EMAC (EMAC)

EMAC 125. Freshman Research on Polymers. 1 Unit.
Freshman research in polymer chemistry, engineering, and physics. Students will be placed in active research groups and will participate in real research projects under the supervision of graduate students and faculty mentors.

EMAC 270. Introduction to Polymer Science and Engineering. 3 Units.

EMAC 276. Polymer Properties and Design. 3 Units.
The course reviews chemical and physical structures of a wide range of applications for synthetic and natural polymers, and addresses "Which polymer do we choose for a specific application and why?" We examine the polymer properties, the way that these depend on the chemical and physical structures, and reviews how they are processed. We aim to understand the advantages and disadvantages of the different chemical options and why the actual polymers that are used commercially are the best available in terms of properties, processibility and cost. The requirements include two written assignments and one oral presentation. Prereq: ENGR 145 and EMAC 270.

EMAC 303. Structure of Biological Materials. 3 Units.
Structure of proteins, nucleic acids, connective tissue and bone, from molecular to microscopic levels. An introduction to bioengineering biological materials and biomimetic materials, and an understanding of how different instruments may be used for imaging, identification and characterization of biological materials. Offered as: EBME 303 and EMAC 303. Recommended preparation: EBME 201, EBME 202, and EMAC 270.

EMAC 325. Undergraduate Research in Polymer Science. 1 - 3 Units.
Undergraduate laboratory research in polymer chemistry/physics/engineering. Students will undertake an independent research project, working under the mentoring of both a graduate student and a faculty member. A mid-term written progress report is required. A written report and oral presentation will be made at the end of the semester. Can be taken for 1-3 credits per semester, up to a total of 6 credit hours. Students are expected to spend approximately 5 hours/week in the laboratory per credit registered each semester. Recommended preparation: Sophomore/Junior standing and consent of instructor.

EMAC 351. Physical Chemistry for Engineering. 3 Units.
Principles of physical chemistry and their application to systems involving physical and chemical transformations. The nature of physical chemistry, properties of gases, overview of the laws of thermodynamics, thermochemistry, solutions, phases and chemical equilibrium, kinetics of chemical reaction, solutions of electrolytes and introduction to quantum mechanics, atomic structure and molecular statistics. Prereq: ENGR 145.

EMAC 352. Polymer Physics and Engineering. 3 Units.
Single chain statistics and thermodynamics of dilute polymer solutions (single chain statistics, Flory-Kringbaum theory, vapor pressure and osmotic pressure, light, small angle X-Ray, and small-angle neutron scattering), solid state properties of polymers (polymer viscoelasticity (time-temperature superposition; rubber thermodynamics and statistics), glasses and related mechanical properties (fracture mechanism), crystals and liquid crystals; structure property relationship, polymer blends, block copolymers and composites, transport phenomena (conversation of mass, momentum and energy, differential forms, integral forms, momentum transport, laminar and turbulent flow, Navier-Stokes equation, mass transport, diffusion, Fick’s law) and transport phenomena of polymer solutions (intrinsinc viscosity, sedimentation and diffusion, dynamic light scattering, polyelectrolytes and block copolymers in solution, size exclusion chromatography). Prereq: EMAC 351

EMAC 355. Polymer Analysis Laboratory. 3 Units.
Experimental techniques in polymer synthesis and characterization. Synthesis by a variety of polymerization mechanisms. Quantitative investigation of polymer structure by spectroscopy, diffraction and microscopy. Molecular weight determination. Physical properties. Prereq: EMAC 276 and (CHEM 290 or CHEM 322).

EMAC 370. Polymer Chemistry. 3 Units.
The fundamentals of organic chemistry of polymer synthesis, suitable for laboratory and industrial polymer production. Prereq: EMAC 270 and (CHEM 224 or CHEM 324).

EMAC 372. Polymer Processing and Testing Laboratory. 3 Units.
Basic techniques for the rheological characterization of thermoplastic and thermostet resins; "hands-on" experience with the equipment used in polymer processing methods such as extrusion, injection molding, compression molding; techniques for mechanical characterization and basic principles of statistical quality control. Prereq: EMAC 377.

