Advanced and Nano Materials Track

This technical track provides undergraduate students a deeper focus in the area of Advanced and Nano Materials. It is a supplement to the solid foundation in chemical engineering principles and practice they will acquire in the CBE program.

Chemical engineers are increasingly involved in industries where various materials are used for diverse applications. Traditionally chemical engineers work in the chemical and petroleum industries, but many are now employed in industries where they deal with different types of materials including "hard materials" (metals, ceramics, plastics, etc.) as well as "soft materials" (liquid crystals, amphiphiles, gels, polymer melts, and biological materials). Many chemical engineering graduates work with advanced and nano materials in different capacities in the pharmaceutical, biomedical, energy, and environmental industries.

Requirements for Advanced and Nano Materials Track

To fulfill the requirement for this track, students must complete two courses (6 credits) with C or better grade for each course from the approved list below. Please note that some of the courses listed are not offered by the Department of Chemical Engineering. Some of the courses are not offered every year and you may need to complete additional courses to meet their pre-req requirements.

With approval of the CBE undergraduate program director, students may substitute one of the courses with 3 credits of Undergraduate Research (155:391, 392, 491, or 492 at the junior or senior level) performed in the Advanced and Nano Materials area supervised by a CBE faculty.

Approved Course List for the Advanced and Nano Materials track.

1) 16:155:555. Chemical Engineering of Advanced Materials (3 credit)
Students will learn advanced materials, i.e., materials utilized in high technology applications. Emphasis is placed on the relationships between the structure, which is controlled by processing, and the properties of advanced materials. Both soft matter, cutting-edge materials evolving daily, and traditional hard matter will be covered.
Prerequisites: 14:635:407 (Mechanical Properties of Materials). Graduate course taken by undergraduates (senior standing and GPA of 3.0 or higher required) with permission of the Undergraduate Program Director.

2) 01:160:409. Organic Chemistry of High Polymers (3 credit)
Introduction to the synthesis and reactions of macromolecules, free-radical polymerization, stereospecific polymerization, and stepwise polymerization.
Prerequisites: 01:160:308 (Organic Chemistry) and 324 (Physical Chemistry, 3 credit), 328 (Physical Chemistry, 4 credit), or 342 (Physical Chemistry: Biochemical Systems).

3) 01:160:461. Concepts in Nanochemistry (3 credit)
Nanochemistry: synthesis and characterization of organic and inorganic materials with nanoscale dimensions; electronic and magnetic properties; applications in medicine, energy, and toxicology.
Prerequisites: 01:160:361 (Chemical Bonding) or 01:160:327 (Physical Chemistry).

4) 14:635:307. Kinetics of Materials Processes (3 credit)
This course takes a phenomenological approach to the solid-state reactions involved in materials processing. It includes phase transformations and phase separation. It discusses mechanisms and transport phenomena.
Prerequisites: 14:635:205 (Crystal Chemistry and Structure of Materials).

5) 14:635:320. Introduction to Nanomaterials (3 credit)

Nanotechnology involves behavior and control of materials and processes at the atomic and molecular levels. This interdisciplinary course introduces the student to the theoretical basis, synthetic processes and experimental techniques for nanomaterials.

Prerequisites: Completion of 60 credits in Engineering, Chemistry or Physics Programs or permission of the Coordinator.

6) 14:635:321. Structural, Mechanical and Chemical Applications of Nanostructures and Nanomaterials (3 credit)

Topics covered will be a nanoscale, fundamentals of grain boundaries and surfaces, application of nanomaterials to batteries, fuel cells and catalysts and mechanical applications such as hardness, yield strength, superplasticity, tribology and wear, microelectro-electro-mechanical systems (MEMS).

Prerequisites: 14:635:320.

7) 14:635:360. Materials Science & Engineering of Ceramics & Glasses (3 credit)

The course focuses on the principal materials fields that are satisfied by ceramic materials. The topics covered go well beyond those covered in Introduction to 14-635:203 (Materials Science and Engineering). These topics include traditional areas such as whitewares, enamels, glazes, glass and refractories. In addition a wide range of advanced materials topics include electronic, magnetic, optic, biomedical, catalyst and structural materials. An emphasis will be placed on understanding the interrelationship between chemistry, structure, properties and performance.

Prerequisites: Permission of the instructor.

8) 14:635:361. Materials Science & Engineering of Polymers (3 credit)

This course focuses on the principal materials fields that are satisfied by organic polymers. The topics covered by this course go well beyond those covered in 14-635:203 (Introduction to Materials Science and Engineering). Topics covered include, polymerization, structure, characterization methods, stress/strain behavior, processing methods, and structure-property relationships with an emphasis on mechanical, optical, and transport properties.

Prerequisites: 01:160:159 and 01:160:160.

9) 14:635:362. Physical Metallurgy (3 credit)

This course focuses on the principal materials fields that are satisfied by metals and alloys. The topics covered go well beyond those covered in Introduction to 14-635:203 (Materials Science and Engineering). These topics include crystallography, phase equilibria, alloy crystal chemistry, and traditional and advanced metal and alloy processing. The relationship between structure -properties-performance will be discussed in detail. These relationships will be used to understand the criteria for process selection, which include Risk assessment, product liability, failure analysis and prevention, and environmental impact.

Prerequisites: freshman calculus, chemistry, and physics courses.

10) 14:635:410. Biological Applications of Nanostructures and Nanomaterials (3 credit)

This course is for senior undergraduate students with a working knowledge of materials and biological systems. The materials or substrates discussed will typically consist of polymers, metals, and semiconductors whereas the biological systems may consist of cells, genes, and proteins. This course integrates biointerfaces across size scales, from nano- to micro-scales.

Prerequisites: Cumulative GPA of 3.2 or above and permission of the instructor.

11) 01:750:406. Introductory Solid State Physics (3 credit)

Fundamental properties of metals, insulators, and semiconductors; dielectrics, magnetism, and superconductivity.

Prerequisites: 01:750:361 (Quantum Mechanics and Atomic Physics) and 01:750:386 (Electromagnetism), or permission of the instructor.