**(B) ABET Criterion 3: Outcomes Met By Course Content**

This brief content assessment should be consistent with the updated Course Syllabet

Course #: **BEE 2220**  Title: **Bioengineering Thermodynamics & Kinetics**

Semester/Year: **S/20110**

Instructor: **Hunter**

Identify the outcomes associated with this course.

Place a “P” or “S” in the left column and leave others blank.

P = Primary outcome that is assessed (suggest 2-3 Primary Outcomes)

S = Secondary outcome that is also assessed

<table>
<thead>
<tr>
<th>P or S</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>P</td>
<td>(a) an ability to apply knowledge of mathematics, science, and engineering</td>
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<td></td>
<td>(b) an ability to design and conduct experiments, as well as to analyze and interpret data</td>
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<tr>
<td>S</td>
<td>(c) an ability to design a system, component, or process to meet desired needs</td>
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<td>(d) an ability to function on multi-disciplinary teams</td>
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<td>P</td>
<td>(e) an ability to identify, formulate, and solve engineering problems</td>
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<td>(f) an understanding of professional and ethical responsibility</td>
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<td>(g) an ability to communicate effectively</td>
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<td>S</td>
<td>(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context</td>
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<td>S</td>
<td>(l-b) An ability to integrate modern biology with engineering principles (BE only)</td>
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<td></td>
<td>(l-e) an ability to create sustainable solutions in the context of a complex natural environment (EnvE only)</td>
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## (C) COURSE OUTCOMES ASSESSMENT MATRIX

**Dept & Course No.:** BEE 2220: Bioengineering Thermodynamics and Kinetics  
**Semester:** SP10  
**Name of Instructor:** Jean Hunter