EMAC 375. Fundamentals of Non-Newtonian Fluid Mechanics and Polymer Rheology. 3 Units.
This course will involve the study of Rheology from the perspectives of rheological property measurement, phenomenological and molecular models, and applicability to polymer processing. In particular, students will be introduced to: 1) General concepts of Rheology and Newtonian Fluid Mechanics, 2) Standard flows and material functions; 3) The role of Rheology as a structural characterization tool, with an emphasis on polymeric systems; 4) Experimental methods in Rheology with quantitative descriptions of associated flows and data analyses; 5) Viscoelasticity and Non-Newtonian Fluid Mechanics, including the application of models, both phenomenological and molecular, to the prediction of rheological behavior and extraction of model parameters from real data sets; and 6) The relevance of rheological behavior of different systems to practical processing schemes, particularly with respect to plastics manufacturing. Offered as EMAC 375 and EMAC 475. Prereq: ENGR 225 or EMAC 404.

EMAC 376. Polymer Engineering. 3 Units.
EMAC 377. Polymer Processing. 3 Units.
Application of the principles of fluid mechanics, heat transfer and mass transfer to problems in polymer processing; elementary steps in polymer processing (handling of particulate solids, melting, pressurization and pumping, mixing); principles and procedures for extrusion, injection molding, reaction injection molding, secondary shaping. Prereq: EMAC 352 or ENGR 225.

EMAC 378. Polymer Engineer Design Product. 3 Units.
Uses material taught in previous and concurrent courses in an integrated fashion to solve polymer product design problems. Practicality, external requirements, economics, thermal/mechanical properties, processing and fabrication issues, decision making with uncertainty, and proposal and report preparation are all stressed. Several small exercises and one comprehensive process design project will be carried out by class members. Offered as EMAC 378 and EMAC 478. Counts as SAGES Senior Capstone.

EMAC 379. Advanced Polymer Engineering. 2 Units.
This Advanced Polymer Engineering course will focus on the ultimate engineering properties for polymers, including fracture mechanics, electrical, and optical properties of polymers. For polymer fracture mechanics, deformation and fracture behavior of polymers will be introduced. The electrical properties include both insulation and conduction/semiconduction properties for polymers. In the optical property section, we will introduce polymer photonics and polymers in liquid crystal displays. The goal of the course is to help students achieve fundamental understanding of advanced polymer properties. EMAC 479 students will do an additional project design. Offered as EMAC 379 and EMAC 479. Prereq: EMAC 376.

EMAC 396. Special Topics. 1 - 18 Units.
(Credit as arranged.)

EMAC 398. Polymer Science and Engineering Project I. 1 - 3 Units.
(Senior project.) Research under the guidance of faculty. Requirements include periodic reporting of progress, plus a final oral presentation and written report. Repeatable up to 3 credit hours. When taken for 3 credits it may be spread over two successive semesters. Counts as SAGES Senior Capstone. Prereq: Senior Standing.

EMAC 399. Polymer Science and Engineering Project II. 1 - 9 Units.
(Senior project.) Research under the guidance of staff, culminating in thesis. Recommended preparation: Majors only and senior standing.

EMAC 400T. Graduate Teaching I. 0 Unit.
This course will engage the Ph.D. students in teaching experiences that will include non-contact (such as preparation and grading of homeworks and tests) and direct contact (leading recitations and monitoring laboratory works, lectures and office hours) activities. The teaching experience will be conducted under the supervision of the faculty. All Ph.D. students will be expected to perform direct contact teaching during the course sequence. The proposed teaching experiences for EMAC Ph.D. students are outlined below in association with undergraduate classes. The individual assignments will depend on the specialization of the students. The activities include grading, recitation, lab supervision and guest lecturing. Recommended preparation: Ph.D. student in Macromolecular Science.

EMAC 401. Polymer Foundation Course I: Organic Chemistry. 3 Units.
The class is an introduction to the synthesis and organic chemistry of macromolecules. The course introduces the most important polymerization reactions, focusing on their reaction mechanisms and kinetic aspects. Topics include free radical and ionic chain polymerization, condensation (step-growth) polymerization, ring-opening, insertion and controlled addition polymerization. There is no limit on the number of students for the class as a whole.

