Fast Track Program with Physics Undergraduate Degree and Master's Degree in Materials Science and Engineering

Contact Information

Pranesh Aswath
Professor
Materials Science and Engineering Department
University of Texas at Arlington
817-272-7108
aswath@uta.edu

INTRODUCTION

The proposed program will enable outstanding senior undergraduate students in Physics to satisfy degree requirements leading to a master's degree (M. Engr.) in Materials Science and Engineering while completing their undergraduate studies in Physics. The program is designed to encourage our most gifted students to complete a master's degree at UTA and is intended to offer these gifted students, who are highly sought after by other institutions, incentives in money and time-saved to remain and complete an advanced degree at UTA. We also hope that this program will help build a relationship with these students that will increase the likelihood that they will remain and pursue doctoral degrees.

The second goal of this program is to attract well qualified **international** students who have a **three** year undergraduate degree in Physics and provide them an opportunity to enter the fast track program as transfer students. These students who satisfy the admission requirements would transfer the courses taken as part of their 3 year undergraduate degree towards undergraduate credit and work towards an undergraduate degree in Physics over a period of one to two years while simultaneously pursuing a master's degree in Materials Science and Engineering. It is anticipated that these would achieve both degrees over a period of 2-3 years. Due to the three year nature of their undergraduate degrees, these students would otherwise be unable to gain admittance into the graduate Materials Science and Engineering Program.

Overview of the Fast Track Program

The proposed program is designed to ensure that gifted students will complete and receive their bachelor's degrees on time while simultaneously making substantial progress in master's level studies. The guidelines presented below will be used to develop applicant screening practices and degree requirements that will ensure student success and preserve the educational quality of their undergraduate and graduate degrees. Once applicants have been screened and selected to participate in this program, they will complete a rigorous and carefully selected set of organized advanced undergraduate and graduate courses. These courses may be used to satisfy both undergraduate and graduate degree requirements. The guidelines contained in this proposal set an upper limit on the number of hours that a student might count toward both the bachelor's and the master's degree. In no case may the jointly counted credit hours exceed the maximum specified below. Both Physics and Materials Science and Engineering Departments will ensure that only outstanding and academically capable students will be allowed to pursue the proposed course of study.

Students at the end of their freshmen year who have completed PHYS 1443 and PHYS 1444 with a GPA of 3.0 and express an interest in the Fast Track

Program will be designated as **"FAST TRACK BOUND"** and encouraged to maintain a GPA of 3.0 or better to retain their eligibility.

Students who have been identified as "FAST TRACK BOUND" as well as other outstanding undergraduates in Physics can apply for the Fast Track Program when they are within 30 hours of completing their bachelor degrees. They must have completed at least 30 hours at UTA, achieving a GPA of at least 3.0 in those courses, and have an overall GPA of 3.0 or better in all college courses. Additionally, they must have completed at least 9 hours of specified undergraduate Foundation Courses that are listed below with a GPA of 3.3 in these courses.

Foundation Courses Required for Admission into the Fast Track Program:

MSE 3300. INTRODUCTION TO MATERIALS SCIENCE AND ENGINEERING (3-0).

PHYS 3313. MODERN PHYSICS (3-0).

PHYS 3321. INTERMEDIATE ELECTRICITY AND MAGNETISM (3-0).

These foundation courses are those that both the Physics and Materials Science and Engineering faculty believe are necessary and have predictive value regarding success in advanced coursework prior to making application. Once admitted, students will be allowed to take a mixture of advanced undergraduate and graduate courses that may be used to satisfy both bachelor's and master's degree requirements. Graduate and undergraduate courses included in this program will be selected because they meet the educational requirements of both the undergraduate and master's degree plans.

Students need not complete the program to receive their bachelor's degrees and may elect to end participation at any time. Graduate and undergraduate courses completed while participating in the Fast Track program will be selected so that they may be applied to the bachelor's degree even if the student exits the program before completing all available courses. Those who successfully complete the program will be automatically admitted to Graduate School prior to completing remaining requirements for the master's degree. They will not be required to take the Graduate Record Examination, complete an application for admission to the Graduate School or pay an application fee.