<table>
<thead>
<tr>
<th>Course outcomes</th>
<th>ABET criterion</th>
<th>How criterion is met</th>
<th>Examples of assessment</th>
<th>Assessment relative to stated goal</th>
<th>Proposed action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain PVT behavior of systems incl. gas/liq phase diagram, critical point, limits of applicability of ideal gas law. Use steam tables and Nelson-Obert chart in calculations.</td>
<td>A</td>
<td>In-class exposition, problem sets 1-4. Also used in problem solving throughout course.</td>
<td>PS 2 #7,8,11 PS 3 #1 PS 7 #5 Prelim1 #1,2,4,5 Prelim2 #3,4 Final #1,5,8 GOAL: 85% class average on HW, 70% on exams</td>
<td>MET. HW grand mean 85.5; P1, P2 and Final means 734.4, 71.9 and 73.5 respectively.</td>
<td>none</td>
</tr>
<tr>
<td>Identify and conceptualize physical processes and break them down into thermodynamic building blocks suitable for calculation</td>
<td>E</td>
<td>In-class problem solving, office hours, Problem sets 1-8, all exams. Some students journaled on this. About 30% of course grade.</td>
<td>PS 1 #2,5,8 PS 2 #1-6 PS 4 any PS 5 #1,2 PS 7 #7b Prelim1 #1,3 Prelim2 #1,4 Final #2,4a,8,9 GOAL: 85% class average on HW, 70% on exams</td>
<td>Partially met. Students do this tolerably well when prompted, less well when it is implicit in problem identification and solution strategy development.</td>
<td>Reinforce this strategy by asking students to explain their solution strategy on selected HW problems. Set aside time in TA office hours for discussion of strategy.</td>
</tr>
<tr>
<td>Determine flows of heat, work, and entropy and changes in the state properties of closed and continuous-flow open systems, using IGL and thermodynamic tables</td>
<td>A, c</td>
<td>In-class dialog and group problem solving, Problem sets 2-7, all exams. About 30% of course grade.</td>
<td>PS 2 13-15 PS 3 #1,3,9 PS 4 all PS 7 most Prelim1 #3 Prelim2 #2,3,4 Final #3,5,8 GOAL: 85% class average on HW, 70% on exams</td>
<td>Met. Students can reliably solve problems comparable to the thermodynamics questions on the FOE exam. Still rather foggy on entropy outside the contexts specifically covered in class</td>
<td>No change.</td>
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<tr>
<td>Explain and discuss the E, h</td>
<td>PS 5-9 esp #7.</td>
<td>PS 6 #6</td>
<td>Met.</td>
<td>Promote more exploration of</td>
<td></td>
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<tr>
<td>Concept of the quality of energy and the relationship among temperature, entropy, efficiency, and energy quality</td>
<td>Journal #3</td>
<td>PS 7 #2,4, Prelim 1 #3bc, Prelim 2 #2,3,4, Final #3,5,B1,B6</td>
<td>GOAL: 85% class average on HW, 70% on exams</td>
<td>Entropy concepts in journals and by giving short assigned readings outside the text.</td>
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<tr>
<td>Identify salient thermodynamic and kinetic features of chemical reactions, e.g. $\Delta h$, $\Delta g$, $K_{eq}$ and rate coefficients. Calculate them from experimental data, extrapolate them to conditions of $T$, $P$ and concentration, Use them to solve problems.</td>
<td>A,E</td>
<td>Coverage of thermochemistry, equilibrium, kinetics in thermochemistry section and 2nd half of course.</td>
<td>PS 5, PS 8, PS 9 all, esp. 3, PS 10 all, Prelim 2 #1,8, Final #4,6,8, B3,B4,B5</td>
<td>GOAL: 85% class average on HW, 70% on exams</td>
<td>Partially met. Thermochemistry and equilibrium well mastered by end of course. Some material in kinetics not covered. Material covered in class was well mastered as indicated on hw, final</td>
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<tr>
<td>Identify the common reference states and units for chemical and thermodynamic systems; discuss their relative advantages and disadvantages; choose appropriate reference states for problems.</td>
<td>E</td>
<td>PS 1 devoted to units-wrangling. PS 7 on entropy. Discussion during in-class problem solving and at office hours.</td>
<td>PS 1, PS 5, PS 8 esp. #1, PS 9 esp. 4b, PS 10, Prelim 2 #1,3, Final 8,9,B3</td>
<td>GOAL: Less than 5% of final exam problems will have units errors</td>
<td>Met. Only two bad errors on units/reference states in the final exam.</td>
</tr>
<tr>
<td>Calculate rate constants and predict reactor performance for first order, second order, and microbial growth (Monod) kinetics in ideal batch, PFR and CSTR reactors.</td>
<td>A,c</td>
<td>Kinetics unit including PS 10 and 11; final exam.</td>
<td>PS 10, Final #4,6,7</td>
<td>GOAL: 85% class average on HW, 70% on exams</td>
<td>Not met. Ran out of time and only covered up through rate constants and batch reactions. HW 10 and 11 were combined. Cut back coverage of other topics, reduce in-class exposition, to leave more time.</td>
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<tr>
<td>Recognize thermodynamic phenomena in natural and human-designed systems;</td>
<td>h</td>
<td>Occasional lengthy design oriented problems in the bio or environmental</td>
<td>PS 1 #7, PS 2 #15, PS 3 #4,5,7,8, PS 4 #5,9</td>
<td>Partially met. Bio related problems were generally well received but</td>
<td>Distribute official formative assessments in class to reserve journals for reflection on other subjects.</td>
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</tbody>
</table>
Believe thermodynamics to be both understandable and useful.

| Contexts of interest to students. Bio/envtl oriented problems in nearly all HW assignments. In-class problems aligned to bio/envtl contexts where possible. 4 journal assignments. In-class discussion. Field trip to new campus cogeneration plant. | PS 5 #3c,4 PS 6 #6 PS 8 #4, 5c PA 9 #3,4, 5c PA 11 #2 Prelim 2#7,8,9 Final #7,8, B6 Observations by TA’s, in-class questions by students. **GOAL: Students will turn in thoughtfully written journal entries.** | Considered too lengthy and detailed. ~90% of journals were turned in on topic and thoughtfully written vs. 100% target. Journal content often dwelt on students’ concerns about the material, and formative assessment of the class, rather than on thermo outside the classroom door. 4 journals is the right amount of journaling. Field trip was a big win. | Develop and implement a specific assessment of student beliefs and attitudes. (Lower priority than goals related to mastery of technical material) **New goal: students will post more about out-of-class than in-class matters in their journals.** |
(D) Course Enhancement Questionnaire