EMAC 402. Polymer Foundation Course II: Physical Chemistry. 3 Units.
This class is an introduction to the physical chemistry of polymers in solution. Topics include: polymer statistics; (microstructure, chain configuration, and chain dimensions), thermodynamics and transport properties of polymers in solution, methods for molecular weight determination, physical chemistry of water-soluble polymers, and characterization of polymer microstructure (IR and NMR). There is no limit on the number of students for the class as a whole.

EMAC 403. Polymer Foundation Course III: Physics. 3 Units.
This class is an introduction to the physics of polymers in the bulk amorphous and crystalline states. Topics include: structural and morphological analysis using X-ray diffraction, electron microscopy and atomic force microscopy, characterization of thermal transitions, viscoelastic behavior and rubber elasticity, and dynamic mechanical analysis. There is no limit on the number of students for the class as a whole.

EMAC 404. Polymer Foundation Course IV: Engineering. 3 Units.
This class is an introduction to the engineering and technology of polymeric materials. Topics include: additives, blends and composites, natural polymers and fibers, thermostatics, elastomers, and thermosets, polymer degradation and stability, polymers in the environment, polymer rheology and polymer processing, and polymers for advanced technologies (membrane science, biomedical engineering, applications in electronics, photonic polymers). There is no limit on the number of students for the class as a whole.

EMAC 405. Polymer Characterization Laboratory. 3 Units.
Laboratory experience through synthesis and characterization of polymers. Synthesis via addition and condensation polymerization. Characterization methods include size exclusion chromatography, infrared and NMR spectroscopy. Solid samples are characterized by x-ray diffraction, electron microscopy, thermal analysis, and physical properties. Fluid samples are characterized by melt rheology. Prereq: EMAC 401, EMAC 402, EMAC 403 and EMAC 404.

EMAC 410. Polymers Plus Self - Assembly and Nanomaterials. 2 Units.
The course focuses on the concepts of supramolecular chemistry and self-assembly specifically as it applies to nano-polymeric systems. After dealing with many of the fundamental aspects of supramolecular chemistry the focus of the class deals with how to access/utilize nano-scale features using such processes, namely the 'bottom-up' approach to nanomaterials/systems. Areas which will be addressed include block copolymers, DNA assemblies, nanotubes and dendrimers. Prereq: EMAC 401 or EMAC 370.

EMAC 413. Polymers Plus Green Chemistry and Engineering. 2 Units.
The course focuses on green chemistry and engineering, particularly as it relates to polymers. Specific topics to be covered in this course will include green chemistry, catalysis, alternative solvents, green processing, renewable materials, and life cycle analysis. Case studies will be utilized to connect lecture topics to real-world examples. Prereq: EMAC 401 and EMAC 404.
EMAC 414. Polymers Plus Advanced Composite and Nanocomposite Materials and Interfaces. 2 Units.
"Advanced Composite and Nanocomposite Materials and Interfaces" will aim at providing advanced concept in composite material structures, importance of interface on the property development, rheological background to be able to manufacture optimized materials, and appropriate processing techniques to choose for a specific product to be manufactured. Specifically, this course will discuss the following items: 1. Basic concept of heterogeneous materials including advantages and problems associated with making multiphase materials. 2. It will review broadly the materials used to make composites and nanocomposites. 3. Unique properties of composites/nanocomposites in rheological, mechanical, and physical properties will be discussed. 4. Various composite processing techniques will be discussed in detail. 5. Surface treatment of the reinforcing materials and interface/interphase structures of composites/nanocomposites will be discussed.

EMAC 415. Polymers Plus Structure and Morphology. 2 Units.
This special topic focuses on polymer structure and morphology and their applications. Topics include solid-state physics of various polymeric materials, ranging from crystalline polymers to liquid crystalline polymers, and block copolymers. First, symmetry operation, space groups, reciprocal spaces are introduced. Examples of the crystalline structures of industrially important polymers and typical polymer crystalline morphology such as lamellar and spherulitic crystals are discussed. Defects in crystalline polymer is also an important issue that determines their physical properties. Second, typical phase structure and transitions of liquid crystals and liquid crystalline polymers are introduced, including both thermotropic and lyotropic liquid crystals. Finally, nanostructure and morphology of block copolymers are discussed. Prereq: EMAC 402 and EMAC 403.

