UND Chemical Engineering Undergraduate Assessment Plan – June 2015

The UND Chemical Engineering undergraduate program assessment plan was initially developed in 1997 and has been regularly updated since based on input from program constituencies. A major update to the plan was officially adopted in August 2011 after approval by the Chemical Engineering faculty and the Department External Advisory Committee. Minor revisions were added in August 2012, August 2013, Fall 2014, and June 2015. Assessment of student learning is centered on 13 “Student Learning Outcomes” that describe what students are expected to know and be able to do by the time of graduation. Each of the student learning outcomes is defined further by one or more specific, measureable “Performance Indicators.” The student learning outcomes are intended to prepare graduates to attain a set of five “Program Educational Objectives” that describe what alumni are able to achieve within a few years after graduation. The student learning outcomes and associated assessment plans are designed to provide data needed for both ABET accreditation and Essential Studies revalidation.

This document details the objectives and outcomes, the assessment and evaluation process, and the instruments and methods used. It is organized using the ABET-directed format and headings from the June 2015 ABET Self Study as follows:

2B. Program Educational Objectives
3A. Student Learning Outcomes
3B. Relationship of Student Learning Outcomes to Program Educational Objectives
4A. Continuous Improvement Process (for assessment and evaluation of student learning outcomes)
4C. Assessment Instruments and Methods
2B. **UND ChE Program Educational Objectives**

Our program educational objectives describe the expectations for graduates within a few years following their graduation. Graduates of the UND Chemical Engineering program will:

1. Be highly competent in conducting the assignments and activities associated with their chosen career path.
2. Attain promotions and/or accept responsibilities beyond their entry-level position in the chemical process and broadly related industries or be pursuing advanced degrees.
3. Continue to develop professionally.
4. Work effectively in teams and as leaders to solve problems and clearly communicate results.
5. Act with integrity and consider the safety, sustainability, and social consequences of their decisions and activities.
3A. UND ChE Student Learning Outcomes

The department uses 13 Student Learning Outcomes, listed in Table 3-1, that define what our students are expected to know and be able to do by the time they graduate from our program. The first eleven Outcomes are the (a) - (k) ABET Student Outcomes. Two additional outcomes, (l) and (m), have been adopted by the department to reflect further aspects of the program that the faculty and our constituents feel are important in undergraduate education.

Specific performance indicators corresponding to each of the student learning outcomes provide further definition of expected student learning by UND Chemical Engineering students. Performance indicators are presented in Table 3-2. These performance indicators incorporate elements of ABET program criteria for chemical engineering programs, UND Essential Studies goals (Essential Studies are the general education requirements that form the academic core of all UND undergraduate programs), and other elements valued by our faculty and constituents. Together they provide an integrated set of learning outcomes and indicators that can be used for both ABET reaccreditation and Essential Studies revalidation.

Table 3-1. UND ChE Student Learning Outcomes

<table>
<thead>
<tr>
<th>The Department of Chemical Engineering at the University of North Dakota will produce graduates who have:</th>
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<tbody>
<tr>
<td>(a) an ability to apply knowledge of mathematics, science, and engineering</td>
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<tr>
<td>(b) an ability to design and conduct experiments, as well as to analyze and interpret data</td>
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<tr>
<td>(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability</td>
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<tr>
<td>(d) an ability to function on multidisciplinary and/or diverse teams</td>
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<tr>
<td>(e) an ability to identify, formulate, and solve engineering problems</td>
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<tr>
<td>(f) an understanding of professional and ethical responsibility</td>
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<tr>
<td>(g) an ability to communicate effectively in both oral and written formats</td>
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<tr>
<td>(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
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<tr>
<td>(i) a recognition of the need for, and an ability to engage in lifelong learning</td>
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<tr>
<td>(j) a knowledge of contemporary issues of relevance to the field of chemical engineering</td>
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<tr>
<td>(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
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<tr>
<td>(l) an understanding of the role of economics in engineering and an ability to apply that understanding to problem solving</td>
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<tr>
<td>(m) a working knowledge of chemistry and chemical engineering topics</td>
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Table 3-2. Performance Indicators for UND ChE Student Learning Outcomes

<table>
<thead>
<tr>
<th>Student Learning Outcome</th>
<th>Performance Indicator</th>
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| **Outcome A:** An ability to apply knowledge of mathematics, science, and engineering. | A1. Students will correctly apply and use mathematics and physics concepts (such as basic integrals, differential equations, statistical measures, mechanics) in solving engineering problems.  
A2. Students will correctly apply and use chemistry concepts (such as chemical reactions and thermodynamics) in solving engineering problems.  
A3. Students will correctly apply and use fundamental engineering concepts (such as material and energy balances; heat, mass, and momentum transfer; vapor-liquid equilibrium) in solving engineering problems. |
| **Outcome B:** An ability to design and conduct experiments, as well as to analyze and interpret data. | B1. Students will formulate a well-designed experimental plan to obtain a desired objective.  
B2. Students will demonstrate appropriate laboratory techniques regarding safety, instrument operation, and record keeping.  
B3. Students will correctly and concisely analyze and interpret experimental data. |
| **Outcome C:** An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. | C1. Students will identify the relevant concepts, issues, and information needed to define a design problem.  
C2. Students will design a system of unit operations and components to transform raw materials into desired products.  
C3. Students will consider **process safety** and other realistic constraints when designing a component, process, or system.  
C4. Students will evaluate design alternatives to develop an optimum system. |
| **Outcome D:** An ability to function on multidisciplinary and/or diverse teams. | D1. Student teams will establish and follow project management goals.  
D2. Student teams will integrate individual contributions into a cohesive high quality product.  
D3. Student teams will maintain an inclusive, respectful climate.  
D4. Students will demonstrate leadership and the ability to fill different team roles. |
| **Outcome E:** An ability to identify, formulate, and solve engineering problems. | E1. Students will identify relevant concepts, equations, and data needed to define a problem.  
E2. Students will formulate appropriate solution strategies.  
E3. Students will properly execute a solution strategy to arrive at a correct solution.  
E4. Students will reflect on the reasonableness of their problem solutions. |
| **Outcome F:** An understanding of professional and ethical responsibility. | F1. Students will be able to demonstrate knowledge of the principles of ethics, identify objective and subjective aspects of ethical judgments, and show an awareness of the ethical obligations of engineers.  
F2. Students will be able to construct and apply reasoning strategies from the theories and principles of ethics to identify and resolve ethical problems. |
**Outcome G:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to communicate effectively in both oral and written formats.

| G1. | Students will exhibit a clear sense of purpose in their written and oral communication  
| G2. | Students will accurately synthesize, analyze, and evaluate technical information  
| G3. | Students will present communication that is well organized, providing guidance for readers and listeners,  
| G4. | Students will express themselves clearly and follow appropriate conventions of format, writing, and speech.  
| G5. | Students will answer questions and revise writing in response to listener and reader feedback  

**Outcome H:** The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

| H1. | Students will demonstrate an awareness of how chemical engineering solutions impact economic, environmental, and societal aspects of the local and global community.  

**Outcome I:** A recognition of the need for and an ability to engage in lifelong learning.

| I1. | Students will identify what needs to be learned and how to learn it.  
| I2. | Students will learn independently and apply that knowledge.  

**Outcome J:** A knowledge of contemporary issues of relevance to the field of chemical engineering.

| J1. | Students will be able to discuss how current trends and social concerns (such as sustainability, globalization, local and global economics, political policy) may affect the chemical engineering field  

**Outcome K:** An ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

| K1. | Students will demonstrate ability to select and use modern computer tools such as process simulators, numerical solvers, spreadsheets, word processors, relational databases, statistical packages.  
| K2. | Students will demonstrate ability to understand and create preliminary design documents for chemical processes.  

**Outcome L:** An understanding of the role of economics in engineering and an ability to apply that understanding to problem solving.

| L1. | Students will be able to perform a thorough economic analysis of a chemical engineering project and make appropriate recommendations based on the analysis.  

**Outcome M:** A working knowledge of chemistry and chemical engineering topics.

| M1. | Students will use correct nomenclature and terminology to describe chemical compounds, reactions, operations, and processes.  
| M2. | Students will be able to design and analyze continuous and stage-wise separation operations  
| M3. | Students will be able to design and analyze chemical reactor systems.  
| M4. | Students will be able to design and analyze chemical process control schemes.  
| M5. | Students will demonstrate an awareness and understanding of emerging technologies and trends relevant to chemical engineering.  

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3B. **Relationship of Student Learning Outcomes to Program Educational Objectives**

Each of our Student Learning Outcomes contributes to attainment of several, or all, of our Program Educational Objectives as shown in Table 3-3.

**Table 3-3. Alignment of Student Learning Outcomes with Program Educational Objectives**

<table>
<thead>
<tr>
<th>Program Educational Objectives</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
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<tbody>
<tr>
<td>1. Be highly competent in conducting the assignments and activities associated with their chosen career path</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>2. Attain promotions and/or accept responsibilities beyond their entry-level position in the chemical process and broadly related industries or be pursuing advanced degrees</td>
<td>X</td>
<td>X</td>
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<td>3. Continue to develop professionally</td>
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<td>X</td>
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<tr>
<td>4. Work effectively in teams and as leaders to solve problems and clearly communicate results</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>5. Act with integrity and consider the safety, sustainability, and social consequences of their decisions and activities</td>
<td>X</td>
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</tbody>
</table>
4A. Continuous Improvement Process (for Assessment and Evaluation of Student Learning Outcomes)

4A.1. Data Collection Methods
Assessment of student learning includes both direct and indirect measures as summarized in Table 4-1. Further details of each assessment activity are provided in the following discussion. Examples of each of the forms, rubrics, surveys, and other assessment instruments will be available during the site visit and are listed in section 4C.

Table 4-1. Assessment Data Collection

<table>
<thead>
<tr>
<th>Data Collection Activity</th>
<th>Frequency</th>
<th>Date</th>
<th>Responsible</th>
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</thead>
<tbody>
<tr>
<td><strong>Direct measures</strong></td>
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<tr>
<td>1. Student Work from upper level courses</td>
<td>Each semester</td>
<td>December, May, August</td>
<td>Course Instructor</td>
</tr>
<tr>
<td><strong>Indirect measures</strong></td>
<td></td>
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<tr>
<td>2. Faculty Course Review Comments</td>
<td>Each semester</td>
<td>December, May, August</td>
<td>Course Instructors</td>
</tr>
<tr>
<td>3. Peer Evaluations from Senior Design Capstone</td>
<td>Annually</td>
<td>April</td>
<td>ChE 412 Instructor</td>
</tr>
<tr>
<td>4. Senior Exit Surveys</td>
<td>Annually</td>
<td>April</td>
<td>CEM Dean’s Office</td>
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<tr>
<td>5. Senior Exit Interview</td>
<td>Annually</td>
<td>April</td>
<td>ChE Chair, ChE Assessment Coordinator</td>
</tr>
<tr>
<td>6. Co-op Employer Surveys</td>
<td>Each Semester</td>
<td>December, May, August</td>
<td>ChE Co-op Coordinator</td>
</tr>
<tr>
<td>7. External Advisory Committee Feedback</td>
<td>Bi-annually</td>
<td>August (typically)</td>
<td>ChE Assessment Coordinator, ChE Chair</td>
</tr>
<tr>
<td>8. Informal student feedback – advisors</td>
<td>Continuous</td>
<td></td>
<td>ChE Faculty Advisors</td>
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<tr>
<td>9. Other</td>
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<tr>
<td><strong>Analysis &amp; Evaluation</strong></td>
<td></td>
<td></td>
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<tr>
<td>Data compilation</td>
<td>Annually</td>
<td>May, June</td>
<td>ChE Assessment Coordinator</td>
</tr>
<tr>
<td>Faculty Assessment Retreat</td>
<td>Annually</td>
<td>Summer</td>
<td>ChE Faculty</td>
</tr>
</tbody>
</table>

4A.1.1. Student Work
The primary direct measure is a rubric-guided rating of selected student work. For each performance indicator, one or more courses in the ChE curriculum have been identified as primary assessment points. During semesters when assessment is scheduled to occur the faculty instructor of the course selects an assignment or portion of an assignment that is appropriate for evaluating the identified performance indicators. If multiple performance indicators are being evaluated in a course, the faculty member may need to use more than one assignment.

After students complete the assignment, the instructor uses a rubric as a guide to assign a rating of 1 (unsatisfactory), 2 (developing), 3 (meets expectations), or 4 (exceeds expectation) for each assignment. This assessment evaluation is separate and distinct from the normal
grading process used to assign course grades and is focused solely on ability to demonstrate the designated performance indicator(s). Due to the relatively small size of our classes, and to avoid statistical sampling errors, assessment is performed for all chemical engineering students in the class. Results of the faculty evaluation are reported on a “Student Outcomes Assessment (SOA) Form”. In 2012 faculty in a few courses began reporting SOA results separately for On-Campus and Online students. Since the 2013/14 academic year all SOA results are reported separately so that the performance of On-Campus and Online students enrolled in the same course can be compared directly.

Rubrics for rating student work have been developed for each of the performance indicators. Our rubrics were adapted from ones in use by Auburn, Benedictine College, Colorado State, Iowa State, Maine, Michigan State, North Carolina State, Rowan, Rose-Hulman, Michigan State, UND Essential Studies, and UND Geological Engineering. In all cases they have been customized to match our specific performance indicators.

**4A.1.2. Faculty comments**

Together with the rating of student work, faculty instructors also use the Student Outcomes Assessment form to submit summary comments on the performance of students. This allows the instructor to put numerical ratings in context, identifying specific areas of weakness or strength, and provide a richer picture of student learning.

Faculty instructors also complete a “Course Review Form” at the end of each course. This form is an opportunity for self-reflection on any changes made to course content or teaching methods, how they impacted student learning, and suggestions for improvements. These reflections provide additional assessment of student performance. By linking student learning outcomes and course delivery, they are an important tool for closing the loop, ensuring that course changes are made in response to assessment and evaluation data.

**4A.1.3. Senior Design Peer Assessments**

In addition to faculty assessments, each student is asked to complete a peer-assessment of each of the members of his or her plant design team at the end of the second semester senior design class. Students rate their team members on a scale of 1-5 (1=poor, 2=below average, 3=average, 4=above average, 5=excellent) for each of the a-m student learning outcomes. This is done on a voluntary basis, and returns are high but less than 100%. The information gathered provides another source of assessment of student learning outcomes from the students’ point of view.

**4A.1.4. Senior Exit Questionnaires**

A written questionnaire is administered by the College of Engineering and Mines to all senior students at the end of Spring semester. The exit questionnaire asks students to rate on a 1-5 scale (1=weak, 5=strong) the degree to which they think their education provided them with the ability to meet the student learning outcomes common to all engineering programs (a-k). The questionnaire also asks for assessment of the overall quality of courses, information on job placement, co-op participation, and overall quality of courses, faculty, and curriculum.

**4A.1.5. Senior Exit Interviews**

The department chair and associate chair conduct a group interview with graduating seniors at
the end of the Spring semester to complement the survey. Feedback gathered during the interview session is specific to chemical engineering and has proven to be an effective means of generating student suggestions for program improvements.

### 4A.1.6. Co-op Supervisor Assessments

The University’s Career Services Office sends an “Employer’s Evaluation” survey to all co-op supervisors, requesting them to evaluate the co-op student halfway through the assignment and at the end of the assignment. The student’s supervisor is asked to respond to 17 questions broken into four categories: skill, performance, judgment, and attitude. A 4-point scale is used (1=unsatisfactory, 2= needs improvement, 3=meets standards, 4=exceeds standards). As this is a university-wide instrument, the individual questions do not correspond directly to each of the Chemical Engineering student learning outcomes, but they do address many of them, and are a supplementary source of assessment data.

Additionally, at the end of the co-op assignment, supervisors are also given a “Chemical Engineering Co-op Program Assessment Form.” This form specifically asks about each of the student learning outcomes. On a 1-5 scale (1=strongly disagree, 5=strongly agree) they rate both the degree to which the student demonstrated proficiency and the degree to which these criteria are important to the company.

### 4A.1.7. External Advisory Committee Feedback

During our External Advisory Committee meetings we present the results of our program assessment, including data on student learning outcomes. Members of the committee are employers of our graduates, alumni of the program, or represent graduate programs where our students enroll. They have personal knowledge of the skills and abilities that graduates of our program possess. We gather feedback from the committee members regarding our current student learning data and their experiences with graduates of our program.

### 4A.1.8. Informal Student Feedback

Students and faculty in the Chemical Engineering program have frequent interactions outside of class where students often comment on what they are, and are not, learning. These interactions include required course registration advising sessions, AIChE meetings and trips, and down time in the student lounge. Faculty take advantage of these opportunities to solicit additional feedback from students. While a very indirect measure, such informal student feedback is valuable for putting other assessment data into context and in understanding how best to structure program improvements.

### 4A.1.9. Other Data

A variety of other data that reflect student learning, but that are only available for a small number or students, is also reviewed as part of our assessment process. Since it is not representative of our overall student population, this data is not used as a primary assessment measure. It is not actively collected, but when it is provided to our department by other groups we do retain the information for discussion at our annual assessment retreats. This data includes: Fundamentals of Engineering (FE) exam results, student responses to questions regarding UND Essential Studies goals on end of course evaluation surveys, summaries of student performance in math and chemistry courses, employer comments, etc.
4A.2. Timing of Data Collection and Evaluation
Student work from selected classes is evaluated with rubrics according to the schedule presented in Table 4-2. Assessments needed for ABET accreditation are conducted annually, those used for UND Essential Studies assessment are conducted biannually, and any data collected for one are also used for the other. Several Chemical Engineering courses also satisfy Essential Studies requirements in the areas of Social Sciences (SS), Capstone (C), Advanced Communication (A), Quantitative Reasoning (Q), and Oral Communication (O). Most chemical engineering courses are taught once a year, such that annual data collection captures all students taking a class in a given year, and biannual collection captures a sample of approximately half of all students going through the program. As shown in Table 4-2 annual evaluations are conducted for Primary ABET Assessments (denoted PA) and associated UND Essential Studies assessments for oral communications (oc), written communication (wc), and quantitative reasoning (qr). A second primary assessment point is used where possible to provide a more robust measure of student performance, minimize instructor rating bias, and capture different aspects of a given Performance Indicator (e.g., applying math concepts to process dynamics and to laboratory data analysis). Additionally, UND Essential Studies assessments for critical thinking (ct) and quantitative reasoning (qr) are used as secondary ABET assessments (sA) and are conducted every other year.

These ABET and ES assessments are planned for courses in the junior and senior years to measure skills and abilities that students have acquired by the end of the program. Additional supplemental intermediate assessments (denoted by * symbol) are scheduled biannually in courses throughout the sophomore and junior years to provide formative assessment data. These data can be used to help interpret the summative ABET and ES data, but students at these levels are not yet expected to have achieved full mastery in the a-m learning outcomes.
<table>
<thead>
<tr>
<th>Course</th>
<th>Apply science, math, eng</th>
<th>Design &amp; analyze experiments, &amp; data</th>
<th>Design system</th>
<th>Diverse teams</th>
<th>ID, formulate, solve eng. problems</th>
<th>Prof. &amp; ethical responsibility</th>
<th>Communicate</th>
<th>Broad educ, impact of engineering</th>
<th>Lifelong learning</th>
<th>Contemporary issues relevant to ChE</th>
<th>Techniques, skills, modern engin. tools</th>
<th>Economics in engin.</th>
<th>Chemistry &amp; ChE topics</th>
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<tbody>
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<td>102 Intro to ChE</td>
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<td>201 ChE Fundamentals</td>
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<td>206 Unit Operations</td>
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<td>232 ChE Lab I</td>
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<td>315 Statistics &amp; Numerical Methods</td>
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<td>331 ChE Lab II</td>
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<td>340 Professional Integrity in Engineering (ES SS)</td>
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<td>408 Process Dynamics &amp; Control</td>
<td>PA</td>
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<tr>
<td>411 Plant Design I (ES C+A)</td>
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<td>sA</td>
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<td>431 ChE Lab IV (ES Q)</td>
<td>PA</td>
<td>PA</td>
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<tr>
<td>412 Plant Design II (ES O)</td>
<td>PA</td>
<td>PA</td>
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</tr>
</tbody>
</table>

PA = primary Direct Assessment for ABET (annual)
sA = secondary Direct Assessment for ABET (biannual)
*
# = specific performance indicator to be assessed
oc = Oral Communications for ES (annual)
c = Capstone
ct = Critical Thinking for ES (biannual)
w = Written Communication for ES (biannual)
qr = Quantitative Reasoning for ES (annual/biannual)

ES = UND Essential Studies
SS = Social Science
C = Capstone
A = Advanced Communication
Q = Quantitative Reasoning
O = Oral Communication
Faculty comments on Student Outcomes Assessment and Course Review forms are collected at the end of each semester. Senior student peer assessments and senior exit interviews are done at the end of the spring semester each year. The College senior exit questionnaire is also given out near the end of the spring semester for all students planning to graduate during that calendar year. Co-op supervisor assessments are collected at the end of a student’s co-op assignment, which may occur in May, August, or December.

Feedback from the External Advisory Committee is collected biannually during the IAC meeting which is typically held in August of odd years. Informal student feedback is received on a nearly continuous basis and is compiled during the annual assessment retreat.

