



DEPARTMENT OF THE ARMY
UNITED STATES MILITARY ACADEMY
West Point, New York 10996

**REPLY TO
ATTENTION OF
MADN-CLS**

07 September 2022

MEMORANDUM THRU COL F. John Burpo, Department Head, Department of Chemistry and Life Science, United States Military Academy, West Point, NY 10996

FOR Dean of the Academic Board, United States Military Academy, West Point, NY 10996

SUBJECT: 2022 Executive Summary of Chemical Engineering (CEN1) Program Assessment

1. This memorandum is an executive summary, per *DPOM 5-07 Assessment of Student Learning in the Academic Program*, outlining the changes in the Chemical Engineering Program's assessment and assessment process, as well as curriculum changes, that have occurred since the last executive summary in September 2021, in response to program assessment.

a. The Chemical Engineering Program obtained validation of 3.0 engineering topics credit for CH350, Bioprocess Engineering, CH300, Biomedical Engineering, and CH450, Bioengineering Modeling and Analysis. Both CH300 and CH350 have been taught in AY22 as pilot courses and the second iteration is currently underway in AY23. Curriculum Committee proposals are currently under review in the Department of Chemistry and Life Science and will be submitted to the Curriculum Committee in AY23-1 for review and approval for permanent USMA Redbook offerings. CH450 is permanently listed in the USMA Redbook. In addition, this is the fourth academic year in which we offered the Chemical Engineering Major (CEN1) program. Previous years had been under the CEN0 program.

(1) A significant curricular change in our program was to add CH367 – Introduction to Automatic Process Control as a required course in the major in AY17. The inaugural offering of CH367 successfully occurred in AY19-2, and this course is now an ongoing course offering in spring semesters. We continue to track cadet performance on the process control topic on the Fundamentals of Engineering Exam (FEE) exam to determine if this course has improved performance with respect to the national average. "Encl 3 – exsum_CEN1_2022-08-FEE Results AY22" shows the previous 10-year progression of our graduating chemical engineers' performance on the FEE in the Process Control section. After the addition of CH367 in AY19, our cadets showed improvement on the process control portion of the FEE (not counting AY20 due to COVID-19; the entire class was unable to take the FEE). Before the addition of the course, the performance data were consistently below average (left of center), but this appears to have been improved. We are cautiously optimistic that we are seeing a positive trend and will continue to monitor progress in this topic.

(2) The standard 8TAP that reflects the curriculum is shown in the attached document "Encl 1 - exsum_CEN1_2022_08 - 8TAP".

b. Student Outcomes (SO) Assessment:

(1) For AY22, the Chemical Engineering Program continued to assess performance against the SOs required by ABET and implemented in AY19. The updated assessment process was fully described in the 2019 Executive Summary of Chemical Engineering (CEN1) Program and more fully described in the 2020 ABET Self-Study.

(2) The SO assessment process requires analysis of our assessment data pack, followed by discussions among faculty members, advisory board members, and students. The assessment data pack for AY22 is included in the attached document "Encl 2 - exsum_CEN1_2022 Assessment Data 2022_08." However, the assessment process is not complete until our advisory board meets after Spring Break in AY23-2. A completed assessment will be submitted upon completion of our process. Of note, the performance of cadets on the Fundamentals of Engineering Exam (FEE) during AY22 was 19/22 (86%) cadets passing first attempt, above this year's national chemical engineering average pass rate of 70.7%. Two more chemical engineers passed the FEE on their second try for an overall 91% pass rate for Class of 2022. While we strive for a 100% pass rate, we are proud that we have exceeded the national average in each year the program has been offered.

(3) FE exam data for Student Outcome 8 is shown in the attached document "Encl 3 – exsum_CEN1_2022-08-FEE Results AY22." The data show an improvement this year in Mathematics, Materials Science, Chemistry & Biology, Heat Transfer, Mass Transfer & Separation, Chemical Reaction Engineering, Economics, Process Design, Process Control, Safety, Health, & Environment and Ethics & Professional Practice sections, respectively (See Encl 3 for FEE data comparison to previous years). Additionally, our cadets' aggregated scores on these topics, per section, were well within one standard deviation from the national average. The cadet's performance on Engineering Sciences, Economics, and Ethics & Professional Practice was one standard deviation above the national average. Economics was a standalone topic separated from the combined Process Design & Economics topic in the AY21 FEE. Chemistry was changed to Chemistry & Biology as a combined topic. Moreover, the overall performance in Thermodynamics and Process Controls are trending upward. The addition of CH365, Thermodynamics in AY13 and CH367 in AY19 demonstrates our assessment-based effort at program improvement.

