Program Educational Objectives
The Chemical Engineering Department’s mission is to provide a high-quality program of teaching, research, and public service for educating chemical engineers to lead the chemical and allied industries. Consistent with the missions of the University, the College of Engineering, and the Department, the Chemical Engineering Department’s educational objectives are:

• to prepare BS graduates for careers in the professional practice of chemical engineering and allied professions,
• to prepare qualified students interested in further study for graduate and professional schools, and
• to maintain and develop a faculty with active, high-quality research programs linked to the undergraduate curriculum for its continued improvement.

Student Learning Outcomes
Based on the Program Educational Objectives described above, the faculty established the Student Outcomes listed below. These were developed by specializing the 11 ABET outcomes for our mission and objectives.

• Technical Knowledge: an ability to apply knowledge of mathematics, science (including chemistry, physics, and biology), in addition to chemical engineering science
• Experiments: an ability to design and conduct experiments, relevant to the study of chemistry and chemical engineering and to analyze and interpret data
• Design: an ability to synthesize and design process systems, including their component unit operations, and to optimize process systems and alternatives to meet desired needs
• Teams: an ability to function on multidisciplinary teams
• Problem Solving: an ability to identify, formulate, and solve chemical engineering problems
• Professional & Ethical: an understanding of professional and ethical responsibility
• Communication: an ability to communicate effectively orally and in writing
• Global/Societal Impact: the broad education necessary to understand the impact of chemical engineering systems in a global, economic, environmental, and societal context
• Life-Long Learning: recognition of the need for, and an ability to engage in life-long learning, particularly through an appreciation of recent research and its impact in chemical engineering
• Contemporary Issues: knowledge of contemporary issues relevant to chemical engineering, achieved particularly through exposure to emerging areas and current research
• Applications: an ability to use the techniques, skills, and modern science and engineering tools necessary for chemical engineering practice

Assessment tools
Indirect methods:
• Student Self-Assessment (SSA), which indicates the students’ perception of their degree of achieving course objectives in each required chemical engineering course.
• Questions added to standard course evaluation forms (SRTI), developed by the department.
• Senior Survey (SS) and Critique (SC), conducted each May, with student feedback on individual courses and their overall assessment of their attainment of the 11 Student Outcomes.
• Alumni Survey (AS), distributed to BS ChE Alumni approximately every two years or as necessary at intervals as needed based on the timing of changes made in the curriculum.
• Advisory Board Survey (ABS), which gives both quantitative and qualitative feedback on the appropriateness of the Program Educational Objectives and Student Outcomes, including the extent to which the curriculum is designed to achieve these objectives and outcomes.
**Data are collected on a numerical scale of 1-5 for the SSA, AS, and ABS, with 5 corresponding to an objective or outcome that is completely accomplished and a score of 1 to an objective that is not accomplished at all.**

**Direct method:**
- Faculty Assessment (FA) in each course, which indicates how well the faculty member judges that students with passing grades attained the Course Objectives. Course objectives for each core course were established by the faculty and are mapped to the 11 Student Outcomes listed above. Changes to the objectives for a course require approval by the faculty. The faculty utilizes a uniform method of FA, whereby indicators for each course objective are selected from the course assignments or exam problems. The faculty member examines student performance on each indicator and converts this to a scale of 1=Poor to 5=Excellent, reflecting student mastery.

The SSA, SRTI, and FA results are evaluated first by the Undergraduate Program Director, the Department Head, and the Undergraduate Curriculum Committee. The results are then presented to and discussed in detail by the entire faculty each semester. The other assessment methods are evaluated annually following a similar procedure. The results are discussed in detail at an Undergraduate Program Retreat at the beginning of the fall semester. If the score for an outcome or objective falls below 3.0 for one year or below 3.5 for a 3-year average, an automatic review is triggered to ensure continual program improvement. Additional program changes are made upon the approval of the faculty in response to student comments at the annual Senior Critique, input from the annual Advisory Board meeting, and faculty suggestions. The department consistently follows this review process of assessment, evaluation, and continuing improvement as part of the ABET accreditation process for engineering departments.

**Highlighted recent activities**
Various inputs from constituents and evaluations of the assessment results have led to several recent curriculum changes. Summaries of the major changes and the supporting rationales are provided below.