The department assessment coordinator collects assessment data gathered throughout the year and compiles it for analysis by the faculty during their annual assessment retreat, which is held each summer. These 2–3 day sessions are attended by all faculty members in the department and are used to explore all aspects of the program. The agenda for the assessment retreat is structured to allow time to review the assessment process and recommend changes. Assessment data are reviewed to determine how well our students are achieving the student learning outcomes and then corrective actions are recommended for those areas where a concern is noted. The group also reviews each course on an individual basis to determine how it is meeting the overall objectives of the department. The departmental strategic plan is also reviewed annually. Feedback from these activities is used to continually improve the program. Major changes to the program are brought before the External Advisory Committee for feedback before implementation. At the following year’s assessment retreat the status of incorporating these improvements is reviewed and progress in improving student learning is evaluated.

4A.3. Expected Level of Attainment
The chemical engineering faculty has set the following goals that define the expected level of attainment of the Student Learning Outcomes for the various assessment measures.

On each rubric-guided Performance Indicator
- >=80% of students should have scores of 3 (meets expectations) or 4 (exceeds expectations)
- The average student score should be >=3.0

On indirect measures of Student Learning Outcomes with numerical ratings (Peer Evaluations from Senior Design Capstone, Senior Exit Surveys, Co-op Employer Surveys)
- Average student score on each outcome should be >=3.5 (where all listed forms use a 1-5 scale)

On indirect measures of Student Learning Outcomes without numerical ratings (Faculty Course Review comments, Senior Exit Questionnaire comments, Senior Exit Interviews, Co-op Supervisor Surveys, IAC Feedback, Informal student feedback)
- No major areas of concern consistently identified

If any of these goals are not met, then the program faculty develops a plan for correcting the deficiency.
4A.5. Documentation of Results

Collected assessment data and results are maintained by the department assessment coordinator. Student Outcome Assessment rating results are kept in a Microsoft Access database searchable by performance indicator, course, year, student type (on campus or DEDP), etc. It is updated each semester after faculty members submit their ratings. Numerical data from senior design peer assessments, senior exit questionnaires, co-op supervisor assessments, etc. are saved in spreadsheets for easy tabulation. They are updated annually. Faculty comments from SOA forms and Course Review Forms are recorded in a Word document organized by course. After each semester when faculty submit these reflections, they are appended to the course discussion to provide a running description of how student performance and the course itself evolves over time. Other narrative data, including notes from senior exit interviews, advisory committee meetings, written comments on surveys, are recorded in separate Word documents. Minutes and action items from weekly faculty meetings and the summer assessment retreat are kept on a sharepoint server.

These raw assessment data are used to prepare various assessment reports, including the ABET Self-Study, annual UND Department Assessment of Student Learning, and UND Essential Studies Program course revalidation. Each of these are also stored online for future reference. And while these reports are important external products, our assessment process and data collection efforts are primarily designed for use internally within the department to guide program improvement.
4C. **Assessment Instruments**

Examples of each of the following assessment instruments are included in the following pages:

- Student Learning Outcome/Performance Indicator Rubrics
- Student Outcomes Assessment (SOA) Form
- Course Review Form
**ABET Outcome A:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to apply knowledge of mathematics, science, and engineering. The corresponding performance indicators are:

1. Students will correctly apply and use mathematics and physics concepts (such as basic integrals, differential equations, statistical measures, mechanics) in solving engineering problems
2. Students will correctly apply and use chemistry concepts (such as chemical reactions and thermodynamics) in solving engineering problems
3. Students will correctly apply and use fundamental engineering concepts (such as material and energy balances; heat, mass, and momentum transfer; vapor-liquid equilibrium) in solving engineering problems

**UND ES Goal #1 Think and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Special Emphasis Area – Quantitative Reasoning**

ES quantitative reasoning courses address the following elements; **confidence with mathematics:** interpreting data; making decisions; mathematics in academic and practical contexts; number sense

---

**Rubric for ABET Outcome A**

<table>
<thead>
<tr>
<th>A1. Apply math &amp; physics concepts</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-QR-1. Confidence with mathematics</td>
<td>Is consistently able to apply and solve basic integrals, differential equations, statistical measures, mechanics as part of engineering problems.</td>
<td>Is able to apply and solve math and physics equations as part of engineering problems.</td>
<td>Is often able to apply and solve math and physics equations as part of engineering problems.</td>
<td>Struggles in applying and solving math and physics equations as part of engineering problems.</td>
</tr>
<tr>
<td></td>
<td>Is able to apply concepts and approaches to unfamiliar problems.</td>
<td>Is sometimes unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is often unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is unable to apply concepts and approaches to unfamiliar problems</td>
</tr>
<tr>
<td></td>
<td>Is comfortable and adept with quantitative ideas and methods</td>
<td>Is comfortable with quantitative ideas and methods</td>
<td>Uses quantitative analysis but may be uncomfortable doing so</td>
<td>Shows signs of reluctance to use quantitative analysis.</td>
</tr>
<tr>
<td></td>
<td>Rarely makes errors</td>
<td>Sometimes makes minor errors.</td>
<td>Often makes minor errors.</td>
<td>Frequently makes errors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A2. Apply chemistry concepts</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is consistently able to apply chemistry concepts (such as chemical reactions and thermodynamics) to engineering problems.</td>
<td>Is able to apply chemistry concepts to engineering problems.</td>
<td>Is often able to apply chemistry concepts to engineering problems.</td>
<td>Struggles in applying chemistry concepts to engineering problems.</td>
<td></td>
</tr>
<tr>
<td>Is able to apply concepts and approaches to unfamiliar problems.</td>
<td>Is sometimes unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is often unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is unable to apply concepts and approaches to unfamiliar problems</td>
<td></td>
</tr>
<tr>
<td>Rarely makes errors or shows misconceptions</td>
<td>Sometimes makes minor errors and shows some misconceptions</td>
<td>Often makes minor errors and shows misconceptions.</td>
<td>Frequently makes errors and shows misconceptions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A3. Apply fundamental engineering concepts</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is consistently able to apply fundamental engineering concepts (such as material and energy balances, transport, vapor-liquid equilibrium) to engineering problems.</td>
<td>Is able to apply fundamental engineering concepts to engineering problems.</td>
<td>Is often able to apply fundamental engineering concepts to engineering problems.</td>
<td>Struggles in applying fundamental engineering concepts to engineering problems.</td>
<td></td>
</tr>
<tr>
<td>Is able to apply concepts and approaches to unfamiliar problems.</td>
<td>Is sometimes unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is often unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is unable to apply concepts and approaches to unfamiliar problems</td>
<td></td>
</tr>
<tr>
<td>Rarely makes errors or shows misconceptions</td>
<td>Sometimes makes minor errors and shows some misconceptions.</td>
<td>Often makes minor errors and shows misconceptions.</td>
<td>Frequently makes errors and shows misconceptions</td>
<td></td>
</tr>
</tbody>
</table>

(Rubric items adapted from Rose-Hulman PO1 Rubric, UND ES Rubric for Quantitative Reasoning)
ABET Outcome B: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design and conduct experiments, as well as to analyze and interpret data. The corresponding performance indicators are:

1. Students will formulate a well-designed experimental plan to obtain a desired objective.
2. Students will demonstrate appropriate laboratory techniques regarding safety, instrument operation, and record keeping.
3. Students will correctly and concisely analyze and interpret experimental data.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. Special Emphasis Area – Quantitative Reasoning

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; mathematics in academic and practical contexts; number sense

Rubric for ABET Outcome B

<table>
<thead>
<tr>
<th>B1. Formulate well-designed experimental plan</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearly defines the objectives of the experiment and relevant variables</td>
<td>Is able to fully define experimental objectives and necessary variables with minimal guidance</td>
<td>Is able to define objectives and variables with more direct guidance</td>
<td>Experimental design targets most important variables, but some relevant parameters are not investigated or extraneous data is collected</td>
<td>Has difficulty identifying objectives and/or related variables.</td>
</tr>
<tr>
<td>Develops an experimental design that effectively uses limited resources to collect all needed data</td>
<td>Experimental design collects all needed data, but not as efficiently</td>
<td>Experimental design is poorly organized, failing to measure important variables</td>
<td>Cannot select appropriate equipment and instruments without direct guidance</td>
<td></td>
</tr>
<tr>
<td>Selects appropriate equipment and instruments to obtain the desired information</td>
<td>Selects appropriate equipment and instruments with minimal guidance</td>
<td>Selects appropriate equipment and instruments with moderate guidance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B2. Demonstrate appropriate laboratory techniques</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistently and thoroughly observes good laboratory safety practices</td>
<td>Observes laboratory safety practices, but not as carefully</td>
<td>Occasionally displays unsafe practices, but is aware of proper procedures</td>
<td>Frequently behaves unsafely and is unaware of proper procedures</td>
<td></td>
</tr>
<tr>
<td>Skillfully and confidently operates equipment and instruments</td>
<td>Operates equipment and instruments correctly, but with less skill or confidence</td>
<td>Occasionally operates equipment and instruments incorrectly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thoroughly and clearly documents experimental procedures and data</td>
<td>Documents experimental procedures and data, but not as clearly</td>
<td>Incompletely documents experimental procedures and data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B3. Analyze and interpret experimental data</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses appropriate theory to correctly calculate and analyze results from experimental data.</td>
<td>Uses appropriate theory to calculate and analyze results from experimental data with only minor errors</td>
<td>Calculates results without fully understanding theory, some errors may be present, analysis is limited</td>
<td>Calculates results and analysis include major errors or omissions</td>
<td></td>
</tr>
<tr>
<td>Performs correct and detailed error analysis</td>
<td>Performs error analysis with minimal errors</td>
<td>Attempts to address errors, but does so incompletely or incorrectly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interprets results carefully and applies findings to experimental objectives</td>
<td>Adequate interpretation of results, may include some irrelevant information</td>
<td>Limited interpretation of experimental results, some errors present, does not apply findings to experimental objectives</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Rubric items adapted from Rose-Hulman PO3 Rubric, MSU B Rubric, Rowan Goal 1, Obj 2, Outcome A and Outcome 2 Rubrics, UND ES Rubric for Quantitative Reasoning)
ABET Outcome C: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The corresponding performance indicators are:

1. Students will identify the relevant concepts, issues, and information needed to define a design problem.
2. Students will design a system of unit operations and components to transform raw materials into desired products.
3. Students will consider process safety and other realistic constraints when designing a component, process, or system.
4. Students will evaluate design alternatives to develop an optimum system.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking**

ES critical thinking courses address the following elements: **knowledge and comprehension, analysis and synthesis, evaluation and conclusions**

### Rubric for ABET Outcome C

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1. Identify relevant concepts, issues, and information</td>
<td>Fully comprehends the design problem. Consistently applies chemical engineering principles to design an effective process.</td>
<td>Comprehends fundamental aspects of the design problem, but not as fully. Applies chemical engineering principles with only minor conceptual errors.</td>
<td>Partially comprehends the design problem. Requires assistance to apply chemical engineering principles; some conceptual errors evident.</td>
<td>Fails to comprehend essential elements of the design problem. Has difficulty applying chemical engineering principles to design, even with assistance.</td>
</tr>
<tr>
<td>ES-CT-1. Knowledge and Comprehension</td>
<td>Selects and designs a carefully integrated set of unit operations and components. Designs a highly efficient process that meets the desired goals.</td>
<td>Selects and designs a set of unit operations and components, but with incomplete integration. Process successfully achieves desired goals and is reasonably efficient, with only minor errors.</td>
<td>Has difficulty in selecting and designing individual unit operations and components, or in combining them into an overall system. Process design contains errors or is highly inefficient.</td>
<td>Has difficulty both in selecting and designing individual unit operations and components, and in combining them into an overall system. Process will not achieve desired goals and contains major errors.</td>
</tr>
<tr>
<td>C2. Design system from unit operations</td>
<td>Safety, environmental, ethical, economic, and other constraints are fully considered and integrated into the design.</td>
<td>Safety, environmental, ethical, economic, and other constraints are considered but not fully integrated into design.</td>
<td>Only partial consideration of safety, environmental, ethical, economic, and other constraints.</td>
<td>Minimal or no consideration of safety, environmental, ethical, economic, and other constraints.</td>
</tr>
<tr>
<td>ES-CT-2. Analysis &amp; Synthesis</td>
<td>Develops several potential solutions and finds optimum. Evaluation of design alternatives is correct, thorough, and well supported.</td>
<td>Develops multiple solutions, but neglects key factors in optimization. Evaluation of design alternatives is correct, but not as thorough or well supported.</td>
<td>Can develop multiple solutions, but neglects key factors, and has difficulty identifying optimum. Evaluation of design alternatives is incomplete and/or incorrect.</td>
<td>Only develops a single solution; no optimization attempted. Evaluation of system design is minimal or absent.</td>
</tr>
<tr>
<td>C4. Evaluate &amp; Optimize</td>
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<tr>
<td>ES-CT-3. Evaluation &amp; Conclusions</td>
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(Rubric items adapted from Rose-Hulman PO4 Rubric, Rowan Goal 2 Objective 1 Rubrics, MSU C Rubric, UND ES Critical Thinking Rubric)
**ABET Outcome D:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to function on multidisciplinary and/or diverse teams. The corresponding performance indicators are:

1. Student teams will establish and follow project management goals
2. Student teams will integrate individual contributions into a cohesive high quality product
3. Student teams will maintain an inclusive, respectful climate.
4. Students will demonstrate leadership and the ability to fill different team roles.

**Rubric for ABET Outcome D**

<table>
<thead>
<tr>
<th>Rubric Items</th>
<th>4 - Exceeds expectations</th>
<th>3 - Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1. Establish and follow project management goals</td>
<td>Realistic and measurable goals are defined, prioritized, and documented. Schedules are generally followed. Team easily makes adjustments to plans as needed. Work is completed on time. Team roles are defined and understood by all. Team members perform all assigned duties and help with others.</td>
<td>Goals are defined, but not as specifically. Team often gets behind schedule and has to play catch up. Makes adjustments, but not as easily or promptly. Work is completed on time. Roles are defined, but not fully understood by all. Members perform nearly all duties of assigned role.</td>
<td>Goals are not fully defined and may not be realistic or prioritized appropriately. Has difficulty staying on schedule. Not always able to make adjustments. Work completed, but not on time. Roles are defined informally and are not well understood. Members perform only some of assigned duties.</td>
<td>Clear goals are not defined or documented. Unable to make or follow a schedule. Unaware or unwilling to make adjustments. Fails to complete work. Roles not defined or not used. Members do not perform assigned duties.</td>
</tr>
<tr>
<td>D2. Integrates contributions into high quality product</td>
<td>Individual work integrated into a cohesive final product. High degree of synergy attained. Feedback from in and out of group successfully incorporated into revisions.</td>
<td>Individual work integrated, but not as cohesively. Clear synergy from working as a team. Feedback incorporated into revisions.</td>
<td>Individual work not fully integrated. Moderate synergy from working as a team. Feedback sometimes not incorporated into revisions.</td>
<td>Minimal integration. Individual work contributes conflict with each other. Minimal or no synergy. Feedback rarely incorporated into revisions.</td>
</tr>
<tr>
<td>D3. Maintains inclusive, respectful climate</td>
<td>All team members listen, encourage participation, and are courteous and respectful to each other. Team works together and makes collective decisions after considering alternate views. Conflicts resolved effectively.</td>
<td>Team members are respectful, but do not actively encourage each other. All members are involved in decision making, but not as fully. One or more members may dominate. Conflicts resolved, but not as effectively</td>
<td>Team members not intentionally disrespectful. Members occasionally blame or criticize each other. Not all members involved in decision making. Conflicts defused, but not fully resolved.</td>
<td>Team members are competitive and argumentative with each other. Members work individually, making decisions without considering other views. Ongoing unresolved conflicts</td>
</tr>
<tr>
<td>D4. Leadership and team roles</td>
<td>Team members will effectively fill the various roles in a team: leader, scribe, participant, scribe, and questioner. Team roles are defined and understood by all. Members easily change roles for different aspects of the assignment as needed for the good of the team. The team demonstrates both individual and collective leadership.</td>
<td>Team members understand team roles and are partially effective in working together in these roles. Role rotation is limited. The team members demonstrate some collective leadership and some individual leadership, but do not fully use team synergy effectively.</td>
<td>Team members do not entirely understand roles and how to use them to work together. One or two individuals dominate the team rather than using team synergy effectively.</td>
<td>Team members do not understand the roles of a team. Team members do not work together, do not establish roles or demonstrate individual or collective leadership.</td>
</tr>
</tbody>
</table>

*(Rubric items adapted from: Auburn EE PO7 Rubric, CSU EE Team Effectiveness Rubric, Iowa State Teamwork Rubric, MSU D Rubric, NC State Team Rubric)*
**ABET Outcome E:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to identify, formulate, and solve engineering problems. The corresponding performance indicators are:

1. Students will identify relevant concepts, equations, and data needed to define a problem.
2. Students will formulate appropriate solution strategies.
3. Students will properly execute a solution strategy to arrive at a correct solution.
4. Students will reflect on the reasonableness of their problem solutions.

**UND ES Goal #1 Think and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking; Special Emphasis Area - Quantitative Reasoning**

ES critical thinking courses address the following elements: knowledge and comprehension, analysis and synthesis, evaluation and conclusions.

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; mathematics in academic and practical contexts; number sense.

### Rubric for ABET Outcome E

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Is consistently able to identify relevant concepts, equations, and data, and distinguish extraneous information.</td>
<td>Creatively combines and integrates diverse concepts to formulate an efficient solution strategy.</td>
<td>Consistently implements solution strategy correctly and gets correct answers.</td>
<td>Applies engineering judgment to carefully check solution for reasonableness. Recognizes implausible answers and is able to correct them</td>
</tr>
<tr>
<td>Consistently able to define unfamiliar problems</td>
<td>Competently identifies and applies optimal mathematical or numerical tools to solve problems.</td>
<td>Implements solution strategy correctly, with occasional minor errors.</td>
<td>Checks solution for reasonableness, but not as carefully. Occasionally may not recognize implausible answers.</td>
</tr>
<tr>
<td>Fully comprehends the question, problem, or issue to be addressed.</td>
<td>Makes connections between concepts and formulates workable strategy, but they may not be optimal and may rely on brute force.</td>
<td>Has difficulty solving problems, and produces frequent errors.</td>
<td>Has difficulty checking solution. Often does not recognize implausible answers, or is unable to correct them.</td>
</tr>
<tr>
<td>Is able to identify relevant concepts, equations, and data, but with some extraneous information.</td>
<td>Identifies appropriate mathematical and numerical tools.</td>
<td>Has some difficulty solving problems, and produces frequent errors.</td>
<td></td>
</tr>
<tr>
<td>Is sometimes unable to define unfamiliar problems.</td>
<td>Comprehends elements of the question, problem, or issue to be addressed</td>
<td>Unable to make connections and formulate coherent strategy for solving problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comprehends the main points of the question, problem, or issue to be addressed</td>
<td>Unable to identify or apply appropriate mathematical or numerical tools.</td>
<td></td>
</tr>
<tr>
<td>Struggles to identify relevant information</td>
<td>Unable to define unfamiliar problems without direct instruction</td>
<td>Fails to comprehend basic elements of the question, problem, or issue to be addressed</td>
<td></td>
</tr>
</tbody>
</table>

(Rubric items adapted from Rose-Hulman PO2 Rubric, Rowan Goal 1 Objective 1 Rubric, MSU E Rubric, UND ES Rubrics for Quantitative Reasoning and Critical Thinking)
ABET Outcome F: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of professional and ethical responsibility. The corresponding performance indicators are:
1. Students will demonstrate knowledge of engineering ethics codes.
2. Students will be able to apply reasoning strategies from the theories and principals of ethics to identify and resolve ethical dilemmas.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking**

ES critical thinking courses address the following elements: **knowledge and comprehension, analysis and synthesis, evaluation and conclusions**

<table>
<thead>
<tr>
<th>Rubric for ABET Outcome F</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1. Knowledge of ethical principles and obligation of engineers</td>
<td>Correctly identifies all of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Correctly identifies the most of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Correctly identifies the some of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Does not identify any ethical principles; shows lack of awareness of ethical principles.</td>
</tr>
<tr>
<td></td>
<td>Correctly identifies objective and subjective aspects of ethics.</td>
<td>Demonstrates a nearly complete understanding of objective and subjective aspects.</td>
<td>Understands the two aspects exist, but is not able to identify them clearly.</td>
<td>Does not appear to know the objective and subjective aspects of ethics.</td>
</tr>
<tr>
<td></td>
<td>Fully recognizes the obligation of engineers to act ethically.</td>
<td>Shows awareness of engineers’ duty to act ethically, but does not recognize some aspects of the obligation.</td>
<td>Shows only a vague notion of the obligation of engineers to act ethically.</td>
<td>Does not recognize the obligation of engineers to act ethically.</td>
</tr>
<tr>
<td></td>
<td>Can explain all the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain most of the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain only some of the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain only a few of the goals and obligations of the AIChE Code of Ethics</td>
</tr>
<tr>
<td>F2. Apply principles to resolve ethical problems</td>
<td>Can consistently identify the ethical dilemmas present in a hypothetical situation</td>
<td>Can identify the ethical dilemmas present</td>
<td>Can usually recognize ethical dilemmas when present</td>
<td>Does not recognize ethical dilemmas without outside guidance</td>
</tr>
<tr>
<td>ES-CT-1. Knowledge and Comprehension</td>
<td>Can explain how ethics principles and theories apply to the situation</td>
<td>Can define some ethics principles and theories that apply to the situation</td>
<td>Has difficulty defining relevant ethics principles</td>
<td>Unable to explain how ethics principles apply</td>
</tr>
<tr>
<td>ES-CT-2. Analysis &amp; Synthesis</td>
<td>Can suggest a resolution to the dilemma that fully incorporates ethical principles</td>
<td>Can suggest a resolution that incorporates some ethical principles</td>
<td>Can suggest a resolution, but does so without clearly basing it on ethical theories and principles.</td>
<td>Cannot formulate a resolution, or suggests a resolution that obviously violates ethical principles</td>
</tr>
<tr>
<td>ES-CT-3. Evaluation &amp; Conclusions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Rubric items adapted from UND-GEOE and Benedictine College rubrics*
ABET Outcome G: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to communicate effectively in both oral and written formats. The corresponding performance indicators are:

1. Students will exhibit a clear sense of purpose in their written and oral communication
2. Students will accurately synthesize, analyze, and evaluate technical information
3. Students will present communication that is well organized, providing guidance for readers and listeners.
4. Students will express themselves clearly and follow appropriate conventions of format, writing, and speech.
5. Students will answer questions and revise writing in response to listener and reader feedback.