(4) AY22 was the seventh iteration of the CH365 Chemical Engineering Thermodynamics course. This course was introduced to address low performance in thermodynamics on the FEE observed prior to AY16. For AY22, the cadets performance was significantly above the national average. In general, the data were consistently near the national average (left of center) for several consecutive years

despite a small set back in AY20 due to COVID-19 implications. Overall, there is a net upward trend in performance when observed over the past five years. Therefore, it appears that this historical weakness in our program's performance in chemical engineering thermodynamics has been corrected by the addition of this course. Continued assessment will need to occur in subsequent years to ascertain whether this upward trend is sustained. The previous ten years of FEE results for thermodynamics are shown in Encl 3. It is evident that after adding the course in AY16 there was an immediate improvement for our chemical engineering cadets (excluding AY20 due to COVID-19; the entire class was not able to take the FEE).

(5) Relatively low scores were seen in some of the embedded indicators for the communication outcome (SO3) in AY20, particularly in the Signature Writing Event (SWE) in MC312. The SWE is administered by Department of Civil and Mechanical Engineering in the MC312 course. The mechanical engineering program tracks scores in the SWE by major and reports the results back to the Chemical Engineering Program for our program assessment. Poor performance in technical writing by some of our chemical engineering cadets led to relatively low scores overall on the SWE. As a result, each chemical engineering cadet now has a chemical engineering faculty mentor for the activity. This change was implemented in AY21 and resulted in a significant increase in scores both in AY21 and AY22, and our cadets were, on average, 3% higher than the course average (85.96% for chemical engineering versus 82.97% course-wide), with no D or F grades reported in AY22. In addition, CH459 Chemical Engineering Lab has a rigorous technical writing, drafting and in-progress-review process to ensure adequate mentorship on technical communication best practices. This process ensures that each cadet receives feedback with respect to writing for each deliverable. Since the faculty mentor model was implemented in AY21 in the SWE, the cadets' performance in CH459 has improved in AY21 and AY22. As shown in Encl 2 for SO3, in AY22 the average course grade was above the 5-year average, which is a significant improvement. As a program, we will continue to assess cadet performance as we transition the SWE to CH459 in AY24 and compare performance going forward to that of MC312 in the past academic years.

(6) The remaining topics on the FE exam were generally within historical variations and/or standard deviations.

(7) During AY22 the program continued to utilize program-developed 1/0 rubrics to assist course directors in more precisely defining embedded indicators. Of significant note, all course directors completed this part of the program assessment correctly and on time. This saved considerable time in the preparation of the assessment data in "Encl 2 - exsum_CEN1_2022 Assessment Data 2022_08".

(8) We acknowledge lower than average scores shown in "Encl 2 - exsum_CEN1_2022 Assessment Data 2022_08" for CH400 on Student Outcome 1. This course presents challenging homework and quiz problems to provide adequate

FEE preparation for the first-class cadets (Firsties). The program has a high level of expectation in CH400, and therefore the scores of the graded events are slightly lower on average than our other chemical engineering courses. CH400, Chemical Engineering Professional Practice is in the 8TAP because it provides a curricular review of relevant content as a way to prepare our Firsties for the FEE. This curricular review strategy is consistent with best practices in industry and academia. We also acknowledge that the cadet surveys have also rated CH400 lower than other courses due to the difficulty of graded events, which we see as a good result (if the course was easier, survey scores would be higher).

(9) The chemical engineering program addresses ethics and process safety separately for the purposes of assessment through student outcome (SO4) and our program criterion (SO8), respectively. It is important that chemical engineering graduates have a level of technical competence that provides general understanding of the standards of professional practice, have an appreciation for the issues faced by chemical engineers, understand engineering ethics and ethical reasoning, and recognize the importance of professional registration and licensure. Standards and ethics are discussed throughout the curriculum in the core courses, the professional practice course (CH400), and the capstone course, CH402 Chemical Engineering Process Design. The program addresses the hazards associated with chemical processes, and process safety education in the curriculum through the chemical engineering laboratory (CH459) and CH402. 1. There is a 10 module Safety and Chemical Engineering Education (SAChE) certificate program that each Firstie must complete while enrolled in CH459. The SAChE program is a cooperative effort between the Center for Chemical Process Safety (CCPS) and engineering schools to provide teaching materials and programs that bring elements of process safety into the education of undergraduate students studying chemical and biochemical products and processes. The SAChE committee comprises academics, industrial practitioners, and AIChE staff; 2. CH400 covers process safety as part of FEE preparation. "Encl 3 – exsum_CEN1_2022-08-FEE Results AY22" shows that our cadets have outperformed the national average on this section of the FEE as exemplified by the cadet's performance above the national average in Safety, Health & Environment and Ethics & Professional Practice.; 3. The capstone project in CH402 as a senior design project has a requirement to include a process safety, exposure, and environmental analysis. The capstone design must not pose any environmental, health or safety hazards that should have been mitigated with better equipment, instrumentation or control. Using process design software (CHEMCAD), cadets explore safety and environmental analysis and use the WAR algorithm to include toxicity and environmental impact reports. They also identify the location of all control valves and sensors, identification of the most important controls, and their proposed method for dealing with thermal issues.