The Fast Track program differs in two important ways from 5-year "stacked" programs currently offered at UTA. It allows students who do not complete the program to use any of the specified graduate course credit in their undergraduate degree plan. This will insure their graduation will not be delayed by taking graduate courses. Thus, the Fast Track program avoids a problem with timely degree completion that can arise in many 5-year programs. Additionally, unlike 5-year programs, the Fast Track program will enable students to receive their

bachelor's degrees prior to receiving their master's degree and being admitted into a graduate program.

Key Elements of the Fast Track Proposal

Participating students will be permitted to use up to 9 hours of undergraduate course work specified by their program to satisfy both undergraduate and graduate degree requirements.[1] Additionally, when senior-level students are within 15 hours[2] of completing their undergraduate degree requirements, they may take up to 12 hours of graduate level coursework designated by their Physics and Materials Science and Engineering Departments. The students are being allowed to take graduate level courses when they are within 15 hours of completion of their undergraduate degree (as opposed to 12 hours) to make it possible for them to take graduate courses over two long semesters as opposed to one single semester. The students will be required to file Degree Plan with the Physics department and demonstrate that they are within 15 hours of completion of the undergraduate degree before they will be allowed to take graduate courses.

The programs also allow up to 21 hours to satisfy both undergraduate and graduate degree requirements. This will be the maximum amount of credit that can be used as joint credit. In the limiting case, a student completing the maximum allowable hours (21) while in undergraduate status would have to take only 15 additional hours to meet minimum requirements for graduation in a 36 hour degree program.

Students pursuing the Fast Track master's degree must take courses totaling 36 hours selected from the course groups listed in the Table I.

[1] At present, credits cannot be applied to more than one degree's requirements. This will change under the current proposal and specified credits will be counted in both the bachelor's and master's degree plans. The rule that no more than 9 hours of advanced undergraduate credit may be used to satisfy master's degree requirements will continue to be in effect.

[2] Current rules allow undergraduate students with GPA of at least 3.0 who are in their final semester of study and who are within 12 hours of completing their degrees (six hours in one summer session) to take up to 12 hours graduate level coursework and apply these credits toward their master's degrees. Total registration may not exceed 15 semester hours in a semester (or 12 hours in the summer sessions).The current proposal will relax this rule for Fast Track participants, allowing them to take graduate level courses when they are within 15 hours of completing their undergraduate degrees. The current limit on the number of graduate credit hours (12-hours) taken as an undergraduate that can be counted toward the master's degree will not be altered under this proposal. Similarly, the current maximum number credit hours that can be taken in a long (15-hours) or summer session (12-hours) will remain in effect. However, undergraduates will not be allowed to enroll in more than 9 graduate credit hours per long semester or 6 graduate credit hours per summer session.