EMAC 417. Functional Polymers. 2 Units.
Polymers have traditionally been used for the so-called passive applications in many areas, ranging from engineering materials to electronics devices. Various functional polymers have now been synthesized with unusual electronic, optical, and mechanical properties. These properties allow polymers to be used as active components for various applications, where they play an active role in regulating the property of materials and performance of devices. Examples include, but not limited to, polymer sensors, polymer actuators, polymer light-emitting diodes, and polymer photovoltaic cells. The objective of this proposed course is to provide polymer engineering and polymer science students with the recent development in functional polymers and their device-related applications. Course Outline: 1). The Concept of Functional Polymers (0.5 week) 2). Electronically Active polymers (1 weeks) - Synthesis, Structure, Conduction Mechanism, and Property 3). Optically Active Polymers (1.5 weeks): Light-Emitting Polymers, Photoactive Polymers, Non-Linear Optical Polymers 4). Stimuli-Responsive Polymers (2 weeks): Solvent/Temperature/pH Responsive Polymers, Field Responsive Polymers 5). Functional Polymers for Device Applications (2 weeks): Polymer Sensors and Actuators, Plastic Electronics, Polymer Light-Emitting Diodes and Photovoltaic Cells, Polymeric Biomedical Devices

EMAC 421. Polymer Plus Hierarchical Structures and Properties. 2 Units.
Discuss the hierarchical solid state structure of synthetic and naturally occurring polymeric systems and relate these structures to their properties. Particular emphasis will be on natural systems containing collagen(s) and carbohydrate(s), and on synthetic crystalline, liquid crystalline, and reinforced composite polymeric materials. In order to prepare students for application of these concepts we will determine how mechanical, transport and optical (photonic) behavior can be controlled by structure manipulation. Prereq: EMAC 403 and EMAC 404.

EMAC 422. Polymers Plus Microscopy. 2 Units.
This course focuses on application of microscopy techniques to the analysis of the microstructure of polymeric materials. Specifically, atomic force microscopy, transmission and scanning electron microscopy, and optical microscopy will be discussed. Practical aspects of these techniques will be applied to a variety of systems, including block copolymers, nanocomposites, LC polymers, and multi-layered films. Prereq: EMAC 403.

EMAC 423. Polymers Plus Adhesives, Sealants and Coatings. 2 Units.

EMAC 425. Polymer Plus Energy. 2 Units.
Energy research has become the focus of the twenty-first century. This course is a special topic on polymers in the energy field and related applications. We primarily focus on polymers for solar cells, fuel cells, batteries, double layer electrochemical capacitors, dielectric capacitors, and wind energy. For solar cells, we will introduce conducting polymers and basic types of polymer solar cells. For fuel cells, we will introduce both proton- and hydroxide-exchange fuel cells. Fundamental issues of ion transport, water management, and fuel cell longevity will be introduced. For supercapacitors, we will introduce porous carbon structures and charge storage mechanism. For dielectric capacitors, we will introduce fundamental concepts in electrostatics, different types of polarization, and loss mechanism. For wind energy, we will introduce polymer composites for wind blades and polymer coatings. This course will combine lectures and contemporary literature reviews/essays.

