS**

All MS&E students are required to abide by a code of ethics. This code is outlined below. Students are also required to sign a copy, included at the front of this manual, which will be kept in their file.

**Policy on Research Ethics**

The effectiveness of the research infrastructure throughout the world is based on the personal and professional integrity of the people involved. The basic assumption that is central to all research endeavors is that researchers have done what they say that they have done. The School of Materials Science and Engineering is part of that infrastructure and the research conducted here must withstand the highest scrutiny. Consequently, we must all ensure that our scholarly work is conducted and reported with the highest ethical standards. We must be careful in our record keeping and diligent in our efforts to always attribute credit where it belongs. In particular, we must guard against any activity that would bring the integrity of the department or the individuals within it into question. Among the activities to be avoided are:

- Falsification of Data - ranging from fabrication to deceptively selective reporting of results or methods, including the purposeful omission of conflicting data with intent to falsify results;
- Misappropriation of Others' Ideas - the unauthorized use of privileged information, however obtained; and
- Plagiarism - representation of another's work as one's own; see pages 2-4 for more information defining plagiarism.
TOPIC OUTLINE for MS&E Ph.D. comprehensive exam

ATOMIC STRUCTURE AND INTER-ACTOMIC BONDING

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  Fundamental Concepts
  Electrons in Atoms
  The Periodic Table

Atomic Bonding in Solids

  Bonding Forces and Energies
  Primary Inter-atomic Bonds
  Secondary Bonding or van der Waals Bonding
  Molecules

THE STRUCTURE OF CRYSTALLINE SOLIDS

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  Unit Cells
  Metallic Crystal Structures
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  Crystal Systems

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  Linear and Planar Atomic Densities
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  TEM
  Specimen Preparation
  Electron Diffraction
  X-ray Compositional Analysis (EDS)
  STM and AFM
X-Ray Diffraction

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Quantitative Analysis
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Basic Knowledge (Operation Principles and Applications)

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X-ray Photoelectron Spectroscopy (XPS)
Low Energy Electron Diffraction (LEED)
Electron Energy Loss Spectroscopy (EELS)

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Vacancies and Self-Interstitials
Impurities in Solids

Miscellaneous Imperfections

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Interfacial Defects
Bulk or Volume Defects
Atomic Vibrations

Microscopic Examination

Microscopy
Grain Size Determination

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Nonsteady-State Diffusion
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Other Diffusion Paths
Materials Processing and Diffusion

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Anelasticity
Elastic Properties of Materials

Plastic Deformation

Tensile Properties
True Stress and Strain
Elastic Recovery During Plastic Deformation
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Hardness
Variability of Materials Properties
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- Microstructure
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- Binary Eutectic Systems
- Equilibrium Diagrams Having Intermediate Phases or Compounds
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- Basic Concepts
- The Kinetics of Solid-State Reactions
- Multiphase Transformations

Microstructural and Property Changes in Iron-Carbon Alloys

- Isothermal Transformation Diagrams
- Continuous Cooling Transformation Diagrams
- Mechanical Behavior of Iron-Carbon Alloys
- Tempered Martensite
- Review of Phase Transformations for Iron-Carbon Alloys

THERMAL PROCESSING OF METAL ALLOYS

Annealing Processes

- Process Annealing
- Stress Relief
- Annealing of Ferrous Alloys

Heat Treatment of Steels

- Hardenability
- Influence of Quenching Medium, Specimen Size, and Geometry
Precipitation Hardening

Heat Treatments
Mechanism of Hardening
Miscellaneous Considerations

**METAL ALLOYS**

Fabrication of Metals

Forming Operations
Casting
Miscellaneous Techniques

Ferrous Alloys

Steels
Cast Irons

Nonferrous Alloys

Copper and Its Alloys
Aluminum and Its Alloys
Magnesium and Its Alloys
Titanium and Its Alloys
Refractory Metals
Superalloys
Noble Metals
Miscellaneous Nonferrous Alloys

**STRUCTURES AND PROPERTIES OF CERAMICS**

Ceramic Structures

Crystal Structures
Silicate Structures
Imperfections in Ceramics
Ceramic Phase Diagrams