(10) The program continues to support the Academic Program Goals and the statements of What Graduates Can Do. The mapping between our student outcomes and the APG/WGCD statements is found in "Encl 4 – exsum_CEN1_2022-08 APG-

WGCD Mapping". Numerical scores are included in the attachment. The scores are based on grades on embedded indicators on a 0-5 scale. Thus a 4 is 80%. In all cases, scores are above 4 and many are above 4.5. This should be interpreted to mean that we are successfully achieving the portions of the APGs supported by our program.

c. CH450 Bioengineering Modeling and Analysis was added to the 2024 Redbook as an approved elective for chemical engineering, with 3.0 validated ET credit by the ABET Committee. We have added as pilot courses: CH300 Biomedical Engineering and CH350 Bioprocess Engineering for AY22.

d. The Chemical Engineering program has proposed an administrative curricular change request for the redesignation of the SWE and Writing in the Major (WiM) for moving the SWE/WiM requirement for cadets majoring in CEN1 and Chemical Engineering Studies (CES1) in AY23. Previously, the WiM requirement for CEN1 cadets was completed in MC312 Thermal-Fluid-Systems II. However, the WiM requirement for mechanical engineering (MEN2) has been moved from MC312 to ME400. Since CEN1 cadets will not be taking ME400, the WiM requirement for CEN1 will be moved to CH459 Chemical Engineering Laboratory course, and for CES1 to CH365 Chemical Engineering Thermodynamics. This change will be effective with the class of 2024. The program will be executing the same academic schedule as AY22, with one course, CH485 – Heat and Mass Transfer will stay a 30-lesson, 75-minute, course for AY23.

e. Other than the stated change to the assessment process to reflect ABET accreditation criteria, there are no planned changes to the Chemical Engineering program's assessment process.

f. Assessment schedule. The program assessment process is currently in progress. The process is initiated during the summer when the data assessment packet is distributed to faculty for analysis. Program assessment for AY22 will be complete by 1 July 2023 (following our next advisory board meeting, at which time the board will evaluate the program data of AY2022) and Encl 2 will be update at that time. The planned Advisory Board meeting for AY23 will occur in late April or early May 2023.

g. The ABET record year was AY19-20 with a remote onsite visit taking place 14-19 November 2020. Overall, the program passed with flying colors. No program shortcomings were reported, and a program strength was reported for the process safety portion of the program and our unique implementation of process simulators in the curriculum

h. The program followed all USMA and department guidelines by teaching in person lessons and labs with COVID-19 HPCON Level Guidance for the Classroom/Lab. All courses and labs were executed in person with social distancing of 3 feet and face coverings in AY22-1 as prescribed by the Dean's Annual Guidance. In AY22-2, the HPCON level was later downgraded to Bravo and face coverings were no longer required later in the semester. Overall, in AY22, the program was able to offer in person

courses to cadets and did not experience any significant disruptions due to the pandemic.

2. We have examined the complimentary support courses and they do exactly what they should be doing which is providing foundations math and applied science framework. EE301, Fundamentals of Electrical Engineering, provides the basis for understanding of electronic circuits to aid chemical engineering process control modeling. MA364/365, Engineering Mathematics, provides the basis and background of the advanced math skills required to master the chemical engineering curriculum moving forward. PH206/256 Physics II provides a deeper understanding of the mathematics and underlying science that is part of the chemical engineering curriculum.