EMAC 426. Biopolymers: Structure, Synthesis, and Application in Medicine. 2 Units.
An introduction to biomacromolecules including DNA, RNA, and proteins. The course will deal with the synthesis and manipulation of biological and synthetic macromolecules as it applies to topics in modern medicine. Topics covered will include nanoparticle gene and drug delivery systems, polymer hydrogels, polymer imaging agents, and protein-polymer conjugates. The purpose of this course is to provide a survey of important areas in medicine where a polymer chemist/engineer can intervene to make a meaningful contribution. Prereq: CHEM 323 and CHEM 324.
EMAC 427. Polymers Plus a Sustainable Economy. 2 Units.
This course is an interdisciplinary seminar-based course surveying the diverse roles played by polymers in a sustainable economy. Specific topics for discussion include: (i) Renewable Energy and the Sustainable Economy; (ii) Renewable Polymers and the Sustainable Economy; (iii) Challenges for Biotechnology in the Sustainable Economy; (iv) Lifetime Analysis of Polymers; Green Policy in the Sustainable Economy; (v) Sustainable Product Innovation in Northeast Ohio; (vi) Advanced Manufacturing for a Sustainable Economy in Northeast Ohio; (vii) Eco-conscious business models in the polymer industry (viii) Bioethics in Biotechnology; (ix) Alternative Solvents and Processing; and (x) Polymers for Energy Storage and Delivery. Prereq: EMAC 401 and EMAC 404.

EMAC 450. The Business of Polymers. 2 Units.
This course will link polymer technology to business and management issues that need to be considered for successful technology commercialization. Topics include project management, finance, opportunity assessment, the voice of the customer, and protection of intellectual property. Case studies from both large and small companies will be used to illustrate key concepts. Recommended preparation: EMAC 270, EMAC 276.

EMAC 460. Polymers Plus Structure-Property Relationships: A Polymer Per Week. 2 Units.
This course serves as a graduate-level introduction to structure-property relationships for synthetic as biologically-derived macromolecules. One specific macromolecular system will be selected per week, with detailed analysis that includes historical considerations, synthesis, chemical and physical structure, and processing, and how these relate intimately to properties (e.g., mechanical, optical, thermal, electrical) and performance. Examples of selected polymers include polyethylene, vinyl polymers, biodegradable synthetic polyesters, high-performance fibers, biopolymers such as collagen and silk, and intrinsically conducting polymers. Discussions will also include emerging opportunities for polymers chosen and potential limitations to a broader range of applications. Grades will be determined from two detailed papers focusing on the molecular origins of structure-property relationships, a presentation on one of the papers, and in-class participation. Prereq: EMAC 270 or requisites not met permission.

EMAC 461. Chemistry of Fire Safe Polymers and Composites. 3 Units.
Chemistry of Fire Safe Polymers and Composites starts with the introduction of characterization techniques used for fire safe materials and combustion phenomena research. General discussion on how reduced flammability of polymers and composites are obtained, for example by additives and preparing intrinsically thermally stable chemical structure and some examples of smart approaches, will be discussed. It also discusses the synthetic methods of preparing high temperature stable polymers in addition to the raw materials used to prepare those materials. Special emphasis will be placed on the thermal stability data obtained by thermogravimetric analysis (TGA) and combustion calorimetry for those fire safe materials. Mechanistic aspects of the flammability of polymers will be explained with special emphasis on the molar contribution of chemical functionality to the heat release capacity. Theoretical derivation of thermokinetic parameters will be explained. In addition, a common sense build-up will be attempted by providing actual numbers associated with those thermokinetic parameters. Upon completion of background formation, a more advanced materials, composites and nanocomposites, will be discussed using the results recently reported. Preliminary attempts to explain flame retardation by nanocomposite structures will also be discussed. Offered as EMAC 461 and EMAE 461.

EMAC 463. Fire Dynamics. 3 Units.
This course introduces compartment fires and burning behavior of materials. Topics include: buoyant driven flow, fire plume, ceiling jet, vent flow, flashover and smoke movement as well as steady burning of liquids and solids; ignition, extinction and flame spread over solids. Recommended Preparation: Elementary knowledge in thermo-fluids is required. Offered as EMAE 463 and EMAC 463.

EMAC 464. Fire Protection Engineering. 3 Units.
This course introduces essentials of fire protection in industry and houses. Topics include: hazard identification (release of flammable gases and their dispersion), fire and explosion hazards, prevention and risk mitigation, fire detection systems, mechanisms of fire extinguishment, evaluation of fire extinguishing agents and systems. Offered as EMAC 464 and EMAE 464.