Mechanical Properties

Brittle Fracture of Ceramics
Stress-Strain Behavior
Mechanisms of Plastic Deformation
Miscellaneous Mechanical Considerations

**APPLICATIONS AND PROCESSING OF CERAMICS**

Glasses

Glass Properties
Glass Forming
Heat Treating Glasses
Glass-Ceramics
Clay Products

The Characteristics of Clay
Compositions of Clay Products
Fabrication Techniques
Drying and Firing

Refractories

Fireclay Refractories
Silica Refractories
Basic Refractories
Special Refractories

Other Applications and Processing Methods

Abrasives
Powder Pressing
Cements
Advanced Ceramics

POLYMER STRUCTURES

Hydrocarbon Molecules
Polymer Molecules
The Chemistry of Polymer Molecules
Molecular Weight
Molecular Shape
Molecular Structure
Molecular Configurations
Copolymers
Polymer Crystallinity
Polymer Crystals

CHARACTERISTICS, APPLICATIONS AND PROCESSING OF POLYMERS

Mechanical and Thermo-Mechanical Characteristics

Stress-Strain Behavior
Deformation of Semi-crystalline Polymers
Melting and Glass Transition Phenomena
Thermoplastic and Thermosetting Polymers
Viscoelasticity
Deformation of Elastomers
Fracture of Polymers
Miscellaneous Characteristics

Polymer Applications and Processing

Polymerization
Polymer Additives
Polymer Types
Plastics
Elastomers
Fibers
Miscellaneous Applications
**COMPOSITES**

Particle-Reinforced Composites

- Large-Particle Composites
- Dispersion-Strengthened Composites

Fiber-Reinforced Composites

- Influence of Fiber Length
- Influence of Fiber Orientation and Concentration
- The Fiber Phase
- The Matrix Phase
- Fiberglass-Reinforced Composites
- Miscellaneous Fiber-Reinforced Plastic Matrix Composites
- Metal Matrix-Fiber Composites
- Hybrid Composites
- Processing of Fiber-Reinforced Composites

Structural Composites

- Laminar Composites
- Sandwich Panels

**CORROSION AND DEGRADATION OF MATERIALS**

Corrosion of Metals

- Electrochemical Considerations
- Corrosion Rates
- Prediction of Corrosion Rates
- Passivity
- Environmental Effects
- Forms of Corrosion
- Corrosion Environments
- Corrosion Prevention
- Oxidation

Corrosion of Ceramic Materials/Degradation of Polymers

- Swelling and Dissolution
- Bond Rupture
- Weathering

**ELECTRICAL PROPERTIES**

Electrical Conduction

- Ohm's Law
- Electrical Conductivity
- Electronic and Ionic Conduction
- Energy Band Structures in Solids
- Conduction in Terms of Band and Atomic Bonding Models
- Electron Mobility
- Electrical Resistivity of Metals
- Electrical Characteristics of Commercial Alloys
Semi-Conductivity

Intrinsic Semi-conduction
Extrinsic Semi-conduction
The Temperature Variation of Conductivity and Carrier Concentration
Semi-conductor Devices

Electrical Conduction in Ionic Ceramics and in Polymers

Conduction in Ionic Materials
Electrical Properties of Polymers

Dielectric Behavior

Capacitance
Field Vectors and Polarization
Types of Polarization
Frequency Dependence of the Dielectric Constant
Dielectric Strength
Dielectric Materials

Other Electrical Characteristics of Materials

Ferroelectricity
Piezoelectricity

THERMAL PROPERTIES

Heat Capacity
Thermal Expansion
Thermal Conductivity
Thermal Stresses

MAGNETIC PROPERTIES

Diamagnetism and Paramagnetism
Ferromagnetism
Anti-ferromagnetism and Ferrimagnetism
The Influence of Temperature on Magnetic Behavior
Domains and Hysteresis
Soft Magnetic Materials
Hard Magnetic Materials
Magnetic Storage
Superconductivity

OPTICAL PROPERTIES

Basic Concepts

Electromagnetic Radiation
Light Interactions with Solids
Atomic and Electronic Interactions
Optical Properties of Metals/Optical Properties of Non-Metals