UND ES Goal #2 Communication: You should be able to write and speak in civic, academic, and professional settings with a sense of purpose and audience.

- ES communication courses are designed to encourage the development of the following skills:
  - awareness of purpose and the construction of argument; awareness of audience; the ability to analyze, synthesize, and incorporate outside sources and the ideas of others; using the conventions associated with citing sources and communicating clearly in various disciplines.

### Rubric for Oral and Written Communication

<table>
<thead>
<tr>
<th></th>
<th>1 - Unsatisfactory</th>
<th>2 - Developing</th>
<th>3 – Meets expectations</th>
<th>4 – Exceeds expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G1. Sense of Purpose</strong></td>
<td>Document or presentation seems disjointed or incoherent.</td>
<td>Lack of focus causes the document or presentation to rely more on summary than on analysis.</td>
<td>While there may be a sense of purpose that holds the document or presentation together, it is often very broad.</td>
<td>There is a controlling idea that holds the document or presentation together.</td>
</tr>
<tr>
<td></td>
<td>Relationship between different sections is unclear or relationship comes only from “stream of consciousness” or tangential connections between ideas.</td>
<td>Author in this category may discover a sense of purpose as they prepare document or presentation, but they haven’t revised the entire communication to reflect this new focus.</td>
<td>The various parts of the document or presentation fit with the author’s sense of project. The author has a reason for communicating</td>
<td>The author is sophisticated in his/her ability to signal purpose to audience.</td>
</tr>
<tr>
<td></td>
<td>Author may seem to be engaged in many different projects at once.</td>
<td>The author has a clear vision of his/her own purpose.</td>
<td>The ideas of others are clearly marked as such.</td>
<td>The various sections of the document or presentation make sense together and the author has indicated the larger implications or importance of the topic.</td>
</tr>
</tbody>
</table>

<p>| <strong>G2. Synthesis, Analysis, and Evaluation</strong> | Credible sources and the ideas of others may be included in the document or presentation, yet the author has trouble controlling the integration of those ideas into the paper in a manner that supports his/her own purpose. The ideas of others may not always be clearly marked as such. | Communication in this category may slip into a presentation of information; only some analysis or evaluation is offered. | Credible sources and the ideas of others are brought into the document or presentation in a manner that generally supports the author’s own purpose. The ideas of others are marked as such. | Credible sources and the ideas of others are integrated into the document or presentation in a manner that supports the author’s own purpose. |
|                  | Communication in this category shows very little evidence of analysis or evaluation. | Makes some errors in interpreting data and error analysis. Misses connections. | Communication in this category does not merely “present” what others have said; instead, the writer offers some analysis or evaluation of those ideas. | Provides insightful conclusions supported by evidence and discusses implications and application. |
|                  | Makes major errors in data interpretation. Does not account for error and uncertainty. | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides insightful conclusions supported by evidence and discusses implications and application. |
|                  | Does not provide any evidence supporting conclusions. Does not discuss implications and applications. | Provides conclusions supported by evidence and some discussion of implications and application | Provides conclusions supported by evidence and some discussion of implications and application | Provides insightful conclusions supported by evidence and discusses implications and application. |
|                  | Provides conclusions supported by evidence and some discussion of implications and application | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides insightful conclusions supported by evidence and discusses implications and application. |
|                  | Communication in this category shows very little evidence of analysis or evaluation. | Makes some errors in interpreting data and error analysis. Misses connections. | Credible sources and the ideas of others are brought into the document or presentation in a manner that generally supports the author’s own purpose. The ideas of others are marked as such. | Credible sources and the ideas of others are integrated into the document or presentation in a manner that supports the author’s own purpose. |
|                  | Makes major errors in data interpretation. Does not account for error and uncertainty. | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty | Provides insightful conclusions supported by evidence and discusses implications and application. |
|                  | Does not provide any evidence supporting conclusions. Does not discuss implications and applications. | Provides conclusions supported by evidence and some discussion of implications and application | Provides conclusions supported by evidence and some discussion of implications and application | Provides insightful conclusions supported by evidence and discusses implications and application. |</p>
<table>
<thead>
<tr>
<th>Rubric item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G3. Guidance for Audience</td>
<td>The author demonstrates a sophisticated awareness of his/her audience. Document or presentation flows smoothly from one idea to another. The author has taken pains to assist the audience in following the logic of the ideas expressed. The author has taken pains to explain and develop his/her ideas.</td>
</tr>
<tr>
<td>G4. Clarity and Conventions</td>
<td>Clarity of ideas is enhanced by careful expression through the author’s use of effective written, verbal, and/or non-verbal delivery. Author seems to be in command of conventions for specific style of communication and uses them to rhetorical advantage. Visual presentation of work, physical delivery, formatting and/or documentation is polished.</td>
</tr>
<tr>
<td>G5. Listen and Respond to Feedback</td>
<td>Listens carefully and responds to all questions and comments directly, clearly, and respectfully. Answers with explanations and elaboration Effectively incorporates comments and suggestions from previous drafts or presentations.</td>
</tr>
</tbody>
</table>

Relevance of the topic to specific audience not as clear. At times, audience may feel lost and unable to follow the author’s train of thought. Author needs to improve sequencing of ideas within the document or presentation and do more to explain the connections between sections. Communication may include examples and illustrations but often lacks explanations of the relevance of those examples; or may include explanations without the examples or illustrations the audience needs to fully understand. |

Communication has not been adapted to interests and backgrounds of audience. The lack of connections between ideas makes following and understanding document or presentation difficult. The lack of examples, illustrations, and explanation makes understanding difficult. |

Clarity and structure, verbal and non-verbal delivery get in the way of clear communication. Author’s inconsistent use of conventions related to the specific communication style is distracting to the audience and interrupts comprehension. Visual presentation of work, physical delivery, formatting and/or documentation is inconsistent and interrupts understanding Document or presentation does not appear completely finished, requiring additional revision and/or rehearsal |

Audience must occasionally guess at author’s meaning. Author’s control of conventions of the specific communication style is uncertain enough to impede comprehension. Visual presentation of work, physical delivery, formatting and/or documentation is inappropriate and impedes understanding. Revision and/or rehearsal appear delinquently absent |

Listens and answers questions, but not as directly or clearly Fails to elaborate when answering questions. Incorporates comments and suggestions from previous drafts or presentations, but not as effectively. |

Sometimes misunderstands questions. Gives lengthy or incomplete answers. Does not directly answer questions. Has some trouble answering questions. Does not address or incorrectly responds to some comments and suggestions from previous drafts or presentations. |

Does not listen carefully to questions. Starts responding before questions finished. Gives evasive or incomplete answers Cannot answer questions about subject. Makes minimal or no revisions in response to comments and suggestions from previous drafts or presentations. |

[Rubric items adapted from UND ES Rubrics for Written Communication and Oral Communication, MSU G1 Rubric, Maine Oral Presentation Rubric, UND ChE Graduate Seminar Evaluation Rubric]
**ABET Outcome H:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. The corresponding performance indicator is:

1. Students will demonstrate an awareness of how chemical engineering solutions impact economic, environmental, and societal aspects of the local and global community.

**UND ES Goal #1 Think and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking**

ES critical thinking courses address the following elements: knowledge and comprehension, analysis and synthesis, evaluation and conclusions

---

**Rubric for ABET Outcome H**

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1.</td>
<td>Shows deep understanding of immediate and long term issues involving the solution</td>
<td>Good understanding of the widespread effects of the solution, but with somewhat limited perspective about long term factors</td>
<td>Some awareness of the more extended effects of the solution</td>
<td>Little or no understanding of (or interest in) the wider impacts of the solution</td>
</tr>
<tr>
<td>ES-CT-1. Knowledge and Comprehension</td>
<td>Considers and understands impact on users and nonusers locally and globally</td>
<td>Considers and understands impact on some, but not all, users and nonusers</td>
<td>Partially considers and understands impact on users and nonusers</td>
<td>Seems to have only considered impact on immediate users</td>
</tr>
<tr>
<td>ES-CT-2. Analysis &amp; Synthesis</td>
<td>Thoroughly considers economic, environmental, and societal factors</td>
<td>Good understanding of the general economic, environmental, and societal factors related to the solution</td>
<td>Moderate understanding of the general factors related to the solution</td>
<td>Little or no attention given to economic, environmental, and societal factors</td>
</tr>
<tr>
<td>ES-CT-3. Evaluation &amp; Conclusions</td>
<td>Shows deep understanding of critical thinking skills and their application in various situations</td>
<td>Good understanding of the widespread effects of critical thinking skills and their application in various situations</td>
<td>Some awareness of the more extended effects of critical thinking skills and their application in various situations</td>
<td>Little or no understanding of (or interest in) the wider impacts of critical thinking skills and their application in various situations</td>
</tr>
</tbody>
</table>

*Rubric items adapted from UND-GEOE Rubric*
**ABET Outcome I:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a recognition of the need for and an ability to engage in lifelong learning. The corresponding performance indicators are:

1. Students will identify what needs to be learned and how to learn it.
2. Students will learn independently and apply that knowledge.

**Rubric for ABET Outcome I**

<table>
<thead>
<tr>
<th>I1. Identify what needs to be learned</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students able to identify what they still need to know. Can identify multiple reliable methods for obtaining that information.</td>
<td>Can identify what they do and don’t know. Able to identify a method for obtaining needed information.</td>
<td>Recognizes what they do know and the need to learn more. Has difficulty identifying what still needs to be learned and methods for learning it.</td>
<td>Does not recognize need to learn more. Expects that all needed information and skills will be provided.</td>
<td></td>
</tr>
<tr>
<td>Takes initiative in finding and learning material from outside sources. Appropriately incorporates into assignments a significant amount of material from reliable outside sources.</td>
<td>Can find and learn material from outside sources without assistance. Incorporates into assignments material from outside sources</td>
<td>Can find and learn material from outside sources with some guidance. Has some difficulty incorporating outside material, especially when in a different format from that taught in class</td>
<td>Unable to find and learn new material without detailed guidance. Unable to incorporate material outside of what is explained in class</td>
<td></td>
</tr>
</tbody>
</table>

(Rubric items adapted from: RoseHulman PO10 Rubric, MSU I Rubric, WSU Skill 3i Rubric)
**ABET Outcome J:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a knowledge of contemporary issues of relevance to the field of chemical engineering. The corresponding performance indicator is:

1. Students will be able to identify and discuss current trends and social concerns at local, national, and global levels relevant to the chemical engineering field (such as sustainability, globalization, local and global economics, political policy).

**Rubric for ABET Outcome J**

<table>
<thead>
<tr>
<th>J1. Identify and discuss current issues</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully aware of and able to discuss in-depth major issues facing local, national, and global society (e.g., sustainability, globalization, economics, politics)</td>
<td>Aware of and has a good understanding of current issues facing society</td>
<td>Some awareness of contemporary issues, but with only a moderate understanding</td>
<td>Can explain how some issues are relevant to chemical engineering, but only at a superficial level</td>
<td>Little or no awareness or understanding of contemporary issues</td>
</tr>
<tr>
<td>Clearly explain how issues are relevant to chemical engineering</td>
<td>Explains how issues are relevant to chemical engineering, but in less depth</td>
<td>Can identify issues where chemical engineers can contribute, but in less depth</td>
<td>Unaware of and uninterested in how chemical engineers can contribute to solving societal problems</td>
<td></td>
</tr>
<tr>
<td>Clearly explains how chemical engineers can contribute to addressing these issues</td>
<td>Explains how chemical engineers can contribute, but in less depth</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Rubric items adapted from UND-GEOE J Rubric, MSU J Rubric]
**ABET Outcome K:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to use techniques, skills, and modern engineering tools necessary for engineering practice. The corresponding performance indicator is:

1. Students will demonstrate ability to select and use appropriate modern computer tools such as process simulators, numerical solvers, spreadsheets, and word processors.
2. Students will demonstrate ability to understand and create preliminary design documents for chemical processes.

**UND ES Goal #1 Thinking and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Special Emphasis Area - Quantitative Reasoning**

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; **mathematics in academic and practical contexts;** number sense

<table>
<thead>
<tr>
<th>Rubric for ABET Outcome K</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1. Select and use modern computer tools</td>
<td>Consistently chooses an appropriate tool for a given task. Effectively and efficiently uses process simulator, numerical solver, spreadsheet and word processor. Applies all relevant features in the software.</td>
<td>Usually chooses an appropriate tool for a given task. Uses computer tools adequately. May not use some advanced features.</td>
<td>Needs help choosing an appropriate tool. Can perform simple tasks requiring computer tools, but has difficulty with more complex operations.</td>
<td>Unable to choose an appropriate tool without direct assistance. Struggles with even simple tasks involving computer tools.</td>
</tr>
<tr>
<td>ES-QR-4. Mathematics in academic and practical contexts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K2. Preliminary design documents</td>
<td>Consistently able to develop and comprehend comprehensive input/output diagrams, block flow diagrams, process flow diagrams, area classifications for safety, preliminary feedstock, product, utility, chemical, and catalyst lists, and design descriptions.</td>
<td>Able to develop and comprehend input/output diagrams, block flow diagrams, process flow diagrams, area classifications for safety, preliminary feedstock, product, utility, chemical, and catalyst lists, and design descriptions. The quality of understanding and/or document content may be uneven.</td>
<td>Does not fully understand the content of input/output diagrams, block flow diagrams, process flow diagrams, area classifications for safety, preliminary feedstock, product, utility, chemical, and catalyst lists, and design descriptions. The quality of understanding and/or document content is incomplete.</td>
<td>Does not understand one or more of the basic preliminary design documents: input/output diagrams, block flow diagrams, process flow diagrams, area classifications for safety, preliminary feedstock, product, utility, chemical, and catalyst lists, and design descriptions. Cannot completely generate or interpret these items.</td>
</tr>
</tbody>
</table>

(Rubric items adapted from Rose-Hulman PO7 Rubric, Rowan Goal 1 Objective 1 Rubric, MSU K Rubric, UND ES Rubric for Quantitative Reasoning)
ABET Outcome L: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of the role of economics in engineering and an ability to apply that understanding to problem solving. The corresponding performance indicator is:

1. Students will be able to perform a thorough economic analysis of a chemical engineering project and make appropriate recommendations based on the analysis.

**Rubric for ABET Outcome L**

<table>
<thead>
<tr>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L1.</strong> Perform economic analysis and make recommendations</td>
<td>Understands the concepts of time value of money and consistently applies proper analysis (NPV and DCFROR)</td>
<td>Usually chooses the correct tools to evaluate the time value of money. NPV and DCFROR calculations typically require only minor revisions</td>
<td>Can perform NPV and DCFROR analysis only with direction from faculty – requires several revisions to properly apply time value of money tools</td>
</tr>
<tr>
<td></td>
<td>Understands broad cost estimation methods and can apply them correctly, along with cash flow analysis for retrofit and new process industry applications</td>
<td>Broad cost estimates and cash flow analysis contain few errors requiring minimal revisions. Inconsistently applies physical and/or financial depreciation concepts.</td>
<td>Broad cost estimates and cash flow analysis consistently contain errors requiring multiple revisions.</td>
</tr>
<tr>
<td></td>
<td>Understands and correctly applies both physical and financial depreciation.</td>
<td>Sensitivity analysis addresses most pertinent variables and ranges.</td>
<td>Does not completely understand the difference between physical and financial depreciation; makes errors in calculations using one or both concepts.</td>
</tr>
<tr>
<td></td>
<td>Consistently explores the appropriate variables over the proper range when performing economic sensitivity analysis</td>
<td>Usually makes the appropriate economic recommendation with proper justification. Does not fully utilize available data to justify the recommendation.</td>
<td>Can perform a sensitivity analysis but needs help identifying parameters and range of variables</td>
</tr>
<tr>
<td></td>
<td>Makes appropriate recommendations and presents well written economic justification fully supported with data</td>
<td>Economic recommendations are poorly written. Does not fully use available data to support recommendation.</td>
<td>Economic recommendations are poorly written. Does not fully use available data to support recommendation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unable to apply standard measures of time value of money, such as NPV and DCFROR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unable to perform a simple broad cost estimate or develop a cash flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Does not understand the concepts of physical and financial depreciation and cannot use these concepts in a financial calculation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Consistently chooses inappropriate parameters and range of variables for sensitivity analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unable to develop, recommendation, or justify decisions based upon economic factors. Does not use data to support decisions</td>
</tr>
</tbody>
</table>
**ABET Outcome M:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a working knowledge of chemistry and chemical engineering topics. The corresponding performance indicators are:

1. Students will use correct nomenclature and terminology to describe chemical compounds, reactions, operations, and processes.
2. Students will be able to design and analyze continuous and stage-wise separation operations.
3. Students will be able to design and analyze chemical reactor systems.
4. Students will be able to design and analyze chemical process control schemes.
5. Students will demonstrate an awareness and understanding of emerging technologies relevant to chemical engineering.

**Rubric for ABET Outcome M**

<table>
<thead>
<tr>
<th>M1. Use correct nomenclature and terminology</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is consistently able to name inorganic and organic compounds and functional groups</td>
<td>Is able to name many chemical compounds and functional groups</td>
<td>Can name only the most common chemical compounds and functional groups</td>
<td>Sometimes unable to recognize and identify common variables and symbols</td>
<td>Struggles in naming even the most common chemical compounds and functional groups</td>
</tr>
<tr>
<td>Can easily recognize and identify common variables and symbols used in chemistry and chemical engineering</td>
<td>Can recognize common variables and symbols and can identify most</td>
<td>Sometimes unable to recognize and identify common variables and symbols</td>
<td>Occasionally unable to recognize and identify common variables and symbols</td>
<td>Frequently unable to identify standard process equipment</td>
</tr>
<tr>
<td>Can easily identify standard chemical process equipment</td>
<td>Can identify most standard process equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M2. Design and analyze separation operations</strong></td>
<td>Consistently chooses the most appropriate technique to perform a given separation.</td>
<td>Usually chooses the most appropriate technique to perform a given separation.</td>
<td>Often makes errors when choosing the most appropriate technique to perform a given separation.</td>
<td>Consistently selects inappropriate technique to perform a given separation.</td>
</tr>
<tr>
<td>Can easily solve mass and energy balances for a separation operation, given the specifications and the appropriate equilibrium or rate expression.</td>
<td>Can usually solve mass and energy balances for a separation operation, but sometimes makes minor errors.</td>
<td>Often makes errors in solving mass and energy balances for a separation operation.</td>
<td>Struggles to solve mass and energy balances for a separation operation.</td>
<td></td>
</tr>
<tr>
<td>Can easily identify key operating parameters and knows how to optimize them.</td>
<td>Can identify important operating parameters but is sometimes unsure how to optimize them.</td>
<td>Often makes errors in identifying and optimizing important operating parameters.</td>
<td>Struggles to identify important operating parameters.</td>
<td></td>
</tr>
<tr>
<td>Is very comfortable using a process simulator to design a separation process.</td>
<td>Can use a process simulator for separation processes, but sometimes makes errors.</td>
<td>Often makes errors when using a process simulator to design a separation process.</td>
<td>Is unable to use a process simulator to design a separation process.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M3. Design and analyze reactor systems</th>
<th>Can easily define and solve the equations governing any ideal reactor system</th>
<th>Is sometimes unable to define or solve equations for unfamiliar systems.</th>
<th>Often makes errors in defining and solving reactor equations</th>
<th>Struggles in defining and solving equations even for familiar systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is comfortable describing the qualitative behavior expected from different reactors and reaction systems under varying conditions</td>
<td>Can usually describe correctly the expected behavior, but sometimes makes minor errors</td>
<td>Often makes errors in describing expected behavior and shows some misconceptions</td>
<td>Has difficulty describing expected behavior and show significant misconceptions</td>
<td></td>
</tr>
<tr>
<td>Can fully and correctly interpret reactor data (e.g., concentration, temperature, rate)</td>
<td>Can correctly interpret major features of reactor data</td>
<td>Can only partially interpret reactor data, and often with errors</td>
<td>Has difficulty interpreting even the most obvious features of reactor data</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M4. Design and analyze control schemes</th>
<th>Is able to describe and explain the concepts of real-time process control and higher level automation functions.</th>
<th>Is sometimes unable to define real-time process control and higher level automation functional concepts.</th>
<th>Has an incomplete understanding of the concepts of real-time process control. May not be understand how higher level automation functions behave or are used.</th>
<th>Cannot adequately explain the principles of process control and higher level automation functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is proficient in the specification and design of simple regulatory</td>
<td>Can usually specify simple regulatory and understand</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### UND Chemical Engineering Undergraduate Student Outcome Assessment Form

<table>
<thead>
<tr>
<th>Performance Indicator Code(s)</th>
<th># Students at Each Performance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 – project management goals</td>
<td>4</td>
</tr>
<tr>
<td>D2 – integrates contributions</td>
<td></td>
</tr>
<tr>
<td>D3 – inclusive, respectful climate</td>
<td></td>
</tr>
<tr>
<td>D4 – leadership &amp; team roles</td>
<td></td>
</tr>
<tr>
<td>E1 - define problem</td>
<td></td>
</tr>
<tr>
<td>E2 – solution strategy</td>
<td></td>
</tr>
<tr>
<td>E3 – correct solution</td>
<td></td>
</tr>
<tr>
<td>E4 - reasonableness</td>
<td></td>
</tr>
<tr>
<td>K1 – computer tools</td>
<td></td>
</tr>
<tr>
<td>K2 – design documents</td>
<td></td>
</tr>
<tr>
<td>M3 – reactor systems</td>
<td></td>
</tr>
</tbody>
</table>

Comments on general trends, specific areas of weakness or strength, etc.