3. Technical writing has been a focus of the chemical engineering program for many years, and many control measures, and techniques have been implemented to facilitate our cadets development in this space. For example, we assign faculty writing mentors to each of our chemical engineers for the SWE in MC312, and mandatory IPRs with lab reports, executive summaries and poster deliverables in the context of CH459 Chemical Engineering Lab for Firsties. As the program transitions the SWE to CH459, the same faculty mentorship approach will be implemented in the course. This has greatly improved our cadets technical writing ability, and we plan on sustaining these strategies moving forward.

4. Point of contact for this action is the AY22 Chemical Engineering Program Director, Dr. Enoch A. Nagelli, at x3904.

4 Enclosures

1. Approved CEN1 8TAP
2. Assessment Process and Data
3. FEE Topical Outcomes Evaluation
4. APG-WGCD Mapping

ENOCH A. NAGELLI PH.D.

Associate Professor

Chemical Engineering Program Director (AY22)

**Enclosure 2 to 2022 Executive Summary of Chemical Engineering Program
Assessment: Assessment Process and Data**

This document is a separate file entitled "Encl 2 - exsum_CEN1_2022 Assessment Data 2022_08"

This file was published to the program on 26 August 2022. An updated file containing Faculty, Advisory Board, and Program Director survey data and input will be published o/a 1 June 2023.

Enclosure 1 to 2022 Executive Summary of Chemical Engineering Program Assessment:
Approved CEN1 8TAP
CEN1 - Class of 2022

4th Class Year Fall Term	Spring Term	3rd Class Year Fall Term	Spring Term	2nd Class Year Fall Term	Spring Term	1st Class Year Fall Term	Spring Term
<i>E</i> MA103 4.0	<i>E</i> MA104 4.5	<i>E</i> MA205 4.5	<i>R</i> CH362 3.5	<i>R</i> CH363 3.5	<i>R</i> CH364 3.5	<i>D,R</i> CH459 3.5	CH402 3.0
EV203/ CH101 4.0	<i>R</i> CH101/ PH205 4.0	<i>R</i> PH205/ PH206 4.0	<i>R/</i> EV203/ PH206 4.0	<i>R</i> EE301 3.5	CH367 3.0	CH365 3.0	CH400 1.5
EN101 3.0	EN102 3.0	<i>R</i> CH102 4	MA364/5 3.0	<i>R</i> CH383 3.5	MC312 3.0	<i>R</i> CH485 3.5	Engr Elective 3.0
IT105 3.0	PL100 3.0	<i>E</i> DFL1 4.0	PY201 3.0	MC311 3.5	MC300 3.0	Engr Elective 3.0	LW403 3.5
HI105 3.0	HI108 3.0	<i>R</i> SS201 3.5	<i>E</i> DFL2 4.0	PL300 3.0	SS307 3.5	Engr Elective 3.0	<i>R</i> HI302 3.0
			<i>R</i> SS202 3.5	MA206 3.0			MX400 3.0

D = Double blocked course R = RSTU lab course

E = Meet every day for 55 minutes

Course should not be moved from that year or term

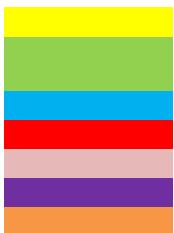
Course may be scheduled in the fall or spring of that academic year