Refraction
Reflection
Absorption
Transmission
Color
Opacity and Translucency in Insulators

Applications of Optical Phenomena

Luminescence
Photoconductivity
Lasers

KINETIC PROCESSES IN MATERIALS

MOTION OF ATOMS AND MOLECULES BY DIFFUSION

Irreversible Thermodynamics and the Coupling between Forces and Fluxes

Entropy and Entropy Production

Entropy Production
Conjugate Forces and Fluxes
Basic Postulate of Irreversible Thermodynamics

Linear Irreversible Thermodynamics

General Coupling between Forces and Fluxes
Flux/Force Relations when Components are constrained
Onsager’s Symmetry Postulate

Driving Forces and Fluxes for Diffusion

Diffusion in Presence of a Concentration Gradient

Self-Diffusion in a Chemically Pure Material
Self-Diffusion of Solute Particles in a Chemically Homogeneous Solution
Diffusion of Substitutional Particles in a Chemical Concentration Gradient
Diffusion of Interstitial Particles in a Chemical Concentration Gradient
On the Algebraic Signs of Diffusivities

Mass Diffusion in the Presence of Stress

Effect of Stress on Mobilities
Stress as a Driving Force for Diffusion: Formation of Solute Atom Atmosphere around Dislocations
Influence of Stress on the Boundary Conditions for Diffusion: Diffusional Creep

Mass Diffusion in an Electrical Potential Gradient
Mass Diffusion in a Thermal Gradient
Mass Diffusion Motivated by Capillarity
The Diffusion Equation

The Diffusion Equation: Flux and Divergence Revisited

$D$ is constant

Geometrical Interpretation of the Diffusion Equation when $D$ is Constant
Variational Interpretation of the Diffusion Equation
Scaling of the Diffusion Equation
Superposition

$D$ as a Function of Concentration
$D$ as a Function of Time
$D$ as a Function of Direction: Tensors, Anisotropy, and the Relations between Vectors

Solutions to the Diffusion Equation

Steady-State Solutions

Constant Diffusivity
Variable Diffusivity

Nonsteady-State Diffusion (Time-Dependent Diffusion)

Instantaneous Localized Sources in Infinite Media
Solutions Involving the Error Function
Estimating the Diffusion Depth and Time to Approach Steady State
Method of Separation of Variables Diffusion on a Finite Domain
Method of Laplace Transforms

Diffusion in Multi-Component and Multiphase Alloys

Atomic Models for Diffusion

Atomic Jumping and Activated Processes

One-Particle Model with Square Potential-Energy Wells
One-Particle Model with Parabolic Potential-Energy Wells
Many-Body Model

Diffusion Resulting from Discrete Jumps

Relation of $D$ to the Mean Square Particle Displacement
Diffusion and Random Walks
Diffusion with Correlated Jumps

Diffusion in Crystals

Atomic Mechanisms

Ring Mechanism
Vacancy Mechanism
Interstitial Mechanism
Interstitial Mechanism
Diffusion Mechanisms in Various Systems

62
Atomic Models for Diffusion Coefficients

Metals
Ionic Solids

Diffusion along Crystal Imperfections

The Diffusion Spectrum in Crystals with Imperfections
Diffusion along Grain Boundaries

Regimes of Grain Boundary Short-Circuit Diffusion
Analysis of the Diffusant Distribution in the A, B, and C Regimes
Mechanism of Fast Grain Boundary Diffusion

Diffusion along Dislocations
Diffusion along Free Surfaces

Diffusion in Non-Crystalline Solids

Diffusion in Liquids
Diffusion in Amorphous Metals

Self-Diffusion
Interstitial Diffusion of Small Solute Atoms

Diffusion of Small Atoms (or Molecules) in Glassy Polymers
Diffusion of Alkali Ions in Network Oxide Glasses
Diffusion of Polymer Chains

Structure of Polymer Chains
Diffusion of Isolated Polymer Chains in Dilute Solutions
Diffusion of Densely Entangled Polymer Chains by Reptation

MOTION OF DISLOCATIONS AND INTERFACES

Motion of Dislocations

Forces on Dislocations

Force due to Stress
Osmotic Force
Curvature Force
The Total Force on a Dislocation