Attach copy of assignment instructions
UND Chemical Engineering Course Review Form

Course: ____________________________  Semester & Year: ____________________________
Teacher: ____________________________  Date: ____________________________
Student Enrollment - on campus: ________________  distance: ________________

Self reflection on course – changes made to content or teaching methods, implementation of planned improvements, interaction with other courses, what was successful, suggestions for improvements, ...

<table>
<thead>
<tr>
<th>Theme</th>
<th>Addressed?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing Tools</td>
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<td>Instrumentation &amp; Control</td>
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<td>Leadership &amp; Teaming</td>
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<td>Professionalism &amp; Integrity</td>
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<td>Statistics &amp; Num. Methods</td>
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<td>Sustainability</td>
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The current UND Chemical Engineering undergraduate program assessment plan was officially adopted in August 2011 after approval by the Chemical Engineering faculty and the Department External Advisory Committee. Minor revisions were added in August 2012. Assessment of student learning is centered on 13 “Student Learning Outcomes” that describe what students are expected to know and be able to do by the time of graduation. Each of the student learning outcomes is defined further by one or more specific, measureable “Performance Indicators.” The student learning outcomes are intended to prepare graduates to attain a set of five “Program Educational Objectives” that describe what alumni are able to achieve within a few years after graduation. The student learning outcomes and associated assessment plans are designed to provide data needed for both ABET accreditation and Essential Studies revalidation.

This document details the objectives and outcomes, the assessment and evaluation process, and the instruments and methods used. It is organized using the ABET-directed format and headings as follows:

2B. Program Educational Objectives
3A. Student Learning Outcomes
3B. Relationship of Student Learning Outcomes to Program Educational Objectives
4A. Process for Assessment and Evaluation of Student Learning Outcomes
4C. Assessment Instruments and Methods
2B. **UND ChE Program Educational Objectives**

Within a few years following their graduation, our alumni should have the characteristics described by the following objectives:

1. Alumni have the knowledge and skills required to analyze and solve problems related to the field of chemical engineering and communicate these results in verbal and written form to a diverse audience.
2. Alumni are prepared for positions in the chemical process and broadly related industries and demonstrate integrity, responsibility, ownership, and accountability for their work.
3. Alumni have a thorough grounding in fundamentals, allowing them to obtain advanced degrees in chemical engineering or to pursue other professional interests such as medicine or law.
4. Alumni have the teamwork, leadership, and lifelong learning skills that prepare them for future professional growth in a broad spectrum of careers.
5. Alumni understand the role of chemical engineering as a profession and their role in addressing societal issues, including sustainability, environmental responsibility, and safety.
3A. UND ChE Student Learning Outcomes

To provide a measure of how well our department is meeting our educational objectives, the department has adopted the eleven ABET student outcomes of Criterion 3 (otherwise known as a through k). Two additional outcomes have been adopted by the department (l and m) to reflect further aspects of the program that the faculty and our constituents feel are important in undergraduate education.

Student learning outcomes as used by our program describe what students are expected to know and be able to do at the time of graduation. The outcomes of the education we provide our students represent the sum total of all knowledge, skills, and values developed over the course of the undergraduate experience, both inside and outside of class.

Specific performance indicators corresponding to each of the student learning outcomes provide further definition of expected student learning by UND Chemical Engineering students. These performance indicators incorporate elements of ABET program criteria for chemical engineering programs, UND Essential Studies goals, and other elements valued by our faculty and constituents. Together they provide an integrated set of learning outcomes and indicators that can be used for both ABET reaccreditation and ES revalidation.

The outcomes are listed below and presented together with their corresponding performance indicators in the following subsection.

3A.1. Student Learning Outcomes

The Department of Chemical Engineering at the University of North Dakota will produce graduates who have:

a = an ability to apply knowledge of mathematics, science, and engineering
b = an ability to design and conduct experiments, as well as to analyze and interpret data
c = an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d = an ability to function on multidisciplinary and/or diverse teams
e = an ability to identify, formulate, and solve engineering problems
f = an understanding of professional and ethical responsibility
g = an ability to communicate effectively in both oral and written formats
h = the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i = a recognition of the need for, and an ability to engage in lifelong learning
j = a knowledge of contemporary issues of relevance to the field of chemical engineering
k = an ability to use the techniques, skills, and modern engineering tools necessary for
engineering practice

l = an understanding of the role of economics in engineering and an ability to apply that understanding to problem solving

m = a working knowledge of chemistry and chemical engineering topics

3A.2. Performance Indicators

**Outcome A:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to apply knowledge of mathematics, science, and engineering. The corresponding performance indicators are:

1. Students will correctly apply and use mathematics and physics concepts (such as basic integrals, differential equations, statistical measures, mechanics) in solving engineering problems
2. Students will correctly apply and use chemistry concepts (such as chemical reactions and thermodynamics) in solving engineering problems
3. Students will correctly apply and use fundamental engineering concepts (such as material and energy balances; heat, mass, and momentum transfer; vapor-liquid equilibrium) in solving engineering problems

**Outcome B:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design and conduct experiments, as well as to analyze and interpret data. The corresponding performance indicators are:

1. Students will formulate a well-designed experimental plan to obtain a desired objective.
2. Students will demonstrate appropriate laboratory techniques regarding safety, instrument operation, and record keeping.
3. Students will correctly and concisely analyze and interpret experimental data.

**Outcome C:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The corresponding performance indicators are:

1. Students will identify the relevant concepts, issues, and information needed to define a design problem.
2. Students will design a system of unit operations and components to transform raw materials into desired products.
3. Students will consider realistic constraints when designing a component, process, or system.
4. Students will evaluate design alternatives to develop an optimum system.

**Outcome D:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to function on multidisciplinary and/or diverse teams. The corresponding performance indicators are:

1. Student teams will establish and follow project management goals
2. Student teams will integrate individual contributions into a cohesive high quality product
3. Student teams will maintain an inclusive, respectful climate.
4. Students will demonstrate leadership and the ability to fill different team roles.

**Outcome E:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to identify, formulate, and solve engineering problems. The corresponding performance indicators are:
1. Students will identify relevant concepts, equations, and data needed to define a problem.
2. Students will formulate appropriate solution strategies.
3. Students will properly execute a solution strategy to arrive at a correct solution
4. Students will reflect on the reasonableness of their problem solutions.

**Outcome F:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of professional and ethical responsibility. The corresponding performance indicators are:
1. Students will be able to demonstrate knowledge of the principles of ethics, identify objective and subjective aspects of ethical judgments, and show an awareness of the ethical obligations of engineers.
2. Students will be able to construct and apply reasoning strategies from the theories and principles of ethics to identify and resolve ethical problems.

*Revised August 2012*

**Outcome G:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to communicate effectively in both oral and written formats. The corresponding performance indicators are:
1. Students will exhibit a clear sense of purpose in their written and oral communication
2. Students will accurately synthesize, analyze, and evaluate technical information
3. Students will present communication that is well organized, providing guidance for readers and listeners,
4. Students will express themselves clearly and follow appropriate conventions of format, writing, and speech.
5. Students will answer questions and revise writing in response to listener and reader feedback

**Outcome H:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. The corresponding performance indicator is:
1. Students will demonstrate an awareness of how chemical engineering solutions impact economic, environmental, and societal aspects of the local and global community.

**Outcome I:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a recognition of the need for and an ability to engage in lifelong learning. The corresponding performance indicators are:
1. Students will identify what needs to be learned and how to learn it.
2. Students will learn independently and apply that knowledge.
**Outcome J:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a knowledge of contemporary issues of relevance to the field of chemical engineering. The corresponding performance indicator is:

1. Students will be able to discuss how current trends and social concerns (such as sustainability, globalization, local and global economics, political policy) may affect the chemical engineering field

**Outcome K:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to use techniques, skills, and modern engineering tools necessary for engineering practice. The corresponding performance indicators are:

1. Students will demonstrate ability to select and use modern computer tools such as process simulators, numerical solvers, spreadsheets, word processors, relational databases, statistical packages.
2. Students will demonstrate ability to understand and create preliminary design documents for chemical processes.

**Outcome L:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of the role of economics in engineering and an ability to apply that understanding to problem solving. The corresponding performance indicator is:

1. Students will be able to perform a thorough economic analysis of a chemical engineering project and make appropriate recommendations based on the analysis.

**Outcome M:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a working knowledge of chemistry and chemical engineering topics. The corresponding performance indicators are:

1. Students will use correct nomenclature and terminology to describe chemical compounds, reactions, operations, and processes.
2. Students will be able to design and analyze continuous and stage-wise separation operations.
3. Students will be able to design and analyze chemical reactor systems.
4. Students will be able to design and analyze chemical process control schemes.
5. Students will demonstrate an awareness and understanding of emerging technologies and trends relevant to chemical engineering.
3B. Relationship of Student Learning Outcomes to Program Educational Objectives

The relationship between the student learning outcomes and our program educational objectives is presented in Table 1 below. We are confident that the solid relationship between our program educational objectives and our student outcomes allows us to properly assess the quality of the education provided by our department and the consistency with the needs of our constituents.

Table 1. Alignment of Student Learning Outcomes with Program Educational Objectives

<table>
<thead>
<tr>
<th>Program Educational Objectives</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have problem-solving and communication skills</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
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<td>x</td>
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<tr>
<td>2. Prepared for positions in chemical process and related industries</td>
<td></td>
<td>x</td>
<td>x</td>
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<td>3. Have grounding in fundamentals for advanced degrees</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
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<td>x</td>
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<tr>
<td>4. Prepared for future professional growth</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
<td>x</td>
<td>x</td>
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<td>5. Understand role in society as a chemical engineering professional</td>
<td>x</td>
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</tbody>
</table>
4A. Process for Assessment and Evaluation of Student Learning Outcomes

4A.1. Data Collection Methods

Assessment of student learning includes both direct and indirect measures as described in the following discussion. Examples of each of the forms, rubrics, surveys, and other assessment instruments are include in section 4C.

Direct Measures

1. Student Work
   The primary direct measure is a rubric-guided rating of selected student work. For each performance indicator, one or more courses in the ChE curriculum have been identified as primary assessment points. During semesters when assessment is scheduled to occur the faculty instructor of the course selects an assignment or portion of an assignment that is appropriate for evaluating the identified performance indicators. If multiple performance indicators are being evaluated in a course, the faculty member may need to use more than one assignment.

   After students complete the assignment, the instructor uses the rubric as a guide to assign a rating of 1 (unsatisfactory), 2 (developing), 3 (meets expectations), or 4 (exceeds expectation) for each assignment. This assessment evaluation is separate and distinct from the normal grading process used to assign course grades and is focused solely on ability to demonstrate the designated performance indicator(s). Due to the relatively small size of our classes, and to avoid statistical sampling errors, assessment is performed for all chemical engineering students in the class. Results of the faculty evaluation are reported on a “Student Outcomes Assessment (SOA) Form”

Indirect Measures

1. Faculty comments
   Together with the rating of student work, faculty instructors also use the Student Outcomes Assessment form to submit summary comments on the performance of students. This allows the instructor to put numerical ratings in context, identifying specific areas of weakness or strength, and provide a richer picture of student learning.

   Faculty instructors also complete a “Course Review Form” at the end of each course. This form is an opportunity for self-reflection on any changes made to course content or teaching methods, how they impacted student learning, and suggestions for improvements. These reflections provide additional assessment of student performance. By linking student learning outcomes and course delivery, they are an important tool for closing the loop, ensuring that course changes are made in response to assessment and evaluation data.

2. Senior Design Peer Assessments
   In addition to faculty assessments, each student is asked to complete a peer-assessment of each of the members of his or her team at the end of the senior design class. Students rate their team members on a scale of 1-5 (1=poor, 2=below average, 3=average, 4=above
average, 5=excellent) for each of the a-m student learning outcomes. This is done on a voluntary basis, and returns are high but less than 100%. The information gathered provides another source of assessment of student learning outcomes from the students’ point of view.

3. **Senior Exit Questionnaires and Interviews**
   For graduates of the program, a written questionnaire is administered by the College of Engineering and Mines and is given to students at the end of the semester in which they graduate. The exit questionnaire ask students to rate on a 1-5 scale (1=weak, 5=strong) the degree to which they think their education provided them with the ability to meet the student learning outcomes common to all engineering programs (a-k). The questionnaire also asks for assessment of the overall quality of courses, information on job placement, co-op participation, and assessment of the overall quality of courses, faculty, and curriculum.

   The department chair and associate chair conduct a group interview with graduating seniors at the end of the semester to complement the survey. Feedback gathered during the interview session is specific to chemical engineering and has proven to be an effective means of generating student suggestions for program improvements.

4. **Co-op Supervisor Assessments**
   The University’s Career Services Office sends an “Employer’s Evaluation” survey to all co-op supervisors, requesting them to evaluate the co-op student halfway through the assignment and at the end of the assignment. The student’s supervisor is asked to respond to 17 questions broken into four categories: skill, performance, judgment, and attitude. A 4-point scale is used (1=unsatisfactory, 2= needs improvement, 3=meets standards, 4=exceeds standards). As this is a university-wide instrument, the individual questions do not correspond directly to each of the Chemical Engineering student learning outcomes, but they do address many of them, and are a supplementary source of assessment data.

   Additionally, at the end of the co-op assignment, supervisors are also given a “Chemical Engineering Co-op Program Assessment Form.” This form specifically asks about each of the a-m student learning outcomes. On a 1-5 scale (1=strongly disagree, 5=strongly agree) they rate both the degree to which the student demonstrated proficiency and the degree to which these criteria are important to the company.

5. **Alumni/Industrial Advisory Board**
   An Alumni/Industrial Advisory Committee has been in place since the early 1980s. The group meets every other year on campus with the departmental faculty. The board currently consists of eight members. Members are invited to serve 6-year terms. Every 2 years, two or three of the members are replaced. Members are chosen to represent a range of age, industry, and terminal degree and include a member from a research intensive university that is not a graduate of our program. The agenda for the board meetings normally includes an update of department activities, a review of educational objectives and program assessment activities, and a recap of proposed changes in the academic program. Those changes may include anything from evolutionary changes in courses to more significant curriculum modifications. Members of the committee are also invited to add items to the agenda. We value the
perspectives of our alumni advisory committee and incorporate changes resulting from discussions with them.


Student work from selected classes is evaluated with rubrics according to the schedule presented in Table 2. Assessments needed for ABET accreditation are conducted annually, those used for Essential Studies are conducted biannually, and any data collected for one is also used for the other. Most chemical engineering courses are taught once a year, such that annual data collection captures all students taking a class in a given year, and biannual collection captures a sample of approximately half of all students going through the program. As shown in Table 2 annual evaluations are conducted for Primary ABET Assessments (denoted PA) and associated Essential Studies assessments for oral communications (oc), written communication (wc), and quantitative reasoning (qr). Essential Studies assessments for critical thinking (ct) and quantitative reasoning (qr), and associated secondary ABET assessments (sA) are conducted every other year.

<table>
<thead>
<tr>
<th>Course Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<th>J</th>
<th>K</th>
<th>L</th>
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</thead>
<tbody>
<tr>
<td>102 Intro to ChE</td>
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<tr>
<td>201 ChE Fundamentals</td>
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<td>206 Unit Operations</td>
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<td>232 Lab. I</td>
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<td>303 Thermodynamics</td>
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<td>331 Lab. II</td>
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<td>305 Separations</td>
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<td>321 Reactor Design</td>
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<td>340 Engineers in a Global Society (ES SS)</td>
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<td>PA</td>
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<td>408 Process Control</td>
<td></td>
<td>PA</td>
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<td>PA</td>
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</tbody>
</table>

Table 2. Chemical Engineering Student Learning Outcome Assessment Course Schedule
These ABET and ES assessments are planned for courses in the junior and senior years to measure skills and abilities that students have acquired by the end of the program. Additional supplemental intermediate assessments (denoted by * symbol) are scheduled biannually in courses throughout the sophomore and junior years to provide formative assessment data. This data can be used to help interpret the summative ABET and ES data, but students at these levels are not yet expected to have achieved full mastery in the a-m learning outcomes.

Faculty comments on Student Outcomes Assessment and Course Review forms are collected at the end of each semester. Senior design peer assessments and senior group interviews are done at the end of the spring semester each year. The College senior exit interview questionnaire is given out near the end of both fall and spring semesters. Co-op supervisor assessments are collected at the end of a student’s co-op assignment, which may occur in May, August, or December.

The department assessment coordinator collects assessment data gathered throughout the year and compiles it for analysis by the faculty during their annual assessment retreat, which is held each summer. These 2–3 day sessions are attended by all faculty members in the department and are used to explore all aspects of the program. The agenda for the assessment retreat is structured to allow time to review the assessment process and recommend changes. Assessment data is reviewed to determine how well our students are achieving the student learning outcomes and then corrective actions are recommended for those areas where a concern is noted. The group also reviews each course on an individual basis to determine how it is meeting the overall objectives of the department. The departmental strategic plan is also reviewed annually. Feedback from these activities is also used to continually improve the program.

### 4.A.3. Expected Level of Attainment

The chemical engineering faculty has set the following goals that define the expected level of attainment of the Student Learning Outcomes.

- On each rubric-guided Performance Indicator
  - >80% of students should have scores of 3 (meets expectations) or 4 (exceeds
• The average student score should be >3.3

On indirect measures of Student Learning Outcomes with numerical ratings (Senior Design Peer Assessments, Senior Exit Questionnaires, Co-op Program Assessment Form)
• Average student score on each outcome should be >3.5 (where all listed forms use a 1-5 scale)

On indirect measures of Student Learning Outcomes without numerical ratings (Faculty comments, Senior Exit Questionnaire comments, Senior Group Interviews, Co-op Supervisor comments)
• No major areas of concern identified
4C. Assessment Instruments

Examples of each of the following assessment instruments are included in the following pages:

- Student Learning Outcome Rubrics (a-m)
- Student Outcome Assessment (SOA) form
- Course Review form
- ChE Senior Design Peer Evaluation
- Senior Exit Questionnaire
- Co-op Employer Evaluation survey
- Chemical Engineering Co-op Program Assessment form
**ABET Outcome A:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to apply knowledge of mathematics, science, and engineering. The corresponding performance indicators are:

4. Students will correctly apply and use mathematics and physics concepts (such as basic integrals, differential equations, statistical measures, mechanics) in solving engineering problems. 
5. Students will correctly apply and use chemistry concepts (such as chemical reactions and thermodynamics) in solving engineering problems. 
6. Students will correctly apply and use fundamental engineering concepts (such as material and energy balances; heat, mass, and momentum transfer; vapor-liquid equilibrium) in solving engineering problems.

**UND ES Goal #1 Think and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Special Emphasis Area – Quantitative Reasoning**

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; mathematics in academic and practical contexts; number sense.