Table I. Course Requirements for Fast Track Master of Engineering Degree

Course Group	Courses	Requirements	Hours Required
Group A	PHYS 4315. (3-0) Thermo. and Statistical Mech.	Select 3 of 6 courses	9
	PHYS 4319. (3-0) Advanced Mechanics		
	PHYS 4324 (3-0) Advanced Elec, and Mag.		
	PHYS 4325. (3-0) Solid State Physics		
	Phys 4326. (3-0) Intro. to Quantum Mechanics		
	MSE 4320. (3-0) Nanoscale Materials		
Group B	MSE 5304. (3-0) Analysis of Materials	Select 3 of 4 courses	9 or 10
	MSE 5405. (4-0) Physics and Thermo. of Materials		
	MSE 5312. (3-0) Mechanical Behavior of Materials		
	MSE 5321. (3-0) Phase Transf. of Materials		
Group C	PHYS 5315. (3-0) Solid State I	Select 2 of 5 courses	6
	PHYS 5307 (3-0) Quantum Mechanics I		
	PHYS 5316. (3-0) Solid State II		
	PHYS 5328. (3-0) Surface Physics		
	PHYS 5330. (3-0) Physics of Semiconductor Processing and Characterization		
Group D	MSE 5314. (3-0) Fracture Mechanics	Select 4 of 11 courses	12
	MSE 5315. (3-0) Fatigue of Engineering Materials		
	MSE 5330. (3-0) Corrosion		
	MSE 5336. (3-0) Electrical Properties of Materials		
	MSE 5333. (3-0 Magnetic Properties of Materials		
	MSE 5334 (3-0) Optical Process Solid Materials		
	MSE 5341 (3-0) Current Topics in Nanotechnology		
	MSE 5345. (3-0) Ceramic Materials		
	MSE 5346. (3-0) Contemporary Polymer Chemistry		
	MSE 5347. (3-0) Polymer Materials Science		
	MSE 5348. (3-0) Fundamentals of Composites		
	MSE 5349. (3-0) Advanced Composites		
Minimum Hours for Master of Engineering Degree			36

Disallowed Course Pairs: PHYS 4325 and MSE 5405; PHYS 4315 and MSE 5405, PHYS 4326 and MSE 5405; PHYS 5315 and MSE 5405.

Substitutions in courses will only be approved after consultation with the graduate advisor and approval by the graduate studies committee.

General Rules of Fast Track Program

In developing the Fast Track Program, the Physics and Materials Science and Engineering faculty have:

1) Chosen 9 hours of undergraduate foundation courses that will be used, in part, to screen potential participants. A minimum CGPA of 3.3 is required in these courses.

2) Selected a set of advanced undergraduate and graduate courses that accepted students will take that will meet the educational requirements of both graduate and undergraduate degrees.

> (a) 9 hours (3 courses) chosen from Group A can be used towards the graduate degree.
>
> (b) A maximum of 12 hours (4 courses) of graduate course work may be used towards the undergraduate program. A maximum of 6 hours may be chosen from Group C and a maximum of 6 hours must be chosen from Groups B and D.

3) The Physics and Materials Science and Engineering faculty have established a minimum GPA of 3.0 to remain in and graduate from the graduate program.

4) Only organized courses have been included in the approved set of courses. Each course included among those that will be used as joint credit must make a specific and unique contribution to the student's degree plans. Undergraduate and graduate courses with significant overlapping content may not both be used to satisfy degree requirements. For example, students may not take both the undergraduate and the graduate versions of a course cross-listed as both an undergraduate and graduate course. Disallowed pairs have been listed earlier.

No other courses may be substituted for those selected for screening applicants or for joint credit toward both degrees unless reviewed and approved by a program's Graduate Advisor, Graduate Studies Committee and the Dean of Graduate Studies once a program has designated these courses. No changes will be allowed to accommodate individual cases. Changes in the courses used to select students or to satisfy degree requirements will take effect in the semester following final approval by the Dean of Graduate Studies.

Student Qualifications and Admission Procedures

Qualifications: All applicants must complete at least 9 hours of prerequisite coursework as specified by participating programs and earn a GPA of at least 3.3 in these courses.

Unconditional Admission: Additional minimum qualifications are specified below. Participating programs may set more rigorous or specify additional requirements.

1. Must be within 30 hours of graduation with a BA or BS from UTA.
2. Must have completed at least 30 hours of study at UTA with a 3.0 GPA or better.
3. Must have an overall GPA of at least 3.0 for all college courses.

Provisional Admission: A student may gain provisional admission if, during the semester in which application is made, he or she will complete any remaining courses needed to satisfy prerequisite requirements. Provisional admission will be changed to unconditional admission upon satisfactory completion of remaining requirements. Students failing to meet all requirements at the end of their semester of application will be removed from the Fast Track program. Any credits earned prior to removal from the program will be applied to the undergraduate degree only. None of the other benefits of the Fast Track program will apply. Provisionally admitted students who have been removed from the program may subsequently apply to graduate programs via the normal application process, paying all fees and meeting all relevant admission criteria. Admission will not be automatic as it will be subject to the normal admission practices of the program to which application is made and the Graduate School.