Dislocation Glide

Uniform Glide Motion in a Linearly Elastic Continuum
Frictional Forces Opposing Glide
Some Experimental Observations
Supersonic Glide Motion
Dislocation Climb

Models for Climb
Diffusion-Controlled versus Source/Sink-Controlled Climb Kinetics
Experimental Observations
Analyses of Two Climb Problems

Motion of Vapor/Crystal and Liquid/Crystal Interfaces

Driving Pressures for Interface Motion
Motion of Vapor/Crystal Surfaces

Structure of Vapor/Crystal Surfaces
Crystal Growth from a Supersaturated Vapor
Surfaces as Sinks for Supersaturated Lattice Vacancies

Motion of Liquid/Crystal Interfaces

Structure of Liquid/Crystal Interfaces
Crystal Growth from an Under-cooled Liquid

Motion of Crystal/Crystal Interfaces

Additional Driving Pressures for Crystal/Crystal Interface Motion
Conservative versus Non-conservative Interface Motion
Conservative Motion

Glissile Motion of Sharp Interfaces by Glide of Interfacial Dislocations
Thermally Activated Motion of Sharp Interfaces by Glide and Climb of Interfacial Dislocations
Thermally Activated Motion of Sharp Interfaces by Atom Shuffling

Thermally Activated Motion of Diffuse Interfaces by Self-Diffusion
Impediments to Conservative Interface Motion

Some Experimental Observations of Thermally Activated Motion

Non-conservative Motion: Interfaces as Sources and Sinks for Atomic Fluxes

Source/Sink Action of Sharp Vicinal Interfaces by the Glide and/or Climb of Interfacial Dislocations
“Diffusion-Controlled” versus “Source/Sink-Controlled” Kinetics

**EVOLUTION OF MICROSTRUCTURE IN THE ABSENCE OF PHASE TRANSFORMATIONS**

Morphological Evolution of Interfaces

Isotropic Surfaces

Smoothing of Free Surfaces by Surface Diffusion
Surface Rearrangements by Evaporation-Condensation

Anisotropic Surfaces
Sintering

Sintering of Systems of Simple Geometry

Sintering Mechanisms
Sintering Rates

Sintering of Powders

Initial, Intermediate, and Final Stages of Powder Sintering

Sintering Mechanisms Maps

Competitive Growth

Coarsening of a Distribution of Particles

Classical Mean-Field Theory of Coarsening
Beyond the Classical Mean-Field of Coarsening

Grain Growth

Grain Growth in Two Dimensions
Grain Growth in Three Dimensions

**THERMALLY ACTIVATED MECHANICAL DEFORMATION PROCESSES**

Diffusional Creep

Diffusional Creep of Systems of Simple Geometry

Creep of Wire with “Bamboo” Grain Boundary Structure
Creep of Two-Dimensional Polycrystal with Hexagonal Grains

Diffusional Creep of Three-Dimensional Polycrystals

Anelasticity ("Internal Friction")

Anelasticity due to Anisotropic Point Defects

General Formulation of Anelastic Behavior
Analogue Model for Standard Anelastic Solid
Frequency Dependence of the Logarithmic Decrement, $\delta$
Determination of Diffusivities

Other sources of Anelasticity

**PHASE TRANSFORMATIONS**

Some General Features of Phase Transformations

Order Parameters and the Order of a Phase Transformation
One-Component Systems
Two-Component Systems
Conserved and Non-conserved Field Variables
Classification of Phase Transformations: Continuous Versus Discontinuous Transformations

Spinodal Decomposition and Order-Disorder Transformations

Free Energy of Inhomogeneous Systems: Diffuse Interfaces and the Functional Gradient

Evolution Equations for Non-conserved and Conserved Order Parameters

The Allen-Cahn Equation
The Cahn-Hilliard Equation
Numerical Simulation

Spinodal Decomposition

Coherency Strain Effects
Solution to the Cahn-Hilliard Equation
The Later Stages of Spinodal Decomposition
Other Theoretical Developments
Spinodal Microstructures

Order-Disorder Transformations

Kinetics of Continuous Ordering: Early Stages
Kinetics of Continuous Ordering: Later Stages