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<table>
<thead>
<tr>
<th>Rubric for ABET Outcome A</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Apply math &amp; physics concepts</td>
<td>Is consistently able to apply and solve basic integrals, differential equations, statistical measures, mechanics as part of engineering problems.</td>
<td>Is able to apply and solve math and physics equations as part of engineering problems.</td>
<td>Is often able to apply and solve math and physics equations as part of engineering problems.</td>
<td>Struggles in applying and solving math and physics equations as part of engineering problems.</td>
</tr>
<tr>
<td>ES-QR-1. Confidence with mathematics</td>
<td>Is able to apply concepts and approaches to unfamiliar problems.</td>
<td>Is sometimes unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is often unable to apply concepts and approaches to unfamiliar problems.</td>
<td>Is unable to apply concepts and approaches to unfamiliar problems.</td>
</tr>
<tr>
<td></td>
<td>Is comfortable and adept with quantitative ideas and methods.</td>
<td>Is comfortable with quantitative ideas and methods.</td>
<td>Uses quantitative analysis but may be uncomfortable doing so.</td>
<td>Shows signs of reluctance to use quantitative analysis.</td>
</tr>
<tr>
<td></td>
<td>Rarely makes errors.</td>
<td>Sometimes makes minor errors.</td>
<td>Often makes minor errors.</td>
<td>Frequently makes errors.</td>
</tr>
</tbody>
</table>

A2. Apply chemistry concepts

| Is consistently able to apply chemistry concepts (such as chemical reactions and thermodynamics) to engineering problems. | Is able to apply chemistry concepts to engineering problems. | Is often able to apply chemistry concepts to engineering problems. | Struggles in applying chemistry concepts to engineering problems. |
| Is able to apply concepts and approaches to unfamiliar problems. | Is sometimes unable to apply concepts and approaches to unfamiliar problems. | Is often unable to apply concepts and approaches to unfamiliar problems. | Is unable to apply concepts and approaches to unfamiliar problems. |
| Rarely makes errors or shows misconceptions | Sometimes makes minor errors and shows some misconceptions. | Often makes minor errors and shows misconceptions. | Frequently makes errors and shows misconceptions. |

A3. Apply fundamental engineering concepts

| Is consistently able to apply fundamental engineering concepts (such as material and energy balances, transport, vapor-liquid equilibrium) to engineering problems. | Is able to apply fundamental engineering concepts to engineering problems. | Is often able to apply fundamental engineering concepts to engineering problems. | Struggles in applying fundamental engineering concepts to engineering problems. |
| Is able to apply concepts and approaches to unfamiliar problems. | Is sometimes unable to apply concepts and approaches to unfamiliar problems. | Is often unable to apply concepts and approaches to unfamiliar problems. | Is unable to apply concepts and approaches to unfamiliar problems. |
| Rarely makes errors or shows misconceptions | Sometimes makes minor errors and shows some misconceptions. | Often makes minor errors and shows misconceptions. | Frequently makes errors and shows misconceptions. |

(Rubric items adapted from Rose-Hulman PO1 Rubric, UND ES Rubric for Quantitative Reasoning)
ABET Outcome B: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design and conduct experiments, as well as to analyze and interpret data. The corresponding performance indicators are:

1. Students will formulate a well-designed experimental plan to obtain a desired objective.
2. Students will demonstrate appropriate laboratory techniques regarding safety, instrument operation, and record keeping.
3. Students will correctly and concisely analyze and interpret experimental data.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. Special Emphasis Area – Quantitative Reasoning

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; mathematics in academic and practical contexts; number sense

Rubric for ABET Outcome B

<table>
<thead>
<tr>
<th>Rubric</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Formulate well-designed experimental plan</td>
<td>Clearly defines the objectives of the experiment and relevant variables</td>
<td>Is able to fully define experimental objectives and necessary variables with minimal guidance</td>
<td>Is able to define objectives and variables with more direct guidance</td>
<td>Has difficulty identifying objectives and/or related variables.</td>
</tr>
<tr>
<td></td>
<td>Develops an experimental design that effectively uses limited resources to collect all needed data</td>
<td>Experimental design collects all needed data, but not as efficiently</td>
<td>Experimental design targets most important variables, but some relevant parameters are not investigated or extraneous data is collected</td>
<td>Experimental design is poorly organized, failing to measure important variables</td>
</tr>
<tr>
<td></td>
<td>Selects appropriate equipment and instruments to obtain the desired information</td>
<td>Selects appropriate equipment and instruments with minimal guidance</td>
<td>Selects appropriate equipment and instruments with moderate guidance</td>
<td>Cannot select appropriate equipment and instruments without direct guidance</td>
</tr>
<tr>
<td>B2. Demonstrate appropriate laboratory techniques</td>
<td>Consistently and thoroughly observes good laboratory safety practices</td>
<td>Observes laboratory safety practices, but not as carefully</td>
<td>Occasionally displays unsafe practices, but is aware of proper procedures</td>
<td>Frequently behaves unsafely and is unaware of proper procedures</td>
</tr>
<tr>
<td></td>
<td>Skillfully and confidently operates equipment and instruments</td>
<td>Operates equipment and instruments correctly, but with less skill or confidence</td>
<td>Occasionally operates equipment and instruments incorrectly</td>
<td>Struggles to operate equipment and instruments correctly</td>
</tr>
<tr>
<td></td>
<td>Thoroughly and clearly documents experimental procedures and data</td>
<td>Documents experimental procedures and data, but not as clearly</td>
<td>Incompletely documents experimental procedures and data</td>
<td>Fails to document experimental procedures and data</td>
</tr>
<tr>
<td>B3. Analyze and interpret experimental data</td>
<td>Uses appropriate theory to correctly calculate and analyze results from experimental data.</td>
<td>Uses appropriate theory to calculate and analyze results from experimental data with only minor errors</td>
<td>Calculates results without fully understanding theory, some errors may be present, analysis is limited</td>
<td>Calculations and data analysis include major errors or omissions</td>
</tr>
<tr>
<td>ES-QR-2. Interpreting data</td>
<td>Performs correct and detailed error analysis</td>
<td>Performs error analysis with minimal errors</td>
<td>Attempts to address errors, but does so incompletely or incorrectly</td>
<td>Makes little effort to address experimental error</td>
</tr>
<tr>
<td></td>
<td>Interprets results carefully and applies findings to experimental objectives</td>
<td>Adequate interpretation of results, may include some irrelevant information</td>
<td>Limited interpretation of experimental results, some errors present, does not apply findings to experimental objectives</td>
<td>Interpretation of experimental results is absent or contains major errors, no connection to experimental objectives</td>
</tr>
</tbody>
</table>

{Rubric items adapted from Rose-Hulman PO3 Rubric, MSU B Rubric, Rowan Goal 1, Obj 2, Outcome A and Outcome 2 Rubrics, UND ES Rubric for Quantitative Reasoning}
ABET Outcome C: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The corresponding performance indicators are:

1. Students will identify the relevant concepts, issues, and information needed to define a design problem.
2. Students will design a system of unit operations and components to transform raw materials into desired products.
3. Students will consider realistic constraints when designing a component, process, or system.
4. Students will evaluate design alternatives to develop an optimum system.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. Skill Area – Critical Thinking

ES critical thinking courses address the following elements: knowledge and comprehension, analysis and synthesis, evaluation and conclusions

Rubric for ABET Outcome C

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1. Identify relevant concepts, issues, and information</td>
<td>Fully comprehends the design problem. Consistently applies chemical engineering principles to design an effective process.</td>
<td>Comprehends fundamental aspects of the design problem, but not as fully. Applies chemical engineering principles with only minor conceptual errors.</td>
<td>Partially comprehends the design problem. Requires assistance to apply chemical engineering principles; some conceptual errors evident.</td>
<td>Fails to comprehend essential elements of the design problem. Has difficulty applying chemical engineering principles to design, even with assistance.</td>
</tr>
<tr>
<td>C2. Design system from unit operations</td>
<td>Selects and designs a carefully integrated set of unit operations and components. Designs a highly efficient process that meets the desired goals.</td>
<td>Selects and designs a set of unit operations and components, but with incomplete integration. Process successfully achieves desired goals and is reasonably efficient, with only minor errors.</td>
<td>Has difficulty in selecting and designing individual unit operations and components, or in combining them into an overall system. Process design contains errors or is highly inefficient.</td>
<td>Has difficulty both in selecting and designing individual unit operations and components, and in combining them into an overall system. Process will not achieve desired goals and contains major errors.</td>
</tr>
<tr>
<td>C3. Consider realistic constraints</td>
<td>Safety, environmental, ethical, economic, and other constraints are fully considered and integrated into the design.</td>
<td>Safety, environmental, ethical, economic, and other constraints are considered but not fully integrated into design.</td>
<td>Only partial consideration of safety, environmental, ethical, economic, and other constraints.</td>
<td>Minimal or no consideration of safety, environmental, ethical, economic, and other constraints.</td>
</tr>
<tr>
<td>C4. Evaluate &amp; Optimize</td>
<td>Develops several potential solutions and finds optimum. Evaluation of design alternatives is correct, thorough, and well supported.</td>
<td>Develops multiple solutions, but neglects key factors in optimization. Evaluation of design alternatives is correct, but not as thorough or well supported.</td>
<td>Can develop multiple solutions, but neglects key factors, and has difficulty identifying optimum. Evaluation of design alternatives is incomplete and/or incorrect.</td>
<td>Only develops a single solution; no optimization attempted. Evaluation of system design is minimal or absent.</td>
</tr>
</tbody>
</table>

{Rubric items adapted from Rose-Hulman PO4 Rubric, Rowan Goal 2 Objective 1 Rubrics, MSU C Rubric, UND ES Critical Thinking Rubric}
**ABET Outcome D:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to function on multidisciplinary and/or diverse teams. The corresponding performance indicators are:

1. Student teams will establish and follow project management goals
2. Student teams will integrate individual contributions into a cohesive high quality product
3. Student teams will maintain an inclusive, respectful climate.
4. Students will demonstrate leadership and the ability to fill different team roles.

### Rubric for ABET Outcome D

<table>
<thead>
<tr>
<th>4 - Exceeds expectations</th>
<th>3 - Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1. Establish and follow project management goals</td>
<td>Realistic and measurable goals are defined, prioritized, and documented. Schedules are generally followed. Team easily makes adjustments to plans as needed. Work is completed on time.</td>
<td>Goals are defined, but not as specifically. Team often gets behind schedule and has to play catch up. Makes adjustments, but not as easily or promptly. Work is completed on time.</td>
<td>Goals are not fully defined and may not be realistic or prioritized appropriately. Has difficulty staying on schedule. Not always able to make adjustments. Work completed, but not on time.</td>
</tr>
<tr>
<td>D2. Integrates contributions into high quality product</td>
<td>Individual work integrated into a cohesive final product. High degree of synergy attained. Feedback from in and out of group successfully incorporated into revisions.</td>
<td>Individual work integrated, but not as cohesively. Clear synergy from working as a team. Feedback incorporated into revisions.</td>
<td>Individual work not fully integrated. Moderate synergy from working as a team. Feedback sometimes not incorporated into revisions.</td>
</tr>
<tr>
<td>D3. Maintains inclusive, respectful climate</td>
<td>All team members listen, encourage participation, and are courteous and respectful to each other. Team works together and makes collective decisions after considering alternate views. Conflicts resolved effectively.</td>
<td>Team members are respectful, but do not actively encourage each other. All members are involved in decision making, but not as fully. One or more members may dominate. Conflicts resolved, but not as effectively.</td>
<td>Team members not intentionally disrespectful. Members occasionally blame or criticize each other. Not all members involved in decision making. Conflicts defused, but not fully resolved.</td>
</tr>
<tr>
<td>D4. Leadership and team roles</td>
<td>Team members will effectively fill the various roles in a team: leader, scribe, participant, scribe, and questioner. Team roles are defined and understood by all. Members easily change roles for different aspects of the assignment as needed for the good of the team. The team demonstrates both individual and collective leadership.</td>
<td>Team members understand team roles and are partially effective in working together in these roles. Role rotation is limited. The team members demonstrate some collective leadership and some individual leadership, but do not fully use team synergy effectively.</td>
<td>Team members do not entirely understand roles and how to use them to work together. One or two individuals dominate the team rather than using team synergy effectively.</td>
</tr>
</tbody>
</table>

{Rubric items adapted from: Auburn EE PO7 Rubric, CSU EE Team Effectiveness Rubric, Iowa State Teamwork Rubric, MSU D Rubric, NCState Teaming Rubric}
ABET Outcome E: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to identify, formulate, and solve engineering problems. The corresponding performance indicators are:

1. Students will identify relevant concepts, equations, and data needed to define a problem.
2. Students will formulate appropriate solution strategies.
3. Students will properly execute a solution strategy to arrive at a correct solution.
4. Students will reflect on the reasonableness of their problem solutions.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. Skill Area – Critical Thinking; Special Emphasis Area - Quantitative Reasoning

ES critical thinking courses address the following elements: knowledge and comprehension, analysis and synthesis, evaluation and conclusions.

ES quantitative reasoning courses address the following elements: mathematics in academic and practical contexts; number sense.

Rubric for ABET Outcome E

<table>
<thead>
<tr>
<th>Rubric</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1. Identify and define problem</td>
<td>Is consistently able to identify relevant concepts, equations, and data, and distinguish extraneous information.</td>
<td>Is able to identify relevant concepts, equations, and data, but with some extraneous information.</td>
<td>Is able to identify some relevant information, but has difficulty distinguishing extraneous information.</td>
<td>Struggles to identify relevant information.</td>
</tr>
<tr>
<td>ES-CT-1. Knowledge and comprehension</td>
<td>Consistently able to define unfamiliar problems.</td>
<td>Is sometimes unable to define unfamiliar problems.</td>
<td>Unable to define unfamiliar problems without some assistance.</td>
<td>Unable to define unfamiliar problems without direct instruction.</td>
</tr>
<tr>
<td>Fully comprehends the question, problem, or issue to be addressed.</td>
<td>Comprehends the main points of the question, problem, or issue to be addressed.</td>
<td>Comprehends elements of the question, problem, or issue to be addressed, but fails to grasp the overall question.</td>
<td>Fails to comprehend basic elements of the question, problem, or issue to be addressed.</td>
<td></td>
</tr>
<tr>
<td>E2. Formulate solution strategies</td>
<td>Creatively combines and integrates diverse concepts to formulate an efficient solution strategy.</td>
<td>Makes connections between concepts and formulates workable strategy, but they may not be optimal and may rely on brute force.</td>
<td>Has difficulty making connections between concepts and planning solution approach for some problems.</td>
<td>Unable to make connections and formulate coherent strategy for solving problems.</td>
</tr>
<tr>
<td>ES-OR-4. Mathematics in academic and practical contexts</td>
<td>Competently identifies and applies optimal mathematical or numerical tools to solve problems.</td>
<td>Identifies appropriate mathematical and numerical tools.</td>
<td>Has difficulty identifying and applying appropriate mathematical or numerical tools.</td>
<td>Unable to identify or apply appropriate mathematical or numerical tools.</td>
</tr>
<tr>
<td>E3. Execute solution strategy</td>
<td>Consistently implements solution strategy correctly and gets correct answers.</td>
<td>Implements solution strategy correctly, with occasional minor errors.</td>
<td>Has some difficulty solving problems, and produces frequent errors.</td>
<td>Often unable to solve a problem, even with a well-defined solution strategy.</td>
</tr>
<tr>
<td>E4. Reflect on reasonableness</td>
<td>Applies engineering judgment to carefully check solution for reasonableness. Recognizes implausible answers and is able to correct them.</td>
<td>Checks solution for reasonableness, but not as carefully. Occasionally may not recognize implausible answers.</td>
<td>Has difficulty checking solution. Often does not recognize implausible answers, or is unable to correct them.</td>
<td>Makes little, if any, effort to check solution. Does not recognize obviously incorrect solutions.</td>
</tr>
</tbody>
</table>

(Rubric items adapted from Rose-Hulman PO2 Rubric, Rowan Goal 1 Objective 1 Rubric, MSU E Rubric, UND ES Rubrics for Quantitative Reasoning and Critical Thinking)
**ABET Outcome F:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of professional and ethical responsibility. The corresponding performance indicators are:

3. Students will demonstrate knowledge of engineering ethics codes.
4. Students will be able to apply reasoning strategies from the theories and principals of ethics to identify and resolve ethical dilemmas.

**UND ES Goal #1 Think and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking**

ES critical thinking courses address the following elements: **knowledge and comprehension, analysis and synthesis, evaluation and conclusions**

**Rubric for ABET Outcome F**

<table>
<thead>
<tr>
<th>Rubric Items</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1. Knowledge of ethical principles and obligation of engineers</td>
<td>Correctly identifies all of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Correctly identifies the most of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Correctly identifies the some of the appropriate ethical principles that pertain to a particular ethical issue.</td>
<td>Does not identify any ethical principles; shows lack of awareness of ethical principles.</td>
</tr>
<tr>
<td></td>
<td>Correctly identifies objective and subjective aspects of ethics.</td>
<td>Demonstrates a nearly complete understanding of objective and subjective aspects.</td>
<td>Understands the two aspects exist, but is not able to identify them clearly.</td>
<td>Does not appear to know the objective and subjective aspects of ethics.</td>
</tr>
<tr>
<td></td>
<td>Fully recognizes the obligation of engineers to act ethically.</td>
<td>Shows awareness of engineers’ duty to act ethically, but does not recognize some aspects of the obligation.</td>
<td>Shows only a vague notion of the obligation of engineers to act ethically.</td>
<td>Does not recognize the obligation of engineers to act ethically.</td>
</tr>
<tr>
<td></td>
<td>Can explain all the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain most of the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain only some of the goals and obligations of the AIChE Code of Ethics</td>
<td>Can explain only a few of the goals and obligations of the AIChE Code of Ethics</td>
</tr>
<tr>
<td>F2. Apply principles to resolve ethical problems</td>
<td>Can consistently identify the ethical dilemmas present in a hypothetical situation</td>
<td>Can identify the ethical dilemmas present</td>
<td>Can usually recognize ethical dilemmas when present</td>
<td>Does not recognize ethical dilemmas without outside guidance</td>
</tr>
<tr>
<td></td>
<td>Can explain how ethics principles and theories apply to the situation</td>
<td>Can define some ethics principles and theories that apply to the situation</td>
<td>Has difficulty defining relevant ethics principles</td>
<td>Unable to explain how ethics principles apply</td>
</tr>
<tr>
<td></td>
<td>Can suggest a resolution to the dilemma that fully incorporates ethical principles</td>
<td>Can suggest a resolution that incorporates some ethical principles</td>
<td>Can suggest a resolution, but does so without clearly basing it on ethical theories and principles.</td>
<td>Cannot formulate a resolution, or suggests a resolution that obviously violates ethical principles</td>
</tr>
</tbody>
</table>

{Rubric items adapted from UND-GEOE and Benedictine College rubrics}
ABET Outcome G: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to communicate effectively in both oral and written formats. The corresponding performance indicators are:
1. Students will exhibit a clear sense of purpose in their written and oral communication
2. Students will accurately synthesize, analyze, and evaluate technical information
3. Students will present communication that is well organized, providing guidance for readers and listeners,
4. Students will express themselves clearly and follow appropriate conventions of format, writing, and speech.
5. Students will answer questions and revise writing in response to listener and reader feedback

UND ES Goal #2 Communication: You should be able to write and speak in civic, academic, and professional settings with a sense of purpose and audience.
- ES communication courses are designed to encourage the development of the following skills: awareness of purpose and the construction of argument; awareness of audience; the ability to analyze, synthesize, and incorporate outside sources and the ideas of others; using the conventions associated with citing sources and communicating clearly in various disciplines.

**Rubric for Oral and Written Communication**

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 – Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1. Sense of Purpose</td>
<td>Author is sophisticated in his/her ability to signal purpose to audience.</td>
<td>There is a controlling idea that holds the document or presentation together.</td>
<td>While there may be a sense of purpose that holds the document or presentation together, it is often very broad.</td>
<td>Document or presentation seems disjointed or incoherent.</td>
</tr>
<tr>
<td></td>
<td>Focused and incisive, reflects a strong sense of what author is trying to do or say.</td>
<td>While the document or presentation might not contain a traditional “thesis statement,” there is a strong sense that the writer has a clear vision of his/her project.</td>
<td>Lack of focus causes the document or presentation to rely more on summary than on analysis.</td>
<td>Relationship between different sections is unclear or relationship comes only from “stream of consciousness” or tangential connections between ideas.</td>
</tr>
<tr>
<td></td>
<td>The various sections of the document or presentation make sense together and the author has indicated the larger implications or importance of the topic</td>
<td>The various parts of the document or presentation fit with the author’s sense of project. The author has a reason for communicating</td>
<td>Author in this category may discover a sense of purpose as they prepare document or presentation, but they haven’t revised the entire communication to reflect this new focus.</td>
<td>Author may seem to be engaged in many different projects at once.</td>
</tr>
<tr>
<td>G2. Synthesis, Analysis, and Evaluation</td>
<td>Author carefully integrates credible sources and the ideas of others into the document or presentation in a manner that supports but does not overshadow the author’s own purpose. The ideas of others are clearly marked as such.</td>
<td>Credible sources and the ideas of others are brought into the document or presentation in a manner that generally supports the author’s own purpose. The ideas of others are marked as such.</td>
<td>Credible sources and the ideas of others may be included in the document or presentation, yet the author has trouble controlling the integration of those ideas into the paper in a manner that supports his/her own purpose. The ideas of others may not be always clearly marked as such.</td>
<td>Credible sources and the ideas of others overshadow the author’s own purpose. The audience has great difficulty interpreting how these sources and/or ideas are connected to the project. The ideas of others are often not clearly marked as such.</td>
</tr>
<tr>
<td></td>
<td>Communication in this category does not merely “present” what others have said; instead, the author can offer thoughtful, complex analysis or evaluation of those ideas</td>
<td>Communication in this category does not merely “present” what others have said; instead, the writer offers some analysis or evaluation of those ideas.</td>
<td>Communication in this category may slip into a presentation of information; only some analysis or evaluation is offered.</td>
<td>Communication in this category shows very little evidence of analysis or evaluation.</td>
</tr>
<tr>
<td></td>
<td>Correctly interprets results, accounting for error and uncertainty</td>
<td>Provides correct, but incomplete analysis and interpretation, partially accounts for error and uncertainty</td>
<td>Makes some errors in interpreting data and error analysis.</td>
<td>Makes major errors in data interpretation. Does not account for error and uncertainty. Provides little or no exploration of results.</td>
</tr>
<tr>
<td></td>
<td>Provides insightful conclusions supported by evidence and discusses implications and application</td>
<td>Provides conclusions supported by evidence and some discussion of implications and application</td>
<td>Does not provide sufficient evidence for conclusions. Provides only minimal discussion of implications and applications.</td>
<td>Does not provide any evidence supporting conclusions. Does not discuss implications and applications.</td>
</tr>
</tbody>
</table>
**G3. Guidance for Audience**

<table>
<thead>
<tr>
<th>The author demonstrates a sophisticated awareness of his/her audience.</th>
<th>The author has established the relevancy of the topic to the specific audience and helped the audience to understand his/her project.</th>
<th>Relevance of the topic to specific audience not as clear. At times, audience may feel lost and unable to follow the author’s train of thought.</th>
<th>Communication has not been adapted to interests and backgrounds of audience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document or presentation flows smoothly from one idea to another. The author has taken pains to assist the audience in following the logic of the ideas expressed.</td>
<td>Sequencing of ideas within the document or presentation and connections between sections make the author’s points easy to follow</td>
<td>Author needs to improve sequencing of ideas within the document or presentation and do more to explain the connections between sections.</td>
<td>The lack of connections between ideas makes following and understanding document or presentation difficult.</td>
</tr>
<tr>
<td>The author has taken pains to explain and develop his/her ideas.</td>
<td>The author has found a way of developing his/her ideas, providing the audience with the examples, illustrations, and explanations necessary to understand the project.</td>
<td>Communication may include examples and illustrations but often lacks explanations of the relevance of those examples; or may include explanations without the examples or illustrations the audience needs to fully understand.</td>
<td>The lack of examples, illustrations, and explanation makes understanding difficult</td>
</tr>
</tbody>
</table>

**G4. Clarity and Conventions**

<table>
<thead>
<tr>
<th>Clarity of ideas is enhanced by careful expression through the author’s use of effective written, verbal, and/or non-verbal delivery.</th>
<th>Word and sentence choices, verbal and non-verbal delivery convey meaning, but not as clearly. Author generally controls conventions of specific communication style. Visual presentation of work, physical delivery, formatting and/or documentation is consistent and generally follows conventions. Occasional missteps in use of conventions or in presentation do not impede understanding.</th>
<th>Word choice, sentence structure, verbal and non-verbal delivery get in the way of clear communication. Author’s inconsistent use of conventions related to the specific communication style is distracting to the audience and interrupts comprehension. Visual presentation of work, physical delivery, formatting and/or documentation is inconsistent and interrupts understanding</th>
<th>Audience must occasionally guess at author’s meaning. Author’s control of conventions of the specific communication style is uncertain enough to impede comprehension. Visual presentation of work, physical delivery, formatting and/or documentation is inappropriate and impedes understanding. Revision and/or rehearsal appear delinquently absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author seems to be in command of conventions for specific style of communication and uses them to rhetorical advantage. Visual presentation of work, physical delivery, formatting and/or documentation is polished.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**G5. Listen and Respond to Feedback**

<table>
<thead>
<tr>
<th>Listens carefully and responds to all questions and comments directly, clearly, and respectfully. Answers with explanations and elaboration Effectively incorporates comments and suggestions from previous drafts or presentations.</th>
<th>Listens and answers questions, but not as directly or clearly. Fails to elaborate when answering questions. Incorporates comments and suggestions from previous drafts or presentations, but not as effectively.</th>
<th>Sometimes misunderstands questions. Gives lengthy or incomplete answers. Does not directly answer questions. Has some trouble answering questions. Does not address or incorrectly responds to some comments and suggestions from previous drafts or presentations.</th>
<th>Does not listen carefully to questions. Starts responding before questions finished. Gives evasive or incomplete answers Cannot answer questions about subject. Makes minimal or no revisions in response to comments and suggestions from previous drafts or presentations.</th>
</tr>
</thead>
</table>

*{Rubric items adapted from UND ES Rubrics for Written Communication and Oral Communication, MSU G1 Rubric, Maine Oral Presentation Rubric, UND ChE Graduate Seminar Evaluation Rubric}*
ABET Outcome H: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. The corresponding performance indicator is:

1. Students will demonstrate an awareness of how chemical engineering solutions impact economic, environmental, and societal aspects of the local and global community.