Denial: Students who are not admissible under the conditions specified above shall be denied admission to the Fast Track program. They may apply to graduate programs via the regular application process, paying all required fees and meeting all relevant admission criteria. Admission will not be automatic as it will be subject to the normal admission practices of the program to which application is made and the Graduate School.

Application Procedures

Application to the Fast Track Program: Undergraduate students will complete an appropriate application form created by the Office of Graduate Studies for this purpose. This form will be submitted to the Graduate School. The Graduate School will send an admission worksheet and the application to the proper program for a decision to admit unconditionally, admit provisionally or deny admission. The Graduate School shall enter that decision into the student information system and provide notification to the student.

Admission to the Graduate School: Students completing their undergraduate degree requirements may apply to continue their studies toward their Master's degrees if they are in good standing in the Fast Track program. Students will submit an application for graduate admission in the semester in which they expect to receive their bachelor's degree. The starting semester typically will be the long semester immediately following the graduation semester. However, students may elect to delay their starting date as specified below.

A special application for admission to the graduate program in which they have begun their studies as Fast Track students will be created by the Graduate School. No fees, transcripts, or test scores will be required and, with the consent of the program's graduate advisor, admission will be automatic. Students planning to pursue a master's degree in a program other than the one in which they participated as Fast Track students must apply as a regular student, completing a full application, paying all fees and meeting all admission requirements. In such cases, admission will not be automatic and will be subject to the normal admission practices of the program and Graduate School.

Good Standing and Course Enrollment Clearance

Good Standing: Students must maintain an overall GPA of at least 3.00 and must earn grades of B or better in all Fast Track-approved courses that will be used to satisfy undergraduate and graduate degree requirements. Students must enroll in at least 2 graduate courses and earn a B or better in all graduate courses taken prior to receiving their bachelor's degree. If a student does not complete the two required graduate courses or fails to make adequate grades, he or she will be obliged to leave the program and apply as a regular graduate student after receiving the bachelor's degree.

Course Enrollment Clearance: Students must obtain clearance each semester from the proper graduate advisor to take graduate courses that will be used to satisfy degree requirements. Advisors will monitor student progress carefully and advise accordingly.

Transition to the Master's Degree

Assuming that a student graduates in good standing as a Fast-Track student, a graduate matriculation will have already been created for them. There is no need to apply for admission to graduate school; no application fee or letters of reference are required, and they need not take the GRE exam. The hours required for them to complete their Master's degree will be adjusted according to the number of Fast Track graduate hours they have completed with grades of B or better. Graduating Fast Track students should see the graduate advisor to ensure a smooth transition.

Time Limit to Begin Graduate Studies

A student may take off one long semester plus a summer after receiving the undergraduate degree before starting as a graduate student. An application for graduate admission must be completed and approved before post-baccalaureate studies can begin. Students returning after longer delays will have to apply as a regular student, completing a full application, paying all fees and meeting all admission requirements.

Taking Breaks During Graduate Studies; Minimum Course Load

Once a student is a graduate student, they are governed by the rules for all graduate students. There is no minimum course load, and they can take breaks, as outlined in the graduate catalog, but they must complete their master's degree within six years. Consult a graduate advisor for more details.

Limits on the Number of Graduate Courses

Before graduating with the bachelor's degree, Fast Track students must complete at least two and at most five Fast Track graduate courses with grades of B or better. If a student takes **X** hours of well chosen graduate courses under Fast Track rules, and earns grades of at least B in these courses, the number of hours required to complete the Master's degree will be reduced by **X**.

Applying to Take Graduate Courses

To register for graduate courses, students must obtain the signatures of the Graduate Advisor (MSE) and Undergraduate Advisor (Physics) on a special course registration form. The Graduate Advisor and Undergraduate advisor will check that they are eligible for the classes that are on the list, that they fit into their undergraduate and graduate degree plans, and that they are not exceeding the 15-hour limit for Fast Track courses.