Nucleation

Homogeneous Nucleation

Classical Theory of Nucleation in One-Component System without Strain Energy
Classical Theory of Nucleation in Two-Component System without Strain Energy
Effect of Elastic Strain Energy
Nucleus Shape of Minimum Energy
More complete Expressions for the Classical Nucleation Rate
Non-Classical Models for the Critical Nucleus

Heterogeneous Nucleation

Nucleation on Grain Boundaries, Grain Edges, and Grain Corners
Nucleation on Dislocations

Growth

Growth of Planar Layers

Diffusion-Controlled Growth
Growth Controlled by Heat Conduction and Mass Diffusion Simultaneously
Interface Source/Sink-Controlled Growth
Growth of Isolated Particles
  Diffusion-Controlled Growth
  Interface Source/Sink-Controlled Growth

Morphological Stability of Moving Interfaces
  Stability of Pure Solid/Liquid Interface during Solidification
  Stability of $\gamma$/$\beta$ Interface During Diffusion-Controlled Particle Growth
  Stability of Liquid/Solid Interface during Alloy Solidification
  Analyses of Interfacial Stability

Concurrent Nucleation and Growth Transformation Kinetics
  Cahn’s Time-Cone Analysis
  Energy-Density Driven Growth: Recrystallization
  TTT-Diagrams

Solidification
  Plane-Front Solidification
    One-Dimensional Solidification
    Zone melting and Zone Leveling
  Cellular Solidification
    Formation of Cells and Dendrites
    Solute Segregation during Dendritic Solidification

Structure of Castings and Ingots

Precipitation
  Some General Features of Precipitation
  Nucleus Morphology and Energy
  Loss of Precipitate Coherency During Growth
  Precipitation in Two Selected Systems
    Cu-Co System
    Al-Cu System

Martensitic Transformations
  Introduction
  Crystallographic Theory of Martensitic Transformations
    Definitions of Quantities in the Crystallographic Theory
    Mechanical Twinning
    Martensitic Transformations

Nucleation of Martensite
THERMODYNAMICS OF MATERIALS

CLASSICAL THERMODYNAMICS

The Laws of Thermodynamics

The Zeroth Law
Work and the First Law
Heat Flow and the Second Law
The Absolute Temperature
The Third Law

Criteria for Equilibrium

The Entropy Principle
Definitions
The Basic Equilibrium Postulate
Additional State Functions
Criteria for Equilibrium
The Isolated System
The Closed Isothermal System
The Closed Isobaric System
The Open Isothermal System

Useful Mathematical Relations

Partial Derivatives
Relation to Measurable Properties
Evaluation of Partial Derivatives
The Cross-Differentiation Identity
Maxwell’s Relations
Integration of the State Function Equations

General Theory of Phase Stability

General Relations
Degrees of Freedom
The Gibbs-Durham Equation
Equilibrium in Multiphase Systems
Thermal Equilibrium
Hydrostatic Equilibrium
Distributive Equilibrium
Chemical Equilibrium
General Criteria for Equilibrium
The Gibbs Phase Rule

FUNDAMENTALS OF STATISTICAL THERMODYNAMICS

Basis of Statistical Thermodynamics

What is Statistical Thermodynamics?
Basic Approach
Relation of Macroscopic to Microscopic Descriptions
Ensembles
Types of Ensembles
Postulates

Evaluation of Probabilities

Application of Postulates
The Microcanonical Ensemble
The Canonical Ensemble
The Grand Canonical Ensemble

Statistical Mechanical Criteria for Equilibrium

The Isolated System and the Function $S'$
The Closed Isothermal System and the Function $F'$
The Open Isothermal System and the Function $(PV)'$

The Connection Between Statistical Thermodynamics and Classical Thermodynamics

The Canonical Ensemble and $\beta$
Evaluation of the State Functions in Terms of $Q$
The Grand Canonical Ensemble and $\gamma$
Evaluations of the State Functions in Terms of $\Xi$
Fluctuations

Evaluation of the Allowed Energies

Models
Quantum Mechanics
Translational Motion
Rotational Motion
Motion in a Potential Field
Degeneracy and Interparticle Effects
Independent Particle Systems
Relation of System Energy to Particle Energies
Distinguishable Particle Systems
Indistinguishable Particle Systems
Independence of Modes of Energy Storage