Complementary Support Courses

Core Engineering Sequence (not applicable) Course 3 Science Depth

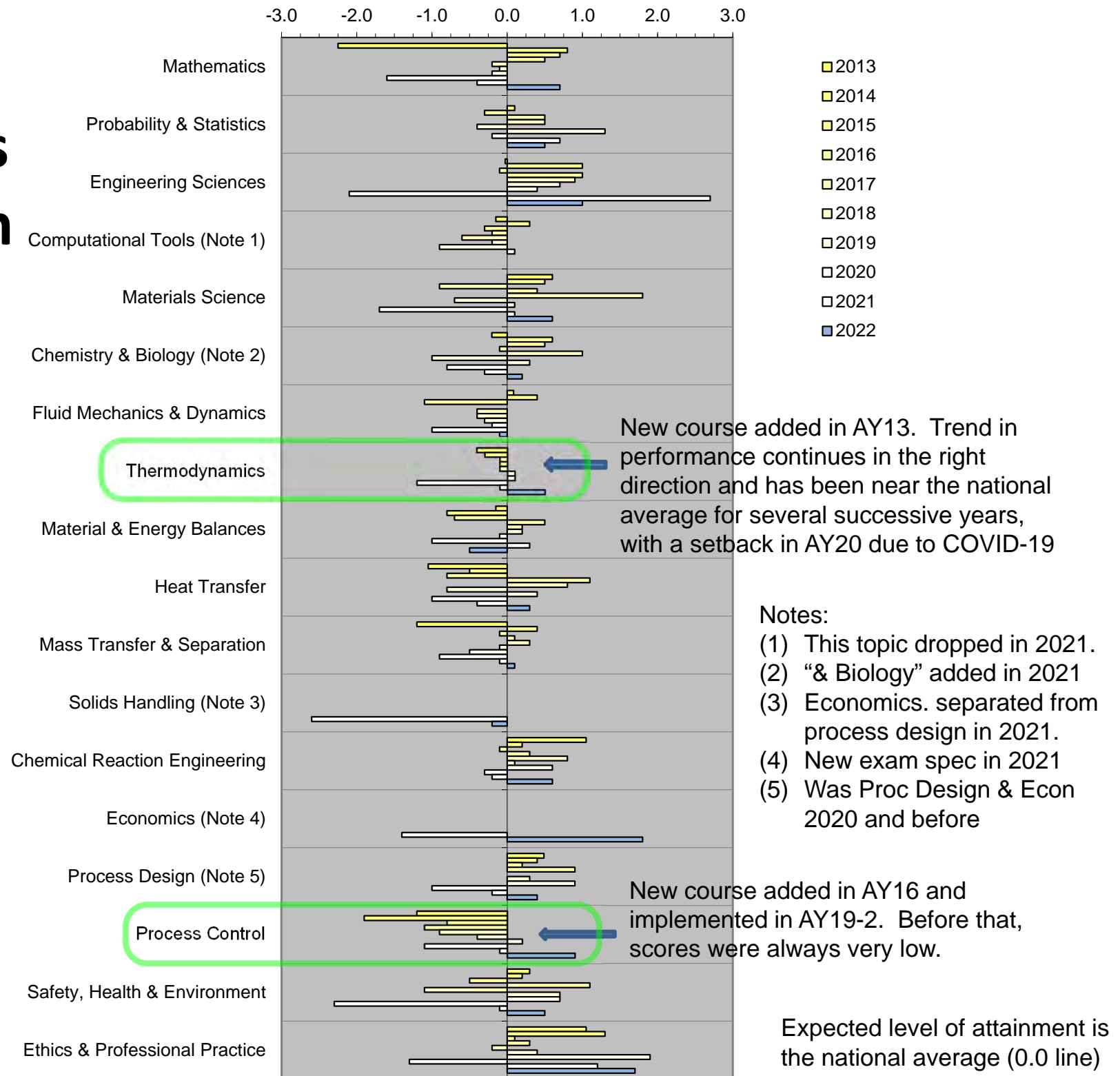
Course 9 STEM Depth

other electives - most popular electives are templated



Topical Outcomes Evaluation

Deviations from National Averages
AY13 to AY22



Student Outcome	Communication					Critical/Creative Thinking						Lifelong Learning				Disciplinary Depth				
	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	7.1	7.2	7.3	7.4	7.5
1						XX										XX	XX	XX	XX	
2						XX	XX		X		X					XX		X		
3	XX	XX	XX													X			X	X
4						XX												X	X	
5	X		X		X	XX	XX						X			X	X	XX	XX	XX
6										XX					X	XX		X		
7					X	XX				X		XX	XX			X			X	X
Total	XX	XX	XX		X	XX	XX		X	XX	X	XX	XX		X	XX	XX	XX	XX	XX

Student Outcome	Communication					Critical/Creative Thinking						Lifelong Learning				Disciplinary Depth				
	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	7.1	7.2	7.3	7.4	7.5
1						4.23										4.23	4.23	4.23	4.23	
2						4.25	4.25		4.25		4.25					4.25		4.25		
3	4.49	4.49	4.49													4.49			4.49	4.49
4						4.27												4.27	4.27	
5	4.65		4.65		4.65	4.65	4.65						4.65			4.65	4.65	4.65	4.65	4.65
6										4.44					4.44	4.44		4.44		
7					4.41	4.41				4.41		4.41	4.41			4.41			4.41	4.41
Average	4.57	4.49	4.57		4.53	4.362	4.45		4.25	4.425	4.25	4.41	4.53		4.44	4.412	4.44	4.368	4.41	4.517

Grade	A+	A	A-	B+	B	B-	C+
GPA	4.33	4.00	3.67	3.33	3.00	2.67	2.33
Scale:	5.00	4.62	4.24	3.85	3.46	3.08	2.69