EMAC 471. Polymers in Medicine. 3 Units.
This course covers the important fundamentals and applications of polymers in medicine, and consists of three major components: (i) the blood and soft-tissue reactions to polymer implants; (ii) the structure, characterization and modification of biomedical polymers; and (iii) the application of polymers in a broad range of cardiovascular and extravascular devices. The chemical and physical characteristics of biomedical polymers and the properties required to meet the needs of the intended biological function will be presented. Clinical evaluation, including recent advances and current problems associated with different polymer implants. Recommended preparation: EBME 306 or equivalent. Offered as EBME 406 and EMAC 471.

EMAC 475. Fundamentals of Non-Newtonian Fluid Mechanics and Polymer Rheology. 3 Units.
This course will involve the study of Rheology from the perspectives of rheological property measurement, phenomenological and molecular models, and applicability to polymer processing. In particular, students will be introduced to: 1) General concepts of Rheology and Newtonian Fluid Mechanics, 2) Standard flows and material functions; 3) The role of Rheology as a structural characterization tool, with an emphasis on polymeric systems; 4) Experimental methods in Rheology with quantitative descriptions of associated flows and data analyses; 5) Viscoelasticity and Non-Newtonian Fluid Mechanics, including the application of models, both phenomenological and molecular, to the prediction of rheological behavior and extraction of model parameters from real data sets; and 6) The relevance of rheological behavior of different systems to practical processing schemes, particularly with respect to plastics manufacturing. Offered as EMAC 375 and EMAC 475. Prereq: ENGR 225 or EMAC 404.

EMAC 476. Polymer Engineering. 3 Units.
Mechanical properties of polymer materials as related to polymer structure and composition. Visco-elastic behavior, yielding and fracture behavior including irreversible deformation processes. Recommended preparation: ENGR 200. Offered as EMAC 376 and EMAC 476.

EMAC 477. Elementary Steps in Polymer Processing. 3 Units.
This course is an application of principles of fluid mechanics and heat transfer to problems in polymer processing. In the first part of the course, basic principles of transport phenomena will be reviewed. In the second part, the elementary steps in polymer processing will be described and analyzed with application to a single screw extruder.
**EMAC 478. Polymer Engineer Design Product. 3 Units.**
Uses material taught in previous and concurrent courses in an integrated fashion to solve polymer product design problems. Practicality, external requirements, economics, thermal/mechanical properties, processing and fabrication issues, decision making with uncertainty, and proposal and report preparation are all stressed. Several small exercises and one comprehensive process design project will be carried out by class members. Offered as EMAC 378 and EMAC 478. Counts as SAGES Senior Capstone.

**EMAC 479. Advanced Polymer Engineering. 2 Units.**
This Advanced Polymer Engineering course will focus on the ultimate engineering properties for polymers, including fracture mechanics, electrical, and optical properties of polymers. For polymer fracture mechanics, deformation and fracture behavior of polymers will be introduced. The electrical properties include both insulation and conduction/semiconduction properties for polymers. In the optical property section, we will introduce polymer photonics and polymers in liquid crystal displays. The goal of the course is to help students achieve fundamental understanding of advanced polymer properties. EMAC 479 students will do an additional project design. Offered as EMAC 379 and EMAC 479. Prereq: EMAC 404.

**EMAC 480. Writing an NSF-Style Scientific Proposal. 2 Units.**
The aim of this course is to learn how to develop a National Science Foundation (NSF) grant proposal. The class will include all aspects of building an NSF proposal from the intellectual merit of the scientific content to its Broader impacts. It will also focus on how to put together the other aspects required for an NSF proposal, such as budget, facilities, NSF-style bio, etc. The class will involve some lectures on the basics of putting the proposal together (best practices, etc.) followed by writing the NSF proposal using the NSF’s current Grant Proposal Guide (GPG). The class will meet once a week to discuss the progress of each of the student’s proposals. The students will be expected to come up with their own polymer-related scientific idea for the grant proposal (which has to be approved by the Macromolecular Sci & Eng Graduate Committee before the end of the second week of class). Toward the end of the class all proposals will be evaluated by the students (each student will be assigned as a primary reviewer for some of the proposals, a secondary reviewer and a scribe for others). The class will then hold a NSF-style proposal panel review. Each proposal will be awarded an NSF evaluation grade (Excellent, Very Good, Good, Fair, Poor) and a final review report for each proposal will be drafted by the students. The final grade for this class depends on the quality of the proposal as well as the students’ participation in the NSF-style panel review process.