**SINGLE-COMPONENT SYSTEMS**

Classical Thermodynamics of One-Component Systems

Free Energy Surfaces
Temperature Dependence of the Thermodynamic Functions
Pressure Dependence of the Thermodynamic Functions
The One-Component Phase Diagram
Molar Properties
The Clapeyron Equation
Evaluation of the State Functions

The Monatomic Ideal Gas

The Model
Number of Available States
Evaluation of $q$
 Evaluation of the Partition Function
 Evaluation of the Thermodynamic Functions
 Electronic Excitation
 The Zero of Energy
 Complete Expressions for the Thermodynamic Functions

The Polyatomic Ideal Gas

The Model
 Evaluation of \( q \)
 Polyatomic Molecules
 The Grand Canonical Ensemble

The Einstein Model of the Solid

The Einstein Model
 Evaluation of the Partition Function
 Limiting Values of \( q_v \)
 Evaluation of the Thermodynamic Functions
 High and Low Temperature Limits

The Debye Model of the Solid

The Debye Model
 Evaluation of the Partition Function
 Evaluation of the Thermodynamic Functions
 Relation of \( \Theta_D \) to Crystal Properties
 High and Low Temperature Limits

Simple Liquids

The Model
 Evaluation of the Partition Function
 Evaluation of the Thermodynamic Functions
 Evaluation of Parameters

Statistical Thermodynamics of Phase Equilibrium in One-Component Systems

Solid-Vapor Equilibrium
 Liquid-Vapor Equilibrium
 The Triple Point
 Solid-Liquid Equilibrium
 A Numerical Example

MULTI-COMPONENT SYSTEMS

Classical Thermodynamics of Multi-component Systems

Activity
 Molar Properties
 Partial Molar Properties
 Relation of Partial to Total Molar Properties
 Calculation of Partial Properties from Total Properties
Classical Thermodynamics of Solutions

Formation of a Solution
Ideal Gas Mixtures
Multi-component Condensed Phases
The Ideal Solution
Dilute Solutions
Concentrated Solutions
Excess Functions

Lattice Statistics

The Ideal Lattice Gas
The Einstein Crystal with Vacancies
Evaluation of the Thermodynamic Functions
The Langmuir Model of Adsorption
The Two-Dimensional Pressure
Evaluation of the Thermodynamic Functions
The Langmuir Adsorption Isotherm

The Lattice Gas with Interactions

The Model
Evaluation of the Partition Function
The Bragg-Williams Approximation
The Quasi-chemical Model

Statistical Thermodynamic Treatment of Solutions

The Model
Solid Solutions
The Ideal Solid Solution
The Bragg-Williams Model and Regular Solutions
The Quasi-chemical Model
Liquid Solutions
The Partition Function
Ideal Liquid Solutions
Regular Liquid Solutions

Phase Equilibrium in Multi-Component Systems

The Model
The Two-Component Ideal Systems
A Numerical Example
Gas-Phase-Condensed-Phase Equilibrium
Two-Component Non-ideal Systems
Phase Separation
A Numerical Example
Solid-Liquid Equilibrium in Non-ideal Systems
A Numerical Example

Chemical Equilibrium

The Equilibrium Constant
Dissociation of a Diatomic Molecule
Isotopic Equilibrium
General Gas-Phase Reactions
Heterophase Reactions

QUANTUM SYSTEMS

The Perfect Electron Gas

The Model
Number of Available States
Evaluation of the Partition Function
Average Number of Particles per State
Evaluation of the Thermodynamic Functions at 0 K
The Fermi Energy and the Work Function
Temperature Dependence of the Thermodynamic Functions

Blackbody Radiation

The Model
Evaluation of the Partition Function
Evaluation of the Thermodynamic Functions
The Spectral Energy Distribution
**TOPIC OUTLINE for PFS Ph.D. comprehensive exam**

**Polymerization Principles**

- Introduction / Definitions
- Polymer Classification, Nomenclature, Molecular Weights
- Criteria for Polymer Formation