UND ES Goal #1 Think and Reasoning: You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Skill Area – Critical Thinking**

ES critical thinking courses address the following elements: **knowledge and comprehension, analysis and synthesis, evaluation and conclusions**

### Rubric for ABET Outcome H

<table>
<thead>
<tr>
<th>H1. Awareness of impact of engineering on society</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES-CT-1. Knowledge and Comprehension</td>
<td>Shows deep understanding of immediate and long term issues involving the solution</td>
<td>Good understanding of the widespread effects of the solution, but with somewhat limited perspective about long term factors</td>
<td>Some awareness of the more extended effects of the solution</td>
<td>Little or no understanding of (or interest in) the wider impacts of the solution</td>
</tr>
<tr>
<td>ES-CT-2. Analysis &amp; Synthesis</td>
<td>Considers and understands impact on users and nonusers locally and globally</td>
<td>Considers and understands impact on some, but not all, users and nonusers</td>
<td>Partially considers and understands impact on users and nonusers</td>
<td>Seems to have only considered impact on immediate users</td>
</tr>
<tr>
<td>ES-CT-3. Evaluation &amp; Conclusions</td>
<td>Thoroughly considers economic, environmental, and societal factors</td>
<td>Good understanding of the general economic, environmental, and societal factors related to the solution</td>
<td>Moderate understanding of the general factors related to the solution</td>
<td>Little or no attention given to economic, environmental, and societal factors</td>
</tr>
</tbody>
</table>

{Rubric items adapted from UND-GEOE Rubric}
**ABET Outcome I:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a recognition of the need for and an ability to engage in lifelong learning. The corresponding performance indicators are:

1. Students will identify what needs to be learned and how to learn it.
2. Students will learn independently and apply that knowledge.

**Rubric for ABET Outcome I**

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1. Identify what needs to be learned</td>
<td>Students able to identify what they still need to know. Can identify multiple reliable methods for obtaining that information.</td>
<td>Can identify what they do and don’t know. Able to identify a method for obtaining needed information.</td>
<td>Recognizes what they do know and the need to learn more. Has difficulty identifying what still needs to be learned and methods for learning it.</td>
<td>Does not recognize need to learn more. Expects that all needed information and skills will be provided.</td>
</tr>
<tr>
<td>I2. Learn independently</td>
<td>Takes initiative in finding and learning material from outside sources Appropriately incorporates into assignments a significant amount of material from reliable outside sources.</td>
<td>Can find and learn material from outside sources without assistance. Incorporates into assignments material from outside sources</td>
<td>Can find and learn material from outside sources with some guidance. Has some difficulty incorporating outside material, especially when in a different format from that taught in class</td>
<td>Unable to find and learn new material without detailed guidance. Unable to incorporate material outside of what is explained in class</td>
</tr>
</tbody>
</table>

*(Rubric items adapted from: RoseHulman PO10 Rubric, MSU I Rubric, WSU Skill 3i Rubric)*
**ABET Outcome J**: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a knowledge of contemporary issues of relevance to the field of chemical engineering. The corresponding performance indicator is:

1. Students will be able to identify and discuss current trends and social concerns at local, national, and global levels relevant to the chemical engineering field (such as sustainability, globalization, local and global economics, political policy).

### Rubric for ABET Outcome J

<table>
<thead>
<tr>
<th>J1. Identify and discuss current issues</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully aware of and able to discuss in-depth major issues facing local, national, and global society (e.g., sustainability, globalization, economics, politics)</td>
<td>Aware of and has a good understanding of current issues facing society</td>
<td>Some awareness of contemporary issues, but with only a moderate understanding</td>
<td>Fails to make connection between current issues and chemical engineering</td>
<td>Little or no awareness or understanding of contemporary issues</td>
</tr>
<tr>
<td>Clearly explain how issues are relevant to chemical engineering</td>
<td>Explains how issues are relevant to chemical engineering, but in less depth</td>
<td>Can explain how some issues are relevant to chemical engineering, but only at a superficial level</td>
<td>Unaware of and uninterested in how chemical engineers can contribute to solving societal problems</td>
<td></td>
</tr>
<tr>
<td>Clearly explains how chemical engineers can contribute to addressing these issues</td>
<td>Explains how chemical engineer can contribute, but in less depth</td>
<td>Can identify issues where chemical engineers can contribute, but can only explain superficially</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Rubric items adapted from UND-GEOE J Rubric, MSU J Rubric*
**ABET Outcome K:** The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to use techniques, skills, and modern engineering tools necessary for engineering practice. The corresponding performance indicator is:

1. Students will demonstrate ability to select and use appropriate modern computer tools such as process simulators, numerical solvers, spreadsheets, and word processors.
2. Students will demonstrate ability to understand and create preliminary design documents for chemical processes.

**UND ES Goal #1 Thinking and Reasoning:** You should be able to use a variety of thinking and reasoning skills, apply these skills as appropriate in various situations, and move among them depending on purpose. **Special Emphasis Area - Quantitative Reasoning**

ES quantitative reasoning courses address the following elements: confidence with mathematics; interpreting data; making decisions; **mathematics in academic and practical contexts**; number sense

<table>
<thead>
<tr>
<th>Rubric for ABET Outcome K</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1. Select and use modern computer tools</td>
</tr>
<tr>
<td>Consistently chooses an appropriate tool for a given task. Effectively and efficiently uses process simulator, numerical solver, spreadsheet and word processor. Applies all relevant features in the software.</td>
</tr>
<tr>
<td>K2. Preliminary design documents</td>
</tr>
<tr>
<td>Consistently able to develop and comprehend comprehensive input/output diagrams, block flow diagrams, process flow diagrams, area classifications for safety, preliminary feedstock, product, utility, chemical, and catalyst lists, and design descriptions.</td>
</tr>
</tbody>
</table>

{Rubric items adapted from Rose-Hulman PO7 Rubric, Rowan Goal 1 Objective 1 Rubric, MSU K Rubric, UND ES Rubric for Quantitative Reasoning}
**ABET Outcome L**: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of the role of economics in engineering and an ability to apply that understanding to problem solving. The corresponding performance indicator is:

1. Students will be able to perform a thorough economic analysis of a chemical engineering project and make appropriate recommendations based on the analysis.

**Rubric for ABET Outcome L**

<table>
<thead>
<tr>
<th>L1. Perform economic analysis and make recommendations</th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understands the concepts of time value of money and consistently applies proper analysis (NPV and DCFROR)</td>
<td>Usually chooses the correct tools to evaluate the time value of money. NPV and DCFROR calculations typically require only minor revisions</td>
<td>Can perform NPV and DCFROR analysis only with direction from faculty – requires several revisions to properly apply time value of money tools</td>
<td>Unable to apply standard measures of time value of money, such as NPV and DCFROR</td>
<td>Unable to perform a simple broad cost estimate or develop a cash flow</td>
</tr>
<tr>
<td>Understands broad cost estimation methods and can apply them correctly, along with cash flow analysis for retrofit and new process industry applications</td>
<td>Broad cost estimates and cash flow analysis contain few errors requiring minimal revisions. Inconsistently applies physical and/or financial depreciation concepts. Sensitivity analysis addresses most pertinent variables and ranges.</td>
<td>Broad cost estimates and cash flow analysis consistently contain errors requiring multiple revisions. Does not completely understand the difference between physical and financial depreciation; makes errors in calculations using one or both concepts. Can perform a sensitivity analysis but needs help identifying parameters and range of variables</td>
<td>Does not understand the concepts of physical and financial depreciation and cannot use these concepts in a financial calculation. Consistently chooses inappropriate parameters and range of variables for sensitivity analysis</td>
<td>Unable to develop, recommendation, or justify decisions based upon economic factors. Does not use data to support decisions</td>
</tr>
<tr>
<td>Understands and correctly applies both physical and financial depreciation. Consistently explores the appropriate variables over the proper range when performing economic sensitivity analysis</td>
<td>Usually makes the appropriate economic recommendation with proper justification. Does not fully utilize available data to justify the recommendation.</td>
<td>Economic recommendations are poorly written. Does not fully use available data to support recommendation.</td>
<td>Economic recommendations are poorly written. Does not fully use available data to support recommendation.</td>
<td>Economic recommendations are poorly written. Does not fully use available data to support recommendation.</td>
</tr>
</tbody>
</table>
ABET Outcome M: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a working knowledge of chemistry and chemical engineering topics. The corresponding performance indicators are:

1. Students will use correct nomenclature and terminology to describe chemical compounds, reactions, operations, and processes.
2. Students will be able to design and analyze continuous and stage-wise separation operations.
3. Students will be able to design and analyze chemical reactor systems.
4. Students will be able to design and analyze chemical process control schemes.
5. Students will demonstrate an awareness and understanding of emerging technologies relevant to chemical engineering.

Rubric for ABET Outcome M

<table>
<thead>
<tr>
<th></th>
<th>4 – Exceeds expectations</th>
<th>3 – Meets expectations</th>
<th>2 - Developing</th>
<th>1 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1. Use correct nomenclature and terminology</td>
<td>Is consistently able to name inorganic and organic compounds and functional groups. Can easily recognize and identify common variables and symbols used in chemistry and chemical engineering. Can easily identify standard chemical process equipment.</td>
<td>Is able to name many chemical compounds and functional groups. Can recognize common variables and symbols and can identify most. Can identify most standard process equipment.</td>
<td>Can name only the most common chemical compounds and functional groups. Sometimes unable to recognize and identify common variables and symbols. Sometimes unable to identify standard process equipment.</td>
<td>Struggles in naming even the most common chemical compounds and functional groups. Often unable to recognize and identify common variables and symbols. Frequently unable to identify standard process equipment.</td>
</tr>
<tr>
<td>M2. Design and analyze separation operations</td>
<td>Consistently chooses the most appropriate technique to perform a given separation. Can easily solve mass and energy balances for a separation operation, given the specifications and the appropriate equilibrium or rate expression. Can easily identify key operating parameters and knows how to optimize them. Is very comfortable using a process simulator to design a separation process.</td>
<td>Usually chooses the most appropriate technique to perform a given separation. Can usually solve mass and energy balances for a separation operation, but sometimes makes minor errors. Can identify important operating parameters but is sometimes unsure how to optimize them. Can use a process simulator for separation processes, but sometimes makes errors.</td>
<td>Often makes errors when choosing the most appropriate technique to perform a given separation. Often makes errors in solving mass and energy balances for a separation operation. Often makes errors in identifying and optimizing important operating parameters. Often makes errors when using a process simulator to design a separation process.</td>
<td>Consistently selects inappropriate technique to perform a given separation. Struggles to solve mass and energy balances for a separation operation. Struggles to identify important operating parameters. Is unable to use a process simulator to design a separation process.</td>
</tr>
<tr>
<td>M3. Design and analyze reactor systems</td>
<td>Can easily define and solve the equations governing any ideal reactor system. Is comfortable describing the qualitative behavior expected from different reactors and reaction systems under varying conditions. Can fully and correctly interpret reactor data (e.g., concentration, temperature, rate).</td>
<td>Is sometimes unable to define or solve equations for unfamiliar systems. Can usually describe correctly the expected behavior, but sometimes makes minor errors. Can correctly interpret major features of reactor data.</td>
<td>Often makes errors in defining and solving reactor equations. Often makes errors in describing expected behavior and shows some misconceptions. Can only partially interpret reactor data, and often with errors.</td>
<td>Struggles in defining and solving equations even for familiar systems. Has difficulty describing expected behavior and show significant misconceptions. Has difficulty interpreting even the most obvious features of reactor data.</td>
</tr>
<tr>
<td>M4. Design and analyze control schemes</td>
<td>Is able to describe and explain the concepts of real-time process control and higher level automation functions. Is proficient in the specification and design of simple regulatory.</td>
<td>Is sometimes unable to define real-time process control and higher level automation functional concepts. Can usually specify simple regulatory and understand.</td>
<td>Has an incomplete understanding of the concepts of real-time process control. May not be understand how higher level automation functions behave or are used.</td>
<td>Cannot adequately explain the principles of process control and higher level automation functions. Has difficulty specifying and understanding simple regulatory.</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Easily applies emerging technologies and solutions to appropriate problems.</td>
<td>Applies new technologies in appropriate applications.</td>
<td>Can only partially apply new technologies to existing problems.</td>
<td>Is unable to apply new tools and technologies</td>
</tr>
<tr>
<td></td>
<td>Recognizes the advantages and disadvantages of new technologies relative to existing technologies.</td>
<td>Does not fully understand limitations.</td>
<td>Has difficulty evaluating advantages and disadvantages of new technologies.</td>
<td></td>
</tr>
</tbody>
</table>

and supervisory control strategies.
Can identify measurement, control, and disturbance variables in process flow and can utilize these variables to construct control schemes.

control strategies
Can usually correctly identify measurement, control, and disturbance variables in a process flow and can usually use these variables in simple control schemes.
Has trouble developing more complicated control schemes.

Often makes errors in specifying and understanding simple regulatory control strategies
Ability to correctly identify measurement, control, and disturbance variables in a process flow is uneven.
Has trouble developing more complicated control schemes.

control strategies
Cannot identify measurement, control, and disturbance variables in process flow.
Cannot develop more complicated control schemes.
### UND Chemical Engineering Undergraduate Student Outcome Assessment Form

<table>
<thead>
<tr>
<th>Course</th>
<th>Semester &amp; Year</th>
<th>Evaluator</th>
<th>Date of Evaluation</th>
<th>Assignment(s)</th>
<th># Students Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChE 321</td>
<td>Spring 2012</td>
<td>Bowman</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Indicator Code(s)</th>
<th># Students at Each Performance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>D1 – project management goals</td>
<td></td>
</tr>
<tr>
<td>D2 – integrates contributions</td>
<td></td>
</tr>
<tr>
<td>D3 – inclusive, respectful climate</td>
<td></td>
</tr>
<tr>
<td>D4 – leadership &amp; team roles</td>
<td></td>
</tr>
<tr>
<td>E1 - define problem</td>
<td></td>
</tr>
<tr>
<td>E2 – solution strategy</td>
<td></td>
</tr>
<tr>
<td>E3 – correct solution</td>
<td></td>
</tr>
<tr>
<td>E4 - reasonableness</td>
<td></td>
</tr>
<tr>
<td>K1 – computer tools</td>
<td></td>
</tr>
<tr>
<td>K2 – design documents</td>
<td></td>
</tr>
<tr>
<td>M3 – reactor systems</td>
<td></td>
</tr>
</tbody>
</table>

Comments on general trends, specific areas of weakness or strength, etc.

Attach copy of assignment instructions
UND Chemical Engineering Course Review Form

Course: ___________________________  Semester & Year: Fall 2012
Teacher: ___________________________  Date: ___________________________
Student Enrollment - on campus: _______  distance: _______

Self reflection on course – changes made to content or teaching methods, implementation of planned improvements, interaction with other courses, what was successful, suggestions for improvements, ...

<table>
<thead>
<tr>
<th>Across the Curriculum Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme</td>
</tr>
<tr>
<td>Computing Tools</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Design</td>
</tr>
<tr>
<td>EHS</td>
</tr>
<tr>
<td>Independent Learning</td>
</tr>
<tr>
<td>Instrumentation &amp; Control</td>
</tr>
<tr>
<td>Leadership &amp; Teaming</td>
</tr>
<tr>
<td>Professionalism &amp; Integrity</td>
</tr>
<tr>
<td>Statistics &amp; Num. Methods</td>
</tr>
<tr>
<td>Sustainability</td>
</tr>
</tbody>
</table>
Program of Self-Study For
Chemical Engineering

Description of Assessment Methodology
Program of Self-Study For
Chemical Engineering

Description of Assessment Methodology

1. Assessment Methods
2. Weighted Criteria
3. Program Outcomes, Objectives, Performance Criteria, and Measurement
4. Improvement Process
5. Departmental Roles
6. Time Table
7. Assessment Instruments (survey forms)
Program of Self-Study For Chemical Engineering
Description of Assessment Methodology

1. Assessment Methods

Assessment methods are ways to gather evidence demonstrating that those outcomes important to the missions and educational objectives are being measured, i.e., outcomes indicators. The following items outline the methods used to collect evidence of desired outcomes as suggested by ABET as well as those selected by this department.

Some of the program outcomes can be measured using “devices” administered by the department; others depend on external assessment. In addition, some program outcomes can be assessed using direct measures while others will probably have to be inferred by observing student behaviors or by indirect measures such as student self-reporting.

The assessment methods listed below were selected for use in this department when the plan was established in 1997. During the past five assessment cycles, some modifications have been made to the original plan. The original and current plan is discussed. A description of each item’s process is outlined on the following pages. Copies of the assessment forms are presented in Appendix III-2.7.

1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
2. Portfolios
4. Alumni Surveys
5. Employer/Recruiter Surveys
6. Placement Data/Exit Interviews
7. Course Evaluations
8. Co-op
   A. Supervisor Surveys
   B. Student Assessment

The following matrix shows which goals are addressed by which assessment methods.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Design: faculty</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior Design: peer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portfolios</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FE Exam</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alumni Surveys</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Recruiter/Employer Surveys</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### 1) Senior Design Projects

This is one of the most important elements of the assessment plan because capstone senior design projects are used to evaluate the students’ comprehensive technical knowledge gained in this undergraduate program.

There are two parts to this assessment method. The first involves faculty assessment of student learning and the second involves student assessment of fellow student learning. Every year, the faculty will review final design projects to assess whether there are any across the board weaknesses. Projects will be evaluated independently of course grades. The following goals will be addressed by the faculty ratings: C, D, E, G, K, L, M and N. Ratings on the whole must demonstrate that the students met or exceeded the standards for these criteria on the following scale: Unsatisfactory, Needs Improvement, Meets Standards, or Exceeds Standards. The assessment form is given in Section III.2.7 The evaluation will include ratings for the reports in the following areas:

- **Communication skills:**
  - Mechanics (grammar, spelling, style, punctuation, use of references)
  - Appropriate for audience (detail, technical level)
  - Organization
  - Use of graphics (tables, diagrams, figures, pictures)
- **Content:**
  - Arguments and appropriate conclusions/recommendations
  - Issues of health, safety, and the environment
  - Meets project minimum criteria (two different separations, a chemical reaction, and necessary economic analysis)

The faculty assessment is currently being used as was established in 1997.

In addition to the faculty assessment component, each student will complete a peer-assessment of each of the members of his or her team at the end of each semester in which senior design is offered. A copy appears in Section III.2.7. The rating form information is not used to determine any student’s grade. Rather the information is gathered to provide another source of assessment of student outcomes from the students’ points of view. All goals will be addressed by the student ratings. The desired outcome is an average score of 3.0 or above for each criterion.