As part of on-going self-assessment for ABET accreditation, instructors are asked to complete this questionnaire for each course they teach each semester. Questionnaires from previous years will be provided to new instructors when the course instructor changes.

Dept & Course #: BEE 2220

Course Title: Bioengineering Thermo & Kinetics

Instructor: Hunter

Semester: S 2010

Report Date: 

1. In this offering of your course, have you made any of the following changes?

   (a) Y / N - New material is being taught (if Y, please describe)
   Added coverage of differential scanning calorimetry to link thermochemistry to students’ interest in biomaterials and protein chemistry
   Increased reliance on students’ prior knowledge of mass balances and general chemistry; this was supposed to reduce the amount of material taught to make room for more kinetics later, but it backfired. Had to backtrack partway to reiterate material on basic thermochemistry, partial pressures and mole fractions that is de-emphasized in the new version of Chem 2090, introductory chemistry for engineers

   (b) Y / N - I have changed the context of my course (if Y, please describe)
   Attempted better integration of simple ideal gas law and units-wrangling with mass and energy balance content from BEE 2600/2510 which most students took just prior to 2220.

   (c) Y / N - I have introduced updated material or examples (if Y, please describe)
   1) Spent more time on thermochemistry as the students found that particularly challenging
   2) Assigned several new homework problems using thermodynamics in a biomedical, biochemical, or manufacturing context; trying to get away from steam and ideal gases.
   3) Reinstated the field trip to the cogeneration plant on campus. Big win.

   (d) Y / N - Different or new technology is being used (if Y, please describe)
   1) Revised/expanded online pre-lecture quizzes (begun in 2009) used to motivate reading the text before class. A challenge to get the questions right, not stupid easy and not too hard.
2. Have you made any of the following changes to your course this term?

(e) Y / N - I have taken new steps to solicit student feedback (if Y, please describe)
   Added extra ABET-related questions to the course evaluations (2009 & planned for 2011, missed 2010)

(f) Y / N - I have made other changes (if Y, please describe)
   1) Continue to reduce initial emphasis on defining thermodynamic states and state variables, and forms of energy; we go more or less directly into ideal gas law/mass balance review, then energy, enthalpy, and the steam tables.
   2) Extended the “pre-testing” of exam questions on the TA’s. The TA’s take the exams before the class do, and give me detailed feedback on content distribution and the time required to complete each part of the exam.
   3) Distributed detailed lists of topics to be covered, and extensive practice problems, before each test.

3. What motivated you to make the changes described above? What impact have the changes had on the outcomes in your course?

   f1) Gets the course off to a quicker start, deals with more concrete subject matter which builds student interest and confidence.
   f2) Scores on tests were higher than last year and students seemed more confident.
   f3) Helped students and TA’s prepare for exams.
   d1) Pre lecture quizzes better organized, at a better level than last year but still too long & hard.
   c1) Lost time put us behind and required material to be left out of the kinetics part of the course.
   c2) The above average students just loved the bio- and real-life related problems. The below average students found it inhibited learning by over-complicating the material.
   c3) Dropped it in 2009 because running out of time; in retrospect should have left it in. Brought it back for 2010. Very enjoyable for students, prompted extensive journaling.

4. What student feedback have you received in response to the changes you have made?

   f2) Grumbling about too-long, too-difficult exams has stopped. Some even said they enjoyed the exams! Extra work for the TA’s but it simplified grading.
   d1) The students did not like the pre-lecture quizzes which were too difficult and time-consuming. In retrospect the questions should have been extremely simple, Bloom level 1-2 but in order to make them “interesting” I pitched them too high.
   c1) Students were fine with this, preferring deep mastery to broad coverage.