**Step Growth Polymerization**

- Synthetic Requirements
- Thermodynamics and Kinetics
- Molecular Weight and Distribution
- Fundamentals of Multichain Polycondensation: Branching & Crosslinking
- Industrial Process Conditions
- The Polymers: Polyesters, Polycarbonates, Polyamides, Polyimides, Polyurethanes, Heterocyclics, Network Polymers, Misc. Processes and Classes

**Chain Growth Polymerization**

- Synthetic Requirements
- Thermodynamics
- Free Radical Polymerization
- Initiation, Propagation and Termination Mechanisms
- Polymerization Kinetics
- Chain Transfer, Molecular Weight Control and Distribution
- Industrial Process Conditions and Polymers

**Ionic Polymerization**

**Insertion Polymerization, Stereochemistry, and New Systems**

**Copolymerization**

- The Copolymerization Equations
- Free Radical and Ionic Copolymerization

**Ring Opening Polymerizations**

- General Characteristics
- Thermodynamics and Kinetics
- Polymer Systems

**Polymer structure**

- Chain structure and configuration
- Molecular weights and sizes
- Polymer solutions and phase separation behavior
- Amorphous and crystalline states
- Glass-rubber transition behavior
- Rubber elasticity
- Polymer viscoelasticity and rheology
- Mechanical behavior of polymers
Polymer surfaces and interfaces
Multicomponent polymeric materials

**Polymers for Fibers General Commercial Materials**

Polymer Terms and Definitions
Addition Polymers/Chain Growth Polymerization
Condensation Polymers/Step Growth Polymerization
Size
Polymolecularity

Polymer Structure
Constitution
Configuration
Conformation

Principals of Polymerization
Thermodynamic and Kinetic Criteria
Step Growth Chain Growth, Ring Opening
Reactions Involving Equilibria
Kinetics of Simple polyesterification

Condensation Polymers
Polyester Formation Reactions
Poly (ethylene terephthalate) (PET)
Properties of PET
Polyester Variants
Saturated and Un-saturated Network Polymers
Liquid Crystalline Polyesters

Polyamide Formation Reactions
Nylon 6
Manufacture
Properties
Nylon 6, 6
Manufacture
Fiber and Polymer Properties
Stabilizers and Side Reactions in the Manufacture of Nylon 6 and 6, 6
Other Nylons of Commercial Interest

Aramids

**Fiber Physics**

Physical properties and their measurement (Listed in order of emphasis.)
Mechanical properties (tensile, torsional, fatigue, and aging)
Thermodynamic properties (e.g., phase transitions (incl. Tg & Tm). thermal conductivity, and moisture sorption)
Essential electrical properties (DC conductivity, dielectric behavior and optical properties)

Production methods (essential features)
Polymer fine structure models: micelles, folded chain crystals, crystalline- amorphous domain structures, spherulites,.....
Theories of mechanical properties of oriented polymers: mathematical models of viscoelasticity; statistics and thermodynamics of rubber elasticity; structure-property relationships.
Theories of thermal behavior: kinetic and free volume theories of the glass transition; time-temperature equivalence; introduction to crystallization and diffusion in polymers.

**Methods for structure determination**

- X-ray diffraction
- Electron microscopy
- Optical birefringence
- Spectroscopy

**Dyeing of natural and synthetic fibers**

- Direct Dyes: Their applications, structures, and products
- Vat Dyes: General properties and application
- Sulfur Dyes: General properties and application
- Reactive Dyes: General properties and application
- Azoic Combinations: Chemistry & applications

- Dyeing Man-Made Fibers: Developments
- Disperse Dyes: Applications to Polyester, Structures & Properties
- Properties of Silk/Nylon/Wool/Sorption
- Dyeing Nylon with Acid Dyes
- Dyeing Acrylics & Other Fibers with Basic Dyes
- Dyeing Polyester/Cellulosic Blends
- Dyeing of Other 2 & 3 Fiber Blends
- Pigments as Textile Colorants: Pigmenting
- Physical Chemistry of Dyeing

**Color: Basic Principles**

- Light, Detector, and Object
- Spectrophotometry
- Transmittance and Reflectance Measurement