### 2) Portfolio Assessment

When established in 1997, the faculty determined which goals are best addressed by portfolios. Then, they determined which class(es) best address those goals. They also determined which
items will be collected to be included in the portfolio assessment. Finally, a stratified random sample of work from those classes, such as finals exams, will be selected each time student work is collected.

Portfolio assessment were to be conducted at the end of each calendar year and represent the graduating class from each (e.g., the class of 1998). Each portfolio was to be comprised of a total of 24 items with six samples of each of the four items kept: one representing an exceptional performance, four representing an average performance, and one representing a poor performance. The faculty member teaching each of the courses from which the samples were taken selected the samples. Listed below is a summary of the criteria/goals that to be assessed from each item. In faculty review of student portfolios, ratings of portfolios on the whole demonstrate evidence of the stated corresponding criteria such that students must meet or exceed standards on the following scale: Unsatisfactory, Needs Improvement, Meets Standards, or Exceeds Standards. A rubric was also created to assist the faculty in assessment efforts.

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria/Goals Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>431 Lab IV final reports</td>
<td>A, B, G, K</td>
</tr>
<tr>
<td>421 Reactor Design final exams</td>
<td>A, E</td>
</tr>
<tr>
<td>405 Separations (final) homework assignments</td>
<td>A, E</td>
</tr>
<tr>
<td>412 Plant Design oral presentations</td>
<td>G</td>
</tr>
</tbody>
</table>

Portfolios were used for the first four assessment periods. Faculty did not feel the original form allowed for a good assessment. The form was revised after the second assessment period and used for the next assessment. After using the new form for two assessment periods, the faculty decided to discontinue the use of portfolios in the assessment process. It was felt that the portfolios were more a measure of the faculty’s ability to write effective tests and homework than the outcomes of our students. Also, the plant design presentations are a factor of the faculty’s assessment of senior design.

The use of portfolios was discontinued beginning with the 2001-2002 assessment period.

3) Nationally-normed Examinations

The faculty and student representatives have selected the Fundamentals of Engineering (FE) exam to assess student outcomes because it is believed to provide the best nationally-normed assessment of student learning in the field of engineering. In addition, the numbers of students in this department who take other nationally-normed examinations such as the GRE are typically very small, and, therefore, not representative of the population. Students will be strongly encouraged to take the FE exam during their senior year, either in the fall or the spring. Typically, at least half of the students eligible to take the exam have elected to take it. The School of Engineering and Mines offers review sessions for the 12 parts of the exam. Chemical engineering faculty members have historically been involved in leading one or multiple review sessions.
Data, starting with the spring of 1987, have been obtained from the School of Engineering and Mines and are stored in a spreadsheet for longitudinal comparison. The database will be updated after each report is received. The numbers of UND chemical engineering students taking, passing, and failing each exam are recorded. The department will also monitor the percentage of eligible students electing to take each exam. National pass rates for all test takers as well as chemical engineering majors are recorded and compared with those of the Department of Chemical Engineering at UND.

The FE exam pass rates will be used to measure performance in three major goal areas: A=an ability to apply knowledge of mathematics, science, and engineering, E=an ability to identify, formulate, and solve engineering problems, and I=a recognition for, and an ability to engage in life-long learning. In addition, student performance on three parts of the FE will be monitored for three corresponding goals: ethics for F=an understanding of professional and ethical responsibility, economics for M=experience in engineering economics, and chemistry for N=AIChE (grounding in chemistry).

A pass rate of 80% on the overall exam has been set as a desired outcome for this measure. A pass rate that is equal to or above the national pass rate for chemical engineers has been set for the minimum acceptable outcome. In regards to performance on the three subset areas, a score that is equal to or above the national average score for chemical engineers has been set for the desired outcome.

This tool is still used as originally designed.

4) Alumni Surveys

The alumni survey provides the faculty with an external perspective. The survey asks for responses that document professional accomplishments and career development activities as well as assessment of learning while in the program. The assessment form is presented in Section III.2.7. Two groups will be surveyed each year to gain longitudinal data: one year out and three years out. For example, in August 1998, the 1997 and 1995 graduates will be surveyed.

This particular assessment tool will be used to assess all goals stipulated by this department. However, each goal has been assigned a weight based on its relative priority in the improvement process. A different level of agreement or strong agreement will be used in this manner. [The initial assessment plan was developed with the following as the desired outcome.]

At least 80% of students will agree or strongly agree that the department met or achieved the criteria for:
A=an ability to apply knowledge of mathematics, science, and engineering
B=an ability to design and conduct experiments, as well as to analyze and interpret data
C=an ability to design a system, component, or process to meet desired needs
E=an ability to identify, formulate, and solve engineering problems
G=an ability to communicate effectively
At least 65% of students will agree or strongly agree that the department met or achieved the criteria for:
D=an ability to function on a multi-disciplinary and/or diverse team
F=an understanding of professional and ethical responsibility
K=an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
L=experience in undergraduate research and engineering in practice
M=an understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving
N=(as submitted by AIChE) a thorough grounding in chemistry and engineering topics, including safety and environmental aspects

At least 50% of students will agree or strongly agree that the department met or achieved the criteria for:
H=the broad education necessary to understand the impact of engineering solutions in global and societal context
I=a recognition of the need for, and an ability to engage in life-long learning
J=a knowledge of contemporary issues of relevance to the field of chemical engineering

We currently use the alumni form devised by the faculty in 1997. We have changed how we interpret the data. The scores of all surveys for a given year are averaged to obtain a mean value for “education received” and “importance to degree”. Two criteria were established. To meet our standards, the mean value for “education received” must by 3.5 higher (on a scale of 1 to 5 with 5 being strongly agree), and, the mean value for “education received” must be no more than 0.5 less than “importance to degree”.

5) Employer Surveys

Employers of our graduates will receive a survey asking them to rate our graduates and our program. A copy of the form appears in the appendix. We emphasize that we need their assistance in offering the kind of curriculum that will produce graduates with the knowledge, skills, and abilities they need in their company. All goals will be addressed with this assessment tool. In employer surveys, ratings of students on the whole will demonstrate evidence of the stated corresponding criteria such that employers will indicate that graduates of the program met or exceeded their standards. To meet our standards, the mean value for “graduate demonstration of” must by 3.5 or higher (on a scale of 1 to 5 with 5 being strongly agree), and, the mean value for “graduate demonstration” must be no more than 0.5 less than “employer significance”.

Our original assessment plan also included recruiter surveys. Very few recruiters completed the surveys. We have discontinued the use of recruiter surveys. We also changed how we implement the employer surveys. Originally, the surveys were sent to the Human Relations Department of the employers company. We received one survey for the two-year span 1999-2001. Starting with 2002, surveys were sent to the alumni with the alumni survey. Our alumni were asked to hand deliver them to their immediate supervisor. Using this method, our return rate was approximately 50%.
6) Placement Data/Exit Interview

This department concurs that placement data are not the best means of assessing any of the ABET student outcomes. However, these data can provide valuable program information. Thus, two distinct exit interviews will be used. For graduates of the program, a written questionnaire issued during a senior plant design class period will be used (see Section III.2.7) [this is now administered by the chair separate from plant design since a significant number of students in plant design may graduate in August or December]. The department chair will also conduct a focus group with graduating seniors at the end of each semester that will complement the survey. Starting in 2002, the dean also began conducting face-to-face interviews with the graduating seniors. Ratings on the whole will demonstrate evidence of the stated corresponding criteria such that students will indicate “agree” and “strongly agree” on the following scale: Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree. Special attention will be given to items mentioned in the questionnaire asking for suggestions on what the department could do to improve the program. To meet our standards, the mean value for “education provided you with the ability to” must by 3.5 or higher (on a scale of 1 to 5 with 5 being strongly agree), and, the mean value for “education provided” must be no more than 0.5 less than “in achieving your professional goals.”

For students who leave the program without graduating, a brief survey will be sent to the student upon notice that the student has withdrawn from the chemical engineering program (see appendix). Special attention will be given to items mentioned in the question asking for suggestions on what the department could have done to prevent the student from leaving the department.

7) Student Evaluations

The UND student evaluation form is given to all students in each chemical engineering course at the end of each semester. In addition, questions asking whether criteria A (an ability to apply knowledge of mathematics, science, and engineering), C (an ability to design a system, component, or process to meet desired needs), and E (an ability to identify, formulate, and solve engineering problems) were achieved through this class are added to the form as numbers 18, 19, and 20 for the following classes:

- 306 Unit Operations
- 405 Mass Transfer
- 408 Process Control
- 412 Senior Plant Design
- 421 Reactor Design (Kinetics)

Results are tabulated and returned to the department chair for distribution to the appropriate faculty member. Each faculty member also reviews the semester evaluations with the department chair. Student evaluations of each class each semester are analyzed and changes in teaching style, course syllabus, and/or curriculum are made as warranted. The three criteria listed above, A, C, and E, will be analyzed by the faculty as a whole. The faculty have elected to
set the desired outcome for the goals A, C, and E as an average score of 3.5 or greater. [Student evaluation scores must be adjusted to account for the different numbering system. The evaluation forms list 1 as strongly agree and 5 as strongly disagree. To keep consistent with the rest of our evaluation numbers, evaluation scores are converted to a scale of 5 = strongly agree and 1 = strongly disagree.]

8) Co-op Supervisor Assessment

Co-op students have two types of assessments. The first is an employer evaluation, which is monitored each semester by the Co-op advisor. A copy of the evaluation form appears in Section III.2.7. These reports become part of a student’s departmental file. Starting in 2002, the department began asking co-op supervisors to fill out an additional survey relating the student’s performance to a-n outcomes. To meet our standards, the mean value for “student demonstrated ability” must by 3.5 or higher (on a scale of 1 to 5 with 5 being strongly agree), and, the mean value for “demonstrated ability” must be no more than 0.5 less employee rated significance”.

The second is a student written report, in which the student evaluates his or her experience as it relates to his or her education so far. These reports are collected throughout the year, but evaluated once each year for assessment purposes. Typical reports range from 3 to 5 pages, not including appendices. The report summarizes the student’s work experience and discusses in detail some educational aspect of the experience. The report should strive to demonstrate how the educational experience has prepared them for co-op and how co-op has affected their education. All goals will be addressed by this criteria. In co-op supervisor review of students, ratings on the whole will demonstrate evidence of the stated corresponding criteria will indicated that students have met or exceeded standards on the following scale: Unsatisfactory, Needs Improvement, Meets Standards, or Exceeds Standards. The desired outcome is all rankings of met or exceeded standards.

2 Weighted Criteria

When this plan was developed in 1997, the chemical engineering faculty, student representatives and the assessment consultant determined that, while all ABET criteria are very important and valued in this program, some are perceived as being vital and deserve the greatest attention. Thus, the following weighting system was developed to help the faculty determine the priorities for the improvement process.

3 = A weighting of 3 suggests that student inadequacy in this criterion may prevent the student from obtaining the Bachelor of Science in Chemical Engineering degree. If the desired outcomes are not met for these criteria, the department will give improvement in these areas the highest priority. Criteria A, B, C, E, and G have been given a weighting of 3 which means that these five criteria are considered to be the most important goals for this department.

A=an ability to apply knowledge of mathematics, science, and engineering
B=an ability to design and conduct experiments, as well as to analyze and interpret data
C=an ability to design a system, component, or process to meet desired needs
E = an ability to identify, formulate, and solve engineering problems
G = an ability to communicate effectively

2 = A weighting of 2 suggests that student inadequacy in this criterion may prevent the student from obtaining desirable or even passing grades in a particular class or knowledge/skill/ability area. Criteria D, F, K, L, M, and N have been given a weighting of 2 which means that these three criteria are considered important and deficiencies will be addressed.
   D = an ability to function on a multi-disciplinary and/or diverse team
   F = an understanding of professional and ethical responsibility
   K = an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
   L = experience in undergraduate research and engineering in practice
   M = an understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving
   N = (as submitted by AIChE) a thorough grounding in chemistry and engineering topics, including safety and environmental aspects

1 = A weighting of 1 suggests that student inadequacy in this criterion is undesirable and will be addressed, but these goals are not seen as part of the primary mission of this department. Criteria H, I, and J have been given a weighting of 1 which means that these items are of a lower relative priority than the other goals. These goals are also being addressed outside the chemical engineering department through the broad liberal arts education offered at this institution. The faculty do occasionally work with the faculty who teach these courses to offer classes that address the needs of engineering students. In addition, the UND Assessment Committee is continually striving to meet these goals and provides feedback on performance.
   H = the broad education necessary to understand the impact of engineering solutions in global and societal context
   I = a recognition of the need for, and an ability to engage in life-long learning
   J = a knowledge of contemporary issues of relevance to the field of chemical engineering

3 Outcomes, Objectives, Performance Criteria, and Evaluation

This section is one of the core components of our assessment plan because it states very specifically the outcomes, objectives, performance criteria, and Evaluation for this educational program. Each of the parts is defined and outlined below.

Outcomes
Outcomes describe the broad outcomes desired by this department. They are far-reaching ideals and describe the best situation that could be desired. A outcome is a general statement of achievement.

Objectives
Objectives are derived from the outcomes and define the circumstances by which it will be known if the desired change has occurred. These objectives are precise in stating:
   - expected change
- how the change should be manifested
- the expected level of change
- the time period over which the change is expected

Performance Criteria
Performance criteria are specific statements identifying level of performance required to meet the objectives. They are confirmable through evidence or indicators.

Evaluation
An outcome is a result of an activity such as an educational experience. The outcomes of a college education are the sum total of all knowledge, skills, and values developed over the course of the undergraduate experience, both inside and outside of class. Outcomes can be measured by developing statements that will help us determine if we have achieved the particular objectives and performance criteria for each outcome. These statements relate directly to evidence gathered through our assessment methods.
Outcome A: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to apply knowledge of mathematics, science, and engineering.

Objective 1) Students will demonstrate the ability to apply mathematical, scientific, and engineering principles to both familiar and unfamiliar problems.

Performance Criteria: Student(s) will
1) Formulate appropriate solution strategies
2) Identify relevant principles, equations, and data
3) Systematically execute the solution strategy
4) Apply engineering judgment to evaluate answers

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
2. Portfolios
4. Alumni Surveys
5. Employer/Recruiter Surveys
6. Placement Data/Exit Interviews
7. Course Evaluations
8. Co-op
   A. Supervisor Surveys
   B. Student Assessment

Objective 2) Our students and alumni will continue to demonstrate the ability to apply mathematical, scientific, and engineering principles to both familiar and unfamiliar problems beyond the classroom.

Performance Criteria: Student(s) will
1) Formulate appropriate solution strategies
2) Identify relevant principles, equations, and data
3) Systematically execute the solution strategy
4) Apply engineering judgment to evaluate answers

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
2. Portfolios
4. Alumni Surveys
5. Employer/Recruiter Surveys
6. Placement Data/Exit Interviews
7. Course Evaluations
8. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome B: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design and conduct experiments, as well as to analyze and interpret data.

Objective 1) When working on tasks and assignments requiring the acquisition of experimental evidence or results, students will make appropriate measurements, record information in a meaningful format, perform the analyses necessary to relate system variables, and convey an interpretation of the results to an appropriate audience.

Performance Criteria: Student(s) will
1) Prepare a laboratory report with technical content appropriate to the audience
2) Present summarized results based on analysis of the measurements
3) Describe in sufficient detail the experimental procedure used in obtaining the measurements
4) Not include uninterpreted measurements as results
5) Apply proper laboratory techniques insuring the health and safety of themselves and the environment
6) Include an estimation of the error of their measurements

Objective 2) When working on tasks and assignments requiring the acquisition of experimental evidence or results, students will synthesize, based on the analysis of system variables, relationships between derived quantities.

Performance Criteria: Student(s) will
1) Describe synthesis results in the laboratory report
2) Demonstrate known relationships (or derive empirical relationships) between the analyzed quantities resulting from the measured variables

Objective 3) When assigned a task requiring experimental evidence, students will develop an experimental design that effectively uses limited resources while obtaining the necessary information.

Performance Criteria: Student(s) will
1) Identify all meaningful variables
2) Determine the relative importance of the variables
3) Decide how many variables are important by balancing the given resources and time with the needed information
4) Determine how to measure these variables
5) Analyze and synthesize the results to obtain the required information
6) Include statistically designed experiments when developing experiments

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
2. Portfolios
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome C: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to design a system, component, or process to meet desired needs.

Objective 1) Students will be able to select a component that is the appropriate size and type.
Performance Criteria: Student(s) will
  1) Size and design different components that would be useful in carrying out process(es)

Objective 2) Students will be able to design a process consisting of operations that transform raw materials into desired products.
Performance Criteria: Student(s) will
  1) apply fundamental principles of chemical engineering to problems involving mass and energy balances to reaction kinetics, thermodynamics, momentum and heat transfer, mass transfer, dynamics, and control of processes
  2) Integrate design of various components into a process

Objective 3) Students will be able to design a system by grouping appropriate processes to transform raw materials into desired products.
Performance Criteria: Student(s) will
  1) Integrate design of various components into a process, and various processes into a system
  2) Conduct a market survey
  3) Select an appropriate plant site for the system
  4) Layout a plant
  5) Select instrumentation
  6) Conduct economic feasibility study

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
  1. Senior Design Projects
     A. Faculty Assessment
     B. Peer Assessment
  2. Alumni Surveys
  3. Employer/Recruiter Surveys
  4. Placement Data/Exit Interviews
  5. Course Evaluations
  6. Co-op
     A. Supervisor Surveys
     B. Student Assessment
Outcome D: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to function on multi-disciplinary teams.

Objective 1) Through fundamental chemistry and physics laboratories, humanities courses, and extracurricular activities including Sunrayce, Skunkworks, and E-council, students will exhibit an ability to function on multi-disciplinary teams.

Performance Criteria: Student(s) will:
   1) interact synergistically with people from other disciplines to achieve a common goal
   2) utilize the different skills and abilities of their team members

Evaluation:
   Students will meet or exceed standards as set for each of the following assessment methods.
   1. Senior Design Projects
      A. Faculty Assessment
      B. Peer Assessment
   2. Alumni Surveys
   3. Employer/Recruiter Surveys
   4. Placement Data/Exit Interviews
   5. Co-op
      A. Supervisor Surveys
      B. Student Assessment
Outcome E: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to identify, formulate, and solve engineering problems.

Objective 1) In classroom and laboratory activities, students will identify known variables, unknown variables, and the relationships between them.

Performance Criteria: Student(s) will:
1) Correctly formulate solutions and solve word problems on exams
2) Prepare adequate laboratory reports

Objective 2) In classroom and laboratory activities, students will be able to discern extraneous from essential information, and be able to identify when essential information is missing.

Performance Criteria: Student(s) will:
1) Correctly formulate solutions and solve word problems on exams
2) Prepare adequate laboratory reports

Objective 3) Students will be able to formulate and solve problems in technical areas or in technologies in which they have not received formal instruction.

Performance Criteria: Student(s) will:
1) Prepare adequate laboratory reports
2) Pass the Fundamentals of Engineering Exam

Objective 4) In all their engineering studies, students will be able to reflect on the reasonableness of their problem solutions.

Performance Criteria: Student(s) will:
1) Prepare adequate laboratory reports
2) Prepare adequate senior design reports

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
2. Portfolios
4. Alumni Surveys
5. Employer/Recruiter Surveys
6. Placement Data/Exit Interviews
7. Course Evaluations
8. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome F: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of professional and ethical responsibility.

Objective 1) Upon completion of their degrees, students will take deep pride in the profession of chemical engineering and to it owe solemn obligations of integrity and high ethical principles in applying technology and engineering principles.

Performance Criteria: Student(s) will:
1) Demonstrate an understanding of the professional obligations such as those outlined in the order of the engineer ceremony
2) Practice integrity and fair dealing, tolerance and respect
3) Uphold devotion to the standards and the dignity of the profession of chemical engineering

Objective 2) When faced with an ethical dilemma, students will be able to link and apply reasoning strategies from the theories and principles of ethics and chemical engineering, and to take ethical responsibility by demonstrating an understanding of the limits of knowledge and safety.

Performance Criteria: Student(s) will:
1) Demonstrate an understanding of ethical issues in the field of chemical engineering
2) Demonstrate knowledge of engineering ethics codes
3) Demonstrate knowledge of ethics theory
4) Participate in none but honest enterprises
5) Make informed ethical choices

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome G: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to communicate effectively.

**Objective 1)** Through multiple opportunities to speak formally and receive feedback when engaged in presenting a technical report to an audience of peers and faculty, the student will exhibit good speaking skills and good listening skills at a professional level.

**Performance Criteria:** Student(s) will:

1) provide an introduction that grabs attention and orients the audience
2) provide a body that is relevant, covers important points, and is complete
3) provide a summary with conclusions and recommendations
4) show enthusiasm
5) speak loud enough and clearly
6) use proper syntax and grammar
7) maintain eye contact and not read from notes
8) answer questions politely, accurately, and completely
9) use appropriate visual aids to communicate (neat, not too crowded, error-free)
10) give a presentation that is appropriate for the specified audience in terms of technical content
11) convey key points clearly and succinctly

**Objective 2)** Through multiple written assignments, by graduation, students will exhibit good written communication skills at a professional level.

**Performance Criteria:** Student(s) will:

1) provide an introduction that grabs attention and orients the reader
2) provide a body that is relevant, covers important points, and is complete
3) provide a summary with conclusions and recommendations
4) use proper syntax and grammar
5) write appropriately for the specified reader in terms of technical content
6) convey key points clearly and succinctly

**Evaluation:**

Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
2. Portfolios
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome H: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have the broad education necessary to understand the impact of engineering solutions in a global/societal context.

Objective 1) By taking a series of required general education courses and through discussion in chemical engineering classes, students will be aware of how the practice of chemical engineering impacts other disciplines and factors in society.