5. Are you planning changes in the course for the next semester?

   1) I will consult with the Chemistry department and the instructor of engineering chemistry (Chem 2090) and our mass and energy balance courses (BEE 2600 and 2510) to identify what areas of chemistry and mass balance need to be recapped in BEE 2220, then adjust the first third of the course accordingly.
   2) Will continue the field trip to the cogeneration facility and add more demos in class
   3) Will continue looking for a better text and will start expanding class notes into a form that could become a textbook. Now discussing “custom publishing” text with publisher.
4. Will split up “content units” now spread over multiple class periods into smaller chunks in which each lecture or half-lecture stands alone; do more examples and less exposition.

6. What is the motivation for the planned changes? What impact(s) do you expect the changes to have on the outcomes in your course?

1) To help students link their chemistry with mass/energy balances in earlier coursework and to avoid duplication. Intended impact: increase motivation by showing connections among different courses and applications to real world problems; build in necessary review to avoid losing time later.

2) To show the practical side of thermo, motivate the study of heat engines, and give a break from chalk, talk and slides. Intended outcome: help hands-on learners, improve student interest.

3) Current texts do not address our students needs for classical engineering thermo AND physical chemistry; either the thermo or the bio is lacking. We need a selection of chapters from both types of textbook.

4) Students are asking for better organization and smaller “bites” of content.

Appendix A. (Missed deadline in 2010; to do in Spring 2011)

Course Evaluation Supplemental Questions Related to ABET Outcomes (a) through (f)

Dept & Course No.: _BEE2220_ Semester: _S 2011_ Name of Instructor: __Hunter__________

Please select (by checking the boxes) up to four (4) supplemental evaluation questions most appropriate to your course to be included in the end-of-semester on-line course evaluation by students. Please return your completed request to the Undergraduate Coordinator by the announced deadline.

Note that all the ABET Outcome questions will have the following instructions:
Answer: Check 1 through 5: _______ (1 = not helpful 5 = extremely helpful)

X (a) Did this course enhance your ability to apply knowledge of mathematics, science, and engineering?
□ (b) Did this course enhance your ability to design and conduct experiments, as well as to analyze and interpret data?
□ (c) Did this course enhance your ability to design a system, component, or process to meet desired needs?
□ (d) Did this course enhance your ability to function on multi-disciplinary teams?
X (e) Did this course improve your ability to identify, formulate, and solve engineering problems?
□ (f) Did this course advance your understanding of professional and ethical responsibility?
□ (g) Did this course improve your ability to communicate effectively?
☐ (h) Did this course improve your ability to understand the impact of engineering solutions in a global and societal context?

☐ (i) Did this course promote recognition of the need for life-long learning?

☐ (j) Did this course enhance your knowledge of contemporary issues?

☐ (k) Did this course enhance your ability to use the techniques, skills, and modern engineering tools necessary for engineering practice?

☐ Select Question (l-b) and/or (l-e) as appropriate

☒ (l-b) Did this course enhance your ability to integrate modern biology with engineering principles?

☐ (l-e) Did this course enhance your ability to create sustainable solutions in the context of a complex natural environment

(Use the back of this sheet if more space is needed for alternative supplemental questions)
Appendix B

**ABET Program Outcomes**

Criterion 3. Program Outcomes and Assessment
Engineering programs must demonstrate that their graduates 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
(d) an ability to function on multi-disciplinary 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
(h) the broad education necessary to understand the impact of engineering solutions in a 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
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Additional Outcome (l-b)* specific to Biological Engineering:
(l-b) An ability to integrate modern biology with engineering principles

Additional outcome (l-e)* specific to Environmental Engineering:
(l-e) an ability to create sustainable solutions in the context of a complex natural environment

*Some courses may find it appropriate to include both outcomes (l-b) and (l-e)