Requirements for Staying in the Fast Track Program

1. A student must maintain an overall GPA (Graduate and Undergraduate) of at least 3.0.
2. A student is expected to get grades of B or better in graduate courses. If they earn a grade of C in a graduate course before they earn their undergraduate degree, they will lose eligibility to remain in the Fast Track Program.

3. They must pass at least two graduate courses with grades of B or better before they graduate with their bachelor's degree to be eligible to remain in the fast track program.
4. During their entire undergraduate experience at UTA, including their period of membership in the Fast Track program, they must not repeat more than three courses, and must not repeat any course more than once. This requirement applies only to undergraduate courses, graduate courses may not be repeated.

If, at any time, a student fails to satisfy these requirements, they will be removed from the Fast Track Program. Any graduate credits earned will be applied only to their undergraduate degree, and none of the other benefits of membership of the Fast Track program will apply. Students dismissed from the Fast Track Program will be eligible to apply to the Materials Science and Engineering Department as a regular applicant. However, graduate courses taken for credit in the undergraduate program cannot be applied towards a graduate degree. They will have to pay the required fee for the application as well as meet all the requirements of admission to graduate school as outlined in the Graduate Catalog.

Appendix. Course Descriptions

Foundation Courses: List of 9 hours of course work that will be used to decide admission into the Fast Track Program.

MSE 3300 INTRODUCTION TO MATERIALS SCIENCE AND ENGINEERING (3-0). Physical, mechanical, electrical, chemical properties of metals, semiconductors, ceramics, polymers, composites, and aggregates and the relationships between these properties and the electronic, crystal, micro and macrostructures of the materials. **Semesters offered:** [Fa, Sp, LS] **Prerequisite:** CHEM 1441 and PHYS 1444.

PHYS 3313 MODERN PHYSICS (3-0). A brief introduction to the theories of quantum mechanics and statistical mechanics followed by a survey of atomic physics, conductors, semiconductors and modern electronic devices, nuclear and sub-nuclear physics. **Prerequisite:** PHYS 1288 or 1444, and MATH 2325 or 2425.

PHYS 3321. INTERMEDIATE ELECTRICITY AND MAGNETISM (3-0). Vector algebra and vector calculus applied to electrostatics, magnetostatics, the study of dielectric materials, and boundary value problems. Prerequisite: PHYS 2311 and MATH 3318 or 3319.

Group A: Maximum of 3 of the following 5 courses can be used for the master's program in Materials Science and Engineering as well as the bachelor's program in Physics

PHYS 4315. THERMODYNAMICS AND STATISTICAL MECHANICS (3-0). Topics in classical thermodynamics include the laws of thermodynamics, Gibbs' and Helmoltz's free energies, the Maxwell relations, heat capacities, entropy change calculations, phase and chemical changes. Statistical mechanics centers on the partition function and its applications, such as the entropy of an ideal gas, the Maxwell velocity distribution, the heat capacity of a solid, photon statistics, and blackbody radiation. Fermi-Dirac and Bose-Einstein statistics. **Prerequisite:** PHYS 3313 and MATH 2326 or permission of the instructor.

PHYS 4319. ADVANCED MECHANICS (3-0). Coupled oscillators, central forces, Lagrange's equations, Hamilton's canonical equations, the moment of inertia tensor, and the application of Euler's angles to rotational motion. **Prerequisite:** PHYS 2311, PHYS 3321, and MATH 3318 or 3319, or permission of the instructor.

PHYS 4325. SOLID STATE PHYSICS (3-0). Classification of crystalline solids and elastic and thermal properties, electric and magnetic properties, and electronic properties of solids. An introduction to current research problems. **Prerequisite:** PHYS 4315 or permission of the instructor.

PHYS 4326. INTRODUCTION TO QUANTUM MECHANICS (3-0). Schroedinger's equation and implications, the free particle, the one-electron atom, the potential barrier, and perturbation theory. **Prerequisite:** PHYS 3313, MATH 3318 or 3319, or permission of the instructor.