Performance Criteria: Student(s) will:

1) Demonstrate an understanding of energy and the environment as these areas relate to chemical engineering
2) Demonstrate an understanding of health and medicine as these areas relate to chemical engineering
3) Demonstrate an understanding of business and economics as these areas relate to chemical engineering
4) Demonstrate an understanding of government, law, and public/organizational policies as these areas relate to chemical engineering

Evaluation:

Students will meet or exceed standards as set for each of the following assessment methods.

1. Senior Design Projects
   A. Peer Assessment
2. Alumni Surveys
3. Employer/Recruiter Surveys
4. Placement Data/Exit Interviews
5. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome I: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a recognition of the need for and an ability to engage in life-long learning.

Objective 1) Students will have an awareness of the technical literature (journals, professional news magazines, trade publications, etc.) and have the ability to find desired information.

Performance Criteria: Alumni will:
1) Be actively engaged in any of the following: attending a continuing education program, attending a technical conference, registered for professional or technical membership (e.g., AIChE), or pursuing registration as a professional engineer

Objective 2) Students will utilize information and perspectives from archival and contemporary technical literature for open ended laboratory exercises and engineering design experiences.

Performance Criteria: Student(s) will:
1) Correctly compare experimental results to results published in the technical literature and is able to accurately describe the differences

Objective 3) Students will demonstrate that they are ‘computer literate.’

Performance Criteria: Student(s) will:
1) Use a computer as a tool for completing assigned projects

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome J: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a knowledge of contemporary issues in the field of chemical engineering.

Objective 1) Students will have an awareness of the technical literature (journals, professional news magazines, trade publications, etc.) and have the ability to find desired information.

Performance Criteria: Alumni will:
1) Be actively engaged in any of the following: attending a continuing education program, attending a technical conference, registered for professional or technical membership (e.g., AIChE), or pursuing registration as a professional engineer

Objective 2) Students will utilize information and perspectives from archival and contemporary technical literature for open ended laboratory exercises and engineering design experiences.

Performance Criteria: Student(s) will:
1) Correctly compare experimental results to results published in the technical literature and are able to accurately describe the differences

Objective 3) Students will demonstrate that they are ‘computer literate.’

Performance Criteria: Student(s) will:
1) Use a computer as a tool for completing assigned projects

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Peer Assessment
2. Portfolios
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Course Evaluations
7. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome K: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

Objective 1) Through projects, assignments, and examinations, the student will be presented with the opportunity to use and develop the necessary problem solving techniques and skill to practice engineering at a professional level.

Performance Criteria: Student(s) will:
1) Students will apply fundamental principles of chemical engineering to problems involving mass and energy balances

Objective 2) The student will be able to use computers, appropriate software packages, and other modern engineering tools to aid the problem solving process.

Performance Criteria: Student(s) will:
1) Students will use word processors in writing reports, spreadsheets to perform calculations and present data in tabular and graphical form, and other tools to analyze and solve engineering problems

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
2. Portfolios
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome L: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have experience in undergraduate research and engineering in practice.

Objective 1) Through laboratory experiences and undergraduate research opportunities, students will gain experience in research principles and practices.

Performance Criteria: Student(s) will:
1) design and execute effective experimental or process simulation plans
2) identify and acquire necessary data
3) analyze and critically interpret results
4) form valid conclusions and make recommendations

Objective 2) Through coop experience, senior plant design and the undergraduate laboratory sequence students will gain experience in engineering in practice.

Performance Criteria: Student(s) will:
1) actively participate in the design of a chemical engineering plant involving a reactor and unit operations
2) utilize engineering equipment
3) evaluate solutions to complex engineering problems
4) interact synergistically in a professional capacity with other engineers

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
2. Alumni Surveys
3. Employer/Recruiter Surveys
4. Placement Data/Exit Interviews
5. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome M: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have an understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving.

Objective 1) Students and alumni will be able to determine the economic impact of engineering decisions and make recommendations based on this impact, even beyond the classroom.

Performance Criteria: Students(s) will
1) Demonstrate an awareness of economic factors
2) Calculate relevant economic parameters
3) Use accepted economic practice to evaluate alternatives
4) Make recommendations incorporating economics as an important criterion

Evaluation:
Students will meet or exceed standards as set for each of the following assessment methods.
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
Outcome N: The Department of Chemical Engineering at the University of North Dakota will produce graduates who have a working knowledge in organic, inorganic and physical chemistry and a background in other advanced chemistry topics as selected by the individual student.

Objective 1) Students will be conversant with the nomenclature commonly used to describe chemical compounds, reactions, operations and processes.

Performance Criteria: Student(s) will:
1) Solve homework and examination problems
2) Conduct laboratory exercises and prepare written reports
3) Complete the capstone design project

Objective 2) Students will be able to balance chemical equations, formulate and solve problems and conduct laboratory exercises, and prepare written materials that convey their background and knowledge of chemistry.

Performance Criteria: Student(s) will:
1) Solve homework and examination problems
2) Conduct laboratory exercises and prepare written reports
3) Complete the capstone design project

Evaluation:
1. Senior Design Projects
   A. Faculty Assessment
   B. Peer Assessment
3. Alumni Surveys
4. Employer/Recruiter Surveys
5. Placement Data/Exit Interviews
6. Co-op
   A. Supervisor Surveys
   B. Student Assessment
4 Improvement Process

Once assessment has been conducted, the faculty will use this improvement process.

Step #1: Review assessment results. If an assessment result indicates that no change is required for practices related to a particular criterion, they will so document “no change required.” If the faculty finds a deficiency in an indicator, they will proceed to step #2.

Step #2: The faculty will determine whether the indicators are accurate. If not, the faculty stop the improvement process and reassess or disregard the finding by indicating no change required. If the indicator is found to be accurate, proceed to step #3.

Step #3: The faculty will determine possible causes for a deficiency. Proceed to step #4.

Step #4: The faculty will determine the severity of a deficiency in terms of how serious it is and the scope (how many Outcomes are affected). Proceed to step #5.

Step #5: The faculty will select one or more of the following strategies depending on what was determined in the previous step.

Strategies:
* modify “unwritten” department policies or recommendations
* modify one or more assessment methods or instruments
* modify one or more Outcomes, objectives, performance criteria, or Evaluation
* modify a class or sequence of classes
* modify departmental policies
* modify professional development to include additional training
* modify faculty advising
* modify mission statement
* modify admissions policy
* modify faculty practice
* modify curriculum
* modify faculty workload
* modify number of faculty

5 Departmental Roles in Assessment Activities

The assessment coordinator is responsible for data collection. He will ensure that the data for the assessment tools are collected at the designated times and are properly stored. A typed summary and a statistical presentation of the data, if applicable, will be prepared for all data collected through assessment methods. All assessment data will be stored in file cabinets in room 314. Prior to the annual assessment period, the ABET coordinator will conduct a preliminary review of the data and be prepared to lead the rest of the group in an analytical discussion of those particular data.

Individual faculty are responsible for portfolios, senior design projects and course evaluations. Portfolios: The faculty members teaching Lab. IV, Kinetics, or Mass Transfer will collect the necessary samples (portfolios were discontinued for 2001-02). Senior Design Projects: The peer
assessment tool will be given to students during a plant design meeting period, and faculty will conduct the faculty assessment portion as part of their reading of the projects. Course evaluations: the department chair and faculty will review all course evaluations, and faculty who are teaching Unit Operations, Mass Transfer, Process Control, or Kinetics will ensure that the three additional assessment items are included. In addition, faculty will collect appropriate samples from senior design projects for the portfolios and ensure that the three additional assessment items are included in the course evaluations.

**Administrative Assistant:**
Assist coordinators with any duplicating, mailing, receiving or data entry of instruments

**ABET Coordinator:**
Nationally-normed Exam: Fundamentals of Engineering
Alumni Surveys
Employer Surveys

**All Chemical Engineering Faculty:**
Review Senior Design Projects
Coordinate Peer Assessment in Senior Design
Distribute three additional assessment items on Course Evaluations, if applicable

**Chair:**
New Student Surveys (now used as a recruiting tool)
Exit Interviews (Graduates and Non-Graduates)

**Co-op Coordinator:**
Co-op Supervisor Surveys and Co-op Student Assessment Reports

6 **Timeline: Assessment Activities**

The faculty has set aside time in May or June after the spring semester to review all assessment data from the year just completed (Summer, Fall, and Spring) and make any changes. The following is a schedule of data collection. If the outcomes are met or exceeded, the faculty may elect to stagger collection times in subsequent years. If an outcome is not met or if a change that impacts data collection is made, the regular schedule will be followed.

**Summer Semester:**
* (early) select samples for portfolios from Spring semester course, 412 Senior Design
* (middle) record spring FE exam results
* (middle) record course evaluations, including the three assessment questions for 306 Unit Operations and 412 Senior Design, from Spring semester;
Review course evaluations on an individual basis and with department chair
* (late) survey alumni from 1 year (i.e., previous calendar year) and 3 years out (previous calendar minus two calendar years)
* (late) collect student placement/exit interview data from Summer graduates
* (late) collect co-op supervisor surveys and student written reports on co-op
* (late or when applicable) give recruiter/employer surveys to on-campus recruiters
Fall Semester:
* (early) administer new student survey
* (middle) record course evaluations from Summer semester; Review course evaluations on an individual basis and with department chair
* (late) administer 3 assessment questions as part of course evaluations in 405 Mass Transfer, 408 Process Control, and 421 Kinetics
* (late) collect student placement/exit data from December graduates
* (late) collect co-op supervisor surveys and student written reports on co-op
* (late or when applicable) give recruiter/employer surveys to on-campus recruiters

Spring Semester:
* (early) select samples for portfolios from Fall semester courses - 431 Lab IV, 421 Kinetics, and 405 Mass Transfer
* (middle) record course evaluations, including the 3 assessment questions for 405 Mass Transfer, 408 Process Control, and 421 Kinetics, from Fall semester; Review course evaluations on an individual basis and with department chair
* (middle) record fall FE exam results
* (late) administer 3 assessment questions as part of course evaluations in 306 Unit Operations and 412 Senior Design
* (late) collect student placement/exit data from Spring graduates
* (late) senior design assessment: peers
* (late) senior design assessment: faculty
* (late) collect co-op supervisor surveys and student written reports on co-op
  • (late or when applicable) give recruiter/employer surveys to on-campus recruiters

7 Assessment Instruments

The instruments used as a part of the annual assessment are presented in this section.
Peer-Assessment for Senior Plant Design (ChE 412)

The Department of Chemical Engineering is gathering information as part of its on-going assessment plan. Please complete one of these sheets on each of your fellow team members and return the sheets in a sealed envelope to Fern Wood. You do not need to include your name or your team members’ names on this form. All information will be kept confidential and will not impact anyone’s grade. Therefore, please give a thoughtful and honest assessment.

Please rate your team member on each of the following attributes on a scale from 1-5. Circle the number that best describes your assessment of your team member in these areas. If you cannot provide a rating, please leave the item blank. If you would like to provide any additional comments related to this team member or these attributes, please do so at the bottom or on the back of this form. Thank you!

<table>
<thead>
<tr>
<th></th>
<th>1 - Poor</th>
<th>2 - Below Average</th>
<th>3 - Average</th>
<th>4 - Above Average</th>
<th>5 - Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ability to apply knowledge of mathematics, science and engineering</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>B. Ability to design and conduct experiments, as well as to analyze and interpret data</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>C. Ability to design a system, component, or process to meet desired needs</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tr>
<tr>
<td>D. Ability to function on multi-disciplinary and/or diverse teams</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>E. Ability to identify, formulate, and solve engineering problems</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>F. Understanding of professional and ethical responsibility</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>G. Ability to communicate effectively</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>H. Understand the impact of engineering solutions in a global and societal context</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I. Recognize the need for, and an ability to engage in life-long learning</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>J. Knowledge of contemporary issues of relevance to the field of Chemical Engineering</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>L. Experience in undergraduate research and engineering in practice</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>M. An understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>N. A thorough grounding in chemistry and engineering topics, including safety and environmental aspects</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Comments:
Faculty Assessment Form for Senior Plant Design (ChE 412)

Team Name: _______________________________ Date: _______________
Project: ________________________________

1=Unsatisfactory  2=Needs Improvement  3=Meets Standards  4=Exceeds Standards

Communication skills:
__ Mechanics (grammar, spelling, style, punctuation, use of references)
__ Appropriate for audience (detail, technical level)
__ Organization
__ Use of graphics (tables, diagrams, figures, pictures)

Content:
__ Arguments and appropriate conclusions/recommendations
__ Issues of health, safety, and the environment
__ Meets project minimum criteria (two different separations, a chemical reaction, and necessary economic analysis)

Team=s demonstrated abilities:

C. Ability to design a system, component, or process to meet desired needs 1 2 3 4

D. Ability to function on multi-disciplinary and/or diverse teams 1 2 3 4

E. Ability to identify, formulate, and solve engineering problems 1 2 3 4

G. Ability to communicate effectively 1 2 3 4

K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice 1 2 3 4

L. Experience in undergraduate research and engineering in practice 1 2 3 4

M. An understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving 1 2 3 4

N. A thorough grounding in chemistry and engineering topics, including safety and environmental aspects 1 2 3 4
The UND Department of Chemical Engineering -- Alumni Survey

The Department of Chemical Engineering is interested in gathering data about our graduates as part of our assessment plan. Please take a few minutes to complete this survey and return it in the postage paid envelope provided for you.

1. When did you graduate from UND? (month, year) ________________________________

2. Please indicate your present status:
   _____ Employed in engineering       _____ Graduate student
   _____ Employed, but not in engineering   _____ Not employed and not a student

3. If employed, current job title: ________________________________________________________________

4. If employed, current employer name: ________________________________________________________________

5. If a graduate student, degree and field sought: ________________________________________________________________

6. If a graduate student, graduate school name: ________________________________________________________________

7. If employed as an engineer, check the types of engineering work you do:
   _____ Research       _____ Technical Support       _____ Teaching
   _____ Marketing       _____ Training       _____ Sales
   _____ Development       _____ Project Engineering       _____ Manufacturing
   _____ Management       _____ Other: ________________________________________________________________

8. If employed in engineering, how do you rate the quality of your educational preparation to be an engineer?
   _____ Far higher than average
   _____ Higher than average
   _____ Average
   _____ Lower than average
   _____ Far lower than average

   Using the following scale, please rate the following items 9-13 -- (1=weak to 5=strong)

9. Overall quality of your UND chemical engineering classes.  1  2  3  4  5

10. Overall quality of your UND chemical engineering laboratory sequence.  1  2  3  4  5

11. Overall quality of your UND general education classes.  1  2  3  4  5

12. Overall quality of the UND chemical engineering faculty.  1  2  3  4  5

13. If you participated in the co-op program, please rate the overall quality of your experience.  1  2  3  4  5

14. Please identify the area or areas of the chemical engineering curriculum that contributed most to your professional development.

15. Please identify the area or areas of the chemical engineering curriculum that contributed least to your professional development. Please indicate how you would modify these.
16. What could we have done to improve your educational experience?

17. Rate the following outcomes based on their importance to achieving your professional goals as well as our effectiveness at providing you with what you needed to demonstrate that you have these abilities.

1=Strongly Disagree  2=Disagree  3=Neutral  4=Agree  5=Strongly Agree

<table>
<thead>
<tr>
<th>Degree to which these criteria are important in achieving your professional goals</th>
<th>Criteria</th>
<th>Degree to which your education provided you with the ability to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
<td>A. apply knowledge of mathematics, science, and engineering</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>B. design and conduct experiments and analyze and interpret data</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>C. design a system, process, or component to meet desired needs</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>D. function on multi-disciplinary and/or diverse teams</td>
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<td>G. communicate effectively</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>H. understand the impact of engineering solutions in a global/societal context</td>
<td>1 2 3 4 5</td>
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<tr>
<td>1 2 3 4 5</td>
<td>I. engage in lifelong learning</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>J. know about contemporary issues of relevance to the field of chemical engineering</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
<td>K. use the techniques, skills and modern engineering tools necessary for engineering practice</td>
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<td>M. understand the role of economics in engineering and an ability to apply that understanding to problem-solving</td>
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<tr>
<td>1 2 3 4 5</td>
<td>N. understand chemistry and engineering topics, including safety and environmental aspects</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
Dear Recruiter/Employer:

The Department of Chemical Engineering at the University of North Dakota is gathering information for outcomes assessment. An important part of this assessment is how our stakeholders view our graduates. When completing this form, the first column is how you view our department’s graduates, and the second column is used to rate the importance of an issue to your company. Please provide any additional comments below or on the back.

Thank you.

1. What is the primary reason you/your company decided to recruit/hire graduates from this department?

2. Please rate these criteria

<table>
<thead>
<tr>
<th>Graduate Demonstration of</th>
<th>Employer Rated Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Poor</td>
<td>1 = Low</td>
</tr>
<tr>
<td>5 = Excellent</td>
<td>5 = High</td>
</tr>
<tr>
<td>1------- 2------- 3------- 4-------5</td>
<td>1------- 2------- 3------- 4-------5</td>
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<tr>
<td></td>
<td>1------- 2------- 3------- 4-------5</td>
</tr>
</tbody>
</table>

A. Ability to apply knowledge of math, science and engineering
B. Ability to design and conduct experiments, and analyze and interpret data.
C. Ability to design a system, component, or process to meet desired needs.
D. Ability to function on multi-disciplinary and/or diverse teams.
E. Ability to identify, formulate, and solve engineering problems.
F. Understanding of professional and ethical responsibility.
G. Ability to communicate effectively.
H. Education necessary to understand the impact of engineering solutions in a global and societal context.
I. Ability to engage in life-long learning.
J. Knowledge of contemporary issues of relevance to the field of Chemical Engineering.
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
L. Experience in undergraduate research and engineering in practice.
M. An understanding of the role of economics in engineering and an ability to apply that understanding to problem-solving.
N. A thorough grounding in chemistry and engineering topics, including safety and environmental aspects.

Comments:
The Chemical Engineering Department is interested in gathering placement/exit data about our graduates as part of our assessment plan. Please take a few minutes to complete this survey. You may write additional comments on the back of these sheets. We may send you an alumni survey within a year to follow up on your status.

Graduation date (please circle one): May August December
Graduation year: ____________
Name: _______________________________________________________
Address: _______________________________________________________
Phone number: _______________________________________________________

1. If you applied for a job or jobs:
   A. How many employers offered you an interview? _____________
   B. How many plant trips did you get? ______________
   C. How many job offers did you receive? _______________

2. If you decided to accept a job offer, please answer A, B, C, and D. If not, go to #3.
   A. Name of employer: ______________________________________________
   B. Type of industry:_________________________________________________
   C. Job title: _______________________________________________________
   D. Please indicate your starting salary: ________________________________

For questions 3 through 8, use the following scale 1=weak to 5=strong
3. Satisfaction with the advisement you received from UND chemical engineering Faculty. 1 2 3 4 5
4. Overall quality of your UND chemical engineering classes. 1 2 3 4 5
5. Overall quality of the UND chemical engineering laboratory sequence. 1 2 3 4 5
6. Overall quality of your UND general education classes. 1 2 3 4 5
7. Overall quality of the UND chemical engineering faculty. 1 2 3 4 5
8. If you participated in the co-op program, please rate the overall quality of your experience. 1 2 3 4 5

9. Please identify the area or areas of the chemical engineering curriculum that contributed most to your professional development.

10. What could we have done to improve your education?
11. Rate the following outcomes based on their importance to achieving your professional goals as well as our effectiveness at providing you with what you needed to demonstrate that you have these abilities.

1=Strongly Disagree  2=Disagree  3=Neutral  4=Agree  5=Strongly Agree

<table>
<thead>
<tr>
<th>Degree to which these criteria will be important in achieving your professional goals.</th>
<th>Criteria</th>
<th>Degree to which your education provided you with the ability to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
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<td>1 2 3 4 5</td>
<td>N. understand chemistry and engineering topics, including safety and environmental aspects</td>
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</table>
Attachment to Course Evaluations
for
ChE 306 Unit Operations
ChE 405 Mass Transfer
ChE 408 Process Control
ChE 412 Senior Plant Design
ChE 421 Reactor Design (Kinetics)

This department is gathering information as part of its on-going assessment plan. As you are completing your course evaluation for one of the courses listed above, please also rate the following three items on the form. These items will serve as numbers 18, 19, and 20 on your form. Please use the same rating scale as is indicated on your form.

(SA=Strongly Agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly Disagree)

18. This course contributed to my ability to apply knowledge of mathematics, science and engineering

19. This course contributed to my ability to design a system, component, or process to meet desired needs

20. This course contributed to my ability to identify, formulate, and solve engineering problems
Dear Co-op Supervisor:

The Department of Chemical Engineering at the University of North Dakota is interested in gathering data about our graduates as part of our assessment plan. Please take a few minutes to complete this survey. You may write any additional comments on the back of this sheet. Please return this sheet at the end of the term. Thank you!

Please rate the following outcomes based on their importance to your company=s goals or needs as well as how well the student assigned to you demonstrated these abilities. If the item is not applicable, please leave it blank.

1=Strongly Disagree  2=Disagree  3=Neutral  4=Agree  5=Strongly Agree

<table>
<thead>
<tr>
<th>Degree to which these criteria are important in achieving your company=s goals.</th>
<th>Criteria</th>
<th>Degree to which your UND Chemical Engineering student demonstrated the ability to:</th>
</tr>
</thead>
<tbody>
<tr>
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<td>A. apply knowledge of mathematics, science, and engineering</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1 2 3 4 5</td>
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