- Colorimetry and the CIE, X, Y, Z

- Color Order Systems & CIE Lab 76
- CMC (l:c) & Color Tolerances
- Shade Sorting/Matching Prediction

**Textile Finishing**

- Mechanical Finishing
- Chemical Finishing
- Durable Press and Crease Resist
- Cross-linking of cotton
- Water/Oil/Stain Repellency
- Flame Retardancy
- Nature of Dye Chemistry
**Textile Structures**

- **Yarn Production**
  - Yarn Structure
  - Mechanics of Continuous Filament Yarns
  - Mechanics of Plied Yarns

**Thermal analysis**

- Thermogravimetric Analysis - TGA
- Differential Scanning Calorimetry - DSC
- Thermomechanical and Dynamic Thermomechanical Analysis- TMA, DTMA
- Other Thermal Methods - DTA - DMA - TEA - etc.

**Microscopy and analysis**

- Optical Birefringence
- Cross polarization
- Electron Scanning
- Atomic Force

**Spectroscopic analysis**

- Infrared, Raman and NIR Analysis
  - Theory
  - Instrumentation
  - Spectral analysis
  - Qualitative analysis
  - Structural Analysis
  - Crystallinity
  - Orientation
**Recommended Reading**

Principles of Polymerization, 4th. Ed., Odian

Textbook of Polymer Science, F. W. Bilmeyer.


Organic Chemistry of Synthetic High Polymers, R. W. Lenz

Polymer Chemistry - An Introduction, 2nd. Ed. Seymour and Carraher

Polymer Chemistry, 2nd. Ed. Stevens


Textile Sizing, Goswami, B.C., Rajesh Anandjiwala, David Hall, Marcel Dekker, 2004.


P. C. Painter and M. M. Coleman, Fundamentals of Polymer Science, Technomic, 1995;


J. R. Fried, Polymer Science and Technology, Prentice Hall, 1995 or 2003;

Aklonis, J. J., et al., "Introduction to Polymer Viscoelasticity"

Alexander, L. E., "X-ray Diffraction Methods in Polymer Science"

Arridge, R. G. C., "Mechanics of Polymers"

Ferry, J. D., "Viscoelastic Properties of Polymers"

Findley, W. N., J. S. Lai, and K. Onaran, "Creep and Relaxation of Nonlinear Viscoelastic Materials, ..."


**Journals (partial list)**

J. Appl. Polymer Science

J. Polymer Sci.- B. Physics

J. Macromolecular Science

J. Materials Science

Polymer

Textile Research Journal

Journal of the Textile Institute

AATCC
TA assessment

Observation of TA teaching by the faculty in charge of the COURSE OR MODULE.

As a TA it is required that your performance has aided student learning. Your overall competence as a TA (as deemed by your course coordinator) is required to be satisfactory or better in order to maintain TA status.

Through your performance as a TA the class has:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating</th>
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<tr>
<td>1. been able to learn effectively, efficiently and independently</td>
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<tr>
<td>2. been able to understand, analyze and synthesis substantial amounts of information</td>
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<td>3. been able to make use of concepts, some of them abstract</td>
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<td>4. been able to engage in critical evaluation of received information</td>
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<td>5. been able to become skilled in reasoning and argument</td>
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<td>6. been able to communicate opinions, clearly, and by giving evidence</td>
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<td>7. been able to recognize, and solve problems and been adaptable and flexible in applying theoretical understandings to problems encountered in the world around them</td>
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<tr>
<td>8. been able to make well-founded judgments on the application of my knowledge</td>
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<tr>
<td>9. been able to cooperate in team work</td>
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<tr>
<td>10. been able to become confident in the use of IT as required for the academic discipline</td>
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<tr>
<td>11. OVERALL Comment on the overall performance as Excellent, Very good, Satisfactory, Poor, or Very Poor</td>
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1= strongly agree,
3= neither agree or disagree,
5 = strongly disagree

Action item for the TA student before starting the TA position

Before you start being a TA, you are required to get a description of your duties and responsibilities from the faculty member in charge of the course. Once you have received this document you should sign it, photocopy it to keep a copy for yourself and then file the original signed copy with the Student Services Coordinator in 160 Sirrine.