MSE 4320. NANAOSCALE MATERIALS (3-0) 3 hours credit.

Group B: Minimum of 3 of the following 4 courses must be part of the master's program in Materials Science and Engineering

MSE 5304. ANALYSIS OF MATERIALS (2-3). Theoretical understandings and practical applications of various characterization techniques to materials analysis, ranging from x-rays and electron diffraction, x-ray spectroscopy, and surface topography, are discussed. Practice of these techniques in lab class typically includes SEM spectroscopy, powder diffraction, Laue diffraction, and the double crystal x-ray diffraction. **Prerequisite:** permission of instructor.

MSE 5405. PHYSICS AND THERMODYNAMICS OF MATERIALS (3-0). Applications of solid-state physics and thermodynamics for fundamental understanding of materials. The solid state physics discusses the mechanisms behind crystal bonding, lattice structure and its property, and band structure of electrons, while thermodynamics focuses on their changes with thermal, chemical and mechanical processes using the concept of thermochemistry. **Prerequisite:** permission of instructor.

MSE 5312. MECHANICAL BEHAVIOR OF MATERIALS (3-0). Concepts of stress and strain, theory of plasticity. Elementary dislocation theory. Deformation of single crystals. Strengthening mechanisms like solid solution strengthening, precipitation hardening, etc. Elementary concepts in fracture mechanics. Microscopic aspects of fracture, fatigue, and creep of materials. **Prerequisite:** MAE 3321 or permission of instructor.

MSE 5321. PHASE TRANSFORMATIONS OF MATERIALS (3-0). The theory of homogeneous and heterogeneous transformations, nucleation and growth, martensitic transformations, heat treatment and control of microstructure. **Prerequisite:** MSE 5305, or permission of instructor.

Group C: Maximum of 2 courses from the list below can be used for the master's program in Materials Science and Engineering

PHYS 5307 QUANTUM MECHANICS I (3-0) Matrix formulation, theory of radiation, angular momentum, perturbation methods.

PHYS 5315. SOLID STATE I (3-0). Crystal structure, lattice vibration, thermal properties, and band theory of solids.

PHYS 5316. SOLID STATE II (3-0). Electrical and magnetic properties of crystalline solids, magnetic resonance, and optical phenomena.

PHYS 5328. SURFACE PHYSICS (3-0). Experimental and theoretical methods for the study of solid surfaces. Geometric and electronic structure of metals and semiconductors. Surfaces as model systems of reduced dimensionality. Adsorption phenomena and film growth.

PHYS 5330. PHYSICS OF SEMICONDUCTOR PROCESSING AND CHARACTERIZATION (3-0). Selection from the following topics: physics of crystal growth, lattice defects, impurity diffusion, ion-implantation, thin film growth and plasma etching. Physics of characterization techniques utilizing resistivity, carrier mobility and lifetimes, electrons, x-rays, ions, Rutherford backscattering, neutron activation analysis, positron annihilation spectroscopy, deep-level transient spectroscopy.

Group D: Minimum of 4 courses from list below must be used for the master's program in Materials Science and Engineering

MSE 5314. FRACTURE MECHANICS (3-0). Theory and applications of linear elastic fracture mechanics. Topics include stress analysis of cracks, crack-tip plasticity, fatigue and stress corrosion. Applicability to materials selection, failure analysis and structural reliability reviewed. **Prerequisite:** permission of instructor.

MSE 5315. FATIGUE OF ENGINEERING MATERIALS (3-0). Cyclic deformation, fatigue crack initiation and growth in ductile solids. Application of fracture mechanics to fatigue. Mechanisms of crack closure. Variable and multiaxial fatigue and corrosion fatigue. Fatigue of brittle solids. **Prerequisite:** permission of instructor.

MSE 5330. CORROSION (3-0). Quantitative application of electrochemical principles to corrosion reactions. Effects of metallurgical factors and environmental conditions on oxidation, erosion, and cracking discussed along with materials selection. **Prerequisite:** permission of instructor.