**Biological Sciences requirement:** The content of the introductory biology courses has been changed. Consequently, the old requirement of Bio 100 has been changed to Bio 151 or Chem-Eng 220, a course that was developed in 2011 to provide a more quantitative introduction to important biology content for chemical engineering majors. As of 2013, Chem-Eng 220 is the required course in the biological sciences for all chemical engineering majors. (Exceptions are made on an individual basis for students who are pre-med.)

Student comments on the Senior Survey and during the Senior Critique indicated a dissatisfaction with Biology 100 for several years due to its very descriptive treatment of the subject matter and lack of connection to chemical engineering. This dissatisfaction was also reflected in a declining trend in the SS scores for the course. Furthermore, there was no chemical engineering course offered during the Fall semester of the sophomore year, which was noted as a potential concern by the departmental Advisory Board. We note that Thermodynamics I (ChE 226) was previously moved from the fall to the spring semester so that all students would have previously completed a course in multivariable calculus. After the hiring of Professor S. Peyton, the department had an opportunity to offer a chemical engineering course on biological systems that addressed all of these issues. ChE 220 provides a quantitative treatment of biological concepts; introduces elementary aspects of thermodynamics, transport phenomena, and kinetics; and helps provide continuity in the teaching of engineering concepts, as it links the treatment of mass and energy balances in ChE 120 (1st year, second semester) with the treatment of chemical engineering thermodynamics in ChE 226 (2nd year, second semester).

**New Laboratory Course:** As part of the department’s growing emphasis on biological applications of chemical engineering, a new laboratory course has been developed. Chem-Eng 590A: Bioprocessing Engineering Laboratory, an interdisciplinary course co-taught with the Department of Biochemistry, can be elected by Seniors in place of the second semester of the traditional Senior Laboratory, Chem-Eng 402. This course was instituted in 2008 in response to written student input in the Senior Survey that
there was considerable interest in additional offerings in bioengineering. In addition, it was suggested in comments from the SSA that the department could benefit from more diverse laboratory offerings, as some students found the two semesters of the Senior Lab (ChE 401 & 402) to be too similar. This course is now an important component of the Concentration in Biochemical Engineering, as discussed earlier.

**Physical Chemistry requirement:** Changes have been made to the required course in Physical Chemistry. At the time of the last review, students could complete either Chem 475, an introduction to modern quantum chemistry, or Chem 476, an introduction to thermodynamics and statistical mechanics. At present, students are required to complete Chem-Eng 475, a section of Chem 475 (with the same content) created for chemical engineering majors. Chem 476 may still be taken to satisfy the Advanced Chemistry Elective requirement or one of the non-Engineering Technical Electives.

The change from requiring either Chem 475 or 476 to requiring that all students complete Chem 475 resulted from the view of the faculty that quantum chemistry and spectroscopy are important topics given the relevance of atomistic and molecular-scale phenomena to modern chemical engineering, while the content of Chem 476 was seen as less important because of an overlap with the material covered in the required chemical engineering thermodynamics sequence.

The change from offering this course in the chemistry department to chemical engineering was made primarily in response to inconsistent teaching of Chem 475 as the instructor varied in different semesters. This problem is evident in the significant drop in the rating of Chem 475 in the Senior Survey from 2011 to 2012. In addition, as the chemical engineering enrollment has grown, the number of students (chemistry and chemical engineering) taking Chem 475 has exceeded the classroom space. The chemistry department has been unwilling to allocate an instructor for an additional section of the course. Chemical engineering students have complained for several years that the lab/discussion section for Chem 475 conflicted with another required course in chemical engineering, but during some semesters the instructor was unwilling to make accommodations.

**Increased choice of Technical Electives:** The number of permissible Technical Electives has been expanded since the last review. Students must complete four Technical Electives, with at least two being Engineering courses at the 200-level or above. There are 381 possible Engineering Technical Electives and 774 possible Non-Engineering Technical Electives. There are 33 possible courses in Chemistry and Biochemistry that satisfy the Advanced Chemistry Elective. In written comment on the SS and AS, feedback at the Senior Critique, and in informal feedback during student advising, students have expressed a desire for more flexibility to specialize in various areas of interest. The increase in the number of permissible courses that satisfy the Advanced Chemistry Elective, Engineering Technical Electives, and Non-Engineering Technical Electives was designed to meet this demand. Furthermore, the increased number of permissible electives should enhance the students’ attainment of the Contemporary Issues outcome, which has received the lowest scores of the 11 Student Outcomes in the last six Senior Surveys. (We note that the scores for this Outcome were still above the threshold.)