**EMAC 490. Polymers Plus Professional Development. 1 Unit.**
This course focuses on graduate student professional development. The course involves weekly meetings and oral presentations with attention on the content and style of the presentation materials (PowerPoint, posters, etc.), oral presentation style and project management skills. This course can be taken for the total of 3 credits over three different semesters.

**EMAC 491. Polymers Plus Literature Review. 1 Unit.**
This course involves weekly presentations of the current polymer literature. It involves at least one presentation by the enrolled student and participation in all literature reviews (at least 10/semester). The course will focus on presentation skills (both oral and written), scientific interpretation, and development of peer-review skills. This course can be taken for a total of 3 credits over three different semesters.

**EMAC 492. Carbon Nanoscience and Nanotechnology. 3 Units.**
This course presents the fundamental aspects of nanoscience and nanotechnology with an emphasis on carbon nanomaterials and nanodevices. This proposed course intents to provide students with the fundamental aspects of nanoscience and nanotechnology. Nanotechnology draws on the strengths of all the basic sciences and is the engineering at the molecular level, which has the potential to lead to novel scientific discoveries as well as new industrial technologies. This course will give students insight into a new, exciting and rapidly developing field. The course has a good balance between basic knowledge and depth with a focus on some key application areas, which will enable students to work in a variety of scientific professions.

**EMAC 500T. Graduate Teaching II. 0 Unit.**
This course will engage the Ph.D. students in teaching experiences that will include non-contact (such as preparation and grading of homework and tests) and direct contact (leading recitations and monitoring laboratory works, lectures and office hours) activities. The teaching experience will be conducted under the supervision of the faculty. All Ph.D. students will be expected to perform direct contact teaching during the course sequence. The proposed teaching experiences for EMAC Ph.D. students are outlined below in association with graduate classes. The individual assignments will depend on the specialization of the students. The activities include grading, recitation, lab supervision and guest lecturing. Recommended preparation: Ph.D. student in Macromolecular Science.

**EMAC 560. Macromolecules and Cells: A Materials Framework. 2 Units.**
This course aims to provide a broad overview of the structure and function of cellular macromolecules, with the major focus being an exploration biological cells as soft materials. Special emphasis is given to connections between cell material properties and macromolecular assemblies (e.g., viscoelasticity and cytoskeletal networks) and roles in determining mechanical, physical, electrical and transport properties. Material properties of collections of cells, namely selected tissues and organs, will be also discussed with special attention to irritability and motion and the design of smart materials and artificial cells using fundamental concepts from macromolecular science and engineering.

**EMAC 600T. Graduate Teaching III. 0 Unit.**
This course will engage the Ph.D. students in teaching experiences that will include non-contact and direct contact activities. The teaching experience will be conducted under the supervision of the faculty. The proposed teaching experiences for EMAC Ph.D. student in this course involve instruction in the operation of major instrumentation and equipment used in the daily research activities. The individual assignments will depend on the specialization of the students. Recommended preparation: Ph.D. student in Macromolecular Science.

**EMAC 601. Independent Study. 1 - 18 Units.**
(Credit as arranged.)

**EMAC 651. Thesis M.S.. 1 - 18 Units.**
(Credit as arranged.)

**EMAC 673. Selected Topics in Polymer Engineering. 2 - 3 Units.**
Timely issues in polymer engineering are presented at the advanced graduate level. Content varies, but may include: mechanisms of irreversible deformation: failure, fatigue and fracture of polymers and their composites; processing structure-property relationships; and hierarchical design of polymeric systems. Recommended preparation: EMAC 376 or EMAC 476.
EMAC 677. Colloquium in Macromolecular Science and Engineering. 0 - 1 Units.
Lectures by invited speakers on subjects of current interest in polymer science and engineering. This course can be taken for 3 credits over three different semesters.

EMAC 690. Special Topics in Macromolecular Science. 1 - 18 Units.

EMAC 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.