MSE 5335. INTEGRATED CIRCUIT MATERIALS AND PROCESSING (3-0). Fundamental properties of conductors, semiconductors, insulators, and polymers. Basic device operating principles for the pn junction, MOSFET, and Schottky diode. Materials processing for oxidation, annealing, thin film deposition, wet chemical etching, reactive ion etching, ion implantation, planarization, and photolithography. **Prerequisite:** permission of instructor.

MSE 5336. ELECTRICAL PROPERTIES OF MATERIALS (3-0). Advanced discussion of electronic structure, transport mechanisms in metals, semiconductors and superconductors, with applications to materials used in various electronic devices. **Prerequisite:** MSE 5305 or permission of instructor.

MSE 5333. MAGNETIC PROPERTIES OF MATERIALS (3-0). Classical and quantum mechanical understandings of magnetic properties of materials. Specific applications of these properties to various devices are discussed. **Prerequisite:** MSE 5405 or permission of instructor.

MSE 5334. OPTICAL PROCESSES IN SOLID MATERIALS (3-0). Basic understanding of optical response of materials based on classical and quantum models. Particular focus on all phenomena involving light in semiconductors and their optoelectronic applications. Optical properties of solid materials with reduced dimensionality such as thin films and quantum wells and dots. **Prerequisite:** MSE 5405 or permission of instructor.

MSE 5345. CERAMIC MATERIALS (3-0). Crystal structure of ceramic materials. Phase equilibria in ceramic materials. The processing of ceramics and ceramic matrix composites. Strengthening mechanisms and mechanical properties of ceramics and ceramic matrix composites including flexure, tensile, fracture toughness, fatigue, and creep. **Prerequisite:** permission of instructor.

MSE 5346. CONTEMPORARY POLYMER CHEMISTRY (3-0). Polymer synthesis and reactions. Principles of polymerization including thermodynamics and kinetic considerations. Physical characterizations including determinations of absolute and relative molecular weights, morphology, and glass transitions. Relationships between macromolecular structure, properties, and uses of

polymeric materials. Also offered as CHEM 5350. **Prerequisite:** CHEM 2321 and CHEM 2322 or permission of instructor.

MSE 5347. POLYMER MATERIALS SCIENCE (3-0). Intermolecular forces of attraction in high polymers, polymer synthesis, morphology and order in crystalline polymers, mechanics of amorphous polymers, time-dependent mechanical behavior, transitional phenomena, mechanical behavior of semicrystalline polymers. **Prerequisite:** permission of instructor.

MSE 5348. FUNDAMENTALS OF COMPOSITES (3-0). Fundamental mechanics concepts of fiber-reinforced composites; relationships between the properties of the constituents and those of the unit composite ply; lamina and laminate anisotropic behavior; structural characteristics of A, B, and D matrices; lamination theory; strength criteria; hygrothermal analysis; interlaminar stress analysis. Also offered as ME 5348 and AE 5315. **Prerequisite:** permission of instructor.

MSE 5349. ADVANCED COMPOSITES (3-0). Review of current state-of-the-art applications of composites; composite structural analysis; structural properties; damage characterization and failure mechanism; stiffness loss due to damage; notched sensitivity; delamination; impact; fatigue characteristics; composite materials testing; materials allowables; characteristics of composite joints. Also offered as AE 5325 and ME 5349. **Prerequisite:** ME 5348 or MSE 5348 or AE 5315 or permission of instructor.

MSE 5351. CURRENT TOPICS IN NANOTECHNOLOGY (3-0). Review and discussion of the latest advances in the field of nanoscale science and technology. Topics include molecular electronics, chemical and biological sensors, synthesis of nanoscale materials, carbon nanotubes, nanowires, nanoparticles, atom-wires, self-assembled monolayers, nanoscale composite materials and techniques for observing and manipulating atoms and molecules. **Prerequisite:** permission of instructor.